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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/920,076	11/27/2012	8320264	AND01 061 US	2431

79172 7590 11/07/2012

Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 812 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

John Arpee, Herndon, VA;
John Peter Carlson, Dulles, VA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

GOOGLE EXHIBIT 1002
Google v. Geoscope

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of John Arpee, et al.

Serial No.: 11/920,076 Art Unit: 2477

Filed: December 15, 2008 Examiner: Ashley L. Shivers

Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

The Office included a "Reasons for Allowance" in the Detailed Action section of the Notice of Allowance paperwork mailed on 12 October 2012. Applicant hereby replies to the Reasons for Allowance.

In paragraph 4 of the Reasons for Allowance, the Examiner states in part:

> 4. The following is an examiner's statement of reasons for allowance:
>
> Gibbons et al. **(U.S. PGPub 2005/0136951)** teaches of measuring signal strength of an active communication channel without disabling any other communication channel **(See [0036], [0048], [0052], [0055], [0067], [0081])**. (emphasis in original)

Gibbons, et al., was never cited in an Office Action against any of the claims that appeared in the application, whether those claims were ultimately either canceled or allowed. Thus,

Applicants have not considered the merits or deficiencies of the Examiner's assertions regarding Gibbons, et al. in the Reasons for Allowance and therefore Applicants do not agree with the above statement.

If the Examiner has any questions relating to this Miscellaneous Letter or the application in general she is respectfully requested to contact the undersigned.

The Commissioner is hereby authorized to charge payment of any additional fees associated with this communication or credit any overpayment to Deposit Account No. 04-1679.

Respectfully submitted,

/Mark C. Comtois/
Mark C. Comtois Reg. No. 46,285

DUANE MORRIS LLP
505 9th Street, N.W., Suite 1000
Washington, D.C. 20004
Telephone: (202) 776-7800
Telecopier: (202) 776-7801

Date: 24 October 2012

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of John Arpee, et al.

Serial No.: 11/920,076 Art Unit: 2477

Filed: December 15, 2008 Examiner: Ashley L. Shivers

Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

MISCELLANEOUS LETTER

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

The Office included an "Examiner-Initiated Interview Summary" (*see* Exhibit A) with the Notice of Allowance paperwork mailed on 12 October 2012. The Examiner-Initiated Interview Summary was prepared by the Examiner regarding the telephone conversation between the Examiner and Applicants' attorney on 26 September 2012.

Applicant hereby replies to The Examiner-Initiated Interview Summary in order to clarify the thrust of the discussion which occurred between the Examiner and Applicant's attorney.

In the "Substance of the Interview" section of the Examiner-Initiated Interview Summary, the Examiner states in full:

> Examiner requested that Applicants cancel claims 1-10 as the Examiner found a new reference by Gibbons which taught of determining the signal strength of an active communications channel without disabling any other communication channel.
>
> Attorney indicated that Applicants would be willing to cancel claims 1-10 and the attached Examiner's amendment details the changes.

It appears that one may misconstrue the above Substance of the Interview and reach the erroneous conclusion that Applicants canceled Claims 1-10 in light of the disclosure in the Gibbons reference. Such is NOT the case. Applicants canceled Claims 1-10 merely for the purpose of furthering prosecution and obtaining allowance of the remaining 41 claims in the application.

If the Examiner has any questions relating to this Miscellaneous Letter or the application in general she is respectfully requested to contact the undersigned.

The Commissioner is hereby authorized to charge payment of any additional fees associated with this communication or credit any overpayment to Deposit Account No. 04-1679.

Respectfully submitted,

/Mark C. Comtois/
Mark C. Comtois Reg. No. 46,285

DUANE MORRIS LLP
505 9th Street, N.W., Suite 1000
Washington, D.C. 20004
Telephone: (202) 776-7800
Telecopier: (202) 776-7801

Date: 24 October 2012

Exhibit A

Examiner-Initiated Interview Summary	Application No.	Applicant(s)	
	11/920,076	ARPEE ET AL.	
	Examiner	Art Unit	
	ASHLEY SHIVERS	2477	

All participants (applicant, applicant's representative, PTO personnel):

(1) *ASHLEY SHIVERS*. (3)_____.

(2) *Mark Comtois/Attorney*. (4)_____.

Date of Interview: *26 September 2012*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☒102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: *1*.

Identification of prior art discussed: *Gibbons et al. (U.S. PGPub 2005/0136951)* .

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Examiner requested that Applicants cancel claims 1-10 as the Examiner found a new reference by Gibbons which taught of determining the signal strength of an active communications channel without disabling any other communication channel.
Attorney indicated that Applicants would be willing to cancel claims 1-10 and the attached Examiner's amendment details the changes.

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/A. S./ Examiner, Art Unit 2477 9/26/2012	/Chirag G Shah/ Supervisory Patent Examiner, Art Unit 2477

Electronic Acknowledgement Receipt

EFS ID:	14066216
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	79172
Filer:	Mark Charles Comtois/laureen ponder
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND01 061 US
Receipt Date:	24-OCT-2012
Filing Date:	15-DEC-2008
Time Stamp:	15:58:27
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	061USSRA.pdf	118990 5560fe7095ea54ddc1d4d692630269b10d568841	no	2

Warnings:	
Information:	

2	Miscellaneous Incoming Letter	061USML.pdf	244693 6880e86575f4e682e028f61c193b91eafca80b37	no	4

Warnings:	
Information:	
Total Files Size (in bytes):	363683

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

79172 7590 10/12/2012

Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/920,076	12/15/2008	John Arpee	AND01 061 US	2431

TITLE OF INVENTION: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1770	$300	$0	$2070	01/14/2013

EXAMINER	ART UNIT	CLASS-SUBCLASS
SHIVERS, ASHLEY L	2477	370-330000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Duane Morris LLP

2

3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Andrew LLC

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Hickory, North Carolina

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

☒ Issue Fee

☒ Publication Fee (No small entity discount permitted)

☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

☐ A check is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 04-1679 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Mark C. Comtois/ Date 24 October 2012

Typed or printed name Mark C. Comtois Registration No. 46,285

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Electronic Patent Application Fee Transmittal

Application Number:	11920076
Filing Date:	15-Dec-2008
Title of Invention:	METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION
First Named Inventor/Applicant Name:	John Arpee
Filer:	Mark Charles Comtois/laureen ponder
Attorney Docket Number:	AND01 061 US

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	1501	1	1770	1770
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**2070**

Electronic Acknowledgement Receipt

EFS ID:	14066447
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	79172
Filer:	Mark Charles Comtois/laureen ponder
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND01 061 US
Receipt Date:	24-OCT-2012
Filing Date:	15-DEC-2008
Time Stamp:	16:08:24
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$2070
RAM confirmation Number	3063
Deposit Account	041679
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	11920076IF.pdf	98510 57597b3a15168527bbb82add1f42641582a6b892	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	32289 7c7501bb38057a820f6bb40c98afaeb30581efbe	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	130799		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
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Examiner-Initiated Interview Summary	Application No.	Applicant(s)	
	11/920,076	ARPEE ET AL.	
	Examiner	Art Unit	
	ASHLEY SHIVERS	2477	

All participants (applicant, applicant's representative, PTO personnel):

(1) *ASHLEY SHIVERS*. (3)_____.

(2) *Mark Comtois/Attorney*. (4)_____.

Date of Interview: *26 September 2012*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☒102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: *1*.

Identification of prior art discussed: *Gibbons et al. (U.S. PGPub 2005/0136951)* .

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

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Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/A. S./ Examiner, Art Unit 2477 9/26/2012	/Chirag G Shah/ Supervisory Patent Examiner, Art Unit 2477

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

79172 7590 10/12/2012

Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

EXAMINER
SHIVERS, ASHLEY L

ART UNIT	PAPER NUMBER
2477	

DATE MAILED: 10/12/2012

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/920,076	12/15/2008	John Arpee	AND01 061 US	2431

TITLE OF INVENTION: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1770	$300	$0	$2070	01/14/2013

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

79172 7590 10/12/2012

Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/920,076	12/15/2008	John Arpee	AND01 061 US	2431

TITLE OF INVENTION: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1770	$300	$0	$2070	01/14/2013

EXAMINER	ART UNIT	CLASS-SUBCLASS
SHIVERS, ASHLEY L	2477	370-330000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/920,076	12/15/2008	John Arpee	AND01 061 US	2431

79172 7590 10/12/2012

Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

EXAMINER	
SHIVERS, ASHLEY L	
ART UNIT	**PAPER NUMBER**
2477	

DATE MAILED: 10/12/2012

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 252 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 252 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No.	Applicant(s)	
	11/920,076	ARPEE ET AL.	
	Examiner	Art Unit	
	ASHLEY SHIVERS	2477	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the Pre-Appeal Conference Request filed on Sept. 4, 2012*.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *11-51 (renumbered 1-41, respectively)*.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☒ Interview Summary (PTO-413), Paper No./Mail Date *9/26/2012* .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/A. S./ Examiner, Art Unit 2477 9/27/2012	/Chirag G Shah/ Supervisory Patent Examiner, Art Unit 2477

DETAILED ACTION

EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Mark Comtois on September 26, 2012.

2. The application has been amended as follows:

Claims 1-10 (**Canceled**)

Reasons for Allowance

3. Claims 11-51 are allowed.

4. The following is an examiner's statement of reasons for allowance:

Gibbons et al. (**U.S. PGPub 2005/0136951**) teaches of measuring signal strength of an active communication channel without disabling any other communication channel (**See [0036], [0048], [0052], [0055], [0067], [0081]**).

Au et al. (**U.S. PGPub 2005/0192042**) teaches the concept of receiving at said receiver an indication of transmission power of a signal (**See [0028]**), measuring at said

receiver the received power of said signal (**See [0028]**) and determining the path loss (**See [0028]**).

The combination of Gibbons and Au fails to teach the combination of identifying a geographic area where path loss is to be determined, identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel without disabling any other communication channel, receiver at said receiver the signal transmitted from said wireless device on said first frequency channel, receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength. Therefore claims 11-51 appear to be novel and inventive.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

5. Any response to this action should be **faxed** to (571) 273-8300 or **mailed** to:

Commissioner of Patents,
P.O. Box 1450
Alexandria, VA 22313-1450

Hand delivered responses should be brought to:
Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ASHLEY SHIVERS whose telephone number is (571)270-3523. The examiner can normally be reached on Monday-Friday 9:00-6:00 EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chirag Shah can be reached on (571) 272-3144. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/A. S./
Examiner, Art Unit 2477
9/27/2012

/Chirag G Shah/
Supervisory Patent Examiner, Art Unit 2477

Notice of References Cited	Application/Control No. 11/920,076	Applicant(s)/Patent Under Reexamination ARPEE ET AL.	
	Examiner ASHLEY SHIVERS	Art Unit 2477	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2005/0136951	06-2005	Gibbons et al.	455/464
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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BIB DATA SHEET

CONFIRMATION NO. 2431

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/920,076	12/15/2008	370	2477	AND01 061 US

APPLICANTS

John Arpee, Herndon, VA;
John Peter Carlson, Dulles, VA;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/US2006/017517 05/17/2006
which claims benefit of 60/681,475 05/17/2005

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

02/25/2009

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /ASHLEY L SHIVERS/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		VA	3	41 ~~51~~	4 ~~5~~

ADDRESS

Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004
UNITED STATES

TITLE

Method and Apparatus for Determining Path Loss by Active Signal Detection

FILING FEE RECEIVED		
2720	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

Issue Classification

Application/Control No.	Applicant(s)/Patent Under Reexamination
11920076	ARPEE ET AL.
Examiner	**Art Unit**
ASHLEY SHIVERS	2477

ORIGINAL		INTERNATIONAL CLASSIFICATION															
CLASS	SUBCLASS	CLAIMED										NON-CLAIMED					
370	252	G	0	8	C	15 / 00 (2006.01.01)											
CROSS REFERENCE(S)		H	0	4	J	1 / 16 (2006.01.01)											
		H	0	4	J	3 / 17 (2006.01.01)											
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)	H	0	4	B	17 / 00 (2006.01.01)											
370	433																
455	67.11	226.2															

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1	7	17	23	33	39	49								
	2	8	18	24	34	40	50								
	3	9	19	25	35	41	51								
	4	10	20	26	36										
	5	11	21	27	37										
	6	12	22	28	38										
	7	13	23	29	39										
	8	14	24	30	40										
	9	15	25	31	41										
	10	16	26	32	42										
1	11	17	27	33	43										
2	12	18	28	34	44										
3	13	19	29	35	45										
4	14	20	30	36	46										
5	15	21	31	37	47										
6	16	22	32	38	48										

/ASHLEY SHIVERS/ Examiner.Art Unit 2477	9/27/2012	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	41	
/CHIRAG SHAH/ Supervisory Patent Examiner.Art Unit 2477	10/09/2012	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	11	2

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	**Art Unit**
	ASHLEY L SHIVERS	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/03/2010	12/17/2010	10/04/2011	06/01/2012	09/27/2012				
	1	✓	✓	✓	✓	-				
	2	✓	✓	✓	✓	-				
	3	✓	✓	✓	✓	-				
	4	✓	✓	✓	✓	-				
	5	✓	✓	✓	✓	-				
	6	✓	✓	✓	✓	-				
	7	✓	✓	✓	✓	-				
	8	✓	✓	✓	✓	-				
	9	✓	✓	✓	✓	-				
	10	✓	✓	✓	✓	-				
1	11	✓	✓	✓	✓	=				
2	12	✓	✓	✓	✓	=				
3	13	✓	✓	✓	✓	=				
4	14	✓	✓	✓	✓	=				
5	15	✓	✓	✓	✓	=				
6	16	✓	✓	✓	✓	=				
7	17	✓	✓	✓	✓	=				
8	18	✓	✓	✓	✓	=				
9	19	✓	✓	✓	✓	=				
10	20	✓	✓	✓	✓	=				
11	21	✓	✓	✓	✓	=				
12	22	✓	✓	✓	✓	=				
13	23	✓	✓	✓	✓	=				
14	24	✓	✓	✓	✓	=				
15	25	✓	✓	✓	✓	=				
16	26	✓	✓	✓	✓	=				
17	27	✓	✓	✓	✓	=				
18	28	✓	✓	✓	✓	=				
19	29	✓	✓	✓	✓	=				
20	30	✓	✓	✓	✓	=				
21	31	✓	✓	✓	✓	=				
22	32	✓	✓	✓	✓	=				
23	33	✓	✓	✓	✓	=				
24	34	✓	✓	✓	✓	=				
25	35	✓	✓	✓	✓	=				
26	36	✓	✓	✓	✓	=				

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	Art Unit
	ASHLEY L SHIVERS	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/03/2010	12/17/2010	10/04/2011	06/01/2012	09/27/2012				
27	37	✓	✓	✓	✓	=				
28	38	✓	✓	✓	✓	=				
29	39	✓	✓	✓	✓	=				
30	40	✓	✓	✓	✓	=				
31	41	✓	✓	✓	✓	=				
32	42	✓	✓	✓	✓	=				
33	43	✓	✓	✓	✓	=				
34	44	✓	✓	✓	✓	=				
35	45	✓	✓	✓	✓	=				
36	46	✓	✓	✓	✓	=				
37	47	✓	✓	✓	✓	=				
38	48	✓	✓	✓	✓	=				
39	49	✓	✓	✓	✓	=				
40	50	✓	✓	✓	✓	=				
41	51	✓	✓	✓	✓	=				

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L4	2	(((john near2 arpee) or (john near2 carlson)).in. or (andrew).as.) and (path near2 loss) with (active near2 channel$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/09/27 11:28
L6	2	((path near2 loss) same (active near2 channel$1)).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/09/27 11:29

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L5	0	(((john near2 arpee) or (john near2 carlson)).in. or (andrew).as.) and (path near2 loss) with (active near2 channel$1)	USPAT; UPAD	OR	ON	2012/09/27 11:29
L7	1	((path near2 loss) same (active near2 channel$1)).clm.	USPAT; UPAD	OR	ON	2012/09/27 11:30

9/27/2012 11:31:16 AM
H:\Workspaces\11920076 - 4th search.wsp

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	**Art Unit**
	ASHLEY L SHIVERS	2477

SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
(path near2 loss) and ((receive$1 near2 signal) or (receive$1 near2 power) or RSS or RSSI) and(455/1,422.1,423,424,456.1,464,39,41.2,501,513,515,522,526,63.1,67.11,67.13,67.14,105,114.2,115.1,115.2,115.3,130,134-135,150.1,151.2,152.1,154.1,161.3,206,226.1,226.3,227,277.2,278.2,283,296,).ccls. and (370/431,433,437,442-443,464,480).ccls	7/2/2010	Ashley Shivers
See EAST Search History	7/2/2010	Ashley Shivers
Performed Double Patenting Search	7/2/2010	Ashley Shivers
Updated EAST Search History	12/17/2010	Ashley Shivers
Updated EAST Search History	10/4/2011	Ashley Shivers
Updated EAST Search History	5/31/2012	Ashley Shivers
Updated EAST Search History	9/19/2012	Ashley Shivers
Performed Double Patenting Search	9/27/2012	Ashley Shivers
See Interference Search History	9/27/2012	Ashley Shivers

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
	See Interference Search Printout	9/27/2012	Ashley Shivers

	/Chirag G Shah/ Supervisory Patent Examiner, Art Unit 2477

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/920,076	12/15/2008	John Arpee	AND01 061 US	2431

79172 7590 10/01/2012

Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

EXAMINER	
SHIVERS, ASHLEY L	
ART UNIT	PAPER NUMBER
2477	
MAIL DATE	DELIVERY MODE
10/01/2012	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of Panel Decision from Pre-Appeal Brief Review	Application No. 11/920,076	Applicant(s) ARPEE ET AL.
	Examiner ASHLEY SHIVERS	Art Unit 2477

This is in response to the Pre-Appeal Brief Request for Review filed 04 September, 2012.

1. ☐ **Improper Request** – The Request is improper and a conference will not be held for the following reason(s):

☐ The Notice of Appeal has not been filed concurrent with the Pre-Appeal Brief Request.
☐ The request does not include reasons why a review is appropriate.
☐ A proposed amendment is included with the Pre-Appeal Brief request.
☐ Other: .

The time period for filing a response continues to run from the receipt date of the Notice of Appeal or from the mail date of the last Office communication, if no Notice of Appeal has been received.

2. ☐ **Proceed to Board of Patent Appeals and Interferences** – A Pre-Appeal Brief conference has been held. The application remains under appeal because there is at least one actual issue for appeal. Applicant is required to submit an appeal brief in accordance with 37 CFR 41.37. The time period for filing an appeal brief will be reset to be one month from mailing this decision, or the balance of the two-month time period running from the receipt of the notice of appeal, whichever is greater. Further, the time period for filing of the appeal brief is extendible under 37 CFR 1.136 based upon the mail date of this decision or the receipt date of the notice of appeal, as applicable.

☐ The panel has determined the status of the claim(s) is as follows:
Claim(s) allowed: _____.
Claim(s) objected to: _____.
Claim(s) rejected: _____.
Claim(s) withdrawn from consideration: _____.

3. ☒ **Allowable application** – A conference has been held. The rejection is withdrawn and a Notice of Allowance will be mailed. Prosecution on the merits remains closed. No further action is required by applicant at this time.

4. ☐ **Reopen Prosecution** – A conference has been held. The rejection is withdrawn and a new Office action will be mailed. No further action is required by applicant at this time.

All participants:

(1) *ASHLEY SHIVERS*.	(3) *KWANG B YAO*.
(2) *Chirag Shah/SPE 2477*.	(4)_____.

/A. S./ Examiner, Art Unit 2477 9/26/2012	/Chirag G Shah/ Supervisory Patent Examiner, Art Unit 2477	/KWANG B YAO/ Supervisory Patent Examiner, Art Unit 2473

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of John Arpee, et al.

Serial No.: 11/920,076 Art Unit: 2477

Filed: December 15, 2008 Examiner: Ashley L. Shivers

Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

PRE-APPEAL CONFERENCE REQUEST BRIEF

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Applicant respectfully requests review of the final rejection in the above-identified application in view of the following remarks.

REMARKS

Applicant acknowledges the withdrawal of the Section 102(a) claim rejection premised upon Wilson. The Office, however, has failed to prove that each and every element of Claims 1-51 are obvious in view of Wilson in view of Benveniste and other references.

I. INTRODUCTION

Applicant's claimed subject matter is generally directed to a system and method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan. Each independent claim requires that such a determination occurs utilizing an active communications channel and/or using measurements from an active communications channel without disabling any other communications channel. That is, Applicant explicitly claims the collection of data from mobile devices that are in active use by a customer (i.e., in active communication) in a cellular network.

The present rejections continue to misunderstand what is claimed. As noted by Applicant in the subject specification, conventional systems may determine path loss values by assigning a dedicated frequency channel to a wireless device and disabling interfering frequency channels

within the wireless communications system. The Office's newly cited reference Benveniste (like Wilson) is such a conventional system and this setting aside of a dedicated frequency channel requires revising a frequency use plan for the respective geographic area which is costly and inefficient. *See* Applicant's published specification at paragraphs [0003], [0006] and [0017].

II. REJECTIONS

A. The Rejection based on Wilson and Benveniste

The Office improperly rejected 1, 3-6 and 8 under 35 U.S.C. § 103(a) as unpatentable in view of Wilson and Benveniste and improperly rejected Claims 2, 7, and 9-51 over Wilson in view of Benveniste and other references (Moulsley, Au, etc.).

1. Wilson

The Office still improperly relies upon Wilson for allegedly teaching "using an active communication channel to determine the signal strength of the wireless device." See, e.g., Final Action at p. 3.

To the contrary and as discussed previously, Wilson is directed to a method and system for characterization of radio frequency propagation in a cellular network and use of the same in RF channel reuse planning. Wilson acknowledges that reuse of RF channels may result in interference between cells using the same RF channel; thus, RF isolation must exist between the cells/sections (C/I ratio). *See* Wilson at 1:11-15; 1:57-2:2. Wilson then describes generating an "Isolation Matrix" which includes the RF isolation for each cell/sector pair in a network. According to Wilson, prior techniques for doing so included "drive testing" which required a dedicated vehicle to drive a specific route and then gather appropriate measurements on a dedicated RF channel. Wilson at 2:6-42. Wilson, however, proposes performing the same drive testing analyses using the assistance of mobile stations in doing so. Wilson at 2:50-64.

Wilson suffers from the deficiencies described in Applicant's background as Wilson requires a frequency channel dedicated to the path loss measurement (hence Wilson's C/I measurement and Isolation Matrix). This dedicated frequency channel is, by definition, not an active communication channel as claimed.

Contrary to the disclosure of Wilson, Applicant's claimed subject matter is directed to a method and system for assessing path loss without setting aside an otherwise active frequency channel or disturbing the frequency use plan – that is – Applicant's claimed subject matter employs

an active communications channel (i.e., a channel used by a customer's mobile device in active traffic communications) in a cellular network – something entirely different than that described in Wilson (or Benveniste for that matter).

Wilson's disclosure confirms Applicant's position:

> According to the present invention, RF isolation between RF channels is determined with the assistance of mobile terminals 234, 236, 238, 240, 242, 244, 246, 248, 250, 252, 254 and 256. In this operation, a particular radio frequency (RF) traffic channel is selected as a beacon channel (B-CH). The B-CH has a particular center frequency and a particular bandwidth. The B-CH is disabled at the other base stations 104-114 so that none of the other base stations 104-114 transmit on the B-CH. In this operation, the B-CH is reserved for collecting RF cell-pair isolation data using the method of the present invention. In one operation, RF channels residing adjacent the B-CH in the frequency spectrum are also disabled at the base station 102 and/or the other base stations 104-114. Such disablement is performed to avoid interference in the adjacent RF channels by the B-CH, which is transmitted at an above-normal power level in such case. Wilson at 4:38-54 (emphasis supplied).

It is clear that the channel utilized by Wilson is not an "active communications channel" as claimed and described in Applicant's specification; rather, Wilson is exactly the art that the claimed subject matter improves upon – that is, Applicant's claimed subject matter does not use channel dedication for path loss measurements (such as Wilson) and/or the subsequent rearrangement of remaining channels of a frequency use plan.

2. Benveniste cannot be relied upon to teach "using an active communication channel without disabling any other communication channel."

The Office cited a new reference, Benveniste, for its alleged disclosure of "using an active communication channel without disabling any other communication channel." See, e.g., Final Action at p. 3. Such a rejection is an improper reading of Benveniste and still ignores what is claimed by "an active communication channel." The Office cites to Fig. 2 and Col. 10, lines 6-32 for this alleged disclosure. This section of Benveniste is provided below in full.

> FIG. 2 is a flowchart of an exemplary method 2000 for self-configuring a wireless system during normal operation, said system including a plurality of cells, each cell including a respective base station and at least one mobile station. Step 2100 involves assigning preliminary control channels to base stations in a plurality of cells during an initialization phase. Step 2200 involves conducting normal traffic transmissions between base stations and mobile stations in each cell. Step 2300 involves time-sharing a calibration frequency assigned for use by consecutive cells during a scheduled interval. Step 2400 involves isolating individual signals from base stations. Step 2500 involves measuring a signal strength of the calibration

> frequency received at mobile stations within a cell and mobile stations nearby the cell from a base station within the cell during the scheduled interval. Step 2600 involves determining signal-to-interference ratios between the base station and the mobile stations as a communication quality metric and/or determining signal attenuation between the base stations on which channel re-use criteria are derived. Step 2700 involves deriving improved channel re-use criteria from said signal-to-interference ratios. Step 2800 involves selectively reassigning channels to the base station based on said improved re-use criteria. Step 2900 involves automatically updating neighbor lists in response to said reassigning channels. Benveniste at 10:6-32 (emphasis supplied).

While step 2200 does appear to state that normal traffic transmissions occur between base stations and mobile stations in each cell, this is irrelevant as step 2500 (emphasized above) provides insight into the actual invention of Benveniste. Benveniste's "calibration frequencies" emphasized above are specifically assigned for use by each cell according to a pre-defined time sharing scheme. See Fig. 1 and 8:5-9 of Benveniste. Thus, cells are able to use their assigned frequencies (whether traffic channels or otherwise) all the time except during their scheduled transmit interval (see Fig. 1 of Benveniste) in which the cell switches to the calibration frequency. See 8:9-19. That is, "active mobiles are assigned the calibration frequency during their cell's schedule transmit interval while base stations make regular measurements on that frequency." See 8:19-22. It is clear that Benveniste specifically teaches setting aside frequencies and channel dedication for path loss measurements. Again, this dedicated frequency channel is, by definition, not an active communication channel as claimed, and Benveniste cannot be relied upon to teach the claimed subject matter.

Thus, it cannot be disputed that the frequencies or channels utilized by Benveniste are not an "active communications channel" as claimed and described in Applicant's specification; rather, Benveniste (as well as Wilson) is exactly the art that the claimed subject matter improves upon.

3. The improper combination of Wilson and Benveniste

Even assuming that Benveniste teaches "using an active communication channel without disabling any other communication channel" (and it does not), the Office's logic is faulty as combining Benveniste with Wilson would render Wilson inoperable for its intended purpose. That is, Wilson describes generating an Isolation Matrix through various disablement of channels as discussed above in Section II.A.1. To combine Wilson with any reference that does not disable channels would thus excoriate the explicit teachings of Wilson and render it operable – something strictly forbidden by the guidelines promulgated by the MPEP.

4. The Claims

As discussed above, Claim 1 requires using the active communications channel as discussed above and/or using measurements from an active communications channel, contrary to the disclosure of Wilson. Further, Benveniste cannot be relied upon to teach "using an active communication channel without disabling any other communication channel" as the reference specifically discloses setting aside frequencies for the measurement purposes which explicitly teaches away from the claimed subject matter.

Each of independent Claims 11, 23, 33 and 41 require using an active communication channel to determine signal strength of a wireless device and using an active communication channel without disabling any other communication channel or similar limitations. As discussed above, neither Wilson nor Benveniste, alone or in combination, teach this claimed subject matter and the rejection of these independent claims and those claims dependent thereon should be withdrawn.

III. All Rejections are Improper

As noted above, the recited elements in the pending claims are not properly found in Wilson in view of Benveniste, and thus the rejections are improper and should be withdrawn. In addition the rejections of dependent claims are improper based on their dependency from improperly rejected independent claims. For at least these reasons, Applicant submits that the Office has failed to establish its case of obviousness and respectfully requests the reconsideration and withdrawal of the rejection of the pending claims.

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Dated: 4 September 2012

Respectfully submitted,

/Mark C. Comtois/

Mark C. Comtois Reg. No. 46,285
Ryan T. Hardee Reg. No. 57,515

Electronic Patent Application Fee Transmittal

Application Number:	11920076
Filing Date:	15-Dec-2008
Title of Invention:	Method and Apparatus for Determining Path Loss by Active Signal Detection
First Named Inventor/Applicant Name:	John Arpee
Filer:	Mark Charles Comtois/laureen ponder
Attorney Docket Number:	AND01 061 US

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Notice of appeal	1401	1	620	620
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**620**

Electronic Acknowledgement Receipt

EFS ID:	13652284
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and Apparatus for Determining Path Loss by Active Signal Detection
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	79172
Filer:	Mark Charles Comtois/laureen ponder
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND01 061 US
Receipt Date:	04-SEP-2012
Filing Date:	15-DEC-2008
Time Stamp:	16:01:20
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$620
RAM confirmation Number	2923
Deposit Account	041679
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		AND01061USNOAPACR.pdf	640686 c67f193b3c0233f003be8e3b3e5b29c098528401	yes	6

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Notice of Appeal Filed	1	1
Pre-Brief Conference request	2	6

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	30168 4214182543ad3ecb373f89fca13bff0e37d7d7ce	no	2

Warnings:

Information:

Total Files Size (in bytes):	670854

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of: John Arpee, et al.

Confirmation No.: 2431

Serial No.: 11/920,076 Art Unit: 2477

Filed: December 15, 2008 Examiner: Ashley L. Shivers

Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

NOTICE OF APPEAL

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

All finally rejected claims in the Final Office Action dated 4 June 2012 are hereby appealed to the Board of Patent Appeals and Interferences.

The Commissioner is hereby authorized to charge payment of any fees associated with this communication or credit any overpayment to Deposit Account No. 04-1679.

Respectfully Submitted,

/Mark C. Comtois/

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Dated: 4 September 2012

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/920,076	12/15/2008	John Arpee	AND01 061 US	2431

79172 7590 06/04/2012

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EXAMINER	
SHIVERS, ASHLEY L	
ART UNIT	PAPER NUMBER
2477	
MAIL DATE	DELIVERY MODE
06/04/2012	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	11/920,076	ARPEE ET AL.	
	Examiner	Art Unit	
	ASHLEY SHIVERS	2477	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *Jan. 17, 2012 (Applicants' Amendment)*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-51* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-51* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *08 November 2007* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

12)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Amendment

1. Applicant's amendment filed on January 17, 2012 has been entered. Claims 1, 11, 23, 33 and 41 have been amended. No claims are canceled. No claims have been added. Claims 1-51 are still pending in this application, with claims 1, 11, 23, 33 and 41 being independent.

Claim Objections

1. Claim 1 is objected to because of the following informalities: While claim 1 is written in the Jepson format, it is unclear which channels are not being disabled as part of the invention. Examiner is requesting clarification into whether only the active communication channels are not being disabled or if all communication channels active/inactive are not being disabled. Appropriate correction is required.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. Claims 1, 3-6 and 8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson et al. (**U.S. Patent No. 6,853,842**), hereinafter referred to as Wilson in view of Benveniste (**U.S. Patent No. 6,990,348**), hereinafter referred to as Benveniste.

Regarding claim 1, Wilson teaches in a method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan (**See col. 1, lines 57-65**), wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device and disabling interfering frequency channels within the wireless communication system (**See col. 2, lines 27-42**), the improvement comprises using an active communication channel to determine the signal strength of the wireless device (**Mobile stations are instructed to measure the strength of both the B-CH and the respective serving RF traffic channels, wherein the serving traffic channels are for ongoing calls. The measured strengths are then reported via the base stations and collected at a central location within cellular wireless communication system. See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Wilson fails to teach of using an active communication channel without disabling any other communication channel.

Benveniste teaches of using an active communication channel (**conducting normal traffic transmissions; See Fig. 2, #2200 and col. 10, lines 14-16**) without disabling any other communication channel (**suggested by the reassigning of channels; See Fig. 2 and col. 10, lines 6-32**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include using an active communication channel without disabling any other communication channel taught by Benveniste in order to improve frequency re-use criteria.

Regarding claim 3, Wilson further teaches the method of claim 1, wherein the active communication channel defines any frequency channel capable for a simplex communication (**See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 4, Wilson further teaches the method of claim 1, wherein the active communication channel defines a communication channel within the frequency use plan (**See col. 4, lines 30-35**).

Regarding claim 5, Wilson further teaches the method of claim 1, wherein the active communication channel defines a reverse control channel (**See col. 4, line 36**).

Regarding claim 6, Wilson further teaches the method of claim 1, wherein the active communication channel defines a forward control channel (**See col. 4, line 36**).

Regarding claim 8, Wilson further teaches the method of claim 1, wherein interfering channels define frequency channels causing at least one of adjacent channel

interference, co-channel interference, inter-symbol interference and cross-rail interference (**See col. 4, lines 48-54**).

Regarding claim 9, Wilson teaches the method of claim 1, but fails to teach of wherein the improvement further comprises using an active communication channel without disabling any interfering channel.

Benveniste teaches of using an active communication channel (**conducting normal traffic transmissions; See Fig. 2, #2200 and col. 10, lines 14-16**) without disabling any other interfering channel (**suggested by the reassigning of channels, wherein the signal strength measurements are used to determine which channels cause interference; See Fig. 2 and col. 10, lines 6-32**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include using an active communication channel without disabling any other interfering channel taught by Benveniste in order to improve frequency re-use criteria.

Regarding claim 10, Wilson teaches the method of claim 1, but fails to teach of wherein the improvement comprises using an active communication channel without disrupting the frequency use plan.

Benveniste teaches of using an active communication channel (**conducting normal traffic transmissions; See Fig. 2, #2200 and col. 10, lines 14-16**) without

disrupting the frequency use plan (**suggested by the reassigning of channels, without disabling any of the channels; See Fig. 2 and col. 10, lines 6-32**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include using an active communication channel without disrupting the frequency use plan taught by Benveniste in order to improve frequency re-use criteria.

4. Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Benveniste in further view of Moulsley (**U.S. PGPub 2002/0172160**), hereinafter referred to as Moulsley.

Regarding claim 2, Wilson teaches the method of claim 1, but fails to teach of the active communication channel defining any frequency channel capable of duplex communication.

Moulsley teaches of the channel being capable of duplex communication (**See [0025]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste to include the active communication channel being defined as any frequency channel capable of duplex communication taught by Moulsley in order to provide a reverse path for monitoring and remote adjustment of equipment in the field.

5. Claims 7, 11, 13-14, 16-23, 25, 27-33, 35-41, 43-45 and 47-49 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Benveniste in further view of Au et al. (**U.S. PGPub 2005/0192042**).

Regarding claim 7, Wilson teaches the method of claim 1, suggests having path loss by determining the interference ratio (**See col. 4, lines 65-67**), but fails to explicitly teach of calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel. Wilson in view of Benveniste also fails to teach of the limitation.

Au teaches of calculating path loss wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste to include calculating path loss wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 11, Wilson teaches a method for determining a path loss value (**interpreted as the interference**) of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a

wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the method comprising the steps of:

identifying a geographic area where the signal strength is to be determined (**A first RF cell (or sector) is chosen; See col. 6, line 26**);

identifying a first cell, a first sector (**A first RF cell (or sector) is chosen; See col. 6, line 26**), and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel (**The Mobile station serviced by the base station is instructed to measure the strength of both the B-CH and the RF channel servicing its call, thereby suggesting that the first frequency channel is identified; See col. 5, lines 1-4**); and

receiving at said receiver the signal transmitted from said wireless device on said first frequency channel (**The mobile stations sends the signal strengths; See col. 5, lines 4-6**).

Wilson fails to teach of the wireless device actively communicating with said receiver using said first frequency channel without disabling any other communication channel. While Wilson suggests having path loss by determining the interference ratio **(See col. 4, lines 65-67),** it also fails to explicitly teach of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Benveniste teaches of the wireless device actively communicating with said receiver using said first frequency channel (**conducting normal traffic transmissions; See Fig. 2, #2200 and col. 10, lines 14-16**) without disabling any other communication channel (**suggested by the reassigning of channels; See Fig. 2 and col. 10, lines 6-32**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include the wireless device actively communicating with said receiver using said first frequency channel without disabling any other communication channel taught by Benveniste in order to improve frequency re-use criteria.

Wilson in view of Benveniste still fails to teach of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Au teaches of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste to include receiving at said receiver an indication of transmission signal strength of said signal,

measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 13, Wilson teaches the method of claim 11, further comprising determining the path loss (**determining the C/I interference ratio; See col. 4, lines 65-67**) for a plurality of geographic areas to compile a database (**All of the mobile stations measure the signal strength, thereby suggesting multiple geographic areas to compile a database; See col. 4, lines 60-65**).

Regarding claim 14, Wilson further teaches the method of claim 11, wherein the receiver is a base station (**base station; See col. 4, lines 14-15**).

Regarding claim 16, Wilson further teaches the method of claim 11, wherein the wireless device is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager (**mobile terminal; See col. 4, lines 40-41**).

Regarding claim 17, Wilson further teaches the method of claim 11, wherein the wireless device is engaged in one of a duplex or simplex communication (**See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 18, Wilson further teaches the method of claim 11, further comprising randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver (**A channel of an ongoing call, wherein there are a plurality of RF channels; See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 19, Wilson further teaches the method of claim 11, further comprising selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute (**See col. 4, lines 65-67**).

Regarding claim 20, Wilson further teaches the method of claim 19, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio and carrier-to-interference ratio (**See col. 4, lines 65-67**).

Regarding claim 21, Wilson further teaches the method of claim 11, further comprising identifying the location of the receiver and the wireless device (**A first RF cell (or sector) is chosen; See col. 6, line 26**).

Regarding claim 22, Wilson in view of Benveniste fails to teach the circuitry configured to implement the method of claim 11.

Au teaches of the circuitry (**See [0044]-[0045]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste to include circuitry taught by Au in order to indicate the components used to perform the operations.

Regarding claim 23, Wilson teaches a method for determining a path loss value (**interpreted as the interference**) of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system, the method comprising:

identifying a first frequency channel in an active communication between the wireless device and the receiver (**The Mobile station serviced by the base station is instructed to measure the strength of both the B-CH and the RF channel servicing its call, thereby suggesting that the first frequency channel is identified; See col. 5, lines 1-4**);

geolocating the wireless device and the receiver (**A first RF cell (or sector) is chosen; See col. 6, line 26**);

receiving at the receiver the signal transmitted from said wireless device on said first frequency channel (**The mobile stations sends the signal strengths; See col. 5, lines 4-6**).

Wilson fails to teach of the identifying a first frequency channel being in active communication between the wireless device and the receiver without disabling any other communication channel. While Wilson suggests having path loss by determining the interference ratio **(See col. 4, lines 65-67),** it also fails to explicitly teach of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal, and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Benveniste teaches of identifying a first frequency channel in an active communication between the wireless device and the receiver (**conducting normal traffic transmissions via a first frequency channel assigned to the devices; See Fig. 2, #2200, col. 6, lines 6-7 and col. 10, lines 14-16**) without disabling any other communication channel (**suggested by the reassigning of channels; See Fig. 2 and col. 10, lines 6-32**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include identifying a first frequency channel in an active communication between the wireless device and the receiver

without disabling any other communication channel taught by Benveniste in order to improve frequency re-use criteria.

Wilson in view of Benveniste still fails to teach of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal, and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Au teaches of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal, and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste to include receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal, and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 25, Wilson teaches the method of claim 23, further comprising determining the path loss (**determining the C/I interference ratio; See col. 4, lines**

65-67) for a plurality of geographic areas to compile a database (**All of the mobile stations measure the signal strength, thereby suggesting multiple geographic areas to compile a database; See col. 4, lines 60-65**).

Regarding claim 27, Wilson further teaches the method of claim 23, wherein the first frequency channel in active communication is engaged in simplex communication (**See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 28, Wilson further teaches the method of claim 23, further comprising selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute (**See col. 4, lines 65-67**).

Regarding claim 29, Wilson further teaches the method of claim 28, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio, inter-symbol interference and carrier-to-interference ratio (**See col. 4, lines 65-67**).

Regarding claim 30, Wilson further teaches the method of claim 23, wherein the receiver is a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device (**base stations; See col. 4, lines 14-15**).

Regarding claim 31, Wilson further teaches the method of claim 23, wherein the receiver is a base station or a wireless location sensor ("WLS") or a combination of the base station and a WLS (**base station; See col. 4, lines 14-15**).

Regarding claim 32, Wilson in view of Benveniste teaches the method of claim 25, but fails to teach of the circuitry configured to implement the method of claim 23.

Au teaches of the circuitry configured to implement the method of claim 23 (**See [0044]-[0045]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste to include circuitry taught by Au in order to indicate the components used to perform the operations.

Regarding claim 33, Wilson teaches a system for determining path loss value (**interpreted as the interference**) of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system to:

identify a geographic area where the signal strength is to be determined (**A first RF cell (or sector) is chosen; See col. 6, line 26**);

identify a first cell, a first sector (**A first RF cell (or sector) is chosen; See col. 6, line 26**), and a first frequency channel associated with the

geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel (**The Mobile station serviced by the base station is instructed to measure the strength of both the B-CH and the RF channel servicing its call, thereby suggesting that the first frequency channel is identified; See col. 5, lines 1-4**); and

receive at said receiver the signal transmitted from said wireless device on said first frequency channel (**The mobile stations sends the signal strengths; See col. 5, lines 4-6**).

Wilson fails to teach of said wireless device is actively communicating with said receiver using said first frequency channel without disabling any other communication channel. While Wilson suggests having path loss by determining the interference ratio **(See col. 4, lines 65-67),** it also fails to explicitly teach of the circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to using the signal strength to determine path loss, receive at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Benveniste teaches of using an active communication channel (**conducting normal traffic transmissions; See Fig. 2, #2200 and col. 10, lines 14-16**) without disabling any other communication channel (**suggested by the reassigning of channels; See Fig. 2 and col. 10, lines 6-32**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Wilson to include using an active communication channel without disabling any other communication channel taught by Benveniste in order to improve frequency re-use criteria.

Wilson in view of Benveniste still fails to teach of the circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to using the signal strength to determine path loss, receive at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Au teaches of the circuitry including a microprocessor and a memory for compiling a database (**See [0044]-[0045]**) for receiving the path loss values, the circuitry configured with instructions to using the signal strength to determine path loss, receive at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Wilson in view of Benveniste to include of the circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to using the

signal strength to determine path loss, receive at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 35, Wilson teaches the system of claim 33, further comprising the circuitry being further programmed with instructions to determine the path loss (**determining the C/I interference ratio; See col. 4, lines 65-67**) for a plurality of geographic areas to compile a database (**All of the mobile stations measure the signal strength, thereby suggesting multiple geographic areas to compile a database; See col. 4, lines 60-65**).

Regarding claim 36, Wilson further teaches the system of claim 33, wherein the receiver is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device, pager, base station and wireless location sensor (**base station; See col. 4, lines 14-15**).

Regarding claim 37, Wilson further teaches the system of claim 33, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio

frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager (**mobile terminal; See col. 4, lines 40-41**).

Regarding claim 38, Wilson further teaches the system of claim 33, wherein the wireless device is engaged in one of a simplex or duplex communication area (**See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 39, Wilson further teaches the system of claim 33, wherein the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic (**A channel of an ongoing call, wherein there are a plurality of RF channels; See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 40, Wilson further teaches the system of claim 33, wherein the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute (**See col. 4, lines 65-67**).

Regarding claim 41, Wilson teaches an apparatus for determining a path loss value (**interpreted as the interference**) of a signal transmitted from a wireless device and received by a receiver, comprising:

identifying an active communication channel supporting at least one desirable attribute (**The Mobile station serviced by the base station is instructed to measure the strength of both the B-CH and the RF channel servicing its call, thereby suggesting that the first frequency channel is identified. The measurements are used to determine the carrier-to-interference ratios for the respective cell pairs; See col. 4, lines 65-67-col. 5, lines 1-4**);

identifying the wireless device and the receiver tasked to communicate on said active communication channel (**Base stations 108 and mobile stations 242**); and

locating said wireless device and said receiver (**A first RF cell (or sector) is chosen; See col. 6, line 26**).

Wilson fails to teach of the wireless device and the receiver being tasked to communicate on said active communication channel without disabling any other communication channel. While Wilson suggests having path loss by determining the interference ratio **(See col. 4, lines 65-67),** it also fails to explicitly teach of the various means for identifying and locating and the means for identifying a transmitted signal strength for signaling on said active communication channel, means for identifying a received signal strength for signaling on said active communication channel, and means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

Benveniste teaches of the wireless device and the receiver using an active communication channel (**conducting normal traffic transmissions; See Fig. 2, #2200 and col. 10, lines 14-16**) without disabling any other communication channel (**suggested by the reassigning of channels; See Fig. 2 and col. 10, lines 6-32**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Wilson to include the wireless device and the receiver using an active communication channel without disabling any other communication channel taught by Benveniste in order to improve frequency re-use criteria.

Wilson in view of Benveniste still fails to teach of the various means for identifying and locating and the means for identifying a transmitted signal strength for signaling on said active communication channel, means for identifying a received signal strength for signaling on said active communication channel, and means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

Au teaches of the means for identifying and locating (**processor and circuitry; See [0044]**), a means for identifying (**processor and circuitry; See [0044]**) a transmitted signal strength for signaling on said active communication channel, means for identifying (**processor and circuitry; See [0044]**) a received signal strength for signaling on said active communication channel, and means for calculating (**processor and circuitry; See [0044]**) the path loss value as a function of the transmitted signal strength and the received signal strength (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Benveniste to include the various means for identifying and locating, means for identifying a transmitted signal strength for signaling on said active communication channel, means for identifying a received signal strength for signaling on said active communication channel, and means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 43, Wilson further teaches the apparatus of claim 41, wherein the means for identifying an active communication channel comprises a microprocessor (**See Fig. 7, #702**) but fails to teach of the antenna and radio receiver. Wilson in view of Benveniste also fails to teach of the limitation.

Au teaches of the identifying means comprising an antenna, radio receiver and processor (**See Fig. 1, and [0044]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Benveniste to include identifying means comprising an antenna, radio receiver and processor taught by Au in order to provide the components performing the above operations.

Regarding claim 44, Wilson in view of Benveniste teaches the apparatus of claim 41, but fails to teach of the means for identifying the wireless device and the receiver

comprises a microprocessor programmed with instructions to search a database stored in a digital memory.

Au teaches of the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory (**See [0044]-[0045]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Benveniste to include the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory taught by Au in order to provide the components performing the above operations.

Regarding claim 45, Wilson further teaches the apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a wireless location system (**system engineering server; See Fig. 7**).

Regarding claim 47, Wilson in view of Benveniste teaches the apparatus of claim 41, but fails to teach of the transmitted signal strength defining the signal strength at the wireless device.

Au teaches of the transmitted signal strength defining the signal strength at the wireless device (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Benveniste to include the

transmitted signal strength defining the signal strength at the wireless device taught by Au in order to determine the load that the wireless device has on the network.

Regarding claim 48, Wilson in view of Benveniste teaches the apparatus of claim 41, but fails to teach of the means for identifying a transmitted signal strength for signaling on said active communication channel comprising an antenna and a signal detection circuit.

Au teaches of the means for identifying a transmitted signal strength for signaling on said active communication channel comprising an antenna (**See Fig. 1**) and a signal detection circuit (**circuitry; See [0044]-[0045]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Benveniste to include the means for identifying a transmitted signal strength for signaling on said active communication channel comprising an antenna (**See Fig. 1**) and a signal detection circuit taught by Au in order to provide the components to perform the operations.

Regarding claim 49, Wilson further teaches the apparatus of claim 41, wherein means for identifying the wireless device and the receiver further comprises means for tasking the wireless device and the receiver to signal on said active communication channel (**An active channel is chosen for the ongoing calls; See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

6. Claims 12, 24, 34 and 50-51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Benveniste and Au in further view of the prior art of Hakalin et al. (**U.S. PGPub 2002/0042276**), hereinafter referred to as PR_Hakalin.

Regarding claim 12, Wilson in view of Benveniste and Au teaches the method of claim 11, but fails to teach of the steps of determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said frequency channel to a third frequency channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste and Au to include determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said frequency channel to a third frequency channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

Regarding claim 24, Wilson in view of Benveniste and Au teaches the method of claim 23, but fails to teach the steps of determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said second frequency channel to a third frequency channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste and Au to include determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said second frequency channel to a third frequency channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

Regarding claim 34, Wilson in view of Benveniste and Au teaches the system of claim 33, wherein the circuitry is further programmed with instructions to determine a second frequency channel which interferes with said first frequency channel and reassign a second signal using said second frequency channel to a third frequency channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Wilson in view of Benveniste and Au to include the circuitry being further programmed with instructions to determine a second frequency channel which interferes with said first frequency channel and reassign a

second signal using said second frequency channel to a third frequency channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

Regarding claim 50, Wilson in view of Benveniste and Au teaches the apparatus of claim 41, but fails to teach of the means for detecting a second communication channel interfering with the active communication channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Benveniste and Au to include detecting a second communication channel interfering with the active communication channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

Regarding claim 51, Wilson in view of Benveniste and Au teaches the apparatus of claim 50 but fails to teach of the means for reassigning the second communication channel to a third communication channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Benveniste and Au to include detecting a second communication channel interfering with the active communication channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

7. Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Benveniste and Au in further view of Stilp (**U.S. PGPub 2002/0172223**), hereinafter referred to as Stilp.

Regarding claim 15, Wilson in view of Benveniste and Au teaches the method of claim 11, but fails to teach of the receiver being a wireless location sensor.

Stilp teaches of the receiver being a wireless location sensor (**See [0017]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste and Au to include the receiver being a wireless location sensor taught by Stilp in order to make highly accurate TDOA and FDOA measurements.

8. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Benveniste and Au in further view of Moulsley.

Regarding claim 26, Wilson in view of Benveniste and Au teaches the method of claim 23, but fails to teach of the first frequency channel in active communication being engaged in a duplex communication.

Moulsley teaches of the active communication being engaged in a duplex communication (**See [0025]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Benveniste and Au to include the active communication being engaged in a duplex communication taught by Moulsley in order to provide a reverse path for the monitoring and remote adjustment of equipment in the field.

9. Claim 42 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Benveniste and Au in further view of Seo et al. (U.S. PGPub 2003/0039217), hereinafter referred to as Seo.

Regarding claim 42, Wilson in view of Benveniste and Au teaches the apparatus of claim 41, but fails to teach of the desirable attribute comprising of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value.

Seo teaches of the attribute comprising an SIR threshold (**See [0121]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Benveniste and Au to include the desirable attribute comprising of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value taught by Seo in order to determine whether the conditions of the channel are acceptable.

10. Claim 46 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Benveniste and Au in further view of Dowling (**U.S. PGPub 2005/0143090**), hereinafter referred to as Dowling.

Regarding claim 46, Wilson in view of Benveniste and Au teaches the apparatus of claim 41, but fails to teach of the means for locating said wireless device and said receiver comprising a geo-positioning system ("GPS").

Dowling teaches of the means for locating comprising a GPS (**See [0019]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Benveniste and Au to include the means for locating comprising a GPS taught by Dowling in order to provide a more precise indication of the location of the devices.

Response to Arguments

11. Applicant's arguments with respect to claims 1-51 have been considered but are moot because the arguments do not apply to any of the references being used in the current rejection.

On pages 12-16 of the Applicants' Response, Applicants state that Wilson et al. (**U.S. Patent No. 6,853,842**), hereinafter referred to as Wilson in view of combinations of the other cited references fails to teach of using an active communication channel and/or using measurements from an active communication channel without disabling any other communication channel.

Examiner agrees and has thus introduced Benveniste (**U.S. Patent No. 6,990,348**), hereinafter referred to as Benveniste to teach of using an active communication as well as measuring signal strength on an active communication channel without disabling any other communication channel (**See Fig. 2 and col. 10, lines 6-33**).

In addition, Examiner has found support for using an active communication channel without disabling other communications channels and determining path loss in Isaksson (**U.S. Patent No. 6,137,991**), hereinafter referred to as Isaksson (**See Fig. 3, Step 6**).

12. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Conclusion

13. Any response to this action should be **faxed** to (571) 273-8300 or **mailed** to:

Commissioner of Patents,
P.O. Box 1450
Alexandria, VA 22313-1450

Hand delivered responses should be brought to:
Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

14. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ASHLEY SHIVERS whose telephone number is (571)270-3523. The examiner can normally be reached on Monday-Friday 9:00-6:00 EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chirag Shah can be reached on (571) 272-3144. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/A. S./
Examiner, Art Unit 2477
6/1/2012

/Gregory B Sefcheck/
Primary Examiner, Art Unit 2477
6/1/2012

Notice of References Cited	Application/Control No. 11/920,076	Applicant(s)/Patent Under Reexamination ARPEE ET AL.	
	Examiner ASHLEY SHIVERS	Art Unit 2477	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,990,348	01-2006	Benveniste, Mathilde	455/447
*	B	US-6,137,991	10-2000	Isaksson, Katarina	455/67.11
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	Art Unit
	ASHLEY L SHIVERS	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/03/2010	12/17/2010	10/04/2011	06/01/2012					
	1	✓	✓	✓	✓					
	2	✓	✓	✓	✓					
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	36	✓	✓	✓	✓					

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	Art Unit
	ASHLEY L SHIVERS	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/03/2010	12/17/2010	10/04/2011	06/01/2012					
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	51	✓	✓	✓	✓					

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	**Art Unit**
	ASHLEY L SHIVERS	2477

SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
(path near2 loss) and ((receive$1 near2 signal) or (receive$1 near2 power) or RSS or RSSI) and(455/1,422.1,423,424,456.1,464,39,41.2,501,513,515,522,526,63.1,67.11,67.13,67.14,105,114.2,115.1,115.2,115.3,130,134-135,150.1,151.2,152.1,154.1,161.3,206,226.1,226.3,227,277.2,278.2,283,296,).ccls. and (370/431,433,437,442-443,464,480).ccls	7/2/2010	Ashley Shivers
See EAST Search History	7/2/2010	Ashley Shivers
Performed Double Patenting Search	7/2/2010	Ashley Shivers
Updated EAST Search History	12/17/2010	Ashley Shivers
Updated EAST Search History	10/4/2011	Ashley Shivers
Updated EAST Search History	5/31/2012	Ashley Shivers

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
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S3	1827	S2 and RSSI	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/21 17:00
S4	202	S3 and "path loss"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/21 17:00
S5	42	frequency near2 use near2 plan	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/21 17:11
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S7	43363	frequency near2 (re$1use or use)	US-PGPUB;	OR	ON	2012/05/23

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S9	1011	S8 and RSSI	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/23 11:05
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S11	0	S9 and 370/433.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/23 12:35
S12	2	S9 and 370/431.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/23 12:35
S13	387	S9 and S10	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/23 12:51
S14	70	S13 and "path loss"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/23 13:05
S15	36070	(monitor$4 or measur$4 or search$4 or estimat$4) with (RSSI or (signal near2 strength))	US-PGPUB; USPAT; USOCR;	OR	ON	2012/05/28 14:20

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S16	4801	S15 same interfer$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 14:21
S17	2787	S16 and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 14:21
S18	66034	((370/276-277,281,295,310.2,319,322,328,329-330,343,344,348,431,433,437,443,480) or (455/434,445-450,455,456.5-456.6,464,39,509,515-517,524-526,62,63.3,67.11,69,70-71,103,105,112-113,115.1,115.3,132-140,150.1-151.1,154.1,161.1-161.3,166.2,179.1,226.1-226.3,227,277.2,278.8,283,296)).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/05/28 14:21
S20	34	S16 same disabl$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 14:21
S21	23	S20 and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 14:22
S22	36070	(monitor$4 or measur$4 or search$4 or estimat$4) with (RSSI or (signal near2 strength))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 15:55
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S26	1066	S24 and S25	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 15:55
S27	298	S26 and (frequency near2 (re$1use or use))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 16:05
S28	210	S26 and (path adj loss)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 19:15
S29	5743	S22 same ("C/I" or SNR or SINR or interfer$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 20:21
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S31	1224	S30 and S25	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 20:22
S32	2485	S22 same ("C/I" or SNR or SINR or interfer$4) same channel$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 21:55

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S34	678	S33 and S25	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/28 21:55
S35	36107	(monitor$4 or measur$4 or search$4 or estimat$4) with (RSSI or (signal near2 strength))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/29 10:52
S36	3504	S35 same ("C/I" or SNR or SINR or interfer$4) same2 channel$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/29 10:52
S37	66141	((370/276-277,281,295,310.2,319,322,328,329-330,343,344,348,431,433,437,443,480) or (455/434,445-450,455,456.5-456.6,464,39,509,515-517,524-526,62,63.3,67.11,69,70-71,103,105,112-113,115.1,115.3,132-140,150.1-151.1,154.1,161.1-161.3,166.2,179.1,226.1-226.3,227,277.2,278.8,283,296)).CCLS.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2012/05/29 10:52
S38	1389	S36 and S37	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2012/05/29 10:52
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S41	689	S40 same ("C/I" or SNR or SINR or interfer$4) same2 channel$4	US-PGPUB; USPAT;	OR	ON	2012/05/29 13:24

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EAST Search History (Interference)

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6/1/2012 12:24:14 AM
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of John Arpee, et al.

Serial No.: 11/920,076 Art Unit: 2477

Filed: December 15, 2008 Examiner: Ashley L. Shivers

Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action mailed October 17, 2011, Applicant submits the following:

Applicant's **Amendment to the Drawings** begins on sheet 2 of this paper.

Applicant's **Amendment to the Claims** begins on sheet 3 of this paper.

Applicant's **Remarks** begin on sheet 12 of this paper.

Amendment to the Drawings:

Please amend Figures 2 and 3 of the present application as shown in Exhibit A attached hereto. Exhibit A contains annotated marked-up drawings and replacement sheets in compliance with 37 C.F.R. § 1.121(d). No new matter has been added.

Amendment to the Claims:

1. (Currently Amended) In a method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan, wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device and disabling interfering frequency channels within the wireless communication system, the improvement comprises using an active communication channel to determine the signal strength of the wireless device and comprises using an active communication channel without disabling any other communication channel.

2. (Original) The method of claim 1, wherein the active communication channel defines any frequency channel capable of a duplex communication.

3. (Original) The method of claim 1, wherein the active communication channel defines any frequency channel capable for a simplex communication.

4. (Original) The method of claim 1, wherein the active communication channel defines a communication channel within the frequency use plan.

5. (Original) The method of claim 1, wherein the active communication channel defines a reverse control channel.

6. (Original) The method of claim 1, wherein the active communication channel defines a forward control channel.

7. (Original) The method of claim 1, further comprising calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel.

8. (Previously Presented) The method of claim 1, wherein interfering channels define frequency channels causing at least one of adjacent channel interference, co-channel interference, inter-symbol interference and cross-rail interference.

9. (Original) The method of claim 1, wherein the improvement further comprises using an active communication channel without disabling any interfering channel.

10. (Original) The method of claim 1, wherein the improvement further comprises using an active channel without disrupting the frequency use plan.

11. (Currently Amended) A method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the method comprising the steps of:

identifying a geographic area where the path loss value is to be determined;

identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel without disabling any other communication channel;

receiving at said receiver the signal transmitted from said wireless device on said first frequency channel;

receiving at said receiver an indication of transmission signal strength of said signal;

measuring at said receiver the received signal strength of said signal; and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

12. (Original) The method of claim 11, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel; and

reassigning a second signal using said second frequency channel to a third frequency channel.

13. (Original) The method of claim 11, further comprising determining the path loss value for a plurality of geographic areas to compile a database.

14. (Original) The method of claim 11, wherein the receiver is a base station.

15. (Original) The method of claim 11, wherein the receiver is a wireless location sensor.

16. (Original) The method of claim 11, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager.

17. (Original) The method of claim 11, wherein the wireless device is engaged in one of a duplex or a simplex communication.

18. (Original) The method of claim 11, further comprising randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver.

19. (Original) The method of claim 11, further comprising selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute.

20. (Original) The method of claim 19, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio and carrier-to-interference ratio.

21. (Original) The method of claim 11, further comprising identifying the location of the receiver and the wireless device.

22. (Original) A circuitry configured to implement the method of claim 11.

23. (Currently Amended) A method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system, the method comprising:

identifying a first frequency channel in an active communication between the wireless device and the receiver without disabling any other communication channel;

geolocating the wireless device and the receiver;

receiving at the receiver the signal transmitted from said wireless device on said first frequency channel;

receiving at said receiver an indication of transmission signal strength of said signal;

measuring at said receiver the received signal strength of said signal; and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

24. (Original) The method of claim 23, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel; and

reassigning a second signal using said second frequency channel to a third frequency channel.

25. (Original) The method of claim 23, further comprising determining the path loss value for a plurality of geographic areas to compile a database.

26. (Original) The method of claim 23, wherein the first frequency channel in active communication is engaged in a duplex communication.

27. (Original) The method of claim 23, wherein the first frequency channel in active communication is engaged in a simplex communication.

28. (Original) The method of claim 23, further comprising selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute.

29. (Original) The method of claim 28, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio, inter-symbol interference and carrier-to-interference ratio.

30. (Original) The method of claim 23, wherein the receiver is a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device.

31. (Original) The method of claim 23, wherein the receiver is a base station or a wireless location sensor ("WLS") or a combination of the base station and a WLS.

32. (Original) A circuitry configured to implement the method of claim 23.

33. (Currently Amended) A system for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system comprising:

a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to:

identify a geographic area where the path loss value is to be determined;

identify a first cell, a first sector, and a first frequency channel associated with the

geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel without disabling any other communication channel;

receive at said receiver the signal transmitted from said wireless device on said first frequency channel;

receive at said receiver an indication of transmission signal strength of said signal;

measure at said receiver the received signal strength of said signal; and

determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

34. (Previously Presented) The system of claim 33, wherein the circuitry is further programmed with instructions to:

determine a second frequency channel which interferes with said first frequency channel; and

reassign a second signal using said second frequency channel to a third frequency channel.

35. (Previously Presented) The system of claim 33, wherein the circuitry is further programmed with instructions to determine the path loss value for a plurality of geographic areas to compile a database.

36. (Previously Presented) The system of claim 33, wherein the receiver is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device, pager, base station and wireless location sensor.

37. (Previously Presented) The system of claim 33, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital

assistant, vehicle security device, vehicle tracking device and pager.

38. (Previously Presented) The system of claim 33, wherein the wireless device is engaged in one of a simplex or a duplex communication area.

39. (Previously Presented) The system of claim 33, wherein the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic.

40. (Previously Presented) The system of claim 33, wherein the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute.

41. (Currently Amended) An apparatus for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, comprising:

means for identifying an active communication channel supporting at least one desirable attribute;

means for identifying the wireless device and the receiver tasked to communicate on said active communication channel without disabling any other communication channel;

means for locating said wireless device and said receiver;

means for identifying a transmitted signal strength for signaling on said active communication channel;

means for identifying a received signal strength for signaling on said active communication channel; and

means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

42. (Original) The apparatus of claim 41, wherein the desirable attribute comprises of at

least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value.

43. (Original) The apparatus of claim 41, wherein the means for identifying an active communication channel comprises an antenna, a radio receiver and a microprocessor.

44. (Original) The apparatus of claim 41, wherein the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory.

45. (Original) The apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a wireless location system.

46. (Original) The apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a geo-positioning system ("GPS").

47. (Original) The apparatus of claim 41, wherein the transmitted signal strength defines the signal strength at the wireless device.

48. (Original) The apparatus of claim 41, wherein the means for identifying a transmitted signal strength for signaling on said active communication channel comprises an antenna and a signal detection circuit.

49. (Original) The apparatus of claim 41, wherein means for identifying the wireless device and the receiver further comprises means for tasking the wireless device and the receiver to signal on said active communication channel.

50. (Original) The apparatus of claim 41, further comprising means for detecting a second communication channel interfering with the active communication channel.

51. (Previously Presented) The apparatus of claim 50, further comprising means for reassigning the second communication channel to a third communication channel.

REMARKS

Claims 1-51 are pending with entry of this paper.

Claims 1-51 stand rejected.

Applicant acknowledges the withdrawal of the claim rejections premised upon Gutowski and/or Walton in view of Gutowski and other references.

I. Drawings

The Office objected to the drawings due to certain informalities. Applicant submits herewith as Exhibit A, annotated marked up drawings and replacement sheets for Figures 2 and 3 in compliance with 37 C.F.R. § 1.121(d) correcting the informalities noted by the Office. No new matter has been added. Consideration and acceptance of Applicant's amended Figures 2 and 3 are respectfully solicited.

II. The Rejections

While the Office improperly rejected 1, 3-6 and 8 under 35 U.S.C 102(a) as unpatentable in view of Wilson and improperly rejected Claims 2, 7, and 9-51 over Wilson in view of other references (Moulsley, Au, etc.), Applicant has amended the independent claims to clarify the claimed subject matter. In the instant rejection, it appears the Office misunderstood what Wilson fairly teaches and misapplied the reference in a rejection of the claimed subject matter, and for these reasons at least the rejection is improper on its face.

A. Background

The claimed subject matter is generally directed to a system and method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan. Each independent claim, however, requires that such a determination occurs utilizing an active communications channel and/or using measurements from an active communications channel without disabling any other communications channel. That is, Applicant explicitly claims the collection of data from mobile devices that are in active use (i.e., in active communication) in a cellular network.

Much of the present rejections, however, appear to misunderstand what is claimed by utilizing an active communications channel and/or measurements therefrom. As noted by Applicant in the instant specification, conventional systems may determine path loss values by assigning a dedicated frequency channel to a wireless device and disabling interfering frequency

channels within the wireless communications system. This setting aside of a dedicated frequency channel requires revising a frequency use plan for the respective geographic area which is costly and inefficient. *See* Applicant's published specification at paragraphs [0003], [0006] and [0017].

B. Wilson

Wilson is directed to a method and system for characterization of radio frequency propagation in a cellular network and use of the same in RF channel reuse planning. *See* Wilson at 1:11-15. More specifically, however, Wilson acknowledges that reuse of RF channels may result in interference between cells using the same RF channel; thus, RF isolation must exist between the cells/sections (C/I ratio). Wilson at 1:57-2:2. Wilson then describes generating an "Isolation Matrix" which includes the RF isolation for each cell/sector pair in a network. According to Wilson, prior techniques for doing so included "drive testing" which required a dedicated vehicle to drive a specific route and then gather appropriate measurements on a dedicated RF channel. Wilson at 2:6-42. Wilson, however, proposes performing the same drive testing analyses using the assistance of mobile stations in doing so. Wilson at 2:50-64.

Wilson, however, suffers from the same deficiencies as Gutowski (cited by the Office in the prior Action). Namely, conventional methods for determining path loss (such as Gutowski's drive testing and Wilson's employment of mobile devices to do the same) require a frequency channel dedicated to the path loss measurement (hence Wilson's C/I measurement and Isolation Matrix). But, as described by Applicant in paragraph [0006], channel dedication for path loss measurements and its rearrangement of remaining channels of a frequency use plan is costly and inefficient. *See* paragraphs [0003], [0006] and [0017] of Applicant's published specification. Applicant's claimed subject matter is directed to a method and system for assessing path loss without setting aside an otherwise active frequency channel or disturbing the frequency use plan – that is – Applicant's claimed subject matter employs an active communications channel by utilizing a mobile device in active communication with a receiver in a cellular network – something entirely different than that described in Wilson (and Gutowski).

Wilson's disclosure confirms Applicant's position:

> According to the present invention, RF isolation between RF channels is determined with the assistance of mobile terminals 234, 236, 238, 240, 242, 244, 246, 248, 250, 252, 254 and 256. **In this operation, a particular radio frequency (RF) traffic channel is selected as a beacon channel (B-CH). The B-CH has a particular center frequency and a particular bandwidth. The B-CH is disabled at the other base stations 104-114 so that none of the other**

> **base stations 104-114 transmit on the B-CH. In this operation, the B-CH is reserved for collecting RF cell-pair isolation data using the method of the present invention. In one operation, RF channels residing adjacent the B-CH in the frequency spectrum are also disabled at the base station 102 and/or the other base stations 104-114**. Such disablement is performed to avoid interference in the adjacent RF channels by the B-CH, which is transmitted at an above-normal power level in such case. Wilson at 4:38-54 (emphasis supplied).

With reference to the emphasized portions of Wilson cited above, it is clear that the channel utilized by Wilson is not an "active communications channel" as claimed and described in Applicant's specification; rather, Wilson is exactly the art that the claimed subject matter improves upon – that is, Applicant's claimed subject matter does not use channel dedication for path loss measurements (such as Wilson and the previously cited Gutowski) and/or the subsequent rearrangement of remaining channels of a frequency use plan.

C. Independent Claim 1

On pages 3-4 of the Action, the Office improperly rejected 1, 3-6 and 8 under 35 U.S.C 102(a) as unpatentable in view of Wilson. Claim 1 requires using the active communications channel as discussed above and/or using measurements from an active communications channel, contrary to the disclosure of Wilson. For example, Claim 1 recites in part:

> the improvement comprises ***using an active communication channel to determine the signal strength of the wireless device and comprises using an active communication channel without disabling any other communication channel.*** (emphasis supplied).

In support of the active communications element of Claim 1 above, the Office cited to Col. 2, ll. 65-67, Col. 3, line 1 and Col. 4 ll. 60-65. These sections are provided below in full.

> Mobile stations operating within the system are then directed to measure and report the signal strength, of the broadcast channel as well as a traffic channel servicing their ongoing calls. Wilson at 2:65-3:1

> While the B-CH is keyed up, the mobile stations 234-256 are instructed to measure the strength of both the B-CH and the respective serving RF traffic channels. The measured strengths are then reported via base stations 104-114 and collected at a central location within cellular wireless communication the system. Wilson at 4:60-65.

These sections of Wilson cited by the Office, however, fail to provide context of Wilson's characterization of RF propagation in a cellular network. As cited by Applicant above, Wilson provides an express teaching away of Applicant's claimed subject matter, namely, Wilson

describes disabling channels in a frequency reuse scheme to obtain the necessary measurements. In view of Applicant's amendment to Claim 1, the rejection of Claim 1 premised on Wilson is moot. Reconsideration and withdrawal of the rejection of Claim 1 and those claims dependent thereon is respectfully solicited.

D. Independent Claims 11, 23 33 and 41

On pages 5-31 of the Action, the Office improperly rejected independent Claims 11, 23, 33 and 41 and those claims dependent thereon over Wilson in view of other references (Moulsley, Au, etc.). Each of these independent claims require using the active communications channel as discussed above and/or using measurements from an active communications channel without disabling any other channel, contrary to the disclosure of Wilson. For example, Claim 11 recites in part:

> identifying a first cell, a first sector, and a first frequency channel associated with the geographic area ***wherein said wireless device is actively communicating with said receiver using said first frequency channel without disabling any other communication channel***;
>
> ***receiving at said receiver the signal transmitted from said wireless device on said first frequency channel;***
>
> receiving at said receiver the signal transmitted from said wireless device on said first frequency channel;
>
> receiving at said receiver an indication of transmission signal strength of said signal;
>
> measuring at said receiver the received signal strength of said signal; and
>
> determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength. (emphasis supplied)

Claim 23 recites in part:

> ***identifying a first frequency channel in an active communication between the wireless device and the receiver without disabling any other communication channel;***
>
> geolocating the wireless device and the receiver;
>
> ***receiving at the receiver the signal transmitted from said wireless device on said first frequency channel***;
>
> receiving at said receiver an indication of transmission signal strength of said signal;
>
> measuring at said receiver the received signal strength of said signal; and
>
> ***determining the path loss value of said first frequency channel*** as a function of the indication of transmission signal strength and the received signal strength.

Claim 33 recites in part:

a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to:

identify a geographic area where the path loss value is to be determined;

identify a first cell, a first sector, and ***a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel without disabling any other communication channel***;

receive at said receiver the signal transmitted from said wireless device on said first frequency channel;

receive at said receiver an indication of transmission signal strength of said signal;

measure at said receiver the received signal strength of said signal; and

determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Claim 41 recites in part:

means for identifying an active communication channel supporting at least one desirable attribute;

means for identifying the wireless device and the receiver tasked to communicate on said active communication channel without disabling any other communication channel;

means for locating said wireless device and said receiver;

means for identifying a transmitted signal strength for signaling on said active communication channel;

means for identifying a received signal strength for signaling on said active communication channel; and

means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

As is clear from the plain language of the claims, the mobile device is in active communication with the respective cellular network via a frequency channel and any measurement therefrom utilizes this active communications channel without disabling any other communication channel. This is in stark contrast to the teachings of Wilson which describes and requires disabling channels in a frequency reuse scheme to obtain the necessary measurements for its Isolation Matrix. For at least this reason, the rejection of independent Claims 11, 23, 33 and 41 and those claims dependent thereon should be reconsidered and withdrawn.

CONCLUSION

Applicant submits the subject application is in condition for allowance and as such respectfully requests allowance of the application.

If the Examiner has any questions relating to this response or the application in general he is respectfully requested to contact the undersigned so that prosecution may be expedited.

The Commissioner is hereby authorized to charge payment of any additional fees associated with this communication or credit any overpayment to Deposit Account No. 04-1679. A duplicate of this sheet is enclosed.

Respectfully submitted,

/Mark C. Comtois/

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Telephone: (202) 776-7800
Telecopier: (202) 776-7801

Date: January 17, 2012

Exhibit A

"Annotated marked-up Drawing"

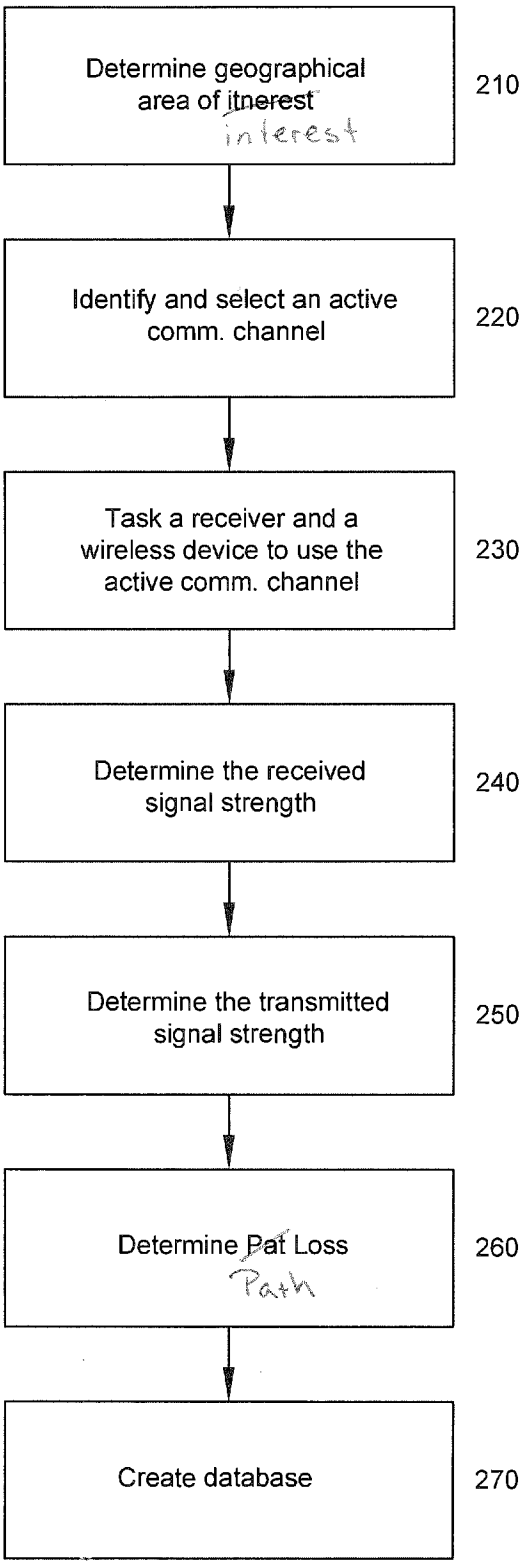


Fig. 2

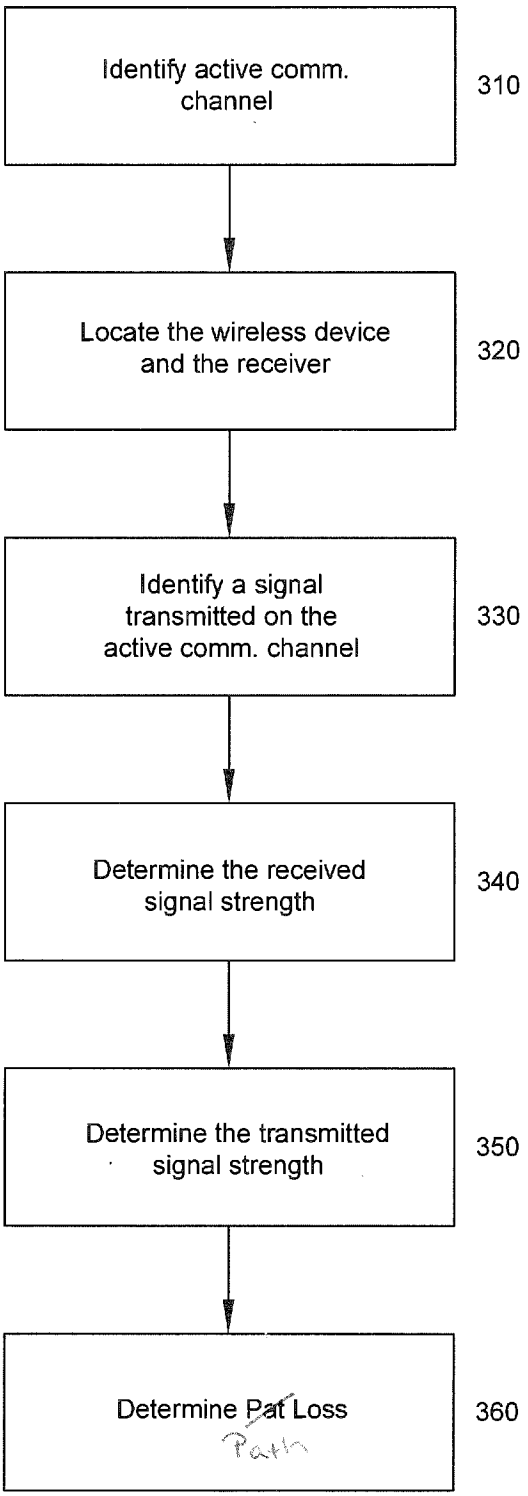

Identify active comm. channel
310
Locate the wireless device and the receiver
320
Identify a signal transmitted on the active comm. channel
330
Determine the received signal strength
340
Determine the transmitted signal strength
350
Determine Pat Loss
Path
360

Fig. 3

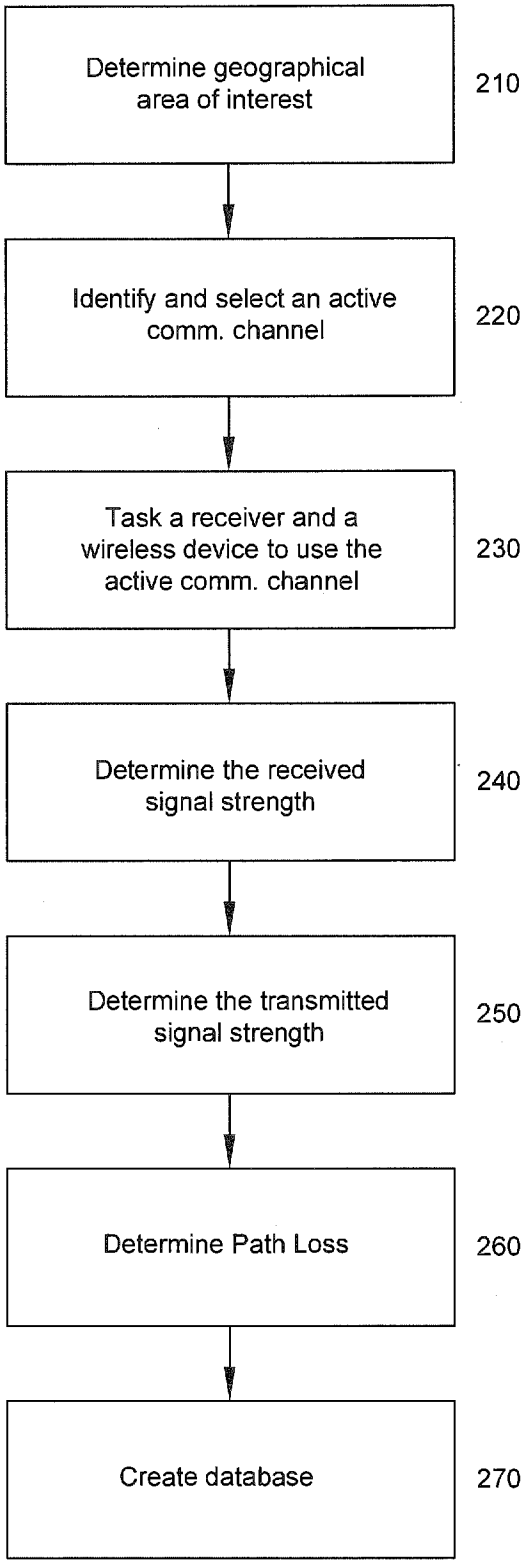

Determine geographical area of interest
210
Identify and select an active comm. channel
220
Task a receiver and a wireless device to use the active comm. channel
230
Determine the received signal strength
240
Determine the transmitted signal strength
250
Determine Path Loss
260
Create database
270

Fig. 2

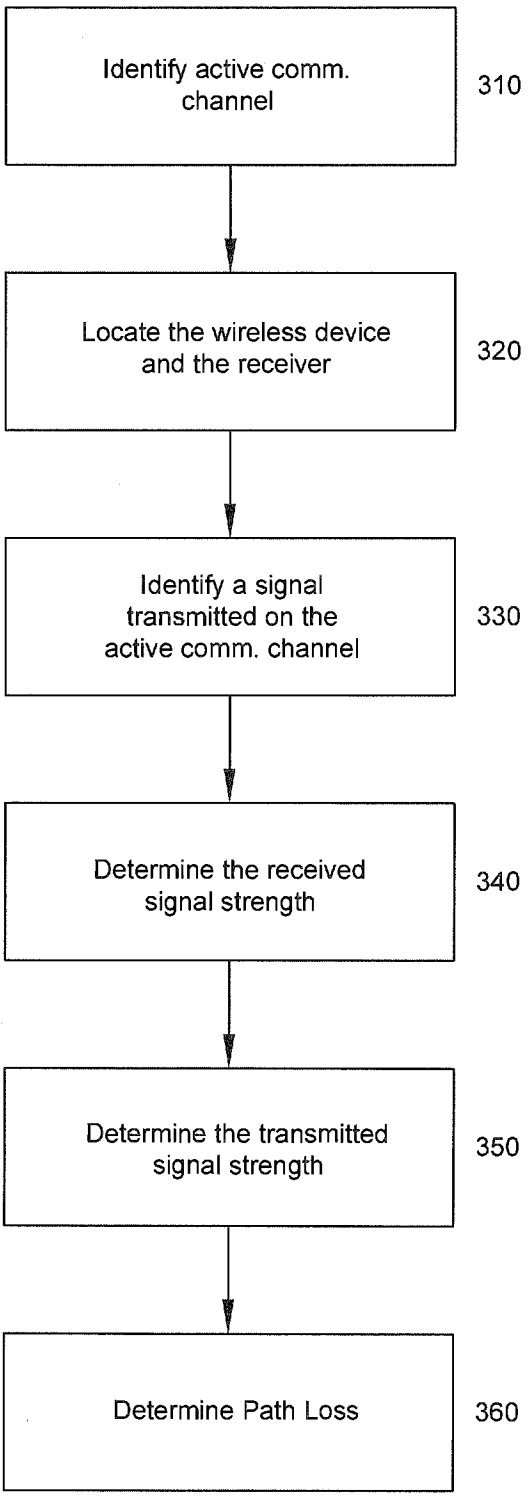

Identify active comm. channel
310
Locate the wireless device and the receiver
320
Identify a signal transmitted on the active comm. channel
330
Determine the received signal strength
340
Determine the transmitted signal strength
350
Determine Path Loss
360

Fig. 3

Electronic Acknowledgement Receipt

EFS ID:	11852851
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and Apparatus for Determining Path Loss by Active Signal Detection
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	79172
Filer:	Mark Charles Comtois/laureen ponder
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND01 061 US
Receipt Date:	17-JAN-2012
Filing Date:	15-DEC-2008
Time Stamp:	16:27:00
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment/Req. Reconsideration-After Non-Final Reject	AND01061USAmdt.pdf	2698440 ee506fcc5daee9e5a6d9708fe8602f0b2eb39324	no	22

Warnings:	
Information:	

Total Files Size (in bytes):	2698440

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
11/920,076	12/15/2008	

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☐		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	01/17/2012	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 49	Minus	** 51	= 0	X $ =		OR	X $60=	0
	Independent (37 CFR 1.16(h))	* 5	Minus	***5	= 0	X $ =		OR	X $250=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/CATHERINE SMITH/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/920,076	12/15/2008	John Arpee	AND01 061 US	2431

79172 7590 10/17/2011

Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

EXAMINER	
SHIVERS, ASHLEY L	
ART UNIT	PAPER NUMBER
2477	
MAIL DATE	DELIVERY MODE
10/17/2011	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	11/920,076	ARPEE ET AL.	
	Examiner	Art Unit	
	ASHLEY SHIVERS	2477	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *March 22, 2011 (Applicants' Arguments)*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-51* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-51* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *08 November 2007* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

12)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Amendment

1. Applicant's arguments filed on March 22, 2011 have been entered. No claims have been amended. No claims are canceled. No claims have been added. Claims 1-51 are still pending in this application, with claims 1, 11, 23, 33 and 41 being independent.

Drawings

2. The drawings are objected to because in Fig. 2, step 210 "interest" and step 260 "path" are spelled incorrectly. In Fig. 3, step 360 "path" is spelled incorrectly. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet"

pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 102

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for a patent.

4. Claims 1, 3-6 and 8 are rejected under 35 U.S.C. 102(a) as being anticipated by Wilson et al. (**U.S. Patent No. 6,853,842**), hereinafter referred to as Wilson.

Regarding claim 1, Wilson discloses in a method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan (**See col. 1, lines 57-65**), wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device and disabling interfering frequency channels within the wireless communication system (**See col. 2, lines 27-42**), the improvement comprises using an active communication channel to determine the signal strength of the wireless device (**Mobile stations are instructed to measure the strength of both the B-CH and the respective serving RF traffic channels, wherein the serving traffic channels are for**

ongoing calls. The measured strengths are then reported via the base stations and collected at a central location within cellular wireless communication system. See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65).

Regarding claim 3, Wilson further discloses the method of claim 1, wherein the active communication channel defines any frequency channel capable for a simplex communication (**See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 4, Wilson further discloses the method of claim 1, wherein the active communication channel defines a communication channel within the frequency use plan (**See col. 4, lines 30-35**).

Regarding claim 5, Wilson further discloses the method of claim 1, wherein the active communication channel defines a reverse control channel (**See col. 4, line 36**).

Regarding claim 6, Wilson further discloses the method of claim 1, wherein the active communication channel defines a forward control channel (**See col. 4, line 36**).

Regarding claim 8, Wilson further discloses the method of claim 1, wherein interfering channels define frequency channels causing at least one of adjacent channel

interference, co-channel interference, inter-symbol interference and cross-rail interference (**See col. 4, lines 48-54**).

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Moulsley (**U.S. PGPub 2002/0172160**), hereinafter referred to as Moulsley.

Regarding claim 2, Wilson teaches the method of claim 1, but fails to teach of the active communication channel defining any frequency channel capable of duplex communication.

Moulsley teaches of the channel being capable of duplex communication (**See [0025]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include the active communication channel being defined as any frequency channel capable of duplex communication taught by Moulsley in order to provide a reverse path for monitoring and remote adjustment of equipment in the field.

7. Claims 7, 11, 13-14, 16-23, 25, 27-33, 35-41, 43-45 and 47-49 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Au et al. (**U.S. PGPub 2005/0192042**), hereinafter referred to as Au.

Regarding claim 7, Wilson teaches the method of claim 1, suggests having path loss by determining the interference ratio (**See col. 4, lines 65-67**), but fails to explicitly teach of calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel.

Au teaches of calculating path loss wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include calculating path loss wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 11, Wilson teaches a method for determining a path loss value (**interpreted as the interference**) of a signal transmitted from a wireless device and

received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the method comprising the steps of:

identifying a geographic area where the signal strength is to be determined (**A first RF cell (or sector) is chosen; See col. 6, line 26**);

identifying a first cell, a first sector (**A first RF cell (or sector) is chosen; See col. 6, line 26**), and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel (**The Mobile station serviced by the base station is instructed to measure the strength of both the B-CH and the RF channel servicing its call, thereby suggesting that the first frequency channel is identified; See col. 5, lines 1-4**); and

receiving at said receiver the signal transmitted from said wireless device on said first frequency channel (**The mobile stations sends the signal strengths; See col. 5, lines 4-6**).

While Wilson suggests having path loss by determining the interference ratio **(See col. 4, lines 65-67),** it fails to explicitly teach of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Au teaches of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 13, Wilson teaches the method of claim 11, further comprising determining the path loss (**determining the C/I interference ratio; See col. 4, lines 65-67**) for a plurality of geographic areas to compile a database (**All of the mobile stations measure the signal strength, thereby suggesting multiple geographic areas to compile a database; See col. 4, lines 60-65**).

Regarding claim 14, Wilson further teaches the method of claim 11, wherein the receiver is a base station (**base station; See col. 4, lines 14-15**).

Regarding claim 16, Wilson further teaches the method of claim 11, wherein the wireless device is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager (**mobile terminal; See col. 4, lines 40-41**).

Regarding claim 17, Wilson further teaches the method of claim 11, wherein the wireless device is engaged in one of a duplex or simplex communication (**See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 18, Wilson further teaches the method of claim 11, further comprising randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver (**A channel of an ongoing call, wherein there are a plurality of RF channels; See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 19, Wilson further teaches the method of claim 11, further comprising selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute (**See col. 4, lines 65-67**).

Regarding claim 20, Wilson further teaches the method of claim 19, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio and carrier-to-interference ratio (**See col. 4, lines 65-67**).

Regarding claim 21, Wilson further teaches the method of claim 11, further comprising identifying the location of the receiver and the wireless device (**A first RF cell (or sector) is chosen; See col. 6, line 26**).

Regarding claim 22, Wilson fails to teach the circuitry configured to implement the method of claim 11.

Au teaches of the circuitry (**See [0044]-[0045]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include circuitry taught by Au in order to indicate the components used to perform the operations.

Regarding claim 23, Wilson teaches a method for determining a path loss value (**interpreted as the interference**) of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system, the method comprising:

identifying a first frequency channel in an active communication between the wireless device and the receiver (**The Mobile station serviced by the base**

station is instructed to measure the strength of both the B-CH and the RF channel servicing its call, thereby suggesting that the first frequency channel is identified; See col. 5, lines 1-4);

geolocating the wireless device and the receiver (**A first RF cell (or sector) is chosen; See col. 6, line 26**);

receiving at the receiver the signal transmitted from said wireless device on said first frequency channel (**The mobile stations sends the signal strengths; See col. 5, lines 4-6**).

While Wilson suggests having path loss by determining the interference ratio **(See col. 4, lines 65-67),** it fails to explicitly teach of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal, and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Au teaches of receiving at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal, and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include receiving at said

receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal, and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 25, Wilson teaches the method of claim 23, further comprising determining the path loss (**determining the C/I interference ratio; See col. 4, lines 65-67**) for a plurality of geographic areas to compile a database (**All of the mobile stations measure the signal strength, thereby suggesting multiple geographic areas to compile a database; See col. 4, lines 60-65**).

Regarding claim 27, Wilson further teaches the method of claim 23, wherein the first frequency channel in active communication is engaged in simplex communication (**See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 28, Wilson further teaches the method of claim 23, further comprising selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute (**See col. 4, lines 65-67**).

Regarding claim 29, Wilson further teaches the method of claim 28, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio, inter-symbol interference and carrier-to-interference ratio (**See col. 4, lines 65-67**).

Regarding claim 30, Wilson further teaches the method of claim 23, wherein the receiver is a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device (**base stations; See col. 4, lines 14-15**).

Regarding claim 31, Wilson further teaches the method of claim 23, wherein the receiver is a base station or a wireless location sensor ("WLS") or a combination of the base station and a WLS (**base station; See col. 4, lines 14-15**).

Regarding claim 32, Wilson teaches the method of claim 25, but fails to teach of the circuitry configured to implement the method of claim 23.

Au teaches of the circuitry configured to implement the method of claim 23 (**See [0044]-[0045]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson to include circuitry taught by Au in order to indicate the components used to perform the operations.

Regarding claim 33, Wilson teaches a system for determining path loss value (**interpreted as the interference**) of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system to:

identify a geographic area where the signal strength is to be determined (**A first RF cell (or sector) is chosen; See col. 6, line 26**);

identify a first cell, a first sector (**A first RF cell (or sector) is chosen; See col. 6, line 26**), and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel (**The Mobile station serviced by the base station is instructed to measure the strength of both the B-CH and the RF channel servicing its call, thereby suggesting that the first frequency channel is identified; See col. 5, lines 1-4**); and

receive at said receiver the signal transmitted from said wireless device on said first frequency channel (**The mobile stations sends the signal strengths; See col. 5, lines 4-6**).

While Wilson suggests having path loss by determining the interference ratio **(See col. 4, lines 65-67),** it fails to explicitly teach of the circuitry including a microprocessor and a memory for compiling a database for receiving the path loss

values, the circuitry configured with instructions to using the signal strength to determine path loss, receive at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Au teaches of the circuitry including a microprocessor and a memory for compiling a database (**See [0044]-[0045]**) for receiving the path loss values, the circuitry configured with instructions to using the signal strength to determine path loss, receive at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Wilson to include of the circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to using the signal strength to determine path loss, receive at said receiver an indication of transmission signal strength of said signal, measuring at said receiver the received signal strength of said signal and determining the path loss of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 35, Wilson teaches the system of claim 33, further comprising the circuitry being further programmed with instructions to determine the path loss (**determining the C/I interference ratio; See col. 4, lines 65-67**) for a plurality of geographic areas to compile a database (**All of the mobile stations measure the signal strength, thereby suggesting multiple geographic areas to compile a database; See col. 4, lines 60-65**).

Regarding claim 36, Wilson further teaches the system of claim 33, wherein the receiver is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device, pager, base station and wireless location sensor (**base station; See col. 4, lines 14-15**).

Regarding claim 37, Wilson further teaches the system of claim 33, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager (**mobile terminal; See col. 4, lines 40-41**).

Regarding claim 38, Wilson further teaches the system of claim 33, wherein the wireless device is engaged in one of a simplex or duplex communication area (**See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 39, Wilson further teaches the system of claim 33, wherein the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic (**A channel of an ongoing call, wherein there are a plurality of RF channels; See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

Regarding claim 40, Wilson further teaches the system of claim 33, wherein the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute (**See col. 4, lines 65-67**).

Regarding claim 41, Wilson teaches an apparatus for determining a path loss value (**interpreted as the interference**) of a signal transmitted from a wireless device and received by a receiver, comprising:

identifying an active communication channel supporting at least one desirable attribute (**The Mobile station serviced by the base station is instructed to measure the strength of both the B-CH and the RF channel**

servicing its call, thereby suggesting that the first frequency channel is identified. The measurements are used to determine the carrier-to-interference ratios for the respective cell pairs; See col. 4, lines 65-67-col. 5, lines 1-4);

identifying the wireless device and the receiver tasked to communicate on said active communication channel (**Base stations 108 and mobile stations 242**); and

locating said wireless device and said receiver (**A first RF cell (or sector) is chosen; See col. 6, line 26**).

While Wilson suggests having path loss by determining the interference ratio **(See col. 4, lines 65-67),** it fails to explicitly teach of the various means for identifying and locating and the means for identifying a transmitted signal strength for signaling on said active communication channel, means for identifying a received signal strength for signaling on said active communication channel, and means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

Au teaches of the means for identifying and locating (**processor and circuitry; See [0044]**), a means for identifying (**processor and circuitry; See [0044]**) a transmitted signal strength for signaling on said active communication channel, means for identifying (**processor and circuitry; See [0044]**) a received signal strength for signaling on said active communication channel, and means for calculating (**processor and**

circuitry; See [0044]) the path loss value as a function of the transmitted signal strength and the received signal strength (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson to include the various means for identifying and locating, means for identifying a transmitted signal strength for signaling on said active communication channel, means for identifying a received signal strength for signaling on said active communication channel, and means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength taught by Au in order to determine how much a mobile device contributes to the load of the sector.

Regarding claim 43, Wilson further teaches the apparatus of claim 41, wherein the means for identifying an active communication channel comprises a microprocessor (**See Fig. 7, #702**) but fails to teach of the antenna and radio receiver.

Au teaches of the identifying means comprising an antenna, radio receiver and processor (**See Fig. 1, and [0044]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson to include identifying means comprising an antenna, radio receiver and processor taught by Au in order to provide the components performing the above operations.

Regarding claim 44, Wilson teaches the apparatus of claim 41, but fails to teach of the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory.

Au teaches of the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory (**See [0044]-[0045]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson to include the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory taught by Au in order to provide the components performing the above operations.

Regarding claim 45, Wilson further teaches the apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a wireless location system (**system engineering server; See Fig. 7**).

Regarding claim 47, Wilson teaches the apparatus of claim 41, but fails to teach of the transmitted signal strength defining the signal strength at the wireless device.

Au teaches of the transmitted signal strength defining the signal strength at the wireless device (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson to include the transmitted signal strength defining the signal strength at the wireless device taught by Au in order to determine the load that the wireless device has on the network.

Regarding claim 48, Wilson teaches the apparatus of claim 41, but fails to teach of the means for identifying a transmitted signal strength for signaling on said active communication channel comprising an antenna and a signal detection circuit.

Au teaches of the means for identifying a transmitted signal strength for signaling on said active communication channel comprising an antenna (**See Fig. 1**) and a signal detection circuit (**circuitry; See [0044]-[0045]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson to include the means for identifying a transmitted signal strength for signaling on said active communication channel comprising an antenna (**See Fig. 1**) and a signal detection circuit taught by Au in order to provide the components to perform the operations.

Regarding claim 49, Wilson further teaches the apparatus of claim 41, wherein means for identifying the wireless device and the receiver further comprises means for tasking the wireless device and the receiver to signal on said active communication

channel (**An active channel is chosen for the ongoing calls; See col. 2, lines 65-67, col. 3, line 1 and col. 4, lines 60-65**).

8. Claims 9-10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Hakalin et al. (**U.S. PGPub 2002/0042276**), hereinafter referred to as Det_Hakalin.

Regarding claim 9, Wilson teaches the method of claim 1, but fails to teach of the improvement further comprising using an active communication channel without disabling any interfering channel.

Det_Hakalin teaches of having multiple cells associated with adjacent and overlapping channels (**See [0038]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Au to include using an active communication channel without disabling interfering channel taught by Det_Hakalin in order to allow for the actual interference to be accurately estimated and the balancing of the interference between different cells.

Regarding claim 10, Wilson teaches the method of claim 1, but fails to teach the improvement further comprising using an active channel without disrupting the frequency use plan.

Det_Hakalin teaches of having multiple cells associated with adjacent and overlapping channels (**See [0038]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Au to include using an active channel without disrupting the frequency use plan taught by Det_Hakalin in order to allow for the actual interference to be accurately estimated and the balancing of the interference between different cells.

9. Claims 12, 24, 34 and 50-51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Au in further view of the prior art of Hakalin et al. (**U.S. PGPub 2002/0042276**), hereinafter referred to as PR_Hakalin.

Regarding claim 12, Wilson in view of Au teaches the method of claim 11, but fails to teach of the steps of determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said frequency channel to a third frequency channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Au to include determining a second frequency channel which interferes with said first frequency

channel and reassigning a second signal using said frequency channel to a third frequency channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

Regarding claim 24, Wilson in view of Au teaches the method of claim 23, but fails to teach the steps of determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said second frequency channel to a third frequency channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Au to include determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said second frequency channel to a third frequency channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

Regarding claim 34, Wilson in view of Au teaches the system of claim 33, wherein the circuitry is further programmed with instructions to determine a second

frequency channel which interferes with said first frequency channel and reassign a second signal using said second frequency channel to a third frequency channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Wilson in view of Au to include the circuitry being further programmed with instructions to determine a second frequency channel which interferes with said first frequency channel and reassign a second signal using said second frequency channel to a third frequency channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

Regarding claim 50, Wilson in view of Au teaches the apparatus of claim 41, but fails to teach of the means for detecting a second communication channel interfering with the active communication channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Au to include

detecting a second communication channel interfering with the active communication channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

Regarding claim 51, Wilson in view of Au teaches the apparatus of claim 50 but fails to teach of the means for reassigning the second communication channel to a third communication channel.

PR_Hakalin teaches the concept of performing a handover when co-channel interference between two channels is unacceptable, thereby suggesting that the second channel is reassigned to the third channel (**See [0007]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Au to include detecting a second communication channel interfering with the active communication channel taught by PR_Hakalin in order to handover to a stronger channel based on measurements of the signal quality.

10. Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Au in further view of Stilp (**U.S. PGPub 2002/0172223**), hereinafter referred to as Stilp.

Regarding claim 15, Wilson in view of Au teaches the method of claim 11, but fails to teach of the receiver being a wireless location sensor.

Stilp teaches of the receiver being a wireless location sensor (**See [0017]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Au to include the receiver being a wireless location sensor taught by Stilp in order to make highly accurate TDOA and FDOA measurements.

11. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Au in further view of Moulsley.

Regarding claim 26, Wilson in view of Au teaches the method of claim 23, but fails to teach of the first frequency channel in active communication being engaged in a duplex communication.

Moulsley teaches of the active communication being engaged in a duplex communication (**See [0025]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Wilson in view of Au to include the active communication being engaged in a duplex communication taught by Moulsley in order to provide a reverse path for the monitoring and remote adjustment of equipment in the field.

12. Claim 42 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Au in further view of Seo et al. (**U.S. PGPub 2003/0039217**), hereinafter referred to as Seo.

Regarding claim 42, Wilson in view of Au teaches the apparatus of claim 41, but fails to teach of the desirable attribute comprising of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value.

Seo teaches of the attribute comprising an SIR threshold (**See [0121]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Au to include the desirable attribute comprising of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value taught by Seo in order to determine whether the conditions of the channel are acceptable.

13. Claim 46 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wilson in view of Au in further view of Dowling (**U.S. PGPub 2005/0143090**), hereinafter referred to as Dowling.

Regarding claim 46, Wilson in view of Au teaches the apparatus of claim 41, but fails to teach of the means for locating said wireless device and said receiver comprising a geo-positioning system ("GPS").

Dowling teaches of the means for locating comprising a GPS (**See [0019]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Wilson in view of Au to include the means for locating comprising a GPS taught by Dowling in order to provide a more precise indication of the location of the devices.

Response to Arguments

14. Applicant's arguments, see pages 2-4, filed March 22, 2011, with respect to claims 11-13 and 19-20 have been fully considered and are persuasive. The rejection of claims 11-13 and 19-20 has been withdrawn.

On pages 2-4 of the Applicants' Response, Applicants state that Gutowski (**U.S. PGPub 2002/0058503**), hereinafter referred to as Gutowski fails to teach of using an active communication channel and receiving the signal transmitted from the wireless device on said active communication channel.

Examiner agrees and has thus removed Gutowski from consideration with the above limitations, however upon further examination, Examiner has introduced Wilson t al. (**U.S. Patent No. 6,853,842**), hereinafter referred to as Wilson to teach of having a first frequency channel actively communicating between the wireless device and the receiver and receiving a signal on the active communication channel (**See col. 5, lines 1-4 and col. 6, line 26**).

15. Applicant's arguments, see page 5, filed March 22, 2011, with respect to claims 1-10 have been fully considered and are persuasive. The rejection of claims 1-10 has been withdrawn.

On page 5 of the Applicants' Response, Applicants state that Walton et al. (**U.S. Patent No. 6,751,187**), hereinafter referred to as Walton in view of Gutowski fails to teach of using an active communication channel to determine the signal strength of the wireless device.

Examiner agrees and has thus removed the above from consideration with regards to the limitation, however upon further examination, Examiner has introduced Wilson to teach of using an active communication channel (**RF channel used in the ongoing call; See col. 2, lines 65-67-col. 3, line 1**) to determine the signal strength of the wireless device (**The mobile station measure the signal strength of the serving RF traffic channels and then reports the values; See col. 4, lines 60-65**).

16. Applicant's arguments, see pages 6-7, filed March 22, 2011, with respect to claims 14-18 and 21-51 have been fully considered and are persuasive. The rejection of claims 14-18 and 21-51 has been withdrawn.

On pages 6-7 of the Applicants' Response, Applicants state that Gutowski in view of various combinations of Agrawal et al. (**U.S. PGPub 2005/0271012**), hereinafter referred to as Agrawal, Stilp (**U.S. PGPub 2002/0172223**), hereinafter referred to as Stilp, Moulsley (**U.S. PGPub 2002/0172160**), hereinafter referred to as Moulsley fails to teach

of the first frequency channel in an active communication between the wireless device and the receiver and receiving the signal transmitted on said first frequency channel.

Examiner agrees and has thus introduced Wilson as indicated above to teach of the active communication channel between the wireless device and the receiver.

Conclusion

17. Any response to this action should be **faxed** to (571) 273-8300 or **mailed** to:

Commissioner of Patents,
P.O. Box 1450
Alexandria, VA 22313-1450

Hand delivered responses should be brought to:
Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

18. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ASHLEY SHIVERS whose telephone number is (571)270-3523. The examiner can normally be reached on Monday-Friday 8:30-5:00 EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chirag Shah can be reached on (571) 272-3144. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/A. S./
Examiner, Art Unit 2477
10/4/2011

/Gregory B Sefcheck/
Primary Examiner, Art Unit 2477
10-6-2011

Notice of References Cited	Application/Control No. 11/920,076	Applicant(s)/Patent Under Reexamination ARPEE ET AL.	
	Examiner ASHLEY SHIVERS	Art Unit 2477	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2005/0192042	09-2005	Au et al.	455/522
*	B	US-2002/0042276	04-2002	Hakalin et al.	455/453
*	C	US-2003/0039217	02-2003	Seo et al.	370/318
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	11920076
Filing Date	2008-12-15
First Named Inventor	ARPEE et al.
Art Unit	2477
Examiner Name	Ashley Shivers
Attorney Docket Number	AND01 061 US

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20040203897	A1	2004-10-14	Rogers	

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	1146760	EP	A2	2001-10-17	ScoreBoard Inc.		☐
	2	94/02995	WO	A1	1994-02-03	Hutchison Telephone Company Limited		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.S./

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920076
	Filing Date	2008-12-15
	First Named Inventor	ARPEE et al.
	Art Unit	2477
	Examiner Name	Ashley Shivers
	Attorney Docket Number	AND01 061 US

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature	/Ashley Shivers/	Date Considered	10/04/2011

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.S./

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	**Art Unit**
	ASHLEY L SHIVERS	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/03/2010	12/17/2010	10/04/2011						
	1	✓	✓	✓						
	2	✓	✓	✓						
	3	✓	✓	✓						
	4	✓	✓	✓						
	5	✓	✓	✓						
	6	✓	✓	✓						
	7	✓	✓	✓						
	8	✓	✓	✓						
	9	✓	✓	✓						
	10	✓	✓	✓						
	11	✓	✓	✓						
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	33	✓	✓	✓						
	34	✓	✓	✓						
	35	✓	✓	✓						
	36	✓	✓	✓						

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	Art Unit
	ASHLEY L SHIVERS	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/03/2010	12/17/2010	10/04/2011						
	37	✓	✓	✓						
	38	✓	✓	✓						
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	40	✓	✓	✓						
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	47	✓	✓	✓						
	48	✓	✓	✓						
	49	✓	✓	✓						
	50	✓	✓	✓						
	51	✓	✓	✓						

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L8	42	L7 and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/10/04 15:43

EAST Search History (Interference)

<This search history is empty>

10/4/2011 4:16:02 PM
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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S25	5773	"path loss" and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:19
S26	2	"20040203897".pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:23
S27	3325	S25 and ((base near2 station) or (wireless near2 location near2 sensor))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:32
S28	2712	S27 and ("370".clas. or "455".clas.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:32
S29	2356	S28 and interference	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:33
S30	406	S29 and (active near2 (communication or channel $1))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:33
S31	140	S30 and (geographic near2 area)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:33

S32	1767	((determin$4 or calculat$4 or measur$4) with "path loss") and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:37
S33	1290	S32 and ((base near2 station) or (wireless near2 location near2 sensor))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:38
S34	1123	S33 and interference	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:38
S35	651	S34 and (signal near2 strength)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:38
S36	151	S35 and (active near2 (communication or channel $1))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:38
S37	109	S36 and ("370".clas. or "455".clas.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:38
S39	557	S35 and ("370".clas. or "455".clas.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:44
S40	218	S39 and cell and sector and (frequenc$4 or channel$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:44

S42	2	"5799005".pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/09/09 23:46

EAST Search History (Interference)

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10/4/2011 4:17:27 PM
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	**Art Unit**
	ASHLEY L SHIVERS	2477

SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
(path near2 loss) and ((receive$1 near2 signal) or (receive$1 near2 power) or RSS or RSSI) and(455/1,422.1,423,424,456.1,464,39,41.2,501,513,515,522,526,63.1,67.11,67.13,67.14,105,114.2,115.1,115.2,115.3,130,134-135,150.1,151.2,152.1,154.1,161.3,206,226.1,226.3,227,277.2,278.2,283,296,).ccls. and (370/431,433,437,442-443,464,480).ccls	7/2/2010	Ashley Shivers
See EAST Search History	7/2/2010	Ashley Shivers
Performed Double Patenting Search	7/2/2010	Ashley Shivers
Updated EAST Search History	12/17/2010	Ashley Shivers
Updated EAST Search History	10/4/2011	Ashley Shivers

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of John Arpee, et al.

Serial No.: 11/920,076 Art Unit: 2477

Filed: December 15, 2008 Examiner: Ashley L. Shivers

Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

RESPONSE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action mailed December 22, 2010, Applicant submits the following:

Applicant's **Remarks** begin on sheet 2 of this paper.

REMARKS

Claims 1-51 are pending with entry of this paper.

Claims 1-51 stand rejected.

Applicant acknowledges the withdrawal of the claim rejections premised upon Walton in view of Agrawal and other references.

I. The § 102(b) Rejection

At paragraph 3 of the Action the Office improperly rejected Claims 11-13 and 19-20 as being unpatentable in view of Gutowski. In the instant rejection, the Office misunderstood what Gutowski fairly teaches and misapplied the reference in a rejection of the claimed subject matter. For these reasons at least the rejection is improper on its face.

A. Background

The claimed subject matter is generally directed to a system and method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan. Each independent claim, however, requires that such a determination occurs utilizing an active communications channel and/or measurements therefrom. That is, Applicant explicitly claims the collection of data from mobile devices that are in active use (i.e., in active communication) in a cellular network.

B. Gutowski

Gutowski is directed to a method and system for optimizing coverage and overcoming interference when designing or reconfiguring a mobile cellular system. *See* paragraph [0009]. More specifically, however, Gutowski is directed to RF data collection to measure signal strength of each sector in a cell and compare these measurements with predicted characteristics (e.g., path

loss models). *See* paragraph [0010]. Each and every embodiment described by Gutowski, however, requires RF data collection by drive testing. *See* Abstract, paragraph [0011], [0025].

Applicant actually acknowledges the deficiencies in prior art such as Gutowski in the background of its specification. *See* paragraphs [0004]-[0005] of Applicant's specification as originally filed. Namely, conventional methods for determining path loss (such as Gutowski) utilize drive testing which requires a frequency channel dedicated to the path loss measurement. But, as described by Applicant in paragraph [0006], drive testing, its channel dedication for path loss measurements, and its rearrangement of remaining channels of a frequency use plan is costly and inefficient. *See* paragraph [0006] of Applicant's specification as originally filed. Thus, Applicant's claimed subject matter is directed to a method and system for assessing path loss without setting aside an otherwise active frequency channel or disturbing the frequency use plan – that is – Applicant's claimed subject matter utilizes an active communications channel by utilizing a mobile device in active communication with a receiver in a cellular network – something entirely different than that described in Gutowski.

C. Claims 11-13 and 19-20

Claim 11 recites in part:

> identifying a first cell, a first sector, and ***a first frequency channel*** associated with the geographic area ***wherein said wireless device is actively communicating with said receiver using said first frequency channel***;
> ***receiving at said receiver the signal transmitted from said wireless device on said first frequency channel;***
> receiving at said receiver the signal transmitted from said wireless device on said first frequency channel;
> receiving at said receiver an indication of transmission signal strength of said signal;
> measuring at said receiver the received signal strength of said signal; and
> determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

(emphasis supplied). As is clear from the plain language of the claims, the mobile device is in

active communication with the respective cellular network via a frequency channel and any measurement therefrom utilizes this active communications channel. This is in stark contrast to the teachings of Gutowski which requires RF measurements from drive testing.

In support of the "active communication" element of Claim 11, the Office cited to paragraph [0011] of Gutowski in support. This paragraph is provided in full below:

> During the data collection to determine RF signal strengths, indication of RF signal strength at a plurality of locations throughout the system is collected. In one form of collection, referred to as a drive test, a mobile unit with a scanning receiver drives over the roads of the test region. The scanning receiver scans, receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system. For each measurement point, this provides a strength measurement of the signal generated by each cell. These strength signals are recorded for the cells and sectors from which they emanate. The collected data indicates RF coverage for the system. Also, by comparing the relative signal strengths of signals originating from different sectors and measured at a common point, it is possible to determine which sectors may potentially interfere with each other in the event they use a common or adjacent channel frequency. Thus, the effective coverage pattern may be used to optimize coverage and the actual interference points may be used to determine whether sufficient interference exists to change the channel group assigned to the particular area. The collected data can also be used for a number of other analysis or implementation applications. The present invention does not rely on any particular data collection nor is the present invention limited to particular analysis application. The present invention is a post-processing technique which can be widely applied to enhance network growth management. (emphasis added)

See paragraph [0011] of Gutowski. Applicant, however, cannot find any support of Applicant's claimed active communication in this paragraph (or anywhere else in Gutowski for that matter). Indeed, paragraph [0011] of Gutowski appears to confirm Applicant's position that each and every embodiment described in the reference requires the inefficient and costly method of drive testing (*see* emphasis above) expressly distinguished by Applicant in the specification and disavowed by Applicant through claiming "wherein said wireless device is actively communicating with said receiver using said first frequency channel" in Claim 11. For at least this reason, the rejection of independent Claim 11 and its dependent Claims 12-13 and 19-20 should be reconsidered and

withdrawn.

II. The § 103(a) Rejections

At paragraphs 5-7 of the Office Action, the Office improperly rejected Claims 1-10 as being unpatentable by Walton in view of Gutowski and /or other references of record. Similar to the rejection above, the Office misunderstood what these references fairly teach and misapplied and improperly combined the two references in a rejection of the claimed subject matter. For these reasons at least the rejection is improper on its face.

A. Claims 1-10

Applicant's discussion regarding the teachings of Walton in Applicant's previous communication stand and have not been rebutted by the Office, and the Office agreed that its previous reference Agrawal utilized to allegedly teach Applicant's claimed elements requiring an active communications channel does not in fact teach these claimed elements. *See* Office Action at paragraphs 12 and 13. As discussed above, however, Gutowski is also silent as to the claimed elements requiring an active communications channel or measurements therefrom. By way of example, Claim 1 requires "wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device and disabling interfering frequency channels within the wireless communication system, the improvement ***comprises using an active communication channel to determine the signal strength of the wireless device***" (emphasis supplied). Incorporating the discussion in Section I above, Gutowski confirms Applicant's position that each and every embodiment described in the reference requires the inefficient and costly method of drive testing – something contrary to that claimed in Claim 1. For at least this reason, the rejection of independent Claim 1 and its dependent claims should be reconsidered and withdrawn.

B. Claims 14-18 and 21-51

At paragraphs 8-11 of the Office Action, the Office improperly rejected Claims 14-18 and 21-51 as being unpatentable by Gutowski in view of other references of record. Similar to each of the rejections above, the Office misunderstood what the primary reference Gutowski fairly teaches and misapplied and improperly combined Gutowski with other references in a rejection of the claimed subject matter. For these reasons at least the rejection is improper on its face.

Claims 14-18 are dependent upon independent Claim 11. The impropriety of the rejection of Claim 11 has been addressed in Section I above and for the same reasons, the rejection of Claims 14-18 is also improper and should be withdrawn. Each of independent Claims 23, 33 and 41 each require a wireless device in active communication with a receiver. For example, Claim 23 recites in part:

> ...***identifying a first frequency channel in an active communication between the wireless device and the receiver***;
> geolocating the wireless device and the receiver;
> ***receiving at the receiver the signal transmitted from said wireless device on said first frequency channel***;
> receiving at said receiver an indication of transmission signal strength of said signal;
> measuring at said receiver the received signal strength of said signal; and
> determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

(emphasis supplied). Claim 33 recites in part:

> ...the system comprising:
> a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to:
> identify a geographic area where the path loss value is to be determined;
> ***identify a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel;***
> ***receive at said receiver the signal transmitted from said wireless device on said first frequency channel...***

(emphasis supplied) Claim 41 recites in part:

> ***...means for identifying an active communication channel supporting at least one desirable attribute;***
> ***means for identifying the wireless device and the receiver tasked to communicate on said active communication channel;***
> ***means for locating said wireless device and said receiver;***
> ***means for identifying a transmitted signal strength for signaling on said active communication channel;***
> ***means for identifying a received signal strength for signaling on said active communication channel...***

(emphasis supplied). As discussed above, Gutowski is silent as to the claimed elements requiring a mobile device in active communications with a receiver. Incorporating the discussion in Section I above, Gutowski confirms Applicant's position that each and every embodiment described in the reference requires drive testing – something contrary to that claimed in independent Claims 23, 33 and 41. For at least this reason, the rejection of independent Claims 22, 33 and 41 and their respective dependent claims should be reconsidered and withdrawn.

CONCLUSION

Applicant submits the subject application is in condition for allowance and as such respectfully requests allowance of the application.

If the Examiner has any questions relating to this response or the application in general he is respectfully requested to contact the undersigned so that prosecution may be expedited.

The Commissioner is hereby authorized to charge payment of any additional fees associated with this communication or credit any overpayment to Deposit Account No. 04-1679. A duplicate of this sheet is enclosed.

Respectfully submitted,

/Mark C. Comtois/
Mark C. Comtois Reg. No. 46,285

DUANE MORRIS LLP
505 9th Street, N.W., Suite 1000
Washington, D.C. 20004
Telephone: (202) 776-7800
Telecopier: (202) 776-7801

Date: March 22, 2011

Electronic Acknowledgement Receipt

EFS ID:	9708378
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and Apparatus for Determining Path Loss by Active Signal Detection
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	79172
Filer:	Mark Charles Comtois/laureen ponder
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND01 061 US
Receipt Date:	22-MAR-2011
Filing Date:	15-DEC-2008
Time Stamp:	11:57:55
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment/Req. Reconsideration-After Non-Final Reject	AND01061USMarchAmdt.pdf	1100349 6d9f44cfba8c6cf89f0f7efc2c68c0ed3788d8cf	no	8

Warnings:	
Information:	

Total Files Size (in bytes):	1100349

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
11/920,076	12/15/2008	

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY ☐ FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	03/22/2011	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 51	Minus	** 51	= 0	X $ =		OR	X $52=	0
	Independent (37 CFR 1.16(h))	* 5	Minus	***5	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	11920076
Filing Date	2008-12-15
First Named Inventor	ARPEE et al.
Art Unit	2477
Examiner Name	Ashley Shivers
Attorney Docket Number	AND01 061 US

U.S.PATENTS

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	1	20040203897	A1	2004-10-14	Rogers	

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	1	1146760	EP	A2	2001-10-17	ScoreBoard Inc.		☐
	2	94/02995	WO	A1	1994-02-03	Hutchison Telephone Company Limited		☐

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	Application Number	11920076
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	First Named Inventor	ARPEE et al.
	Art Unit	2477
	Examiner Name	Ashley Shivers
	Attorney Docket Number	AND01 061 US

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	Art Unit	2477
	Examiner Name	Ashley Shivers
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Name/Print	Mark C. Comtois	Registration Number	46,285

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(54) Apparatus and method for adaptive channel allocation in a cellular telephone system

(57) A process which utilizes actual received signal level data gathered from closely spaced locations covering an entire cellular system to calculate interference levels at each location. The process determines those base stations which most probably communicate with a mobile unit at each particular location, compiles a list of neighbor base stations for each base station at each location throughout the system and calculates interference levels at each base station for a variety of channel assignment to each base station. The process allocates channels to various cells on an adaptive basis to minimize interference and maintain call quality. Minimizing interference requires a cost evaluation of all resulting interference from implementation of a particular channel allocation. Data which indicates the actual strengths of all signals to be transmitted by a plurality of cells each positioned at an individual physical position in a mobile communications system and to be received by a mobile unit at a plurality of points of an entire mobile communications system is collected and utilized to establish a relational data matrix. The system relating data indicating the actual strengths of all signals to the physical positions from which the signals are to be transmitted, identifying cells transmitting signals likely to serve each point of the plurality of points, and comparing planned frequencies to be used at any position serving a point with planned frequencies to be used at other positions to identify cells transmitting signals which might interfere with signals transmitted by cells serving a point and to identify least likely interference patters for channel reuse.

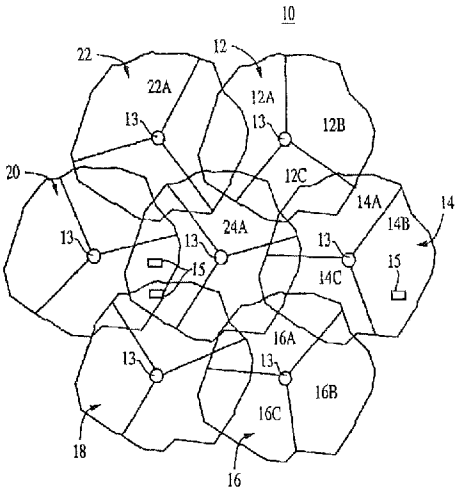


FIG. 2

EP 1 146 760 A2

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to cellular telephone systems and to modeling cellular telephone systems for the allocation of channels to the different cells within a wireless telecommunications system for optimizing utilization of the available overall radio spectrum. More particularly, the present invention relates to fixed and adaptive channel allocation in radio communication systems with an interference matrix developed and maintained for utilization by a mobile telephone switching office.

[0002] The service area of a wireless communications system is partitioned into connected service domains known as cells, where radio telephone users communicate, via radio links, with the base station serving the cell. The cells can be further partitioned into segments. The base station is coupled to the land line network.

[0003] Presently available commercial mobile communication systems typically include a plurality of fixed cells each of which transmits signals to and receives signals from mobile units within its communication area. Each base station is assigned a plurality of channels (each 30KHz wide) within a frequency spectrum over which it can communicate with mobile units. A mobile unit within range of the base station communicates with the base station using these channels. Typically, the channels used by a base station are separated from one another in some manner (typically skipping 1, 7 or 21 intermediate channels) sufficiently that signals on any channel do not interfere with signals on another channel used by that base station. To accomplish this, an operator typically allots to a base station a group of channels each of which is widely separated from the next. So long as a mobile unit is within the area in which the signal from a base station is strong enough and is communicating with only that base station, there is no interference with the communication.

[0004] In order to allow mobile units to transmit and receive telephone communications as the units travel over a wide geographic area, each cell is normally physically positioned so that its area of coverage is adjacent to and overlaps the areas of coverage of a number of other cells. When a mobile unit moves from an area covered by one base station to an area covered by another base station, communications with the mobile unit are transferred (handed off) from one base station to another in an area where the coverage from the adjoining cells overlaps. Because of this overlapping coverage, the channels allotted to the individual cells are carefully selected so that adjoining cells do not transmit or receive on the same channels. The channels used by adjoining base stations are also theoretically separated from the channels of each adjoining base station sufficiently that signals from any base station do not interfere with signals from another adjoining base station. This separation is typically accomplished by assigning a group of widely separated non-interfering channels to some central cell and then assigning other groups of widely separated non-interfering channels to the cells surrounding that central cell using a pattern which does not reuse the same channels for the cells surrounding the central cell. The pattern of channel assignments continues similarly with the other cells adjoining the first group of cells. When a cell is sufficiently removed from another cell to theoretically avoid interference, the two cells may use some of the same frequencies or channels. When two cells in the same system use the same frequencies, the pattern is often called a channel reuse pattern.

[0005] There are a number of different types of mobile communications systems. Channels are defined in different manners in each of the different systems. The design and operation of such a system is described in an article entitled Advanced Mobile Phone Service by Blecher, IEEE Transactions on Vehicular Technology, Vol. VT29, No. 2, May, 1980, pp. 238-244. Commonly known as the AMPS system, this system had allocated to it by the FCC a block of the UHF frequency spectrum (824MHz to 894MHz) further subdivided into pairs of narrow frequency bands called channels. At present there are 832 channels, each 30 kHz wide allocated to cellular mobile communications in the United States. A table of the frequencies dedicated to mobile communications in the U.S. is illustrated in Figure 1. Of the 832 available channels, there are 21 control channels dedicated each to the A-carrier and the B-carrier. These 42 control channels provide system information and cannot be used for voice traffic. The remaining 790 channels, known as voice or traffic channels, carry voice and/or data communication.

[0006] In a typical AMPS system, each channel uses a fixed FM frequency band width of 30 KHz for down-link transmission from a base station to a mobile unit and another fixed FM frequency band width of 30 KHz for up-link transmission from a mobile unit to a cell. Typically, the frequencies assigned to the down-link transmissions for an entire cellular system immediately adjoin one another and are widely separated (by 45 MHz) from the frequencies assigned to the respective up-link transmissions which also immediately adjoin one another.

[0007] Since channels are defined by frequency in an AMPS system, each base station is allotted a single a set of channels with frequencies which are each separated from one another sufficiently to eliminate interference between those channels. In some AMPS systems, especially those with cells in urban areas carrying heavy traffic, each cell may be further divided into two, three or more sectors each of which may include channels having the above-described frequency allotment of channels. Each sector may include its own transmission equipment the antennas of which provide 180, 120 or less degree coverage, respectively. Dividing cells into sectors allows closer spacing of cells and therefore al-

lows for greater density of mobile units, allowing a system with a fixed geographical area to accommodate a greater number of users.

[0008] Although the channels allotted to the individual cells are carefully selected so that adjoining cells do not transmit or receive on the same frequencies, it is very difficult to eliminate all interference in a system where channels are based on differences in frequencies. Antenna patterns, power levels, scattering, and wave diffraction differ from cell to cell. Buildings, various other structures, hills, mountains, foliage, and other physical objects cause signal strength to vary over the region covered by a cell. Consequently, the boundaries at which the signal strength of a channel falls below a level sufficient to support communications with a mobile unit vary widely within a cell and from cell to cell. For this reason, cells adjacent one another do not, in fact, typically form precise geometric boundaries. Because the boundaries of cells are imprecisely defined, signals will often interfere with one another even though they are generated by cells which are at distances theoretically sufficient to eliminate interference. This is especially true when a sectored cell pattern is used because the cells are much closer to one another than in a simple cell pattern.

[0009] In another common type of mobile system called Time Division Multiple Access (TDMA), frequencies are assigned to the entire system in groups much like those of an AMPS system. However, each frequency can be further time divided into additional channels within each frequency. Each base station sends and receives in bursts during some number of different intervals or time slots. These time intervals within frequency bands then effectively constitute the individual channels. Individual channels in a frequency increases the use capacity of a cell.

[0010] A CDMA system transmits messages digitally. All transmissions in a CDMA system are on the same frequency spectrum so the digital signals constituting each message must somehow be recognizable from all of the possible transmissions available. To accomplish this, the digital messages are encoded by a series of overlaid digital codes. One of these codes, called a pseudorandom noise (PN) code, is applied to all transmissions throughout a CDMA system. The PN code is used to encode the individual bits of the original message at the transmitter and to decode the encoded message at the receiver. In order to recognize messages from a particular base station, each base station uses a distinct time offset (Called a PN offset) from some repeating initial time to begin encoding the transmission using the PN code. Thus, one base station may begin an encoded transmission at the initial time, a second base station at an offset of one unit from the initial time, a third at an offset of two units from the initial time, and so on up to a total of 512 offsets.

[0011] Each transmission between a mobile unit and a base station is also placed on what is effectively a separate channel by further encoding the transmission with one of a plurality of Walsh codes. A message encoded using a Walsh code, as with a PN code, can only be decoded by the same Walsh code at the receiver. Thus, an encoded transmission on a particular channel is decoded by applying a mask including both the Walsh and/or PN codes to the received pattern of information bits commencing at the PN offset designated for the particular base station.

[0012] A base station normally has sixty-four Walsh codes available for defining channels on which it can establish transmissions with mobile units, certain of the channels are preassigned to function as control channels. For example, in order to advise mobile units of the particular PN offset used, each base station continuously broadcasts the PN code using its assigned PN offset on one of the channels (a pilot channel) defined by Walsh codes. Mobile units monitor this preassigned pilot channel. When a mobile unit finds an offset at which a pilot is decodable, it refers to another control channel (a synchronization channel) to determine the initial time and thereby identify the PN offset of the base station. Each system also maintains a paging channel upon which indications are posted that new messages are arriving. A total of nine channels are provided for these and other control functions.

[0013] In order to allow mobile units to transmit and receive telephone communications as the units travel over a wide geographic area, each base station is normally physically positioned so that its area of coverage is adjacent to and overlaps the areas of coverage of a number of other base stations. When a mobile unit moves from an area covered by one base station to an area covered by another base station, communication with the mobile unit is transferred (handed off) from one base station to another base station in an area where the coverage from different base stations overlaps.

[0014] In most other types of cellular communication systems, a mobile unit communicates with only one base station at a time. However, since all transmissions in a CDMA system take place on the same frequency spectrum, a mobile unit actually has available all of the information which is within its range. However, it only decodes information on PN offsets and Walsh code channels which are directed to it. A CDMA mobile unit uses a receiver which is able to apply a number of decoding masks simultaneously at different offsets of the entire spectrum of information which it receives. At present, a mobile receiver may decode as many as six PN offsets at once. However, usually only three PN offsets are used to decode messages while the others decode control information. Because a mobile unit in a CDMA system may be receiving the same information from a number of different base stations at the same instant, it may decode information from a single message sent to it from a number of different base stations simultaneously using different PN offsets and Walsh codes and combine that information to produce a single output

message. Thus, while a signal transmitted from one base station may be fading, the same message may be being received with adequate strength from another base station. This allows a CDMA system to offer the possibility of significantly better transmission. The situation in which a mobile is communicating with a number of base stations at once is called "soft handoff".

[0015] In order for a system operator to allocate resources to a cellular telephone system intelligently, the operator typically models the system. In order to utilize the advantages offered by CDMA technology, an operator should be able to model the system accurately. However, because a CDMA system can involve a plurality of base stations each communicating with the same mobile unit simultaneously, much more data must be dealt with and more resources have been required than are available to accurately model such a system. This has led to the use of probability techniques which utilize only a small number of locations throughout the system and extrapolate between those locations. This has produced less than accurate results leading to incorrect allocation of assets.

[0016] Efficient use of the available radio frequency spectrum when channels are defined by frequency offset can be increased through the reuse of the same radio frequencies in designated co-user cells that are sufficiently separated by distance so that the combined interference generated by all co-user cells is below tolerable levels. The assignment of radio frequencies to cells has been based on regularity assumptions (i.e., equal-sized regularly-spaced cells with uniformly distributed traffic loads), which enable the adoption of simple rules for identifying co-user cells, and for partitioning the RF spectrum into channel sets. When the regularity assumptions do not hold—as is frequently the case in real world situations—the rules of regular channel assignment do not lead necessarily to the efficient utilization of the RF spectrum, if they can be applied at all. Accordingly, a channel assignment approach, known as non-regular channel assignment, has evolved for optimal utilization of the RF spectrum, which requires a solution of the non-regular channel assignment problem. Both regular and non-regular channel assignment approaches belong to class known as fixed channel assignment, which is characterized by a fixed relationship between cells and the channels serving them. Only the channels allocated to a cell can serve calls in that cell, and each channel can be used simultaneously by all the cells to which the channel is assigned.

[0017] In theory, these forms of cell arrangement and channel assignments allows channel reuse patterns to be repeated at distances separated sufficiently to negate interference between mobile units on the same and adjacent channels. They also allow signals used by the different cells in a particular system to be strong enough to provide complete coverage of the system area. However, interference and insufficient coverage do occur.

[0018] Antenna patterns, power levels, scattering, and wave diffraction differ from cell to cell. Buildings, various other structures, hills, mountains, foliage, and other physical objects cause signal strength to vary over the region covered by a cell. Consequently, the boundaries at which the signal strength of a channel falls below a level sufficient to support communications with a mobile unit vary widely from cell to cell. For this reason, cells adjacent one another do not, in fact, typically form the precise geometric boundaries suggested above. Since cell boundaries must overlap to provide complete coverage of an area and the boundaries of cells are imprecisely defined, overlapping coverage often occurs between channels which might interfere with one another.

[0019] Another reason that interference and insufficient coverage can occur in the various mobile systems is that the various factors in the system may change over time. Various components of the system may deteriorate or fail in some way so that cells operate at less than optimum. Also, physical characteristics of the topography of the cell system may change. Building come and go and vegetation changes. This may reduce the signal strength provided by certain cells thereby changing the patterns from those originally planned for the system. Such pattern changes reduce coverage in some areas and may cause undesired overlap of signals from remote cells. Component failures may be rapid or slow. Antennas are often physically damaged or misaligned. This can cause a lower level response or actually shift the antenna pattern. Connections loosen or otherwise become less than optimum so that lower levels of current are transferred. Any number of other causes may affect the level at which a cell transmits, the direction of that transmission, or other characteristics of the transmission. When a cell is transmitting or receiving at less than optimum, the tolerances expected in the system may no longer exist thereby causing spurious signals to reach the same level as desired signals.

[0020] The transferring of a communication with a mobile unit from one cell to another is accomplished by a process referred to as a "hand-off." Each cell site has a scanning receiver which measures signal levels sent from a mobile unit. When the received signal strength falls below a threshold level, a cell connected to a mobile unit sends a message to a switching center which controls the area covered by the cell. The switching center includes software which maintains data tables which list the switching thresholds, channels assigned to cells, and the positions of the cells in the system. The switching center sends a message to the neighboring cells which overlap the cell connected to the mobile unit asking the neighboring cells to use their scanning receivers to measure the signal level being sent by the mobile unit on the particular channel. The neighboring cells each measure the signal level and also measure some identification signal (e.g., a supervisory audio tone which is sent in an AMPS system on the channel at a frequency above the level of the audio of the mobile channel) to

identify the signal from a particular mobile unit. All of the cells report back the signal levels received to the switching center. The switching center software determines whether any neighboring cell is receiving a stronger signal from the mobile unit than the cell presently carrying the mobile transmission. If a cell is receiving a significantly stronger signal (set at a value determined by the switching software), the switching software signals the serving cell to notify the mobile unit to switch to a new channel. The switching software sends another message to the neighboring cell receiving the stronger signal telling it to commit a new channel to the mobile. The first connection is disabled, and the mobile unit tunes to the new channel.

[0021] To carry out this hand-off process, the signal levels provided at the boundaries of adjacent cells must each be strong enough to support transmission; or the transmission with a mobile unit will be interrupted. Since the pattern around each cell defined by the signal strength just insufficient to support transmission with that cell is not a neat geometric shape, overlapping occurs in widely varying patterns. The odd shaped boundaries of the individual cells and the necessity that the cells overlap means that signals on the same channel will often interfere with one another even though they are generated by cells which are at distances theoretically sufficient to eliminate interference. This is especially true when a sectored cell pattern is used because the cells are much closer to one another than in a simple cell pattern.

[0022] Interference can take the form of co-channel interference, when a first signal on a channel from a remote cell interferes with a second stronger signal carrying a mobile transmission on the same channel within the coverage area of a cell. Interference is defined when the drop in signal strength between the signals is less than some threshold level (typically measured in decibels). Moreover, signals on adjacent channels are carried by abutting cells in accordance with the above-described frequency reuse pattern. These signals can cause adjacent channel interference. Although each signal is restricted to a 30KHz band width, some spillover outside the assigned band width is experienced. Typically, frequency filtering is insufficient to eliminate adjacent frequencies entirely; consequently, there may be adjacent channel interference. A signal from another cell on a channel at a frequency adjacent the frequency of a channel carrying a mobile transmission interferes when the strength of the adjacent channel signal is greater than a second threshold level compared to the second signal. When the drop in strength of the interfering signal from the serving signal is less than some second usually higher threshold level; normally an adjacent channel may be closer in strength to a serving channel because frequency filtering eliminates some substantial portion of the adjacent frequency signal.

[0023] In order to overcome interference when designing or improving the coverage of a mobile cellular system, it has been typical for a cellular system operator to use predictive software to determine what signal strength is to be expected from each of a particular set of cells. This software utilizes data describing the physical characteristics of the terrain surrounding each cellular site and the physical characteristics of the cellular station to plot expected signal strengths around a cellular site. These signal strength predictions are then overlaid on a graphical plot to determine where antennas should be placed to provide optimum coverage with appropriate overlapping areas for hand-offs. Deciding upon optimum coverage may require that the operator move the points at which individual cells are positioned and use the predictive software to replot expected signal strengths around a cellular site to eliminate expected interference. Once the antenna sites have been determined, the operator assigns channel groups to the cells in accordance with the technique described above.

[0024] It is possible that expected interference cannot be eliminated by overlaying signal strength predictive plots; and the operator may place test antennas in position using the results of these predictive mappings and testing to determine if actual interference exists. Alternatively, the predictive plots may predict that no interference is likely to occur, and the operator may place the antennas to be used in the system. The operator may later find that interference, in fact, occurs at some positions and test to determine how to eliminate the interference. The determination of whether interference actually exists and where it exists is made by drive tests which measure signal strength of channels at the positions either where a graphical plot shows that interference might occur within the cellular system area or where interference has been reported. Since the predictive software provides only an educated guess at the actual signal strengths produced by the channels at a cell, the points at which interference is predicted are often inaccurately placed. In fact, the predictive software provides an estimation of signal strength with a typical error having a standard deviation of 8 dB. This error is very large compared to the required design tolerances which may range from 3 dB to 17 dB.

[0025] During the drive tests to determine actual interference, a single channel at each cell or sector of a cell involved in the interference testing is enabled. A mobile unit with a scanning receiver drives over the roads and highways of the system. The scanning receiver scans and measures the strength of the frequency transmitted by each cell at the points of possible interference as the mobile unit moves. This provides strength measurements of signals generated by each cell at each test point. These strength signals are then plotted on the graphical plot against the cells from which they are believed to emanate. Thus, the expected interference points on channels from different cells which actually interfere with one another may be viewed graphically to determine whether sufficient interference exists to change the channel group assigned to the particular

area. As may be seen, this requires a substantial amount of time and limits the interference determination to those points at which a system operator expects to find interference, an expectation the accuracy of which is very suspect.

[0026] If the number of points of interference for a cell are sufficiently great, the patterns of channels are changed. That is, the frequency group assigned to a cell (or cells) is typically changed in its entirety to another frequency group in which channels which would interfere with channels carried by other cells do not occur. Sometimes, interference may be eliminated by changing the cell characteristics (such as antenna tilt or power used in particular cells) without changing the channels used. Once channels have been assigned to cells which provide acceptable coverage and expected interference has been eliminated, the system is fixed and operated.

[0027] This method of placing cells, assigning frequencies, and eliminating interference is quite slow and labor intensive. Moreover, it does not provide a complete understanding of interference which actually exists in a system since typically only those positions at which prediction software leads the operator to believe that interference may exist are tested to determine whether interference actually exists. In addition, whenever the physical pattern of individual cells in a system changes, the computation of predicted cell coverage, graphical plotting of predicted cell coverage, drive testing to check actual interference, actual interference plotting, and assessment of actual interference takes place over again. This is a very labor intensive process which greatly increases the costs of creating and maintaining mobile systems without guaranteeing that interference will be eliminated. Because of the emerging nature of the market for cellular telephones, those system changes are taking place constantly and at an accelerating rate.

[0028] Partially in response to the limitations of fixed channel assignment and also in order to increase capacity, a new classification has been developed known as flexible or adaptive channel assignment. Such adaptive channel assignment methods, exploit the capability of a system for remote, software-driven, retuning of the base station radios, which capability enables channel capacity to adapt to traffic variation.

[0029] Fixed channel assignment, as noted, includes both regular channel assignment, which is optimal for a system with traffic distributed uniformly across cells, and non-regular channel assignment, which will be applied when the traffic distribution is not uniform. An optimal non-regular channel allocation methodology allocates channels to cells according to their traffic load. Such an optimal non-regular channel assignment will outperform regular channel assignment.

[0030] Adaptive channel allocation, or ACA, is a method of dynamically allocating frequencies throughout a cellular system to increase system capacity and adaptability. Under an ACA scheme, more frequencies would be reallocated to busy cells from more lightly loaded cells as usage and demands varied. In addition, the channels can be reallocated such that all links have satisfactory quality. A common feature of ACA systems is that they allocate a channel out of a set of channels which fulfills some predetermined quality criteria. However, different ACA schemes select channels from the set based upon different criteria.

[0031] Although adaptive channel assignment methods exploit the capability of a system for remote, software-driven, retuning of the base station radios, which capability enables channel capacity to adapt to traffic variation. A concern here is with short-term variations. One example of such short-term variation is the variation due to the random nature of calls, which causes the number of calls in different cells to be different even though their average over time remains constant. Another variation of interest is due to a trend change; that is, a change in the average number of calls per cell. Such a change may occur either expectedly (sometimes repeating regularly, as during the daily rush hour) or unexpectedly.

[0032] The concept of ACA is well-known to those skilled in the art, and its potential has been described in various publications. For example, *"Capacity Improvement by Adaptive Channel Allocation"*, by Hakan Eriksson, IBEE Global Telecomm. Conf., Nov. 28-Dec. 1, 1988, pp. 1355-1359, illustrates the capacity gains associated with a cellular radio system where all of the channels are a common resource shared by all base stations. In the above-referenced report, the mobile measures the signal quality of the down-link, and channels are assigned on the basis of selecting the channel with the highest signal to interference ratio (C/I level).

[0033] Another approach is described by G. Riva, *"Performance Analysis of an Improved Dynamic Channel Allocation Scheme for Cellular Mobile Radio Systems"*, 42nd IEEE Veh. Tech. Conf., Denver, 1992, pp. 794-797 where the channel is selected based on achieving a quality close to or slightly better than a required C/I threshold. Furuya Y. et al., *"Channel Segregation, A Distributed Adaptive Channel Allocation Scheme for Mobile Communications Systems"*, Second Nordic Seminar on Digital Land Mobile Radio Communication, Stockholm, Oct. 14-16, 1986, pp. 311-315 describe an ACA system wherein the recent history of link quality is considered as a factor in allocation decisions. In addition several hybrid systems have been presented where ACA is applied to a small block of frequencies on top of an FCA scheme. Such an example is presented in Sailberg, K., et al., *"Hybrid Channel Assignment and Reuse Partitioning in a Cellular Mobile Telephone System"*, Proc. IEEE VTC '87, 1987, pp. 405-411.

[0034] This feature of ACA is particularly attractive when system changes are implemented, when new base stations are added, or when the environment changes, for example by the construction or demolition of large buildings.

[0035] It is desirable to provide a process by which

interference between cellular telephone system channels operating at the same frequency and/or adjacent frequencies may be accurately predicted over each entire cell of an entire system based upon dynamic information corresponding to in-use performance and for adaptively reallocating channels based upon the in-use interference performance to maximize capacity while minimizing overall interference within the system.

SUMMARY OF THE INVENTION

[0036] Improved performance of a cellular system is achieved by the present invention which allocates channel assignments in an adaptive channel allocation system based upon a data set of information assembled from actual and predicted interference scores. The present invention utilizes actual received signal level data gathered from closely spaced locations covering an entire cellular system to calculate interference levels at each location. The present invention can utilize a data gathering system and method such as that described in co-pending patent application 08/648,998, incorporated herein by reference. This patent application describes apparatus and methods for effective signal data collection for establishing a data set for implementation of interference evaluation and for execution of the present invention. Minimal gaps in gathered data can be filled by predictive algorithms with increased accuracy based upon a near complete data set. The assembled data set allows the adaptive assignment of channels to cell cites or cell cite sectors. The base station with the highest probability of communication with a mobile unit at each particular location is determined based upon the data set. A list of neighbor base stations for each base station at each location throughout the system is compiled and a determination of the transmit power necessary for each base station to communicate with a mobile unit at each location is made. The interference levels at each base station are calculated and a determination of the transmit power necessary for a mobile unit at each location to communicate with each base station which most probably communicates with a mobile unit at that particular location is made.

[0037] Because the cellular system embodies adaptive channel allocation, no permanent assignment of channels need be made to any individual cell or cell sector. Channels are assigned and reassigned on the basis of minimal overall system interference. In the event that changes in usage or coverage requires a reassignment of channels within the cellular system, the algorithm of the present invention is utilized to determine the interference effect on the system of reassignment of channels or groups of channels. The interference scores for each pair of co-channel and adjacent channel assignments in both the up-link and down-link direction are summed to determine a total interference score for each potential reassignment. In order to be evaluated as a potential reassignment, a reassignment would first need to meet a minimum interference score. A reassignment exceeding the minimum interference score may create an overall degradation in call quality unacceptable even as a trade off for increased capacity. All assignments meeting the minimum score criteria are compared and the reassignment with the minimum total interference score for the system is implemented.

[0038] The evaluation criteria of the present invention can also include a disruption factor. Reassignment of a channel from a first yielding cell to a second receiving cell can require retuning a call on the transferred channel at the first cell. The evaluation criteria may determine that the best channel to be transferred from the yielding cell to the receiving cell may be a channel which is already carrying a call at the yielding cell. Although one embodiment of the present invention will transfer that channel on the basis of minimal interference criteria, regardless of the potential momentary disruption of retuning the call to a different channel at the yielding cell, a second embodiment of the present invention will weigh the cost of retuning against the cost difference between the least interference channel reassignment and the next least cost channel reassignment.

[0039] In order to minimize future reassignments, the present invention considers factors relevant to the likely future interference of a current reassignment and considers the likely future reassignment because of a current assignment. A current reassignment from a low traffic cell to a high traffic cell may result in denial of service at the yielding cell in the near term. Alternatives to reassignment, such a power reduction to minimize interference are weighted in the decision of the present invention in assessing channel reassignments. The cost of degrading call quality based on signal reduction is weighed against the cost and near future cost of channel reassignment.

[0040] Because a cellular system collects data on operational parameters such as effective radiated power to adjust the transmit power of mobile units, the information collected may be utilized to augment the data set from which the interference matrix is developed. Information from ERP changes or handoff information can be utilized to update interference criteria. This data is collected over the control channels and indicative of in use conditions within the system. The data is input into the data set and later utilized to alter the interference matrix.

[0041] The present invention also allows for consideration of physical changes to the system without the immediate need for additional collection of actual field data. The interference matrix use for channel allocation evaluation is updated by applying decreased statistical significance to data collected prior to any physical reconfiguration. As described above, physical changes can include antenna repositioning, construction of large buildings, significant changes in surrounding vegetation, alterations in operating power levels and the like. Physical changes can have varying effects on signal

propagation and on differing portions of the signal field of an antenna dependant on signal overlap and edge areas.

[0042] In another embodiment of the present invention, call assignment as well as channel assignment is subject to relative cost evaluation prior to assigning a call to a particular channel. When a call is being assigned to a cell, either as at initiation of a call or as a handoff, the interference effect of the up-link transmission from the mobile unit is factored as a weight in assignment of a channel to the call. The effect of low power assignment on both the call and the interference matrix is also evaluated to determine if the call is best established on a first channel at low power or on a second channel at a higher power.

[0043] The acquisition of additional data on the live operating parameters are incorporated into data set updates. Improved data allows for simulations and analysis of the interference matrix under various predictive load conditions. Simulations results can be used to assemble look up tables for real time implementation and utilization by the mobile telephone switching office to accommodate actual operating conditions as they arise.

[0044] These and other features of the invention will be better understood by reference to the detailed description which follows taken together with the drawings in which like elements are referred to by like designations throughout the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045]

Figure 1 is an illustration of the allocated cellular frequency spectrum.

Figure 2 is a diagram of a portion of a cellular telephone system.

Figure 3 is a graphical view of signal strength data obtained in drive tests for evaluating the arrangement of cells and channels within cells in a system such as that of Figure 2.

Figure 4 is a flow chart illustrating a process in accordance with the present invention for predicting interference in a system such as that illustrated in Figure 2.

Figure 5 is an illustration of the manner of practicing a second embodiment of the invention.

Figure 6 is a probability curve used to evaluate the likelihood of a base station providing a received signal having a particular ratio of signal-to-interference level serving a particular location.

Figure 7 is a diagram illustrating probabilities for receipt of signals from each possible group of base stations at a location within a cellular telephone system.

Figure 8 illustrates an exemplary process in accordance with the present invention for initial establishment of the interference matrix.

Figure 9 illustrates an exemplary process for implementing channel reassignment in accordance with the present invention.

Figure 10 is a first logical diagram illustrating exemplary evaluation criteria for selection of the lowest interference score channel reassignment.

Figure 11 is a second logical diagram illustrating additional evaluation criteria for selection of the lowest interference score channel reassignment.

Figure 12 is a third logical diagram illustrating additional evaluation criteria for selection of the lowest interference score channel reassignment.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0046] Figure 2 illustrates a portion of an exemplary cellular system including a plurality of cell sites with base stations each divided into three segments by use of directional antennae. The sites could be divided into any number of segments including a single segment per cell, three segments are illustrated only for the sake of example. A first cell site 12 has a base station 13 with three antennae sectors which divide cell 12 into segments 12A, 12B and 12C. Adjacent to cell 12 is cell 14, also divided into three segments of 120° each. Similarly, cells 16, 18, 20, 22 and 24 are divided into segments A, B and C. The cells, 12 through 24 overlap to provide effective coverage in the region of the cellular system illustrated in Figure 2.

[0047] As detailed in copending applications, a statistically significant number of measurements are taken throughout the cellular system as illustrated in Figure 3 to determine the relative signal strength between each base station and each mobile unit location. The probability of interference between cell segments is determined and an interference matrix is established by a process as illustrated in Figure 4. The process of the present invention is then utilized to assign frequencies to each segment of each cell in the system.

[0048] For example, the interference matrix would indicate a high probability of interference between segments 24B and 16A. Therefore, common channels would not be assigned to segments 24B and 16A. Alternatively, segments 16B and 22A would likely have a low interference quotient on the interference matrix and therefore the process could assign common channels to the segments. Once assigned, the distribution of frequencies and channels is assimilated into the data set and used to update the interference matrix for implementation of channel reassignments.

[0049] The initial distribution of channels is accomplished, after determining which base stations may be serving a location. A probabilistic test is applied in accordance with the present invention in the manner illustrated in Figure 8. Utilizing a probability curve such as that illustrated in Figure 6 (derived from data for the system) which evaluates the likelihood of a base station

providing a received signal at a particular location having a particular ratio of signal-to-interference level (Ec/Io), the probability of each individual base station serving the location may be determined. For any location, the Ec/Io ratio may be determined as detailed in the copending applications for the appropriate system (AMPS /TDMA / CDMA) Where more than one base station may serve a mobile location, the probability for each of the base stations individually is determined. Then, the probability for each possible group of those base stations from which discernible signals have been received may be obtained by multiplying the probabilities for each individual base station being received in the group by the probabilities of all others in the group and by the probabilities that all base stations not in the group will not be received.

[0050] The determination of cellular signal strength and overlap at actual physical locations is made by drive tests which measure signal strength of channels at the positions where the graphical plot generated by the predictive software shows that interference might occur within the cellular system area. Since the predictive software used presumes general characteristics derived from similar terrain and cells to determine cell coverage, overlap such as the overlap of cells into the boundaries of non-adjacent cells is often not predicted. Consequently, signal strength measurements of test frequencies generated by each cell are taken only at the test points where interference is expected and may entirely miss interference which actually occurs. These signal strength measurements are then plotted on the graphical plot against the cells from which they emanate. As may be seen, this process requires a substantial amount of time and limits the interference determination to those points at which a system operator expects to find interference.

[0051] If the points of interference are sufficiently great, the groups of channels assigned to the cells are changed. This is accomplished by determining at any point whether interference greater than an acceptable level exists. If interference exists, it may be tested again by more drive tests. However, if interference is ultimately found to exist in an area which is expected to carry significant traffic, the groups of channels assigned to the cells are changed. The frequency group assigned to a cell (or cells) is typically changed in its entirety to another frequency group in which charmels which would interfere with channels carried by the other cells do not occur. Sometimes, interference may be eliminated by changing the cell characteristics (such as antenna tilt or power used in particular cells) without changing the groups of channels used. Once channels which provide acceptable coverage have been assigned to cells and expected interference has been eliminated, the system is fixed and operated.

[0052] This operation is slow, labor intensive, and does not provide a complete understanding of interference which may actually exist. Moreover, whenever the physical pattern of individual cells in a system changes, the generation of predictive patterns of probable cell coverage, the graphical plotting of expected cell strength patterns, the drive testing to determine whether expected interference actually exists, the plotting of actual interference determined by the drive tests, and the assessment of interference takes place over again. This is a very labor intensive process which greatly increases the costs of creating and maintaining mobile systems without guaranteeing that interference will be eliminated.

[0053] The present invention overcomes the problems of the prior art by providing a process by which measured signal level data for an entire system is utilized to provide predictive plots which may be utilized to establish cell site positions and channel assignments. The process allows plots and channel assignments to be easily changed at minimal cost whenever a system undergoes changes or is updated, including during channel reassignment during use.

[0054] In one embodiment, the process begins with a drive test of the entire system area. In the drive test for this embodiment, a single channel at each projected cell site or sector of a cell is transmitted; and a different channel is transmitted by any other cell in the test area. If an entirely new system is being designed, expected cell sites may be selected in any of a number of different ways such as by use of prior art predictive plotting software; and then test transceivers may be placed at the proposed cell site positions. If a cellular system already exists, then the cell sites which exist may be used along with any proposed new test sites. A mobile unit with a scanning receiver drives over all of the roads and highways of the area to be changed in the system. The roads include those which make up all of the most likely reception points of the entire communication system. Thus, it would not be necessary to drive four wheel vehicle trails unless it was expected to serve mobile units on those trails. The scanning receiver constantly scans and measures the strength (usually received signal power) of each channel transmitted from each of the cell sites as the mobile unit moves. The mobile unit also includes equipment (such as Loran or Global Positioning System (GPS) equipment) which constantly records the position of the mobile unit as each set of strength measurements is taken. This provides strength measurements of frequencies generated by transmitters at all of the cell sites proposed to be included in the system which can be received at any point in the service area over which the mobile unit drives. By transmitting from each cell on a single channel, interference which might complicate the readings is eliminated; that is, none of the transmitted signals should interfere with any other transmitted signal so that the cell from which any channel is transmitted is positively known. These signal strength measurements are recorded in a database with the position at which they were recorded by equipment in the mobile unit as the test continues.

[0055] The data in the database is then compared with data which indicates the characteristics of the cells (especially the channel being transmitted by each cell) during the test. This generates a database which indicates the cell or sector from which each signal received by the mobile unit was sent. The database may be used to generate a graphical plot of the actual signal strengths of each of the cells (or sectors) in the cellular system. The signal strength pattern if plotted from points taken over the entire area could be made to produce a plot such as that illustrated in Figure 3. In any case, the cellular strength graphical plot will illustrate actual, rather than projected, signal strengths.

[0056] It should be noted that if the signal strength data for an area is compiled from more than a single drive test, the data from all of the drive tests must be combined and the individual tests weighted to account for changes in the system and to provide grater weight to more recent tests so that the data of each drive test matches that of other drive tests. Thus, for example, if higher transmission power was used in one drive test than in another, then the strength values would need to be scaled (typically linearly) to provide data having the same significance. The data collected from one drive test may also be "combined" with previously collected data from other drive tests if the new data represents only a portion of cells in the network. This step is useful when economics or operational issues preclude collecting data for the entire network or proposed network all at once. Combining is also useful when adding new cells to a network so that the effect of new cells may be determined without having to re-collect data for the entire network.

[0057] Because the measuring process is not strictly controlled, data collected in different drive tests will be at slightly different locations even though the same routes are driven. The combination process uses a variety of methods to relate data samples that are near each other from differing drive tests and create a composite data sample. In one embodiment, each data sample is combined with other data samples within one hundred feet of each other. Redundant channel measurements are averaged together. In another embodiment a propagation model is used to interpolate missing channel measurements from channel measurements near the current location. At this point, the process compares the data for each channel received at each point in the entire area with the data for all other channels received at the point to determine at any point which cells should serve the point. These cells are called 'likely servers.' A number of criteria may be used.

[0058] A cell is a likely server at a particular location if there is a non-trivial probability that a cell will provide the transmission path to or 'serve" a mobile unit at that location. The methods used to determine likely servers can be simple or very complex. Given below are three likely server methods. More are possible.

[0059] The simplest likely server method identifies as likely servers all cells that serve a location with a signal strength within 3 dB of the strongest signal strength for that location. A more advanced likely server method accounts for signal path imbalances which have been discovered caused by network hardware and software settings to determine likely servers for each location. Such a method may balance the up-link and down-link strengths where they vary, may bias certain strength determinations in favor of particular cells, or provide other adjustments to match the particular area of the system. A third likely server method provides specific tests for each different type of network hardware and accounts for network configuration and control information (e.g. how mobile unit hand-off is performed) as well as signal path imbalances to determine likely servers for each location.

[0060] For example, using the first of these methods, the strongest frequency is chosen from a group of all channels within 3 dB of the strongest channel at each point. In general, all channels transmitting at any cell provide, on an average, signals of the same strength at any given point so long as the test frequencies of the channels are within approximately ten percent of the frequencies to be used. Thus, the strongest frequency at a point typically designates the cell to serve that point; while frequencies transmitted by adjoining cells received at the point within the 3 dB range typically define a hand-off (overlap) area. Other more sophisticated methods of selecting a cell to serve a point may be used to force traffic onto a certain cell, for instance.

[0061] The relationships of the signal strengths of the likely servers at each test position in the cellular system from all of the cells are then associated with the channels proposed for each cell to determine if the proposed channel selection causes either co-channel or adjacent frequency interference. The cells serving the points of an area are known, and the proposed channel selection data for each of the cells or sectors may be associated with those cells. Since the points at which any particular channel transmitted from one cell will have a certain strength and may interfere with signals from another cell may be determined from the signal strength data which has been collected, such a determination may be made for each proposed channel for any drive test. The determination is usually made by subtracting the signal strength in dB of each signal received at each point on a channel which might interfere with a channel carried by the cell serving the point from the signal strength of the signal serving the point in dB. The desired cell serving at each point has already been determined from the test to determine cells serving a point. For co-channel interference in the AMPS system, if the difference is less than 17 dB, interference exists. For adjacent channel interference in the AMPS system, if the difference is less than from 3 to 6 dB (depending on the criteria used), interference exists. If there is interference at any point in the system, the pattern of channel assignments and other cell configuration information (such as effective ra-

diated power (ERP)) may be changed; and the actual signal strength database may be run against the new cell channel assignments. This requires no new testing or other operations by the operator, simply running the software until channel selections which exclude interference are determined.

[0062] A plot like that illustrated in Figure 3 showing this possible interference information may be prepared which illustrates the points at which interference would occur were the proposed channels to be utilized in the system.

[0063] Not only may the inventive process be used to update or plan a new system, the process also allows signal strength measurements derived from drive tests conducted using a particular type of cellular system such as an American Mobile Phone System to be used for determining coverage and interference patterns for cell sites which utilize entirely different types of systems. This has the advantage of allowing drive test results accumulated from an older system be used to predict interference which may occur in newer types of systems which might be installed at the same sites. The same signal strength test results may be utilized as a system is changed in any manner. The new channel assignments may be tested by the software against the signal strength measurement database to derive new predictions of interference. If additional cells or sectors are to be added, this may be accomplished by drive tests for signals from the new cells only. These may be added to the signal strength measurement database and the updated database used to determine new channels to be used. The cost of placing cells and assigning channel groups is reduced drastically by use of the process of the present invention.

[0064] Figure 4 is a flow chart illustrating in detail the operation of one embodiment of a process in accordance with the present invention. As may be seen, data representing the actual signal strengths of frequencies received at each position on the streets, highways, and roads of a cellular system area at which a drive is reasonably able to be conducted is furnished as input to the program. This drive test data typically includes the signal strength of all frequencies measured at each position of the drive tests. Each data point may also include a time of test indication, the channels received, the geographic coordinates of the test point, and a list of the signal level measurements taken. In a particular case, the list may include the level of all channels received at the point or a list of the level of all channels received at the point which are over a particular level.

[0065] The drive test information is compared with a database indicating the channels which were functioning at each cell during the drive test. This database may also include power levels, antenna direction, and other significant data regarding the test configuration which may be compared later in the program to determine whether changes in these factors may be changed so that signals received on frequencies planned to be used will not actually interfere. This provides a signal level matched to cell or sector output database. The signal level matched to cell or sector output database is transferred to a process which identifies the likely servers for each signal position. This process may be of any of a number of different types. For example, it may determine for any geographic position which cell provides the strongest signal and use that as the likely cell to serve the position. It may then also include all other cells which provide signals having a strength within 3 dB of the strongest signal. On the other hand, the process may manipulate the signals received to utilize a particular cell in a particular area whenever possible in order to direct traffic to a particular cell or sector.

[0066] The signal level matched to cell or sector output database is also transferred to a process which reviews the frequencies at each point and introduces the planned frequency assignment data for cells servicing the point to determine frequencies which might interfere. Those frequencies which might interfere are then transferred to a process which compares the signal levels of channels serving a point to signals levels of interfering signals. This latter process may utilize input data defining configuration data for each of the cells including planned power levels and antenna tilt. The result of the process is an interference level calculation for frequencies which serve any point of the cellular system.

[0067] The results of this process are transferred to a process which utilizes the interference threshold algorithms to determine whether any interference is significant. The result is a database which may be graphically plotted to show the cellular system with all significant interference. Any significant interference points may then be eliminated by providing new channel selections for the cells to replace the previously planned frequency assignments and running the program again. Various characteristics of the cells may also be changed to determine the effect on interference. This process may continue until significant interference is eliminated.

[0068] A second embodiment of the invention provides substantial economies over the first embodiment in situations in which a new system is being designed. In this second embodiment, when a system is being planned, general areas in each of which a site might be positioned are first determined in some manner. For example, this may be done by using prior art predictive software as in the previous embodiment. A problem encountered in designing new systems is in selecting one particular position for a site from a number of possibilities in the same general area where a number of different positions may appear feasible. In order to determine which position is better suited before acquiring the site, the method of the first embodiment of this invention would conduct drive tests with transmitters placed at each of the possible sites. Such a drive test for each of the individual sites might take as long as one day if a number of individual positions are possible at each site. Thus, for an entire area, drive tests might take many

days.

[0069] In the second embodiment which is generally illustrated in Figure 5, the drive tests are conducted by placing a single transmitter in a mobile unit and using fixed receivers (rather than expensive scanning receivers) at all of the proposed positions at each of the sites over an extensive area for which new cells are proposed. The mobile unit drives over the roads encompassed by the new cells transmitting on a single frequency while all of the receivers attempt to detect the transmission. The power level transmitted by the mobile antenna is measured at the mobile unit once or more times sufficient to assure that it is known accurately. A GPS or other positioning system is linked to the mobile unit to provide position indications at each point of measurement. The transmitter sends a signal at the selected frequency, and all of the receivers measure its strength. The position indications of the mobile unit may be transmitted by the mobile unit with each of the test transmissions and received by the receivers at the proposed sites. Alternatively, the positions may be recorded in a database by the mobile unit with the times of the transmissions; and the times of reception may be recorded by each receiver with the signal strength received (e.g., using computers connected to record the signal strengths received at each proposed site). The signal strength received at a cell site from the mobile transmitter in an up-link transmission is on an average the same as the signal strength which would be received at a mobile unit from a cell site in a down-link transmission. If the down-link transmission is at a different effective radiated power than the up-link transmission used for collecting data, the collected data is adjusted by simply multiplying one or the other to compensate. Consequently, the data gathered by the drive test in this second embodiment may be directly substituted for the data gathered in the drive tests for the previous embodiment. However, the drive tests of the second embodiment provide significant economic advantages over those used in the first embodiment. First, scanning receivers need not be used since only a single frequency is used for all transmissions to the sites. Each receiver requires computer equipment for recording the data. Only a single test transmitter is necessary instead of transmitters at each of the sites.

[0070] More importantly, an entire area could be covered in a single drive test since the number of frequencies available does not limit how many stations may be tested at once. The only limit to the testing is the distance of stations from the mobile unit. Thus, labor costs are substantially reduced. Consequently, a single drive over the entire area is all that is necessary to both select a site and to gather all of the data necessary to accurately determine interference between all of the stations of the area being planned. If enough test equipment is used, by using more than one mobile unit and different frequencies for the different mobile units and for the sites which each mobile unit tests, an entire system may be tested in a single day compared to the weeks of testing required by prior art methods.

[0071] The data, once gathered using this second embodiment, is utilized in a manner essentially identical to the method of the first embodiment. The method illustrated in Figure 4 may be utilized in the same manner. As has been illustrated, the invention offers a number of substantial advantages over the prior art. This process allows the complete testing of a system frequency plan before any changes are made in the physical structure of a cellular system and essentially eliminates the time consuming human element from the process of determining interference between channels. The process also allows a complete determination of actual interference over the entire cellular system to be conducted within a very short period of time and eliminates most unsuspected interference.

[0072] The drive test data, once collected and analyzed, provides a relative scoring of the interferences between the antennae in the cell system. This scoring can be used to rank the relative interferences between antennae and to selective from least cost interference configurations of channel distributions among the antennae of the cell system. The relative predictive interference scores derived above and incorporated into the interference matrix of the present invention can then be effectively utilized to reassign channels with the least cost effect on potential interference.

[0073] When reassigning a channel between two cells, or cell segments, in a first embodiment, a minimal interference criteria is set and the systems accepts the first reassignment which met the minimal criteria for reassignment. In an alternative and preferable embodiment, the total interference scores for any channel reassignment is evaluated and the lowest score of all evaluated reassignments is accepted. As illustrated in Figure 10, to determine the total interference score, the interference of each pair of co-channel and adjacent channels for each potential reassignment have to be evaluated. The up-link interference and the down-link interference must be scored and then the total score must be compared. The up-link interference evaluation should include consideration for the power level of the mobile unit transmit. The drive tests have determined the cells with potential interfering with the receiving cell and this information is part of the system matrix. The channels on those cells are also known to the system. The interference score is then based upon an evaluation of this information. Depending upon the cell site distribution and the interference distribution detected in drive testing, the proposed channel reassignment may effect only a few or a large number of cell pair to be evaluated.

[0074] As an additional criteria, as illustrated in figure 11, an evaluation of the cost of retuning a call at the yielding cell which is utilizing the reassigned channel can be made. This cost is then added into the current interference score and the lowest total score is reevaluated to determine the least cost reassignment. The

costs of retuning can include the interruption cost to the ongoing channel use and factors such as call volume load at the yielding cell.

[0075] In an alternative embodiment, the matrix developed by the drive test method may be updated when changes in ERP are detected or when the data send over the SACCH indicate alterations in received power levels. Data collected prior to adjustments in systems architecture or changes in system performance are maintained with less statistical significance than dat updated for such changes.

[0076] Additionally, the system can assess the interference score and system cost of reassignment in likely future demands on channel use. Channel use patterns from previous reassignments are maintained by the system as a layer within the reassignment matrix. Mobile use traffic can be evaluated and predicted from the use history to provide criteria for evaluation of the effects of reassignment future use demands for the reassigned channel. As illustrated in Figure 12, the system can evaluate if the reassignment from a yielding cell at a current time is likely to result in that cell needing a channel in the near future. The cost of reassigning a channel form that yielding cell is factored into the total cost score and compared against other potential reassignments to again evaluate the least cost score for reassignment.

[0077] Although the present invention has been described in terms of preferred embodiments, it will be appreciated that various modifications and alterations, might be made by those skilled in the art without departing from the spirit and scope of the invention. The above-described exemplary embodiments are therefore intended to be illustrative in all respects, rather than restrictive, of the present invention. Thus the present invention is capable of many variations in detailed implementation that can be derived from the description contained herein. All such variations and modifications are considered to be within the scope and spirit of the present invention as defined by the following claims.

Claims

1. A system which utilizes actual received signal level data gathered from closely spaced locations over an entire cellular system at which a mobile unit is likely to communicate with base stations to calculate interference levels at each location, comprising the steps of:

   identifying base stations which most probably communicate with a mobile unit at each particular location;
   compiling a list of likely interfering base stations for each identified base station at each location throughout the system;
   determining the probable likely transmit signal power received from each identified base station by a mobile unit at each location;
   comparing the probable likely transmit signal power of likely interfering base stations at each location;
   identifying actual interfering base stations and assigning corresponding interference scores indicative of the likelihood and magnitude of interference between respective identified base stations;
   establishing an interference matrix corresponding to said calculated base interference scores; and
   assigning channels to said base stations in accordance with said interference matrix to minimize base station interference;
   monitoring said system for channel reassignment requests; and
   reassigning a channel from a yielding base station to a receiving base station in response to reassignment requests based upon a reassignment determination made in accordance with said interference matrix to minimize base station interference.

2. The system of Claim 1, further including:

   identifying potential reassignment channels; and
   evaluating each potential reassignment channel for interference caused by reassignment.

3. The system of Claim 2, wherein said interference matrix includes:
   interference scores for each evaluated potential reassignment channel.

4. The system of Claim 2, further including:
   evaluating the impact of each reassignment on the yielding base station, including the assignment of disruption scores for loss of reassigned channels from respective yielding base stations.

5. The system of Claim 4, wherein said reassignment determination is based upon combined interference and disruption scores for each potential reassigned channel.

6. The system of Claim 1, wherein said reassignment determination includes:
   an evaluation of the effect of reassignment on said yielding station, including an evaluation of the impact of momentary call interruption at the yielding base station.

7. The system of Claim 1, wherein said reassignment determination includes:

   a determination of the total interference scores

for any potential channel reassignment; and selection of the lowest score of all evaluated potential reassignments.

8. The system of Claim 7, wherein said total interference score determination includes:
the interference of each pair of co-channel and adjacent channels for each potential reassignment;

9. The system of Claim 7, wherein said total interference score determination includes:
an evaluation of the cost of retuning a call at the yielding cell which is utilizing the reassigned channel.

10. The system of Claim 7, wherein said total interference score determination includes:
an evaluation of the score of future costs to the cellular system in subsequent reassignment of the potential reassigned channel.

11. The system of claim 1, further including:
updating said interference matrix, based upon alteration of conditions of said cellular system, including applying decreased statistical significance to data collected prior to said alteration to said cellular system.

12. The system of claim 1, further including:
updating said interference matrix, based upon the acquisition of additional data on the live operating parameters conditions of said cellular system, including applying decreased statistical significance to data collected prior to said data acquisition.

SYSTEM	BANDWIDTH (MHz)	NUMBER OF CHANNELS	BOUNDARY CHANNEL NUMBER	TRANSMITTER CENTER FREQUENCY (MHz)	
				MOBILE	BASE
NOT USED		1		(824.010)	(869.010)
A"	1	33	991 1023	824.040 825.000	869.040 870.000
A	10	333	1 333	825.030 834.990	870.030 879.990
B	10	333	334 666	835.020 844.980	880.020 889.980
A'	1.5	50	667 716	845.010 846.480	890.010 891.480
B'	1.5	83	717 799	846.510 848.970	891.510 893.970

TRANSMITTER	CHANNEL NUMBER	CENTER FREQUENCY (MHZ)
MOBILE	$1 \le N \le 799$ $990 \le N \le 1023$	0.030 N + 825.000 0.030 (N-1023) + 825.000
BASE	$1 \le N \le 799$ $990 \le N \le 1023$	0.030 N + 870.000 0.030 (N-1023) + 870.000

FIG. 1
PRIOR ART

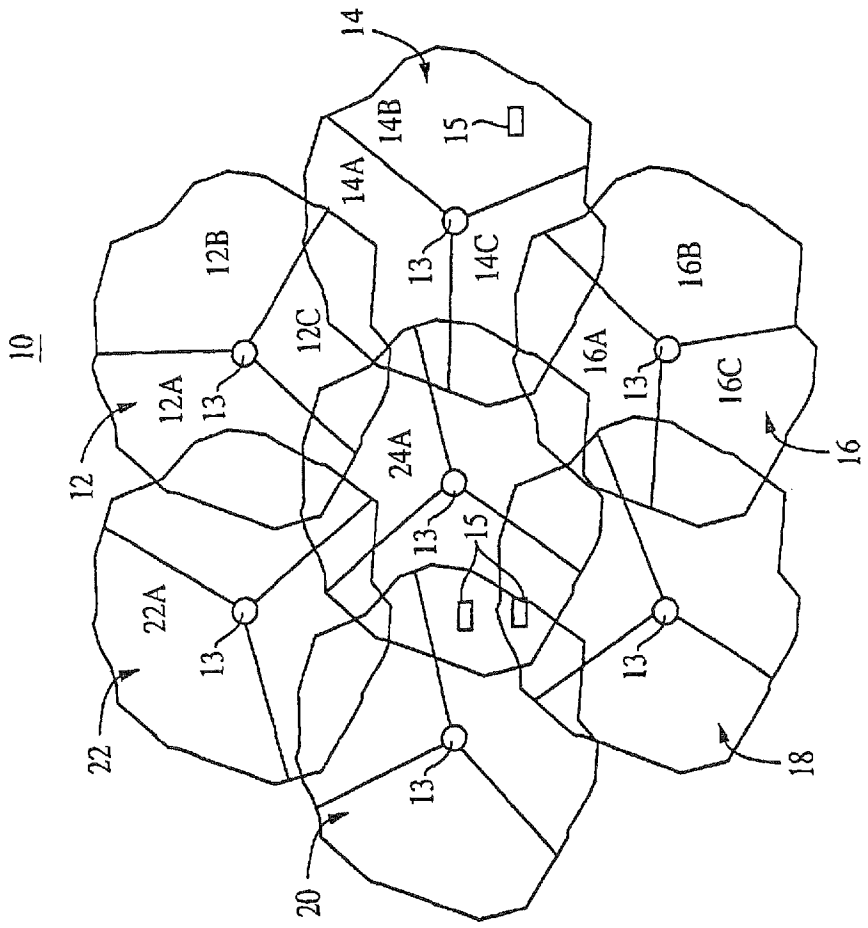

10
12
12A
12B
12C
13
14
14A
14B
14C
15
16
16A
16B
16C
18
20
22
22A
24A

FIG. 2

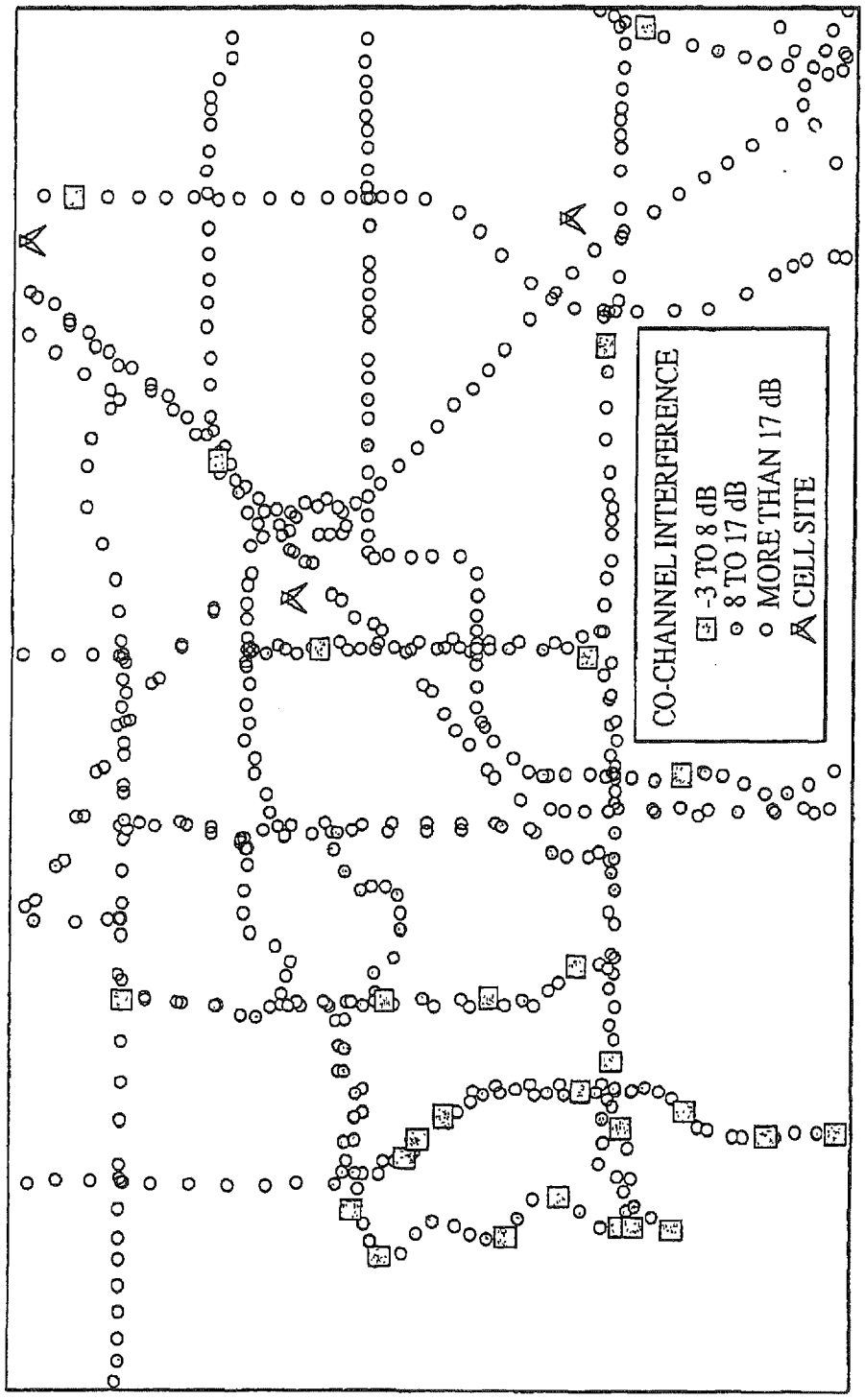

CO-CHANNEL INTERFERENCE
-3 TO 8 dB
8 TO 17 dB
MORE THAN 17 dB
CELL SITE

FIG. 3

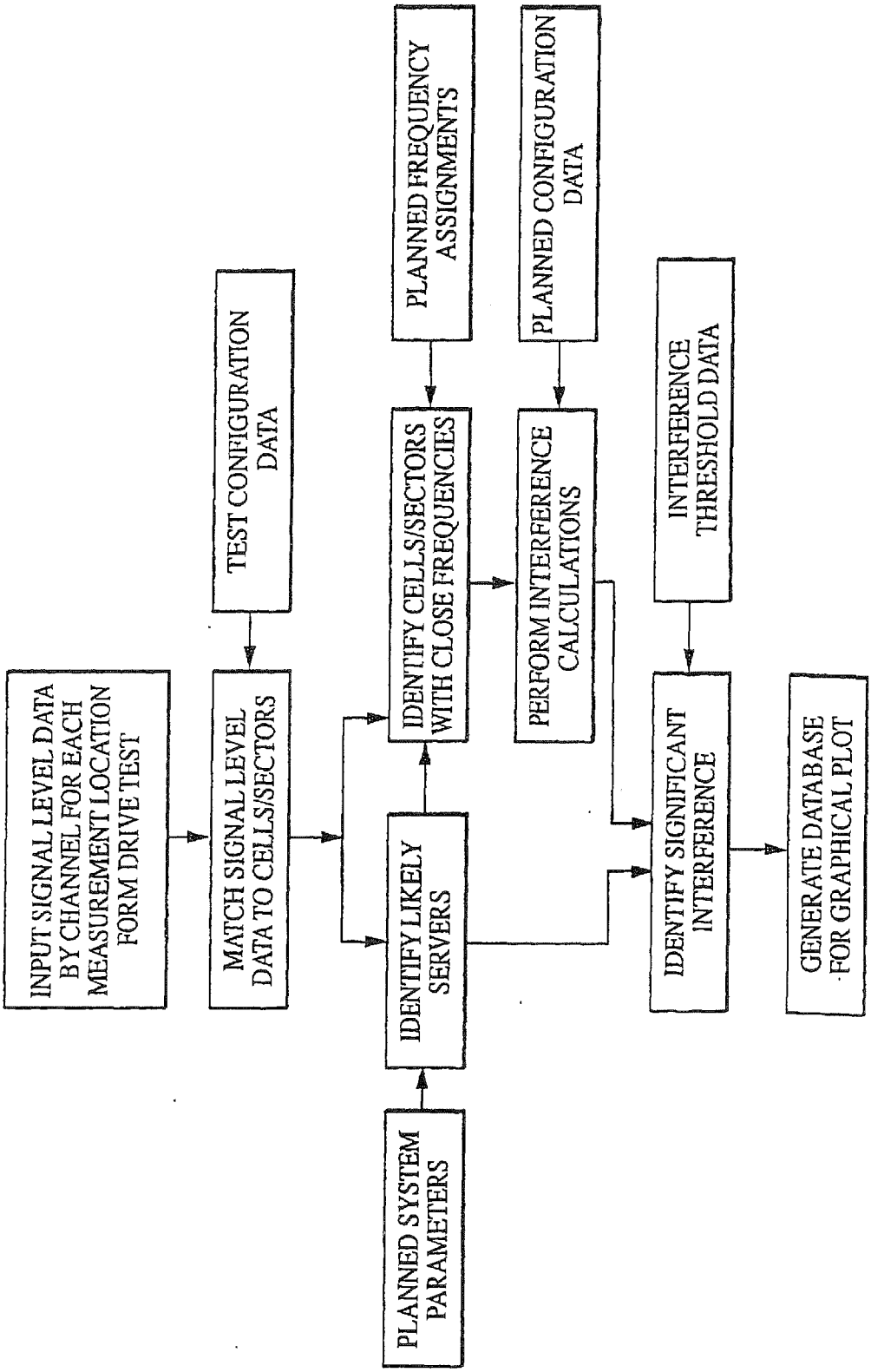

INPUT SIGNAL LEVEL DATA BY CHANNEL FOR EACH MEASUREMENT LOCATION FORM DRIVE TEST
TEST CONFIGURATION DATA
MATCH SIGNAL LEVEL DATA TO CELLS/SECTORS
PLANNED SYSTEM PARAMETERS
IDENTIFY LIKELY SERVERS
PLANNED FREQUENCY ASSIGNMENTS
IDENTIFY CELLS/SECTORS WITH CLOSE FREQUENCIES
PLANNED CONFIGURATION DATA
PERFORM INTERFERENCE CALCULATIONS
INTERFERENCE THRESHOLD DATA
IDENTIFY SIGNIFICANT INTERFERENCE
GENERATE DATABASE FOR GRAPHICAL PLOT

FIG. 4

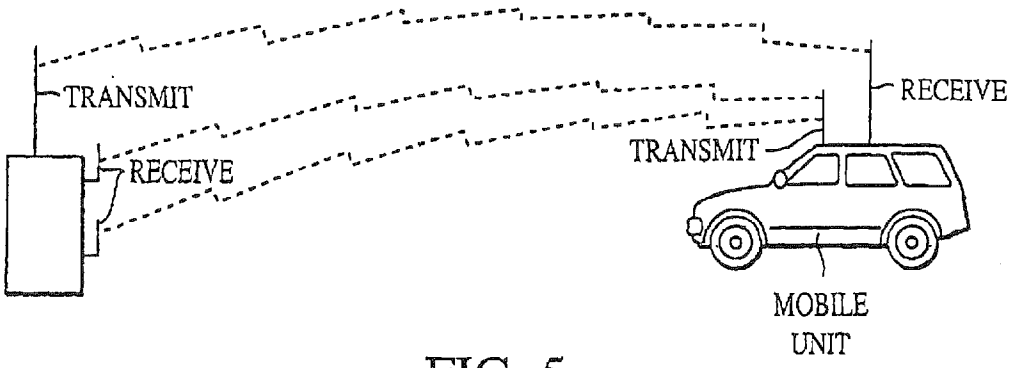

TRANSMIT
RECEIVE
RECEIVE
TRANSMIT
MOBILE
UNIT

FIG. 5

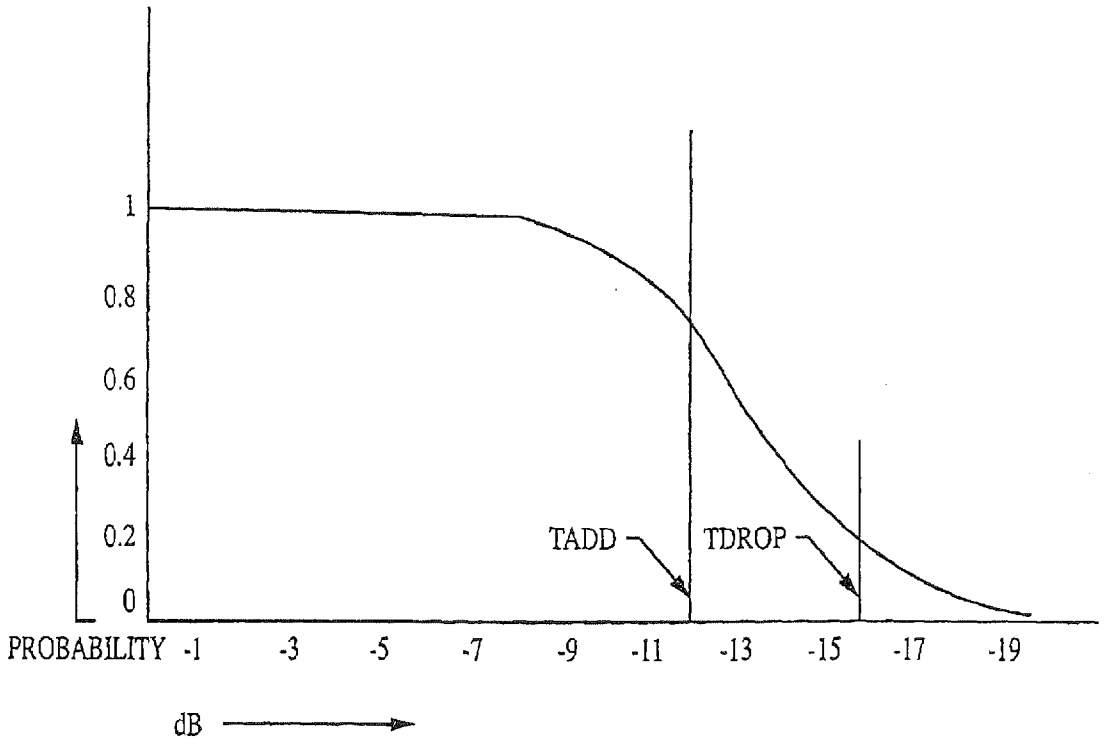

1
0.8
0.6
0.4
0.2
0
PROBABILITY
TADD
TDROP
-1
-3
-5
-7
-9
-11
-13
-15
-17
-19
dB

FIG. 6

PILOT	Ec/Io	p(X)	pπ(X)
A	-8	0.95	0.95
B	-10	0.92	0.92
C	-13	0.60	0.58
D	-15	0.21	0.12

P(X)	CD	C'D	CD'	C'D'
AB	0.000	0.089	0.505	0.276
A'B	0.007	0/004	0.022	0.015
AB'	0.012	0.006	0.036	0.024
A'B'	0.001	0.000	0.002	0.001

FIG. 7

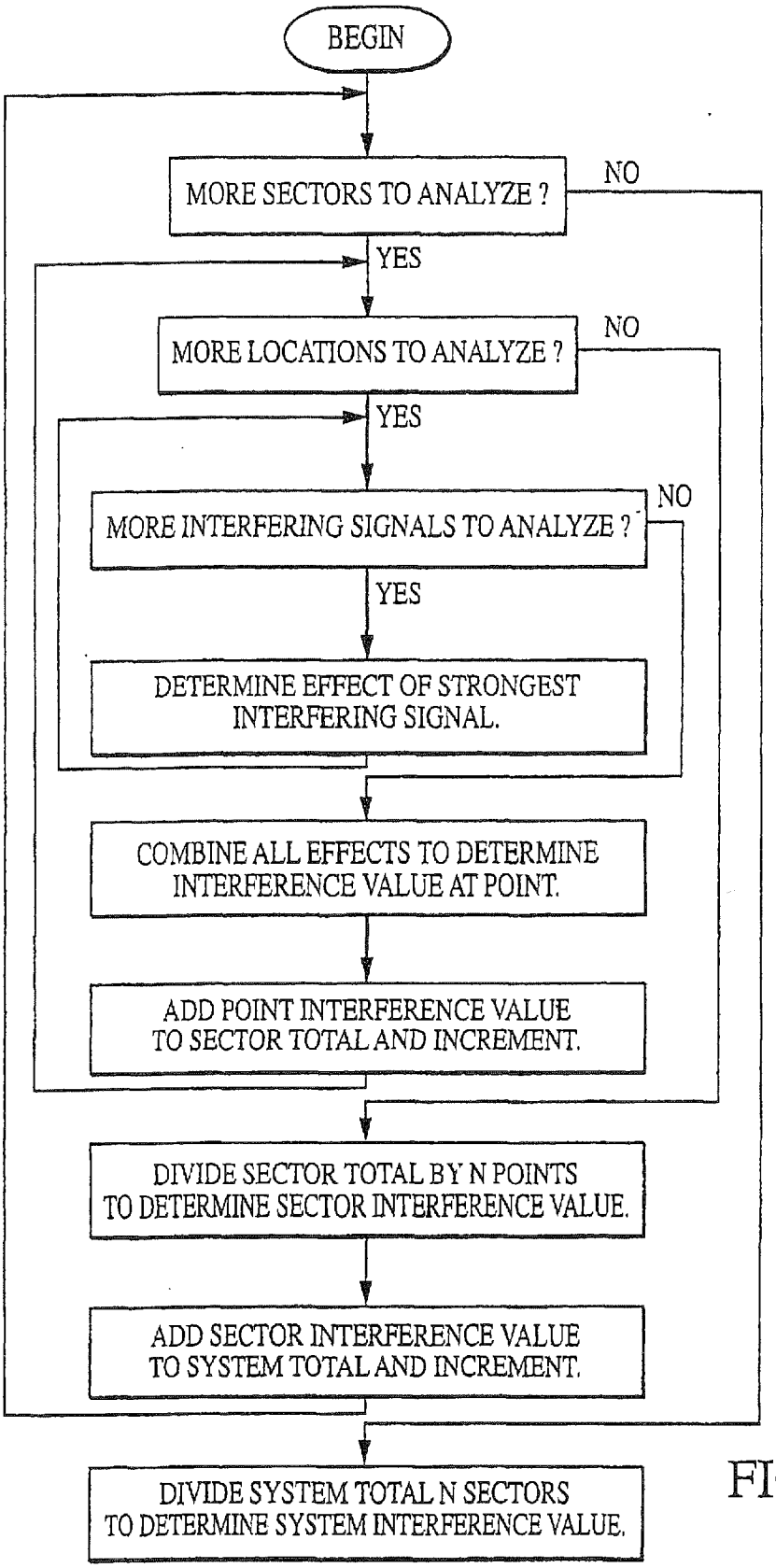

BEGIN
MORE SECTORS TO ANALYZE ?
NO
YES
MORE LOCATIONS TO ANALYZE ?
NO
YES
MORE INTERFERING SIGNALS TO ANALYZE ?
NO
YES
DETERMINE EFFECT OF STRONGEST INTERFERING SIGNAL.
COMBINE ALL EFFECTS TO DETERMINE INTERFERENCE VALUE AT POINT.
ADD POINT INTERFERENCE VALUE TO SECTOR TOTAL AND INCREMENT.
DIVIDE SECTOR TOTAL BY N POINTS TO DETERMINE SECTOR INTERFERENCE VALUE.
ADD SECTOR INTERFERENCE VALUE TO SYSTEM TOTAL AND INCREMENT.
DIVIDE SYSTEM TOTAL N SECTORS TO DETERMINE SYSTEM INTERFERENCE VALUE.

FIG. 8

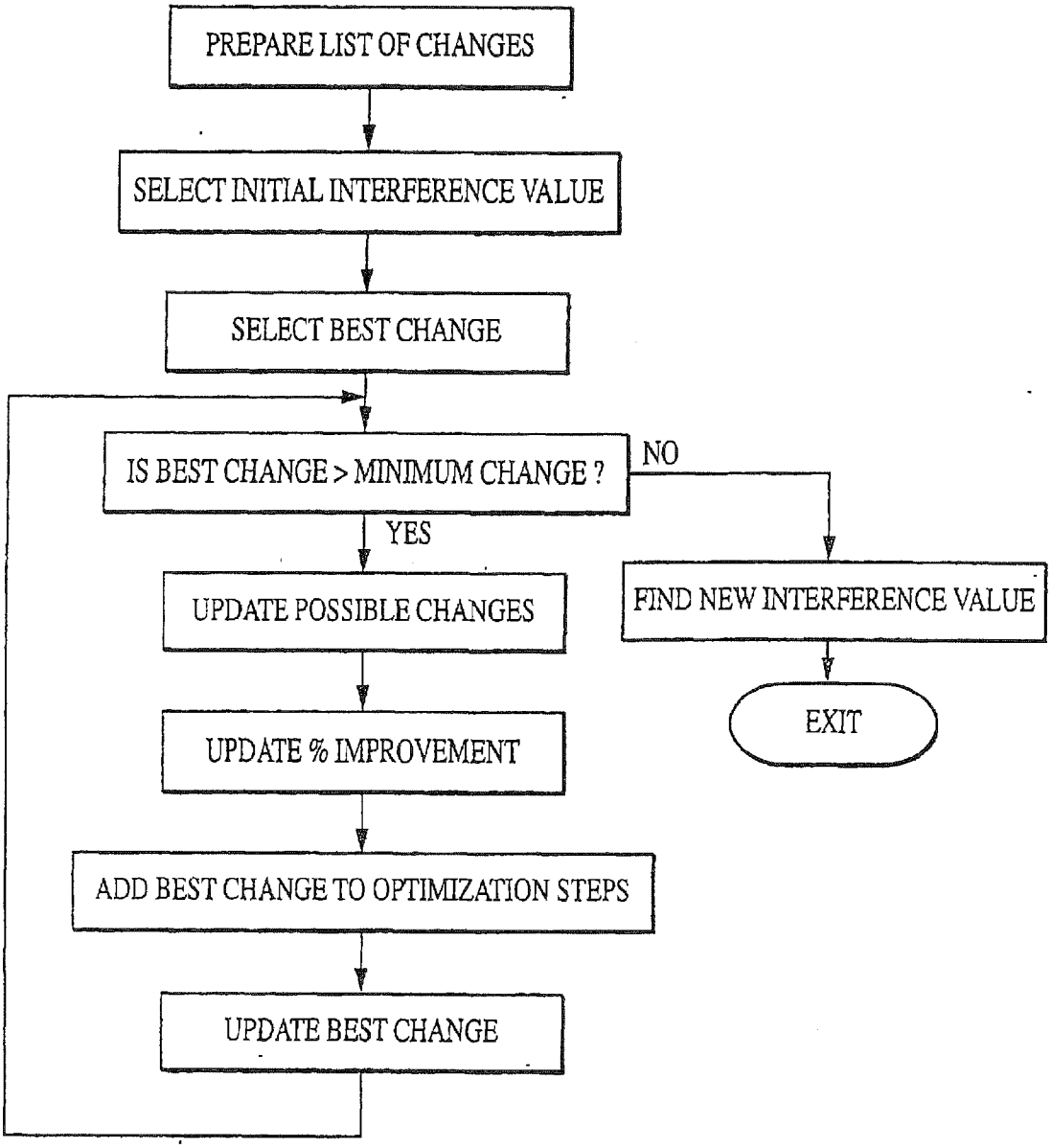

PREPARE LIST OF CHANGES
SELECT INITIAL INTERFERENCE VALUE
SELECT BEST CHANGE
IS BEST CHANGE > MINIMUM CHANGE ?
NO
YES
FIND NEW INTERFERENCE VALUE
EXIT
UPDATE POSSIBLE CHANGES
UPDATE % IMPROVEMENT
ADD BEST CHANGE TO OPTIMIZATION STEPS
UPDATE BEST CHANGE

FIG. 9

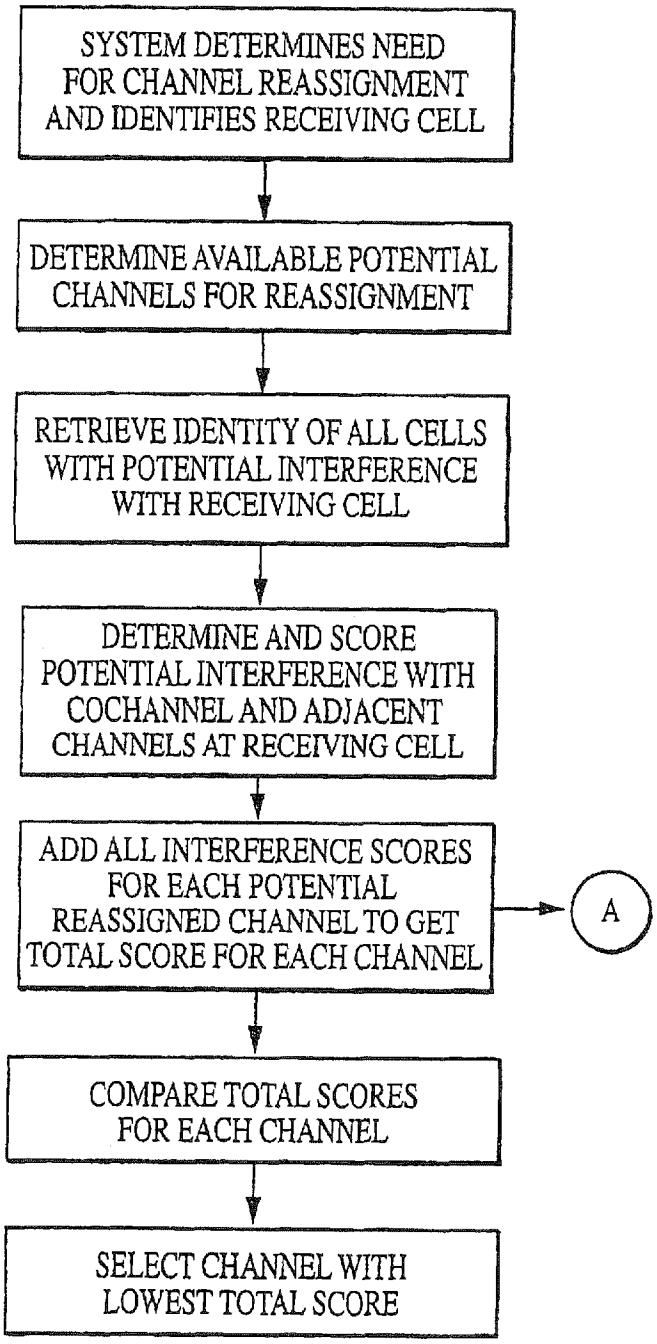

SYSTEM DETERMINES NEED FOR CHANNEL REASSIGNMENT AND IDENTIFIES RECEIVING CELL
DETERMINE AVAILABLE POTENTIAL CHANNELS FOR REASSIGNMENT
RETRIEVE IDENTITY OF ALL CELLS WITH POTENTIAL INTERFERENCE WITH RECEIVING CELL
DETERMINE AND SCORE POTENTIAL INTERFERENCE WITH COCHANNEL AND ADJACENT CHANNELS AT RECEIVING CELL
ADD ALL INTERFERENCE SCORES FOR EACH POTENTIAL REASSIGNED CHANNEL TO GET TOTAL SCORE FOR EACH CHANNEL
A
COMPARE TOTAL SCORES FOR EACH CHANNEL
SELECT CHANNEL WITH LOWEST TOTAL SCORE

FIG. 10

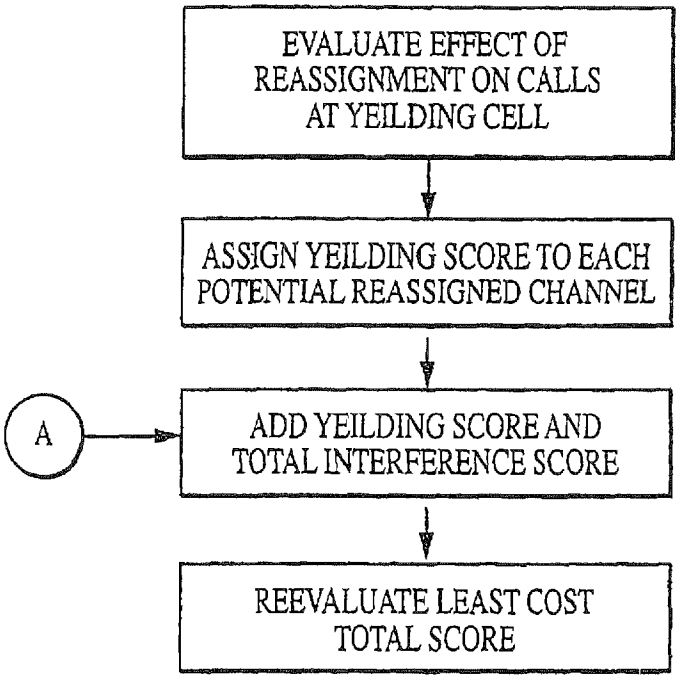

EVALUATE EFFECT OF REASSIGNMENT ON CALLS AT YEILDING CELL
ASSIGN YEILDING SCORE TO EACH POTENTIAL REASSIGNED CHANNEL
A
ADD YEILDING SCORE AND TOTAL INTERFERENCE SCORE
REEVALUATE LEAST COST TOTAL SCORE

FIG. 11

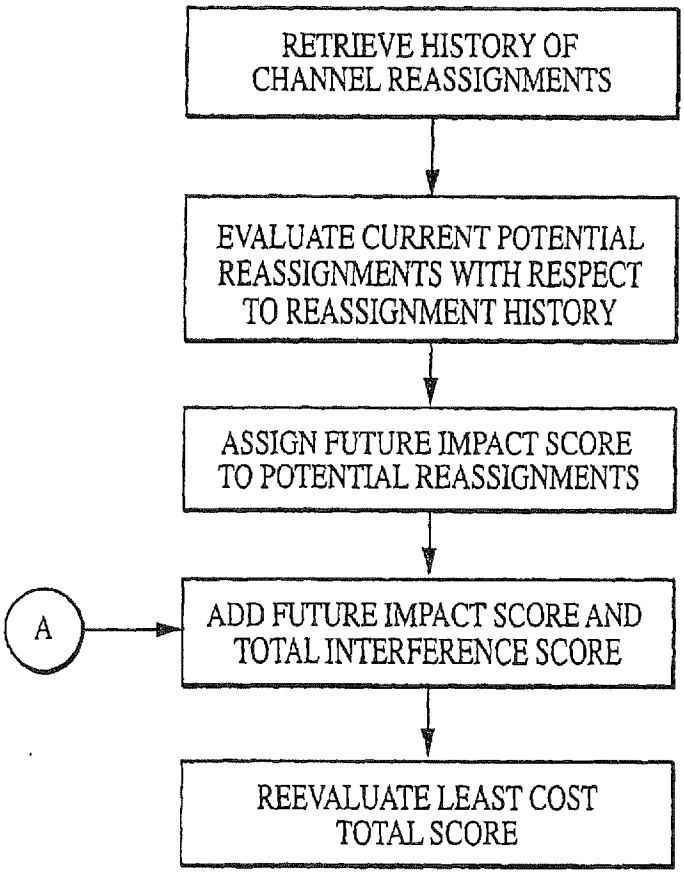

RETRIEVE HISTORY OF CHANNEL REASSIGNMENTS
EVALUATE CURRENT POTENTIAL REASSIGNMENTS WITH RESPECT TO REASSIGNMENT HISTORY
ASSIGN FUTURE IMPACT SCORE TO POTENTIAL REASSIGNMENTS
A
ADD FUTURE IMPACT SCORE AND TOTAL INTERFERENCE SCORE
REEVALUATE LEAST COST TOTAL SCORE

FIG. 12

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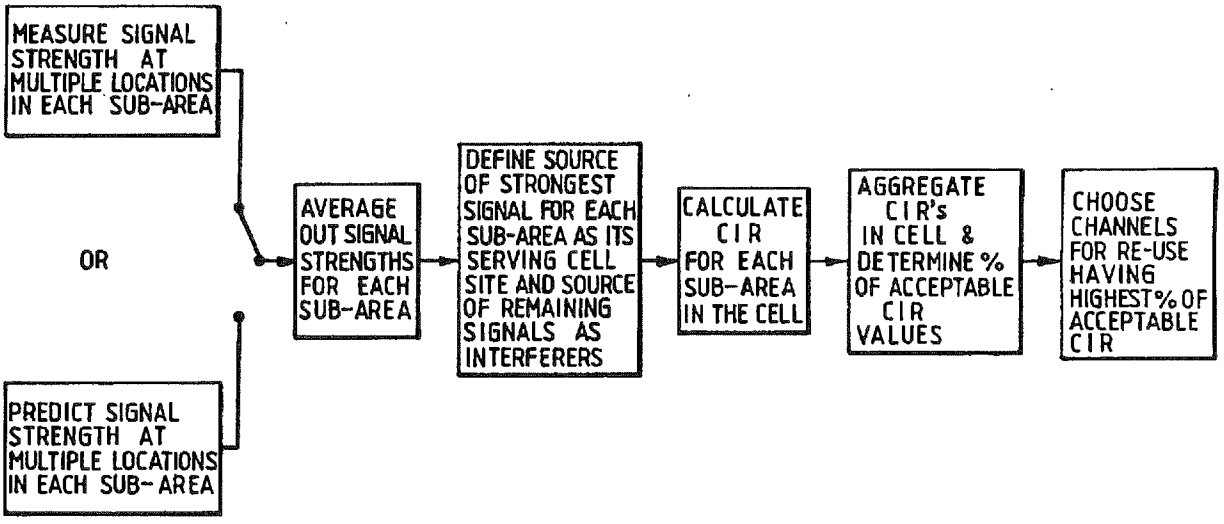
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(57) Abstract

In a cellular telephone network the geographical area covered by the network is subdivided into a large number of small sub-areas of generally equal shape and size. The received signal strengths are measured at each sub-area and the source of the strongest signal for the sub-area is defined as the serving cell site and the remaining signals as interferer signals. Carrier to interference (CIR) ratios are thereafter calculated and compared to a predetermined minimum CIR level for the network. For each cell site of the network the total number of sub-areas in which signal strengths have been ascertained is aggregated and compared with the number of such sub-areas in which the CIR is above the minimum value, to thereby determine the probability of interference occurring in that cell with one or more signals received from other cell sites if the same channel frequency is reused. The method therefore provides a means to optimize channel selection by selecting a channel having the lowest probability of co-channel interference.

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Method of Optimizing Channel Selection in Cellular Telephone Networks

This invention relates to cellular telephone networks and is primarily, but not exclusively, concerned with optimizing the selection of channels throughout part or all of such networks to minimize interference and maximize the performance and capacity of the network.

Cellular telephone networks stem from the realization that it is statistically improbable for a large number of subscribers to such a telephone system to be geographically close to each other at any given instant in time and/or would wish to make or receive radio telephone calls at the same time in the same location.

Given the finite number of radio channels which are available for use within radio telephone networks, the cellular network system provides a means whereby a very large number of calls can be made or received at the same time using a relatively small number of channels. To achieve this, short-range transmitters and receivers are installed

in a cell-like configuration over the entire area covered by the telephone network, each such cell having a different range of radio channels to that of a neighboring cell, but often the same as those of several other cells in the network.

Although the or each radio transmitter in each cell is relatively short-range, it will be appreciated that it would still be possible for signals of any particular channel to be picked up by receivers in nearby cells where the same channel is being reused, which can then lead to "cross-talk" interference during telephone calls. To minimize this undesirable effect it is necessary to ensure that the signal strength from a nearby cell using the same channel is sufficiently less than the signal strength for the same channel used in a particular cell so as to enable the weaker signal to be differentiated and discarded so that only the stronger signal is used during the telephone call. To achieve this aim, in the construction of cellular radio systems the concept of Carrier-to-Interference Ratio (CIR) is used, meaning, essentially, the ratio of the carrier signal strength in one cell compared

with interfering signal strength received from a nearby cell using the same channel frequency.

The CIR may also be conveniently expressed in decibels where the actual signal strength is measured in Watts. Thus, if the strength of the carrier signal in a channel is measured to be, say, $C=10\times10^{-7}$mW, then C(in decibel expression) can be written to be 10 times the logarithm of the power ratio to 1 milliwatt. Hence:

$$C(dBm)=10\log\frac{10\times10^{-7}mW}{1mW} \quad (1)$$

$$C(dBm)=10\log(10\times10^{-7}) \quad (2)$$

$$C(dBm)=-60dBm \quad (3)$$

Similarly, if the strength of the interfering channel I is, say, 5×10^{-7}mW then we have

$$I(dBm)-10\log\frac{5\times10^{-7}mW}{1mW} \quad (4)$$

$$I(dBm)-10\log(5\times10^{-7}) \quad (5)$$

$$I(dBm) = -63dBm \quad (6)$$

Then since:

$$CIR = 10\log\left(\frac{10\times10^{-7}mW}{5\times10^{-7}mW}\right) \quad (7)$$

and:

$$CIR(dB) = 10\log\left(\frac{10\times10^{-7}mw}{1mW}\right) - 10\log\left(\frac{5\times10^{-7}mW}{1mW}\right) \quad (8)$$

Therefore:

$$CIR(dB) = C(dBm) - I(dBm) \quad (9)$$

$$CIR(dB) = -60dBm - (-63dBm) \quad (10)$$

$$CIR(dB) = 3dB \quad (11)$$

Thus, it will be seen that if the signal strengths of the carrier and interferer are expressed in Watts then the CIR is simply ten times the

logarithm of their ratio as defined in equation (7); whereas if the signal strengths of the carrier and interferer are measured in decibel milliwatts, the CIR is obtained by calculating their difference, as shown in equation (10).

Typically, in cellular mobile radio analog systems such networks require a CIR of greater than 17 dB although it will be understood that the choice of this value is arbitrary and depends on the technology employed in the hardware used and how efficiently it is able to differentiate between signals received from identical channels but located in different cells.

In an ideal situation, the design of a cellular telephone network is relatively straightforward in that all that is required are short-range radio stations comprised of transmitters/receivers, often using common antennae, located at evenly spaced intervals over the entire geographical area required for the network, with each such station then defining the cell site centre of its respective cell. Propagation of electro magnetic radiation in such circumstances generally occurs

spherically outwards which necessarily means that if each station is positioned in the most efficient manner with respect to adjacent stations then a partially overlapping arrangement of cells results. Although the true locus of signals receivable from each station transmitter defines a circular path around its antenna, it is usually convenient to consider in an ideal situation that each cell has an hexagonal shape and when planning networks of this kind it is usually convenient to draw out the geographical spread of the network with the use of hexagonal cells, which thereby appear to interlock with adjacent cells.

In the situation referred to above it will be apparent that there is effectively only one primary consideration when planning the geographical extent of such a telephone system, being a trade-off between the cost of installing and operating stations in each cell, as opposed to the end-user requirements for making telephone calls to or from each cell. Thus, the more geographically distant a cell becomes from a centre of human population, the less cost effective it becomes to maintain and operate a cell

from that location. Hence, the planning of such an ideal network is relatively straightforward.

However, in the real world, there are many other complicating factors affecting the design of cellular telephone networks which are brought about primarily by topography and demography, or the non-availability of ideal sites where stations can be situated. Topographical factors often arise in towns and cities with high rise buildings and/or natural geological features such as hills and valleys. Demographic factors result from variations in human population densities, particularly in and around towns and cities.

The problems caused by variations in topography can generally be summed up as meaning that the ideal hexagonal shape for a cell cannot be assumed valid because there will be areas in such a cell which are blocked from receiving or transmitting radio frequency radiation as a result of the presence of buildings etc.. This problem can be solved by placing additional stations to cover the blind area within the cell, hopefully in the most economic fashion possible. Sometimes, it is even necessary to

install antennas inside buildings, particularly shopping malls and the like, where there is a high statistical probability that subscribers to the telephone network would wish to make or receive a telephone call. Alternatively, more than one attenna could be used in each cell, but located at different sector points within the cell to cover discrete sectors of the cell and thereby allow for as near complete coverage as is feasible, given the constraints dictated by the topography. Thus cells can be serviced by a single station, or split into cell-sectors, each with its own attenna, but all operating over the same bandwidth.

Demographic considerations also play their part in complicating the design of such networks because areas of high population density obviously require a greater number of available channels in order to guarantee that a caller can make and a receiver can receive a call. Given that there are only a finite number of channels usually available for allocation to a cellular telephone network, it will be apparent that efficient design of the network is necessary in order to extract the greatest amount of use possible from the available channels.

Presently, the approach taken to the design of cellular telephone networks has generally relied upon trial and error, rather than by adopting a more scientific approach, except where topographical and demographical variations are insignificant. Even in networks which have been painstakingly and carefully designed to achieve the maximum efficiency out of the number of channels available, it is still necessary to constantly review and adjust cell design within the network in response to the construction of new buildings and the demolition of old ones. Minor changes to the topography or demography can sometimes be accommodated by placing additional stations at strategic locations but, over time, the cumulative effect may make it more efficient or economical to occasionally completely redesign the network by altering the number and position of the various stations or the channels allocated to them.

Conventionally, the approach taken to optimizing the allocation of channels for re-use in neighbouring cells has been to visually analyze a radio frequency signal strength contour map for each cell, and by comparing the contour map from one cell with that of another cell, to then make a judgement,

often based upon experience, on whether or not to re-use a particular channel from a choice of several which may be available for re-use.

Obviously, if one cell receives a significant proportion of incoming radio frequency radiation from a neighbouring cell at a relatively high signal strength then it is impractical to re-use channels of the same frequency since there will be an unacceptable level of interference. Difficulties, however, arise when comparing radio frequency contour maps of cells in order to try to determine for any given cell what channels are available for re-use with the minimum possibility of interference occurring with neighbouring cells using the same channels. It may be clear from the radio frequency contour maps that certain particular channels are inappropriate for re-use, and at the other end of the scale it may be that certain other channels would be available for use since there is little or no chance of interference arising. In between these two extremes is a spectrum of possibilities and a value judgement then has to be made as to which channels to reallocate or re-use.

The present invention seeks to overcome the problem of selection of channels for re-use in neighbouring cells by introducing statistical concepts which provide a more scientific approach to the selection process. In particular, the invention effectively provides a measurement of the level of confidence for the re-use of each channel between a worst-case scenario wherein 100% interference will be experienced from a neighbouring cell using the same frequency, to a position where there is no interference whatsoever and hence 100% confidence that there will be no interference when a telephone call is made or received. Using this concept in accordance with the method of the present invention it is possible to identify confidence levels for all of the channels in the network with respect to each cell so that when a choice has to be made as to which channels to re-use in other cells the choice can be made with reference to a scale of confidence ranging from 0% up to 100%.

In accordance with the invention there is provided a method of optimizing channel selection in a radio telephone network of the type utilizing a plurality of radio stations comprised of

transmitters/receivers and antennae arranged in a cell-like configuration, the method comprising the steps of:-

(a) defining a minimum acceptable level of carrier-to-interference ratio (CIR) for the network,

(b) subdividing the geographical area covered by the network into a large number of small sub-areas of generally equal shape and size,

(c) ascertaining the strength of signals from transmitters of respective stations within the network at at least one location within all or a large number of sub-areas,

(d) for each such sub-area and for each transmitter defining the average value of the ascertained signal strength as representing the average signal strength for the transmitter in all parts of that sub-area,

(e) defining the transmission source of the strongest such signal as the serving cell-site

centre for that sub-area and the signal itself as the carrier signal,

(f) defining the remaining such signals from other transmitters within the network as interfering signals and for each calculating the CIR with respect to the carrier signal for that sub-area,

(g) for each cell-site of the network aggregating the total number of sub-areas in which signal strengths have been ascertained and comparing the number of such sub-areas in which each CIR is above the minimum acceptable value with the aggregate total of sub-areas in the cell-site, to thereby determine the probability of no interference occurring in that cell with one or more signals received from other cell-sites within the network if the same channel is re-used, and

(h) when choosing a channel for use in a cell, selecting the one having the lowest probability of interference with signals from other cells using the same channel, thereby to optimize channel selection.

It will be understood that one or more of the steps referred to above and in the appended claims may be interchanged, for example if it is found to be more convenient to ascertain at various locations the value of signals received from various transmitters first and then define sub-areas and cell-sites accordingly. The method of the invention is therefore not intended to be sequentially limited and, similarly, it will be apparent that the method can be used to optimize channels selection even in new networks or networks which are completely re-designed and where no existing cell-sites have yet been allocated.

If the signal strengths are ascertained only once at each sub-area then obviously each value is also the average value and no separate averaging step is necessary.

The signal strengths of the various channels at the various locations within the network can be ascertained either by direct measurement or by predictive means such as by using mathematical models to calculate the likely propagation of radio frequency radiation. However, in cities with a high

density of high rise buildings mathematical calculation of radio frequency propagation becomes extremely complex and in such circumstances direct measurement is preferred.

Preferably, particularly when optimizing channel selection in radio telephone networks for use in cities, the geographical area covered by the network may be subdivided into layers of sub-areas of generally equal shape and size so as to accommodate variations in radio frequency propagation caused by the presence of buildings or other geographical features. Thus, one layer may correspond to ground level and the second layer may correspond to, say, a floor above ground level and so on. In this way, vertical abnormalities of radio frequency propagation can be accounted for and adjustments made to channel selection as necessary.

Conveniently, a grid system may be used to subdivide the geographical area covered by the network (using longitude and latitude) to define the sub-areas and where more than one layer is used one grid may directly overlay another.

Preferably, the likelihood of interference occurring in any particular cell with one or more signals received from other cell sites within the network if the same channel is re-used in that cell may be expressed as a level of confidence ranging from 0%, meaning that interference will occur whenever a call is made from whatever location within the cell site, to 100%, meaning that interference will never occur at any location within the cell site. Hence, the level of confidence for re-use of a channel at any point within the entire network can be calculated and expressed in the form of a look-up table so that for any one of perhaps several hundred available channels in a network then, depending upon the geographical position identified, there will exist a variety of options on whether or not to re-use any particular channel, with some channels having a low confidence level for re-use and others having a high level of confidence, perhaps nearing 100%.

The advantage of such a system is that it does not rely upon an intuitive interpretation of radio frequency contour maps but more upon

statistical data obtained by direct measurement or calculation.

The method of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a radio contour map of a cell site within a conventional cellular telephone network,

Figure 2 is a radio coverage map of the cell site of Figure 1,

Figure 3 is a block diagram showing the principle steps involved in the method of the invention,

Figure 4 is a simplified schematic diagram showing a number of transmitters within a network and locations for which measurements of signal strength have been taken, including various sub-areas defined by grid lines over the territorial extent of the network,

Figure 5 is a further schematic diagram similar to that of Figure 4 but in which two layers of sub-areas are defined by grid lines,

Figure 6 is a table showing a list of signal strength measurements taken at various locations within a sub-area,

Figure 7 is a table showing the average of the signal strengths of Figure 6,

Figure 8 is a table showing in percentage terms the probability of interference occurring through the use of the same channel at various cell sites within the network,

Figure 9 is a probability distribution graph of a collection of CIR's between two transmitters,

Figure 10 shows the cumulative probability distribution of the graph of Figure 9, and

Figure 11 is a table corresponding to Figure 8 but expressing probability of interference in dB.

Referring firstly to Figure 1 there is shown a radio contour map of a cell site S1 located within a large city having a multitude of high-rise buildings and/or geographical features which block or hinder the typically spherical propagation of electro magnetic radiation. The map includes blank areas which typically signify the presence of buildings, or areas which are otherwise inaccessible for taking measurements of signal strength. The locations of other cell-sites S2, S3, S4 and S5 in the network are also shown.

But for the presence of buildings and assuming that the topography was completely flat the contour map would show signal strength diminishing at a rate solely depending upon the distance from the transmission source. In practice, however, a typical contour map such as the one depicted is highly irregular in shape and extent. It will be understood that the contour map of Figure 1 depicts the variation in signal strength over distance in respect

of a transmitter placed at the centre of the cell site and that for each cell site on the map a different contour would result such that if contour maps for a number of adjacent or neighbouring cell sites were overlaid one on top of the other the resulting combined contour map would be extremely complex and difficult to interpret.

In Figure 2 there is shown a radio coverage map of cell site S1 corresponding to the contour map of Figure 1 but showing only those areas having signals stronger than those receivable from adjacent cells so that the map shows those areas where the cell site S1 provides dominant signal strength to make and receive radio telephone calls. As mentioned previously, it is generally accepted that in cellular mobile radio analog systems, a signal strength difference greater than 17dB is necessary to ensure that the telephone equipment within the cell can differentiate the carrier signal from interferer signals of the same frequency emanating elsewhere.

Turning to Figure 3 there is shown a block diagram of a schematic arrangement in which the preferred method of the invention can be realized in

which it will be seen that the first step can be achieved in either of two ways, either by direct measurement of signal strength or by calculating the signal strength at various points over the entire network. Prior to this, the geographic extent of the network is subdivided into sub-areas and in the example shown with reference to Figure 4 it will be seen that a square grid system is used where each of the sub-areas is of the same size and shape. In practice, the sub-areas are in fact much smaller than those depicted in Figure 4 and may typically measure 50 metres by 50 metres so that for each cell of the network a large number of sub-areas can be defined. In general, the larger the number of sub-areas defined, the greater the statistical accuracy is of the method in accordance with the invention. The grid is preferably defined and the sub-areas individually identified using latitude and longitude.

Predictive calculation of the signal strength in each sub-area can be used with reasonable accuracy over generally flat terrain including areas of water but becomes less reliable with increasing irregularity of topography and/or distance from each station within the network. Thus, in and around

cities direct measurement of signal strength is preferred to calculation and for this purpose a specialized road-going vehicle can be used equipped with conventional instruments and tracking apparatus in order to determine at any point in time the exact geographical location of the vehicle and to take at regular intervals of, say, 10 or 20 metres, measurements of signal strengths being received from nearby transmitters, the vehicle equipment automatically recording data as it moves along for later analysis. This will generally mean that such a vehicle will have to travel along roads and other areas where vehicular access is possible throughout the entire network in order to obtain a meaningful quantity of data which can then be used to provide the basis for the statistical method of the invention. In areas where vehicular access is impossible then measurements may have to be taken individually, or mathematical methods may be used instead in order to ascertain the likely signal strength at such inaccessible parts of the network. The greater the number of sub-areas covered, the greater the statistical accuracy of the method.

Once the data is collected, by whatever means, the mean signal strength in each sub-area for each transmitter is calculated and the transmission source of the strongest such averaged signal is then defined as being the serving cell site centre for that particular sub-area and therefore the signal itself is defined as being the carrier signal. The remaining signals are thereafter defined as interferer signals so that it is then possible to simply calculate the carrier to interference ratio with respect to each of the interferers for the sub-area. Obviously, the geographical extent of the cell includes all sub-areas in which the transmission signal for that cell is the strongest, but the cell itself may extend to other areas where measurements may not have been taken.

For each sub-area in each cell the average CIR with respect to nearby transmitters is therefore known and, accordingly, will be either above or below the minimum acceptable value of CIR for the network. For all sub-areas in the cell where a CIR value is known the number of such sub-areas is then aggregated and the percentage having a CIR value above the minimum acceptable is thereafter determined, in

respect of each of the interferers, from which it will be understood that this percentage in reality reflects a level of confidence in whether or not there is likely to be interference in that cell if the same channel as is used in a neighbouring cell is re-used. Thus, when choosing which channel to re-use it is simply necessary to choose the one with the highest percentage of acceptable CIRs, rather than having to rely upon the "look and feel" of radio contour maps, which has traditionally been the method used.

Turning now again to Figure 4 it will be seen that in the simplified arrangement shown measurements have been taken, (indicated by an "X") at various points over several sub-areas and at each such point measurements have been taken corresponding, respectively, to signals received from transmitters at cell sites S1 to S5. As explained above, for each sub-area the signal strengths for each transmitter are averaged out for each sub-area and the source of the strongest signal is thereafter defined as being the cell site centre for that sub-area.

In Figure 5 the two dimensional grid network is expanded to three dimensions by introducing a second layer overlying the first. More than two layers could, of course, be used depending upon the prevalence of, particularly, high rise buildings in the network although it will be appreciated that taking measurements of signal strengths at locations on the second and any successive layers is more difficult than taking measurements of signal strengths at ground level.

Turning now to Figure 6 there is shown a table of actual measurements (expressed in dBm) taken in one particular sub-area of a network where a total of four measurements have been made for each of five transmitters in cell sites S1 to S5, such measurements being taken at various positions of latitude and longitude within the sub-area. At position 22.309818 North and 114.169511 East the signal strength of the transmitter of S1 was recorded as -90dBm, that of S2-115dBm, S3 at -109dBm and S4-114dBm, and so on.

In Figure 7 there is shown a table in which the data collected and recorded in Figure 6 has been

averaged out, including the average location and, of course, the mean signal strength for each of the transmitters from S1 to S5. In practice, most networks include a large number of transmitters at a correspondingly large number of stations and hence in reality a very large number of measurements and calculations would have to be made to cover the entire network, for which purpose computer processing of the data is almost indispensable.

As mentioned with reference to Figure 3, the averaged data for each sub-area is then collated with reference to other sub-areas in each cell so that if, say, there are 100 sub-areas in a given cell and the measurements taken indicate that in 90 of those sub-areas the CIR with respect to a neighbouring transmitter is below the acceptable value of 17dB then it follows that this can be expressed as only a 10% confidence level of there not being interference anywhere in the cell should the same channel of the neighbouring cell be re-used in that cell. Conversely, if 90 out of the 100 sub-areas measured show that the signal strength from a neighbouring transmitter is relatively low so that the CIR is above the acceptable level of 17dB then

this translates into a 90% level of confidence that if that same channel is re-used in the cell then for most of the time no interference will be experienced. Obviously, the nearer one gets to 100% then the greater the certainty that no interference will occur.

Using these concepts it is therefore possible to tabulate in percentage terms the level of confidence of re-use of channels within the network for each cell or cell-sector so that it is possible to produce a look-up table of the type as is shown in Figure 8. In the table it will be seen that percentage levels of confidence have been calculated for each transmitter with respect to other transmitters in the network and, as is to be expected, those transmitters furthest away from each other usually produce higher levels of confidence and, conversely, the nearer transmitters are to each other the lower the level of confidence. In the table, and looking initially at the transmitter of S1, it will be seen that with respect to itself and by definition there is 0% confidence of interference not occurring by the re-use of the same channel. The

same is true of the transmitter at S2 with respect to itself and so on.

Referring, for example, to cell site S3 it will be noted that there is a 97% confidence level with respect to cell site S5, meaning that if the same channel is re-used in S5, 97% of the total sub-areas covered by S3 are free of interference. Conversely, there is only 3% probability, on average, in the S3 coverage area of interference occurring as a result of cross talk. Alternatively, if the same channels are used by S3 and S5, 95% of the S5 coverage area will anticipate no interference and only 5% of the S3 area is likely to suffer from interference.

The table shown in Figure 8 is necessarily simplistic, bearing in mind that a typical cellular telephone network can have over 300 individual channels within the radio frequency bandwidth allocated to it. For a single large city, there may be as many as 100 cell sites, each being allocated a number of channels dependent upon the user requirements in each cell and, of course, including some channels which are being re-used elsewhere

significantly below 17dB and, conversely, there is also a low probability of the CIR being significantly above about 35dB. Most of the CIR values lie between about 20dB and 35dB.

If the probability distribution shown in Figure 9 is expressed cumulatively, then we have the graph shown in Figure 10 in which, again, only a small percentage of the sample contains a CIR of less than 17dB. In the graph the 10% percentile represents a 90% confidence level and gives a CIR reading of 23dB. Accordingly, the confidence level of 80%, 70% and 60% are, respectively, represented by 20%, 30% and 40% percentiles respectively. The larger the CIR value, the higher is the confidence level. By applying the percentile method and again using 10% as the chosen percentile, Figure 8 can therefore be expressed in a different manner, as is shown in Figure 11. In the table it will be seen that as with the percentage levels of confidence shown in Figure 8, we now have confidence expressed in decibels and, as is to be expected, those transmitters furthest away from each other usually produce a higher level of dB then those which are relatively near to each other, although this is not

within the network by other cell sites. Whilst this illustrates the complexities involved in the conventional methods of trying to optimize channel selection and cellular telephone networks, it also illustrates how the statistical method of the present invention can be used for providing a sound basis for making a choice as to which channels to reallocate elsewhere, and where they can be most efficiently allocated.

Figure 8 illustrates how the confidence level for reusing channels throughout the network can be expressed in percentage terms although it will be appreciated that other ways of expressing whether or not interference is likely could be used. The percentage method shown above shows the degree of confidence of the CIR being above the acceptable value of 17dB. An alternatively is to express the CIR value in dB if the confidence level is fixed to a predetermined acceptable percentage of, say, 90%. In Figure 9 there is shown a probability distribution of a collection of CIR data between two transmitters each located at two different cell sites in the network. In this illustrative example it will be seen that there is a low probability of the CIR being

always the case due to variations in radio propagation cause by the presence of buildings, or areas of water which tend to increase the distance over which the radio frequency being can propagate without serious degradation. Looking initially at the transmitter of S1 it will be seen that with respect to itself and by definition the CIR is 0dB. Conversely, with respect to S1 the CIR is 29dB meaning that if the same channel is used in both of these cell sites then there is little risk of interference occurring.

Claims

1. A method of optimizing channel selection in a radio telephone network of the type utilizing a plurality of radio stations comprised of transmitters/receivers and antennae arranged in a cell-like configuration, the method comprising the steps of:-

(a) defining a minimum acceptable level of carrier-to-interference ratio (CIR) for the network,

(b) subdividing the geographical area covered by the network into a large number of small sub-areas of generally equal shape and size,

(c) ascertaining the strength of signals received from respective stations within the network at at least one location within all or a large number of sub-areas,

(d) for each such sub-area and for each transmitter defining the average value of the ascertained signal strength as representing the average

signal strength for the transmitter in all parts of that sub-area,

(e) defining the transmission source of the strongest such signal as the serving cell-site centre for that sub-area and the signal itself as the carrier signal,

(f) defining the remaining such signals from other transmitters within the network as interfering signals and for each calculating the CIR with respect to the carrier signal for that sub-area,

(g) for each cell-site of the network aggregating the total number of sub-areas in which signal strength have been ascertained and comparing the number of such sub-areas in which each CIR is above the minimum acceptable value with the aggregate total of sub-areas in the cell-site, to thereby determine the probability of no interference occurring that cell with one or more signals received from other cell-sites within the network if the same channel is re-used, and

(h) when choosing a channel for use in a cell, selecting the one having the lowest probability of interference with signals from other cells using the same channel, thereby to optimize channel selection.

2. The method according to Claim 1 further characterized in that the sub-areas are defined by a grid system using longitude and latitude to identify each such sub-area.

3. The method according to Claim 1 or Claim 2 in which layers of sub-areas of generally equal shape and size, but vertically separated, are provided.

4. The method according to any one of the preceding claims further characterized in that the probability of interference occurring in a cell in which the same channel is being used elsewhere within the network is expressed as a level of confidence.

5. The method according to Claim 5 in which the confidence is expressed in the form of a look-up table.

6. The method according to Claim 4 or Claim 5 in which the confidence is expressed as a percentage, 0% corresponding to a high probability that interference will be experienced and 100% corresponding to a very low or zero probability that interference will be experienced.

7. The method according to Claim 4 or Claim 5 in which the confidence is expressed as a CIR value above or below the minimum acceptable CIR for the network.

8. The method according to Claim 7 in which the confidence is expressed in dBs.

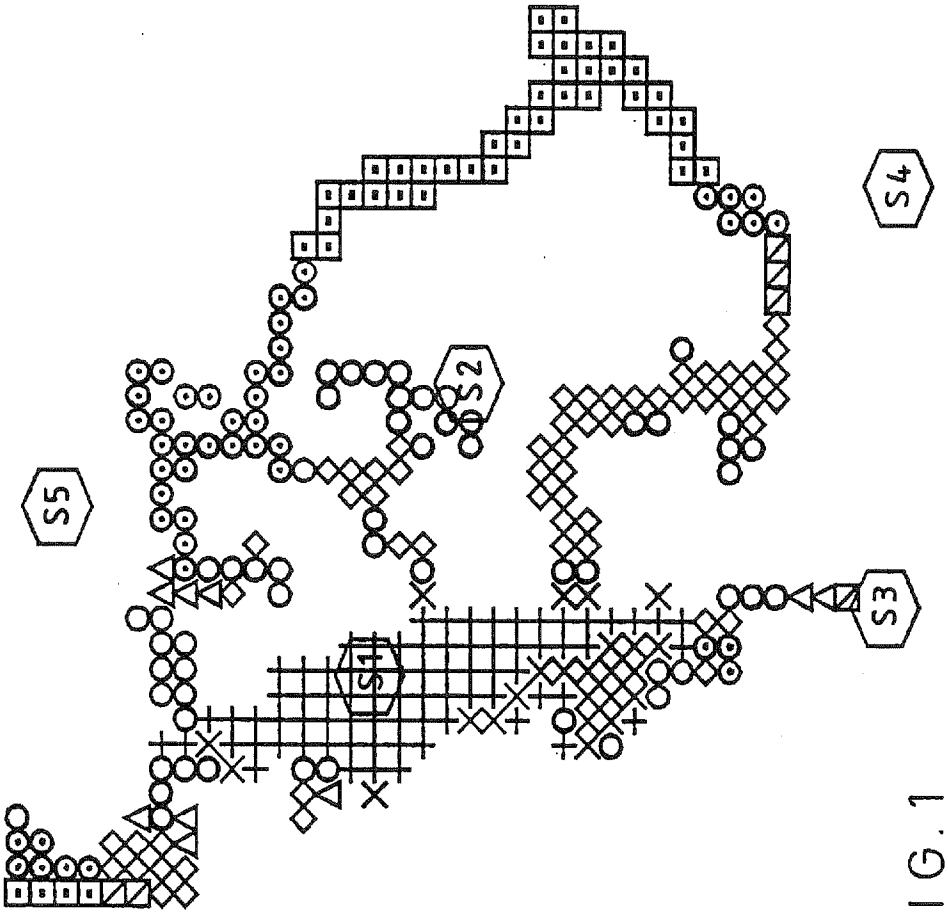


FIG. 1

Signal Strength Ranges:-

- -135 to -110dBm
- -110 to -100dBm
- -100 to -95dBm
- -95 to -90dBm
- -90 to -85dBm
- -85 to -80dBm
- -80 to -75dBm
- -75dBm or above

Sn Location of Cell Site Center

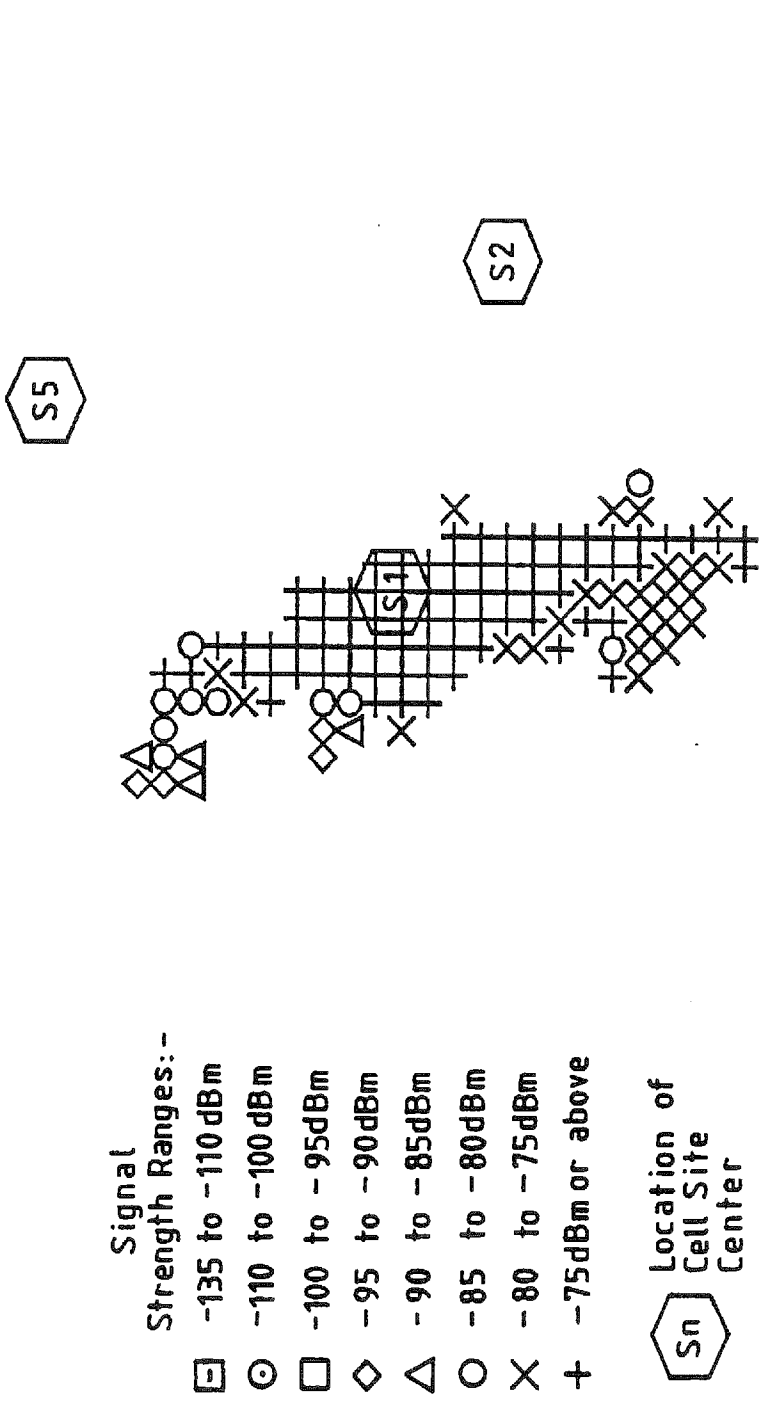

S5
S2
S4
S1
S3
Signal
Strength Ranges:-
-135 to -110 dBm
-110 to -100 dBm
-100 to -95 dBm
-95 to -90 dBm
-90 to -85 dBm
-85 to -80 dBm
-80 to -75 dBm
-75 dBm or above
Sn
Location of
Cell Site
Center

FIG.2

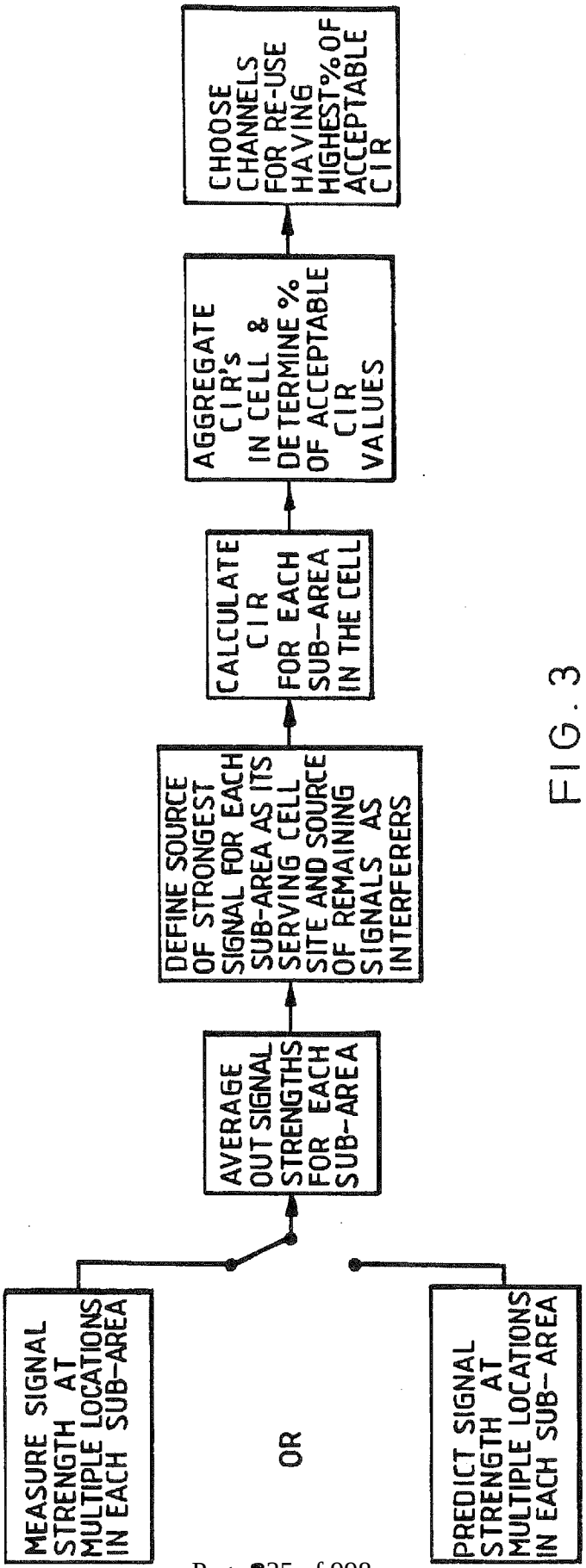

MEASURE SIGNAL STRENGTH AT MULTIPLE LOCATIONS IN EACH SUB-AREA
OR
PREDICT SIGNAL STRENGTH AT MULTIPLE LOCATIONS IN EACH SUB-AREA
AVERAGE OUT SIGNAL STRENGTHS FOR EACH SUB-AREA
DEFINE SOURCE OF STRONGEST SIGNAL FOR EACH SUB-AREA AS ITS SERVING CELL SITE AND SOURCE OF REMAINING SIGNALS AS INTERFERERS
CALCULATE C I R FOR EACH SUB-AREA IN THE CELL
AGGREGATE C I R's IN CELL & DETERMINE % OF ACCEPTABLE C I R VALUES
CHOOSE CHANNELS FOR RE-USE HAVING HIGHEST % OF ACCEPTABLE C I R

FIG. 3

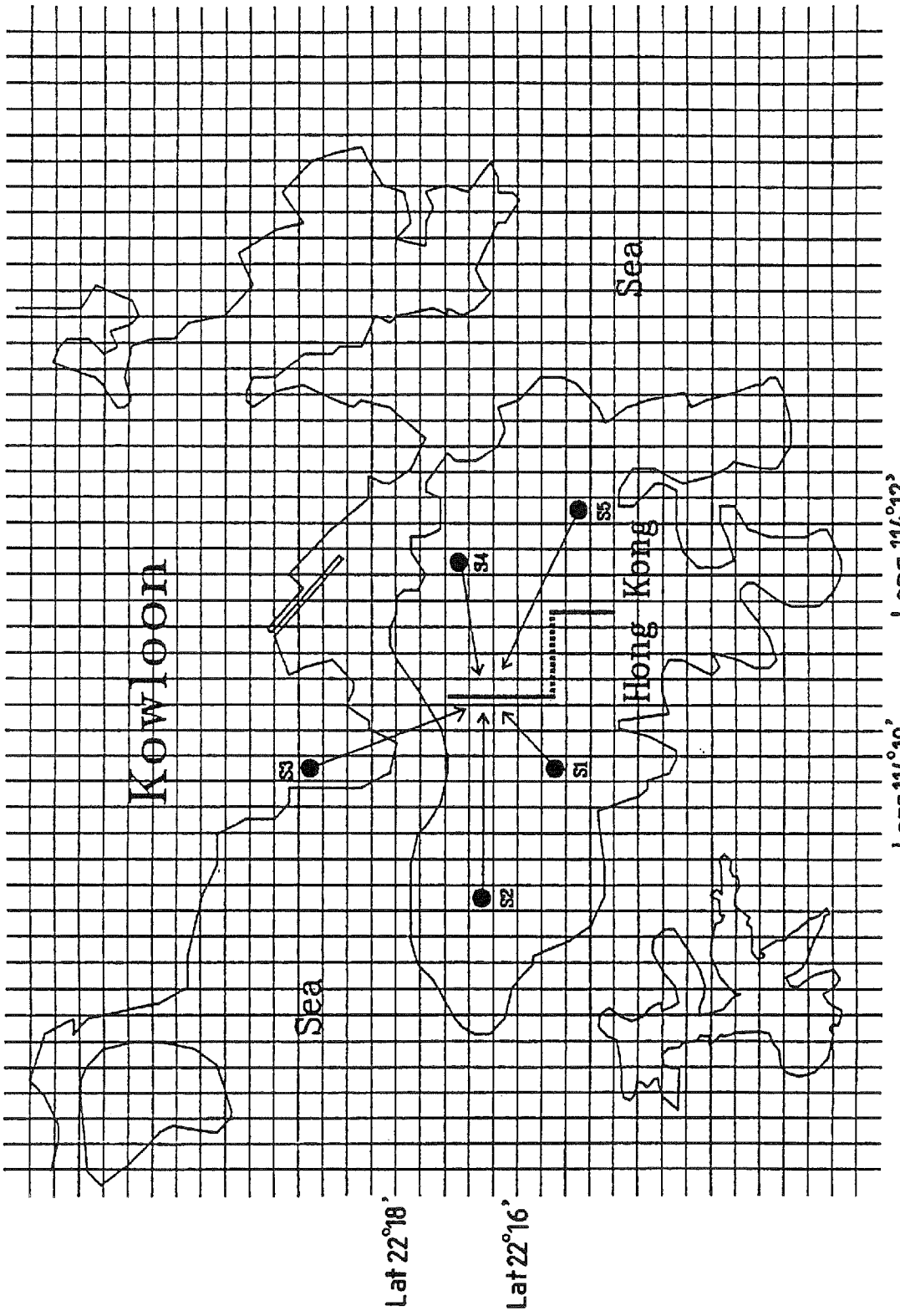
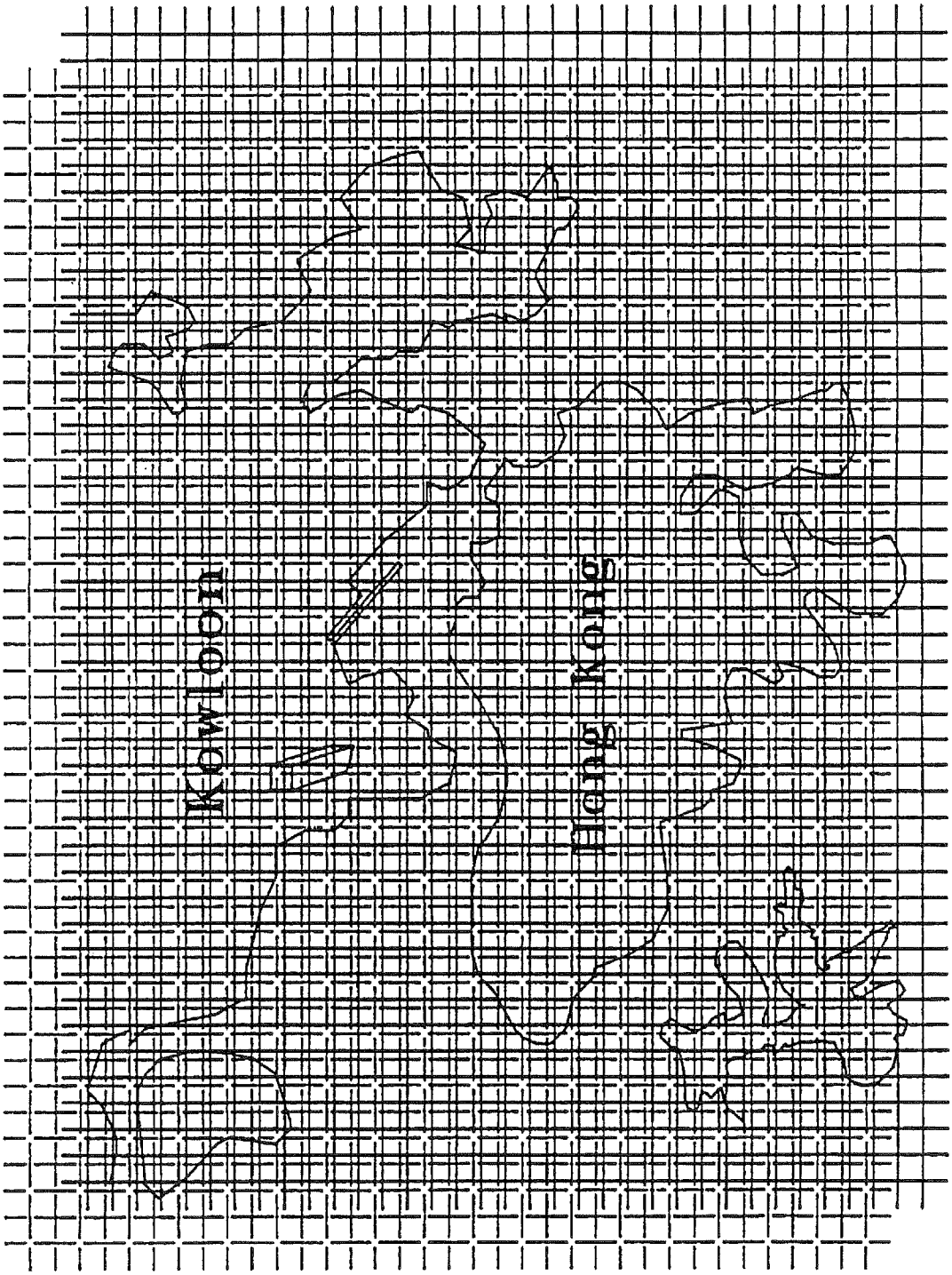


FIG.4

SUBSTITUTE SHEET

FIG.5



RECORD No.	LATITUDE	LONGITUDE	S1 (	S2	S3 dBm	S4	S5)
1	22.309818N	114.169511E	-90	-115	-109	-114	-95
2	22.309901N	114.169149E	-78	-114	-93	-112	-80
3	22.310000N	114.168774E	-70	-114	-99	-101	-75
4	22.310420N	114.168778E	-75	-109	-97	-111	-78
.	.	.	.	.	.	.	.

FIG.6

Sub-area No.	LATITUDE	LONGITUDE	S1 (	S2	S3 dBm	S4	S5)
1	22.309900N	114.169000E	-78	-113	-100	-110	-82
.	.	.	.	.	.	.	.

FIG.7

Confidence	S1	S2	S3	S4	S5
S1	0%	65%	90%	70%	59%
S2	60%	0%	83%	77%	75%
S3	88%	75%	0%	70%	97%
S4	70%	80%	72%	0%	35%
S5	62%	78%	95%	30%	0%

FIG.8

SUBSTITUTE SHEET

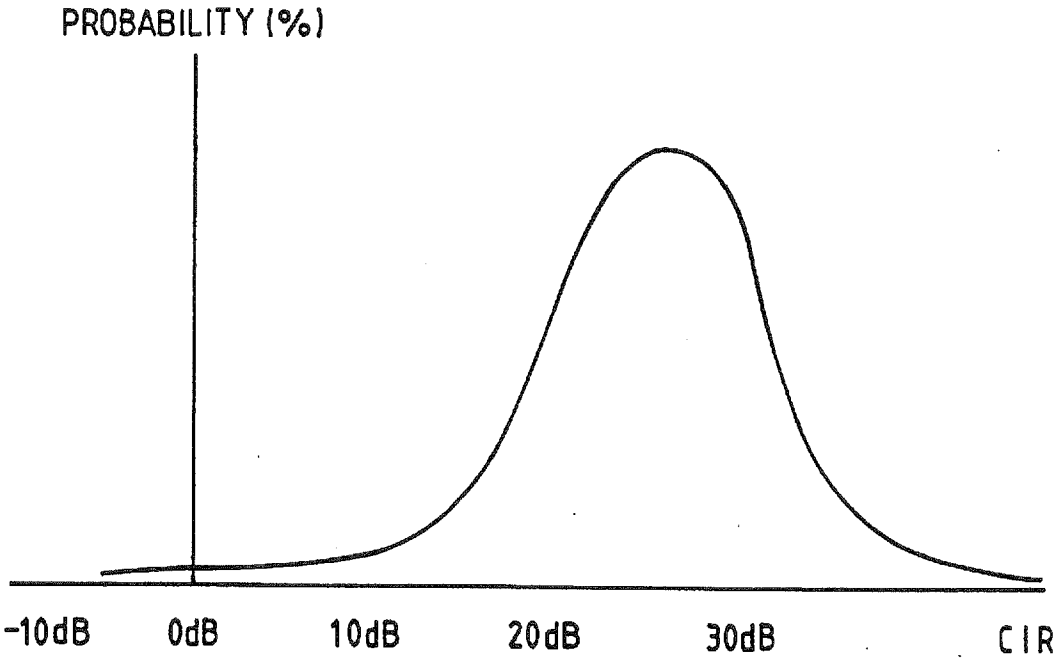

PROBABILITY (%)
-10dB
0dB
10dB
20dB
30dB
CIR

FIG. 9

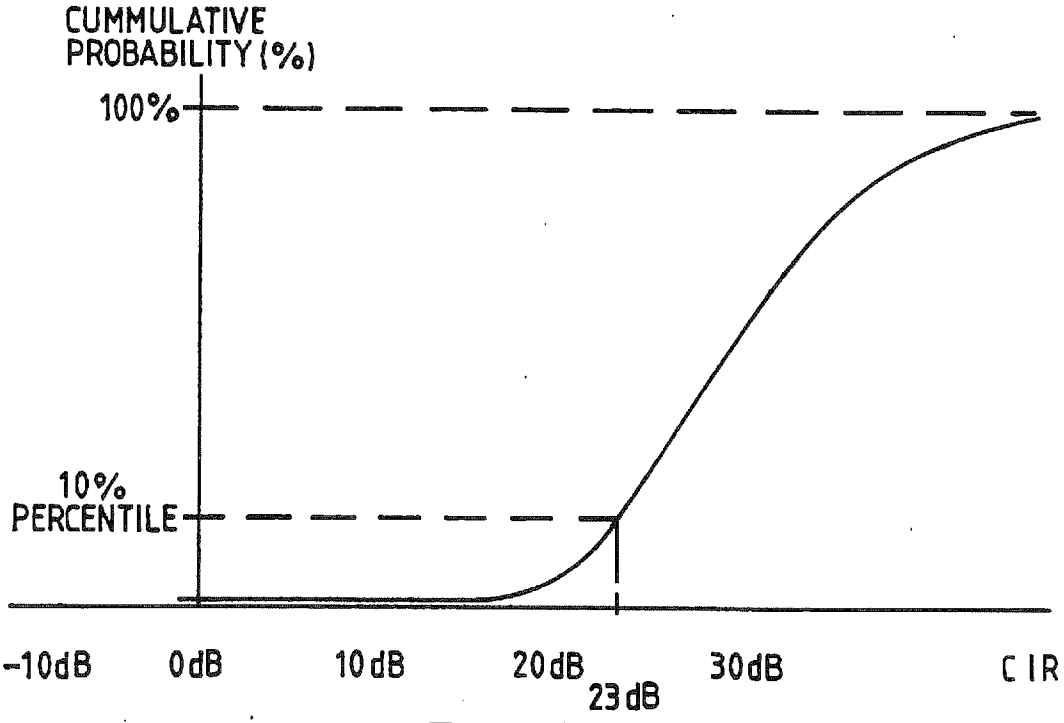

CUMMULATIVE
PROBABILITY (%)
100%
10%
PERCENTILE
-10dB
0dB
10dB
20dB
23dB
30dB
CIR

FIG. 10

Confidence	S1	S2	S3	S4	S5
S1	0dB	12dB	29dB	19dB	10dB
S2	14dB	0dB	23dB	20dB	18dB
S3	25dB	17dB	0dB	15dB	35dB
S4	16dB	21dB	20dB	0dB	4dB
S5	10dB	19dB	38dB	2dB	0dB

FIG.11

SUBSTITUTE SHEET

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 H04B7/26; H04Q7/04

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	H04Q

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	DE,A,4 037 190 (TELEVERKET) 20 June 1991 see column 2, line 26 - line 42 see column 3, line 13 - line 16 see column 5, line 32 - line 43	1
A	WO,A,9 010 341 (TELEVERKET) 7 September 1990 see page 4, line 17 - page 5, line 4 see page 6, line 20 - line 24 see page 9, line 29 - page 13, line 39	1

-/--

° Special categories of cited documents :[10]

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14 SEPTEMBER 1993	30.09.93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	BEHRINGER L.V.

Form PCT/ISA/210 (second sheet) (January 1985)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	IEEE COMMUNICATIONS MAGAZINE. vol. 24, no. 2, February 1986, PISCATAWAY, N.J., US pages 8 - 15 J.F.WHITEHEAD 'Cellular system Design: An Emerging Engineering Discipline' see page 8, right column, line 62 - page 9, left column, line 1 see page 11, right column, line 25 - page 13, right column, line 20	1

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9301126
SA 74620

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A-4037190	20-06-91	SE-B- 465004	08-07-91
		GB-A- 2239319	26-06-91
		SE-A- 8904251	19-06-91
		US-A- 5179722	12-01-93
WO-A-9010341	07-09-90	SE-B- 465146	29-07-91
		EP-A- 0461176	18-12-91
		SE-A- 8900742	04-09-90

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

Electronic Acknowledgement Receipt

EFS ID:	9304934
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and Apparatus for Determining Path Loss by Active Signal Detection
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	79172
Filer:	Mark Charles Comtois/Nicola Kinney
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND01 061 US
Receipt Date:	25-JAN-2011
Filing Date:	15-DEC-2008
Time Stamp:	18:23:04
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	061USIDS.pdf	526022 b432a8f665da3aac60a0cba92d032e1fa3f9556e	no	3

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New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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11/920,076	12/15/2008	John Arpee	AND01 061 US	2431

79172 7590 12/22/2010

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EXAMINER	
SHIVERS, ASHLEY L	
ART UNIT	PAPER NUMBER
2477	
MAIL DATE	DELIVERY MODE
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	11/920,076	ARPEE ET AL.	
	Examiner	Art Unit	
	ASHLEY L. SHIVERS	2477	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *Oct. 11, 2010 (Applicants' Amendment)*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-51* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-51* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *08 November 2007* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Amendment

1. Applicant's amendment filed on October 11, 2010 has been entered. Claims 1, 8, 34-40 and 51 have been amended. No claims are canceled. No claims have been added. Claims 1-51 are still pending in this application, with claims 1, 11, 23, 33 and 41 being independent.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

3. Claims 11-13 and 19-20 are rejected under 35 U.S.C. 102(b) as being anticipated by Gutowski (**U.S. PGPub 2002/0058503**), hereinafter referred to as Gutowski.

Regarding claim 11, Gutowski discloses a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the method comprising the steps of:

identifying a geographic area where the path loss value is to be determined (**A test region is determined; See [0011]**);

identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel (**The scanning receiver receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system; See [0011]**);

receiving at said receiver the signal transmitted from said wireless device on said first frequency channel (**The scanning receiver receives the signals; See [0011]**);

receiving at said receiver an indication of transmission signal strength of said signal (**See [0011]**);

measuring at said receiver the received signal strength of said signal (**The scanning receiver receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system; See [0011]**); and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (**Path loss is measured; See [0014]-[0018]**).

Regarding claim 12, Gutowski further discloses the method of claim 11, further comprising the steps of:

> determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said second frequency channel to a third frequency channel (**If the geographic region of interference is sufficiently great, the channel assignment pattern for the system may be changed. That is, a frequency or a frequency group assigned to an antenna, a sector or a cell (or cells) is typically changed in its entirety to another non-interfering frequency group; See [0012]**).

Regarding claim 13, Gutowski further discloses the method of claim 11, further comprising determining the path loss value for a plurality of geographic areas to compile a database, wherein a test region suggests multiple geographic areas (**See [0011]-[0018] and [0086]**).

Regarding claim 16, Gutowski further discloses the method of claim 11, wherein the wireless device is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager (**mobile unit during a drive test; See [0011]**).

Regarding claim 19, Gutowski further discloses the method of claim 11, further comprising selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute (**See [0011]-[0020]**).

Regarding claim 20, Gutowski further discloses the method of claim 19, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio (**See [0020]**) and carrier-to-interference ratio.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claims 1, 4 and 7-10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Walton et al. (**U.S. Patent No. 6,751,187**), hereinafter referred to as Walton in view of Gutowski.

Regarding claim 1, Walton teaches a method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a

frequency use plan, wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device and disabling the interfering frequency channels within the wireless communication system (**See col. 28, lines 41-65**).

Walton fails to teach of using an active communication channel to determine the signal strength of the wireless device.

Gutowski teaches of performing a drive test on an active communication channel to determine the signal strength of the wireless device (**See [0011]-[0020]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include using an active communication channel to determine the signal strength of the wireless device taught by Gutowski in order to receive real time network power information.

Regarding claim 4, Walton teaches the method of claim 1, but fails to teach of the active communication channel defines a communication channel within the frequency use plan.

Gutowski teaches the active communication channel defining a communication channel within the frequency use plan (**See [0011]-[0020]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include the active communication channel defining any frequency channel within the frequency use plan

taught by Gutowski in order to prevent the reduction of system capacity in the affected cells/sectors.

Regarding claim 7, Walton teaches the method of claim 1, but fails to teach of calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel.

Gutowski teaches of calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel (**See [0011]-[0020]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel taught by Gutowski in order to calculate real time power information.

Regarding claim 8, Walton teaches the method of claim 1, but fails to teach of interfering channels defining frequency channels causing at least one of adjacent channel interference, co-channel interference, inter- symbol interference and cross-rail interference.

Gutowski teaches of the interfering channels defining channels causing at least one of adjacent channel interference, co-interference, inter-symbol interference and cross-rail interference (**See [0020]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include the interfering channels defining channels causing at least one of adjacent channel interference, co-interference, inter-symbol interference and cross-rail interference taught by Gutowski in order to indicate the types of communication that cause a reduction in successful data transmission.

Regarding claim 9, Walton teaches the method of claim 1, but fails to teach of the improvement further comprises using an active communication channel without disabling any interfering channel.

Gutowski teaches of using an active communication channel without disabling any interfering channel (**See [0011]-[0020]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include using an active communication channel without disabling any interfering channel taught by Gutowski in order to eliminate interference without causing a disruption in communication.

Regarding claim 10, Walton teaches the method of claim 1, but fails to teach of the improvement further comprises using an active channel without disrupting the frequency use plan.

Gutowski teaches of using an active channel without disrupting the frequency use plan (**See [0011]-[0020]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include using an active channel without disrupting the frequency use plan taught by Gutowski in order to eliminate interference without causing a disruption in communication.

6. Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Walton in view of Gutowski in further view of Moulsley (**U.S. PGPub 2002/0172160**), hereinafter referred to as Moulsley.

Regarding claim 2, Walton in view of Gutowski teaches the method of claim 1, but fails to teach of the active communication channel defining any frequency channel capable of a duplex communication.

Moulsley teaches of the channel being capable of duplex communication (**See [0025]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton in view of Gutowski to include the channel being capable of duplex communication taught by Moulsley in order to

provide a reverse path for the monitoring an remote adjustment of equipment in the field.

7. Claim 3 is rejected under 35 U.S.C. 103(a) as being unpatentable over Walton in view of Gutowski in further view of Agrawal et al. (**U.S. PGPub 2005/0271012**), hereinafter referred to as Agrawal.

Agrawal teaches the active communication channel defining any frequency channel capable for a simplex communication (**Communication with the base station; See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton in view of Gutowski to include the active communication channel defining any frequency channel capable for a simplex communication taught by Agrawal in order to prevent the reduction of system capacity in the affected cells/sectors.

Regarding claim 5, Walton in view of Gutowski teaches the method of claim 1, but fails to teach of the active communication channel defining a reverse control channel.

Agrawal teaches of the active communication channel defining a reverse control channel (**See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton in view of Gutowski to include the active communication channel defining a reverse control channel taught by Agrawal in order to prevent the reduction of system capacity in the affected cells/sectors.

Regarding claim 6, Walton in view of Gutowski teaches the method of claim 1, but fails to teach of the active communication channel defining a forward control channel.

Agrawal teaches of the active communication channel defining a forward control channel (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton in view of Gutowski to include the active communication channel defining a forward control channel taught by Agrawal in order to prevent the reduction of system capacity in the affected cells/sectors.

8. Claims 14, 17-18, 21-25, 27-40 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gutowski in view of Agrawal.

Regarding claim 14, Gutowski teaches the method of claim 11, but fails to teach of the receiver being a base station.

Agrawal teaches of the receiver being a base station (**See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include the receiver being a base station taught by Agrawal in order to initiate interference cancellation routines.

Regarding claim 17, Gutowski teaches the method of claim 11, but fails to teach of wherein the wireless device is engaged in one of a duplex or a simplex communication.

Agrawal teaches of the device being in communication with a base station (**See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include the wireless device being engaged in one of a duplex or simplex communication taught by Agrawal in order to determine real time statistics.

Regarding claim 18, Gutowski teaches the method of claim 11, but fails to teach of randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver.

Agrawal teaches of randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in

active communication with said receiver (**Selection is made from the "restricted" set of frequency sub-bands; See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver taught by Agrawal in order to increase the likelihood of varied results of the measurements taken.

Regarding claim 21, Gutowski teaches the method of claim 11, but fails to teach of identifying the location of the receiver and the wireless device.

Agrawal teaches of identifying the location of the receiver and the wireless device (**See [0059]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include identifying the location of the receiver and the wireless device taught by Agrawal in order to determine the area being tested for signal strength.

Regarding 22, Gutowski fails to teach a circuitry configured to implement the method of claim 11.

Agrawal teaches of an ASIC within the device (**See [0096]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include circuitry configured to implement the method taught by Agrawal in order to indicate the means for performing the operations.

Regarding claim 23, Gutowski teaches a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system, the method comprising:

identifying a first frequency channel in an active communication between the wireless device and the receiver (**The scanning receiver receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system; See [0011]**);

receiving at the receiver the signal transmitted from said wireless device on said first frequency channel (**The scanning receiver receives the signals; See [0011]**);

receiving at said receiver an indication of transmission signal strength of said signal (**See [0011]**);

measuring at said receiver the received signal strength of said signal (**The scanning receiver receives, identifies and measures the strength of signals**

transmitted by the cells and/or sectors as the mobile unit moves throughout the system; See [0011]); and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (**Path loss is measured; See [0014]-[0018]**).

While Gutowski teaches of locating the wireless device, it fails to teach of geolocating the wireless device and the receiver.

Agrawal teaches of geolocating the receiver and the wireless device (**See [0059]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include geolocating the receiver and the wireless device taught by Agrawal in order to determine the area being tested for signal strength.

Regarding claim 24, Gutowski further teaches the method of claim 23, further comprising the steps of determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said second frequency channel to a third frequency channel (**If the geographic region of interference is sufficiently great, the channel assignment pattern for the system may be changed. That is, a frequency or a frequency group assigned to an antenna, a sector or a cell (or cells) is typically changed in its entirety to another non-interfering frequency group; See [0012]**).

Regarding claim 25, Gutowski further teaches the method of claim 23, further comprising determining the path loss value for a plurality of geographic areas to compile a database, wherein a test region suggests multiple geographic areas (**See [0011]-[0018] and [0086]**).

Regarding claim 27, Gutowski teaches the method of claim 23, but fails to teach of the first frequency channel in active communication is engaged in a simplex communication.

Agrawal teaches of the device being in communication with a base station (**See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include the wireless device being engaged in one of a duplex or simplex communication taught by Agrawal in order to determine real time statistics.

Regarding claim 28 , Gutowski further teaches the method of claim 23, further comprising selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute (**See [0011]-[0020]**).

Regarding claim 29, Gutowski further teaches the method of claim 28, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio (**See [0020]**), inter-symbol interference and carrier-to-interference ratio.

Regarding claim 30, Gutowski teaches the method of claim 23, but fails to teach of the receiver being a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device.

Agrawal teaches of the receiver being a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device (**See Fig. 1**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include the receiver being a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device taught by Agrawal in order to expand the search area for the received signal power.

Regarding claim 31, Gutowski teaches the method of claim 23, but fails to teach of the receiver being a base station or a wireless location sensor ("WLS") or a combination of the base station and a WLS.

Agrawal teaches of the receiver being a base station (**See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include the receiver being a base station taught by Agrawal in order to initiate interference cancellation routines.

Regarding claim 32, Gutowski fails to teach of a circuitry configured to implement the method of claim 23.

Agrawal teaches of an ASIC within the device (**See [0096]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include circuitry configured to implement the method taught by Agrawal in order to indicate the means for performing the operations.

Regarding claim 33, Gutowski teaches a system for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system comprises instructions to:

identify a geographic area where the path loss value is to be determined (**A test region is determined; See [0011]**);

identify a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating

with said receiver using said first frequency channel (**The scanning receiver receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system; See [0011]**);

receive at said receiver the signal transmitted from said wireless device on said first frequency channel (**The scanning receiver receives the signals; See [0011]**);

receive at said receiver an indication of transmission signal strength of said signal (**The scanning receiver receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system; See [0011]**);

measure at said receiver the received signal strength of said signal (**See [0011]**); and

determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (**Path loss is measured; See [0014]-[0018]**).

Gutowski fails to teach of the circuitry , microprocessor, and memory for compiling a database.

Agrawal teaches of circuitry (**ASIC; See [0096]**), microprocessor, and memory for compiling a database (**See Fig. 10**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Gutowski to include the circuitry, microprocessor and memory for compiling a database taught by Agrawal in order to determine the components that make up the receiver.

Regarding claim 34, Gutowski further teaches the system of claim 33, wherein the circuitry is further programmed with instructions to:

> determine a second frequency channel which interferes with said first frequency channel and reassign a second signal using said second frequency channel to a third frequency channel (**If the geographic region of interference is sufficiently great, the channel assignment pattern for the system may be changed. That is, a frequency or a frequency group assigned to an antenna, a sector or a cell (or cells) is typically changed in its entirety to another non-interfering frequency group; See [0012]**).

Regarding claim 35, Gutowski further teaches the system of claim 33, wherein the circuitry is further programmed with instructions to determine the path loss value for a plurality of geographic areas to compile a database, wherein a test region suggests multiple geographic areas (**See [0011]-[0018] and [0086]**).

Regarding claim 36, Gutowski further teaches the system of claim 33, wherein the receiver is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device, pager, base station and wireless location sensor (**See [0011]**).

Regarding claim 37, Gutowski further teaches the system of claim 33, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager (**See [0011]**).

Regarding claim 38, Gutowski teaches the system of claim 33, wherein the wireless device is engaged in one of a simplex or a duplex communication area.

Agrawal teaches of the device being in communication with a base station (**See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Gutowski to include the wireless device being engaged in one of a duplex or simplex communication taught by Agrawal in order to determine real time statistics.

Regarding claim 39, Gutowski teaches the system of claim 33, wherein the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic.

Agrawal teaches of randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver (**Selection is made from the "restricted" set of frequency sub-bands; See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Gutowski to include randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver taught by Agrawal in order to increase the likelihood of varied results of the measurements taken.

Regarding claim 40, Gutowski teaches the system of claim 33, wherein the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute (**See [0011]-[0020]**).

Regarding claim 41, Gutowski teaches an apparatus for determining a path loss value of a signal transmitted from a wireless device and received by a receiver that:

identifies an active communication channel supporting at least one desirable attribute (**The scanning receiver receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system; See [0011] and [0020]**);

identifies the wireless device and the receiver tasked to communicate on said active communication channel (**A test region is determined; See [0011]**);

identifies a transmitted signal strength for signaling on said active communication channel (**The scanning receiver receives the signals; See [0011]**);

identifies a received signal strength for signaling on said active communication channel (**The scanning receiver receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system; See [0011]**); and

calculates the path loss value as a function of the transmitted signal strength and the received signal strength (**Path loss is measured; See [0014]-[0018]**).

Gutowski fails to teach of the means for performing the above operations as well as the means for locating said wireless device and said receiver.

Agrawal teaches of the means for performing operations (**See Fig. 10**) and the means for locating said wireless device and said receiver (**See [0059]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Gutowski to include the means for performing the operations and the means for locating the receiver and the wireless device taught by Agrawal in order to determine how the signals are processed and the area being tested for signal strength.

Regarding claim 42, Gutowski further teaches the apparatus of claim 41, wherein the desirable attribute comprises of at least one of a signal-to-noise ratio, a signal-to-interference ratio (**See [0020]**), an inter-symbol interference and a carrier-to-interference ratio below a threshold value.

Regarding claim 43, Gutowski teaches the apparatus of claim 41, but fails to teach of the means for identifying an active communication channel comprises an antenna, a radio receiver and a microprocessor.

Agrawal teaches of the means comprising a radio receiver and a microprocessor (**See Fig. 10**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Gutowski to include the an antenna, a radio receiver and a microprocessor taught by Agrawal in order to determine the components that make up the receiver.

Regarding claim 44, Gutowski teaches the apparatus of claim 41, but fails to teach of the means for identifying the wireless device and the receiver comprising a microprocessor programmed with instructions to search a database stored in a digital memory.

Agrawal teaches of the microprocessor and memory (**See Fig. 10**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Gutowski to include the means for identifying the wireless device and the receiver comprising a microprocessor programmed with instructions to search a database stored in a digital memory taught by Agrawal in order to indicate how the information is processed.

Regarding claim 46, Gutowski fails to teach the apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a geo-positioning system ("GPS").

Agrawal teaches of a GPS (**See [0059]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Gutowski to include the means for locating said wireless device and said receiver comprising a GPS taught by Agrawal in order to determine the location of the components being tested.

Regarding claim 47, Gutowski further teaches the apparatus of claim 41, wherein the transmitted signal strength defines the signal strength at the wireless device (**See [0011]**).

Regarding claim 48, Gutowski teaches the apparatus of claim 41, and of identifying a transmitted signal strength for signaling on said active communication channel but fails to teach of the means comprising an antenna and a signal detection circuit.

Agrawal teaches of the means for performing operations (**See Fig. 10, #1052x and 1054x**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Gutowski to include the means for identifying a transmitted signal strength taught by Agrawal in order to indicate the components that receive the signals.

Regarding claim 49, Gutowski teaches the apparatus of claim 41, further identifying the wireless device and the receiver further tasking the wireless device and the receiver to signal on said active communication channel, but fails to teach of the means for performing the above operations.

Agrawal teaches of the means for performing the operations (**processor; See Fig. 10**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Gutowski to include the means for identifying the wireless device and the receiver comprising a means for tasking the wireless device and the receiver to signal on said active communication channel taught by Agrawal in order to indicate how the information is processed.

Regarding claim 50, Gutowski teaches the apparatus of claim 41, further comprising detecting a second communication channel interfering with the active communication channel but fails to teach of the means for performing the detecting.

Agrawal teaches of the means for detecting (**controller; See Fig. 10**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Gutowski to include the means for detecting a second communication channel interfering with the active communication channel taught by Agrawal in order to indicate how the information is controlled.

Regarding claim 51, Gutowski teaches the apparatus of claim 50, further comprising reassigning the second communication channel to a third communication channel but fails to teach of the means for performing the operations.

Agrawal teaches of the means for reassigning the channel (**processor; See Fig. 10**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Gutowski to include the means for reassigning the second communication channel to a third communication channel taught by Agrawal in order to indicate how the information is processed.

9. Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over Gutowski in view of Stilp (**U.S. PGPub 2002/0172223**), hereinafter referred to as Stilp.

Regarding claim 15, Gutowski teaches a method of claim 11, but fails to teach of the receiver being a wireless location sensor.

Stilp teaches of the receiver being a wireless location sensor (**See [0017]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski to include the receiver being a wireless location sensor taught by Stilp in order to make highly accurate TDOA and FDOA measurements.

10. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Gutowski in view of Agrawal in further view of Moulsley.

Regarding claim 26, Gutowski in view of Agrawal teaches the method of claim 23, but fails to teach of the first frequency channel in active communication is engaged in a duplex communication.

Moulsley teaches of the channel being engaged in a duplex communication (**See [0025]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Gutowski in view of Agrawal to include the channel being capable of duplex communication taught by Moulsley in order to provide a reverse path for the monitoring an remote adjustment of equipment in the field.

11. Claim 45 is rejected under 35 U.S.C. 103(a) as being unpatentable over Gutowski in view of Agrawal in further view of Stilp.

Regarding claim 45, Gutowski in view of Agrawal teaches the apparatus of claim 41, but fails to teach of the means for locating said wireless device and said receiver comprising a wireless location system.

Stilp teaches of the receiver being a wireless location sensor (**See [0017]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Gutowski in view of Agrawal to include the means for locating said wireless device and said receiver comprising a wireless location system taught by Stilp in order to make highly accurate TDOA and FDOA measurements.

Response to Arguments

12. Applicant's arguments, see pages 12-15, filed October 11, 2010, with respect to the rejection(s) of claim(s) 1, 2-6 and 8-10 under Walton et al. (**U.S. Patent No. 6,751,187**), hereinafter referred to as Walton in view of Agrawal et al. (**U.S. PGPub 2005/0271012**), hereinafter referred to as Agrawal have been fully considered and are persuasive. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made using Walton et al. (**U.S. Patent No. 6,751,187**), hereinafter referred to as Walton and various combinations of Gutowski (**U.S. PGPub 2002/0058503**), hereinafter referred to as Gutowski, Agrawal and Moulsley (**U.S. PGPub 2002/0172160**), hereinafter referred to as Moulsley.

On pages 12-15 of the Applicants' Response, Applicants state that Walton in view of Agrawal fails to teach of using an active communication channel to determine the signal strength of the wireless device.

Examiner agrees and has thus removed the above references from consideration, however upon further examination, Examiner has introduced Gutowski to teach of using an active communication channel to determine the signal strength of the wireless device while performing a drive test of a test region (**See [0011]-[0018]**).

13. Applicant's arguments, see pages 15-17, filed October 11, 2010, with respect to the rejection(s) of claim(s) 11-51 under Agrawal in view of Garceran et al. (**U.S. Patent No. 6,522,888**), hereinafter referred to as Garceran have been fully considered and are

persuasive. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made using Gutowski in view of various combinations of Agrawal, Stilp (**U.S. PGPub 2002/0172223**), hereinafter referred to as Stilp, Moulsley.

On pages 15-17 of the Applicants' Response, Applicants state that Agrawal in view of Garceran fails to teach of determining signal strength of an active communication channel.

Examiner agrees and has thus removed the above references from consideration, however upon further examination, Examiner has introduced Gutowski to teach of determining the signal strength of an active communication channel while performing a drive test of a test region (**See [0011]-[0018]**).

Conclusion

14. Any response to this action should be **faxed** to (571) 273-8300 or **mailed** to:

Commissioner of Patents,
P.O. Box 1450
Alexandria, VA 22313-1450

Hand delivered responses should be brought to:
Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

15. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ASHLEY L. SHIVERS whose telephone number is (571) 270-3523. The examiner can normally be reached on Monday-Friday 8:30-5:00 EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chirag Shah can be reached on (571) 272-3144. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/A. L. S./
Examiner, Art Unit 2477
12/17/2010

/KWANG B. YAO/
Supervisory Patent Examiner, Art Unit 2473

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
1192007 6	11920076	ARPEE ET AL.
	Examiner	**Art Unit**
	ASHLEY L SHIVERS	2477

SEARCHED			
Class	**Subclass**	**Date**	**Examiner**

SEARCH NOTES		
Search Notes	**Date**	**Examiner**
(path near2 loss) and ((receive$1 near2 signal) or (receive$1 near2 power) or RSS or RSSI) and(455/1,422.1,423,424,456.1,464,39,41.2,501,513,515,522,526,63.1,67.11,67.13,67.14,105,114.2,115.1,115.2,115.3,130,134-135,150.1,151.2,152.1,154.1,161.3,206,226.1,226.3,227,277.2,278.2,283,296,).ccls. and (370/431,433,437,442-443,464,480).ccls	7/2/2010	Ashley Shivers
See EAST Search History	7/2/2010	Ashley Shivers
Performed Double Patenting Search	7/2/2010	Ashley Shivers
Updated EAST Search History	12/17/2010	Ashley Shivers

INTERFERENCE SEARCH			
Class	**Subclass**	**Date**	**Examiner**

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
11920076	11920076	ARPEE ET AL.
	Examiner	**Art Unit**
	ASHLEY L SHIVERS	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/03/2010	12/17/2010							
	1	✓	✓							
	2	✓	✓							
	3	✓	✓							
	4	✓	✓							
	5	✓	✓							
	6	✓	✓							
	7	✓	✓							
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	27	✓	✓							
	28	✓	✓							
	29	✓	✓							
	30	✓	✓							
	31	✓	✓							
	32	✓	✓							
	33	✓	✓							

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
1192007 6	11920076	ARPEE ET AL.
	Examiner	Art Unit
	ASHLEY L SHIVERS	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/03/2010	12/17/2010							
	34	✓	✓							
	35	✓	✓							
	36	✓	✓							
	37	✓	✓							
	38	✓	✓							
	39	✓	✓							
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	42	✓	✓							
	43	✓	✓							
	44	✓	✓							
	45	✓	✓							
	46	✓	✓							
	47	✓	✓							
	48	✓	✓							
	49	✓	✓							
	50	✓	✓							
	51	✓	✓							

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	134	"path loss" and "drive test"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/15 18:16
S2	112	S1 and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/15 18:17
S3	5613	"path loss" and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:05
S4	3499	S3 and ("370" or "455" or "709").clas.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:05
S5	76	S4 and 370/229-236.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:05
S6	2	"5799005".pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:07
S7	5613	"path loss" and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:31

S8	3499	S7 and ("370" or "455" or "709").clas.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:31
S9	76	S8 and 370/229-236.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:31
S10	60	S9 and (locat$4 or geo $1locat$4 or GPS)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:31
S11	58	S9 and interfer$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:31
S12	7	(S11 or S10) and (frequenc $4 near2 (use or re$1use))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 01:34
S13	2	"20030129987".pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:15
S14	1716	(calculat$4 or measur$4 or determin$4) with "path loss" and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:19
S15	1252	S14 and ("370" or "455" or "709").clas.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:19

S16	1105	S15 not disabl$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:20
S17	946	S16 and interfer$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:20
S18	804	S17 and (locat$4 or GPS or geo$1locat$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:21
S19	371	S18 and "370".clas.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:22
S20	144	"path loss" and (drive near2 test)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:27
S21	119	S20 and (@ad<"20050517" or @rlad<"20050517" or @ptad<"20050517" or @pd<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:27
S22	79	S21 and ("370" or "455" or "709").clas.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 19:27
S23	2	"5862124".pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 21:32

S24	2	"6526279".pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/17 21:39

EAST Search History (Interference)

<This search history is empty>

12/17/2010 11:39:07 PM
C:\Documents and Settings\ashivers\My Documents\EAST\Workspaces\11920076 - 2nd search.wsp

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of John Arpee, et al.

Serial No.: 11/920,076 Art Unit: 2477

Filed: December 15, 2008 Examiner: Ashley L. Shivers

Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

RESPONSE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action mailed July 12, 2010, Applicant submits the following:

Applicant's **Amendment to the Claims** begins on sheet 2 of this paper.

Applicant's **Remarks** begin on sheet 11 of this paper.

Amendment to the Claims:

1. (Currently Amended) In a method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan, wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device and disabling interfering frequency channels within the wireless communication system, the improvement ~~comprising~~ comprises using an active communication channel to determine the signal strength of the wireless device.

2. (Original) The method of claim 1, wherein the active communication channel defines any frequency channel capable of a duplex communication.

3. (Original) The method of claim 1, wherein the active communication channel defines any frequency channel capable for a simplex communication.

4. (Original) The method of claim 1, wherein the active communication channel defines a communication channel within the frequency use plan.

5. (Original) The method of claim 1, wherein the active communication channel defines a reverse control channel.

6. (Original) The method of claim 1, wherein the active communication channel defines a forward control channel.

7. (Original) The method of claim 1, further comprising calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel.

8. (Currently Amended) The method of claim 1, wherein interfering channels define frequency channels causing at least one of adjacent channel interference, co-channel interference, ~~inter-symbol interference,~~ inter-symbol interference and cross-rail interference.

9. (Original) The method of claim 1, wherein the improvement further comprises using an active communication channel without disabling any interfering channel.

10. (Original) The method of claim 1, wherein the improvement further comprises using an active channel without disrupting the frequency use plan.

11. (Original) A method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the method comprising the steps of:

identifying a geographic area where the path loss value is to be determined;

identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel;

receiving at said receiver the signal transmitted from said wireless device on said first frequency channel;

receiving at said receiver an indication of transmission signal strength of said signal;

measuring at said receiver the received signal strength of said signal; and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

12. (Original) The method of claim 11, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel; and

reassigning a second signal using said second frequency channel to a third frequency channel.

13. (Original) The method of claim 11, further comprising determining the path loss value for a plurality of geographic areas to compile a database.

14. (Original) The method of claim 11, wherein the receiver is a base station.

15. (Original) The method of claim 11, wherein the receiver is a wireless location sensor.

16. (Original) The method of claim 11, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager.

17. (Original) The method of claim 11, wherein the wireless device is engaged in one of a duplex or a simplex communication.

18. (Original) The method of claim 11, further comprising randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver.

19. (Original) The method of claim 11, further comprising selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute.

20. (Original) The method of claim 19, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio and carrier-to-interference ratio.

21. (Original) The method of claim 11, further comprising identifying the location of the receiver and the wireless device.

22. (Original) A circuitry configured to implement the method of claim 11.

23. (Original) A method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system, the method comprising:

identifying a first frequency channel in an active communication between the wireless device and the receiver;

geolocating the wireless device and the receiver;

receiving at the receiver the signal transmitted from said wireless device on said first frequency channel;

receiving at said receiver an indication of transmission signal strength of said signal;

measuring at said receiver the received signal strength of said signal; and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

24. (Original) The method of claim 23, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel; and

reassigning a second signal using said second frequency channel to a third frequency channel.

25. (Original) The method of claim 23, further comprising determining the path loss value for a plurality of geographic areas to compile a database.

26. (Original) The method of claim 23, wherein the first frequency channel in active communication is engaged in a duplex communication.

27. (Original) The method of claim 23, wherein the first frequency channel in active communication is engaged in a simplex communication.

28. (Original) The method of claim 23, further comprising selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute.

29. (Original) The method of claim 28, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio, inter-symbol interference and carrier-to-interference ratio.

30. (Original) The method of claim 23, wherein the receiver is a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device.

31. (Original) The method of claim 23, wherein the receiver is a base station or a wireless location sensor ("WLS") or a combination of the base station and a WLS.

32. (Original) A circuitry configured to implement the method of claim 23.

33. (Original) A system for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system comprising:

a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to:

identify a geographic area where the path loss value is to be determined;

identify a first cell, a first sector, and a first frequency channel associated with the

geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel;

receive at said receiver the signal transmitted from said wireless device on said first frequency channel;

receive at said receiver an indication of transmission signal strength of said signal;

measure at said receiver the received signal strength of said signal; and

determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

34. (Currently Amended) The system ~~method~~ of claim 33, wherein the circuitry is further programmed with instructions to:

determine a second frequency channel which interferes with said first frequency channel; and

reassign a second signal using said second frequency channel to a third frequency channel.

35. (Currently Amended) The system ~~method~~ of claim 33, wherein the circuitry is further programmed with instructions to determine the path loss value for a plurality of geographic areas to compile a database.

36. (Currently Amended) The system ~~method~~ of claim 33, wherein the receiver is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device, pager, base station and wireless location sensor.

37. (Currently Amended) The system ~~method~~ of claim 33, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager.

38. (Currently Amended) The system ~~method~~ of claim 33, wherein the wireless device is engaged in one of a simplex or a duplex communication area.

39. (Currently Amended) The system ~~method~~ of claim 33, wherein the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic.

40. (Currently Amended) The system ~~method~~ of claim 33, wherein the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute.

41. (Original) An apparatus for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, comprising:

means for identifying an active communication channel supporting at least one desirable attribute;

means for identifying the wireless device and the receiver tasked to communicate on said active communication channel;

means for locating said wireless device and said receiver;

means for identifying a transmitted signal strength for signaling on said active communication channel;

means for identifying a received signal strength for signaling on said active communication channel; and

means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

42. (Original) The apparatus of claim 41, wherein the desirable attribute comprises of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value.

43. (Original) The apparatus of claim 41, wherein the means for identifying an active communication channel comprises an antenna, a radio receiver and a microprocessor.

44. (Original) The apparatus of claim 41, wherein the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory.

45. (Original) The apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a wireless location system.

46. (Original) The apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a geo-positioning system ("GPS").

47. (Original) The apparatus of claim 41, wherein the transmitted signal strength defines the signal strength at the wireless device.

48. (Original) The apparatus of claim 41, wherein the means for identifying a transmitted signal strength for signaling on said active communication channel comprises an antenna and a signal detection circuit.

49. (Original) The apparatus of claim 41, wherein means for identifying the wireless device and the receiver further comprises means for tasking the wireless device and the receiver to signal on said active communication channel.

50. (Original) The apparatus of claim 41, further comprising means for detecting a second communication channel interfering with the active communication channel.

51. (Currently Amended) The apparatus of claim 50, further comprising means for reassigning the second communication channel to a third communication channel.

REMARKS

Claims 1-51 are pending with entry of this paper.

Claims 1-51 stand rejected.

Objection to the Drawings

On page 2 of the Action, the Office objected to the drawings as not showing every feature of the invention specified in the claims. More specifically, the Office stated that the antenna, radio receiver and microprocessor of claim 43, the microprocessor, database and memory of claim 44, the WLS of claim 45, the GPS of claim 46 and the antenna and signal detection circuit of claim 48 must be shown or the features cancelled from the claim.

Applicant respectfully directs the attention of the Office to Figure 1 which is a schematic representation of a cellular communication system. With reference to Figure 1 and the attendant paragraphs in the published specification (see paragraphs [0015]-[0017], the claimed receiver 120 is shown, whereby the receiver 120 may include a WLS (see paragraph [0015]) and directional antennas may also be used at the receiver (see paragraph [0015]). It is well known that such a receiver or the system itself may include a microprocessor, applicable circuitry, a database and/or memory as claimed. Thus, where the elements are not explicitly shown in Figure 1, the elements identified by the Office would be conventional features disclosed in the description where their detailed illustration are not essential for a proper understanding of the claimed subject matter. For at least these reasons, Applicant respectfully requests reconsideration and withdrawal of the objection to the drawings.

Objection to the Claims

Applicant has amended the claims to correct the informalities identified by the Office. Reconsideration and withdrawal of the objection to the claims is respectfully requested.

The § 103(a) Rejections

At paragraph 4 of the Office Action, the Office improperly rejected Claims 1, 3-6 and 8-10 as being unpatentable by Walton in view of Agrawal. In the instant rejection, however, it is apparent that the Office misunderstood what these references fairly teach and has misapplied and improperly combined the two references in a rejection of the claimed subject matter. For these reasons at least the rejection is improper on its face.

1. Walton

Walton is generally directed to techniques for processing data for transmission in a wireless communication system using selective channel transmission and defined transmit power allocation. *See* 1:16-20 and 1:60-63. More specifically, Walton teaches several embodiments of network capacity or allocation plans by (1) determining a set of transmission channels using selective channel transmission as a function of channel state information (CSI); (2) allocating available transmit power to selected transmission channels as a function of CSI; and (3) processing data for selected transmission channels using certain coding schemes. *See* 4:30-5:18. The portion of Walton cited by the Office (28:41-65) for a teaching of portions of Claim 1 is directed to an embodiment of (1) above – namely – prior to data transmission, a data bit may be used (0 or 1) to enable or disable a specific channel. Another embodiment described in this section of Walton also describes using run-length coding indicative of the channel to identify the channel – again, prior to data transmission.

What Walton fails to teach – as admitted by the Office – is "using an active communication channel to determine the signal strength of the wireless device" as claimed. The Office attempts to utilize Agrawal to supplement this deficiency; however, the Office has misread the fair teachings of Agrawal and has improperly combined these two references.

2. The mischaracterization of Agrawal in the rejection of Claim 1

In the rejection of Claim 1, the Office mischaracterized and misapplied the teachings of Agrawal with regard to the element of each of "using an active communication channel to determine the signal strength of the wireless device." For example, the Office states that, at paragraphs [0011], [0029] and [0035], the receipt of a reverse link signal is somehow analogous to this element. Applicant cannot find any recitation of a teaching of the claimed subject matter in these cited sections of Agrawal, and Applicant does not understand how the mere receipt of a signal from a wireless device on a reverse link can be a disclosure of "using an active communication channel to determine the signal strength of the wireless device." Clarification in this regard is respectfully requested.

To the contrary, Agrawal is directed to implementation of a soft handoff in a frequency reuse scheme. *See* paragraphs [0008]-[0009] and [0011]. To do so, Agrawal allocates sub bands in a usable channel set to users in a sector by taking into account the users' channel conditions. *See* Table 1. For example, Sector x of a multi-sector cell may allocate any of the sub bands in a usable set to strong users (users in a sector with no interference) and may allocate sub bands in restricted sets to weak users. *See* Table 1 and paragraph [0051]. These usable and/or restricted (or forbidden) sets may be determined based on pilot signal measurements. *See* [0056]. As the Office is aware, a pilot signal is generally a sine wave tone utilized for receiver synchronization. The power of this pilot tone is typically 1%-10% of the total transmitted power. It is also known that the sensing receiver has a perfect knowledge of the pilot signal and may perform appropriate (e.g., coherent) processing of the signal (usually by a matched filter or the like).

What the Office has done in this case, however, has improperly and incorrectly equated a mere disclosure of "pilot measurement" in Agrawal is the same as a disclosure or teaching of

determining signal strength of an active communication channel. This is incorrect. First, there is no disclosure in Agrawal to support such a position. Indeed, it appears that Agrawal merely detects the presence of a pilot signal and compares this against a power threshold. *See* [0056]-[0057]. Second, as the Office is surely aware, it is well known in the art that a "pilot measurement" may be a myriad of different possibilities and the equating of this phrase to the claimed subject matter is improper. For example, depending upon the circuitry of the receiver, a pilot measurement may be a measurement of the sinusoidal waveform, may be a measurement of phase, may be a measurement of the phase-error, may be a measurement of power (as it appears is disclosed in Agrawal), may be a measurement of SNR, and so forth. Third, Applicant asks the Office how a pilot signal (or even the signal strength thereof – which was not expressly disclosed in Agrawal) could be indicative of the signal strength of a signal from a wireless device on an active communication channel. As the Office is aware, this active communication channel is one which is "in use" (*i.e.,* being used for communication with another subscriber) by the device (see paragraphs [0021]-[0023] of Applicant's specification). Thus, it appears that the Office is improperly and incorrectly equating a pilot signal and/or measurement thereof to an actual communication signal in this case.

Therefore, the conclusion provided by the Office in its rejection is both without merit in the reference of record and appears to be a mere conclusory statement. As the Office is aware, a "rejection[] on obviousness cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *KSR*, 550 U.S. at 418, 82 USPQ2d at 1396 *quoting In re Kahn*, 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006).

3. The improper combination of Agrawal and Walton

While the cited references overlap in the regard they are directed to wireless communication systems and usage of channels for data transmission, Applicant does not understand how they could ever be combined to teach the claimed subject matter. Rather, as stated above, Agrawal is directed to a frequency reuse scheme to effect a soft handover between cells in the network and Walton is directed to network capacity or allocation plans as a function of channel state information (*e.g.*, coding schemes available on the channel, logical state of an inserted data bit, etc.). None of these references teach, alone or in combination, a method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system by using an active communication channel to determine the signal strength of the wireless device. To state otherwise would be an unsupported conclusion (which was apparently performed by the Office) and cuts against *KSR* and its progeny. For at least these reasons, the rejection of Claim 1 and those claims dependent thereon is improper and should be withdrawn.

4. The rejection of independent Claims 11, 23, 33 and 41

On pages 10-28 the Office improperly rejected Claims 11-51 as being unpatentable by Agrawal in view of Garceran and other references. Again, this rejection under Section 103(a) appears to be premised upon a misunderstanding of what these references fairly teach and a subsequent misapplication and improper combination thereof. For this reason at least the rejection is improper on its face.

As discussed above, Agrawal is directed to implementation of a soft handoff in a frequency reuse scheme. *See* paragraphs [0008]-[0009] and [0011]. Agrawal allocates sub bands in a usable channel set to users in a sector by taking into account the users' channel conditions. *See* Table 1 and paragraph [0051]-[0056]. In the instant case, however, the Office improperly and incorrectly

equated a mere disclosure of "pilot measurement" in Agrawal to a disclosure or teaching of determining signal strength of an active communication channel. For the reasons discussed above, there is no disclosure in Agrawal to support such a position. Additionally, as discussed above, the disclosed pilot measurement in Agrawal may be a measurement of the sinusoidal waveform, may be a measurement of phase, may be a measurement of the phase-error, may be a measurement of power (as it appears is disclosed in Agrawal), may be a measurement of SNR, and so forth. Thus, a mere possibility (without more) is a meritless conclusion expressly forbidden by *KSR* and its progeny.

What is quizzical about the rejection of independent Claims 11, 23, 33 and 41 is that the Office improperly and incorrectly alleges (as discussed above) that a receiver of Agrawal receives signal strength of said signal but later admits that Agrawal "fails to teach...receiving the transmit signal strength of said signal..." *See, e.g.,* pp. 10, 15, 19 and 23. Applicant wholeheartedly agrees with the Office that Agrawal fails to teach this element but also posits that, as discussed above, Agrawal fails to teach that a "pilot measurement" can be attributable to the claimed "measuring at said receiver the received signal strength of said signal." For at least these reasons, the burden of the Office in formulating its rejection under Section 103(a) is incorrect and the rejection must be withdrawn; however, as discussed above, the disclosure of the primary reference is utterly lacking and for this substantive reason, the rejection of independent Claims 11, 23, 33 and 41, and those claims dependent thereon, should also be withdrawn.

5. The combination of Garceran and Agrawal

Applicant does not understand how the Office can support its position that Garceran and Agrawal may be combined. For example, Garceran is directed to cell site planning. *See* 1:9-11, 1:56-8. Rather than performing a manual collection of data in a network (drive testing), Garceran

discloses determining/receiving location information for a wireless device and determining radio frequency (RF) coverage for an applicable cell/area in a network. *See* 1:59-2:28.

In the instant case, however, it appears that the Office performed a word search for "path loss" and blindly applied this disclosure to the claimed subject matter. For example, Garceran certainly discloses determining path loss in a network. *See* 11:10-12:11 and Figs 6A-6B. This path loss, however, is an embodiment of the location information described in 1:59-2:28 and is explicitly used to for cell site planning (RF coverage). *See* 11:10-13. Thus, it is breathtaking how the Office can take the position that a mere disclosure of path loss in a cell site planning reference (Garceran) could be combined with a reference directed to the implementation of a soft handoff in a frequency reuse scheme (Agrawal). Clearly, the Office has again jumped to a meritless and unsupported conclusion which is expressly forbidden by *KSR* and its progeny. For at least the reasons discussed above, the rejection of independent Claims 11, 23, 33 and 41, and those claims dependent thereon, should also be withdrawn.

CONCLUSION

Applicant submits the subject application is in condition for allowance and as such respectfully requests allowance of the application.

If the Examiner has any questions relating to this response or the application in general he is respectfully requested to contact the undersigned so that prosecution may be expedited.

The Commissioner is hereby authorized to charge payment of any additional fees associated with this communication or credit any overpayment to Deposit Account No. 04-1679. A duplicate of this sheet is enclosed.

Respectfully submitted,

/Mark C. Comtois/
Mark C. Comtois Reg. No. 46,285

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Date: October 11, 2010

Electronic Acknowledgement Receipt

EFS ID:	8597613
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and Apparatus for Determining Path Loss by Active Signal Detection
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	79172
Filer:	Mark Charles Comtois/laureen ponder
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND01 061 US
Receipt Date:	11-OCT-2010
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Application Type:	U.S. National Stage under 35 USC 371

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		AND01061Resp.pdf	2239259 bb4fd2f513a5947647d3f36eec887d23a82c884e	yes	18

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	10
	Applicant Arguments/Remarks Made in an Amendment	11	18
Warnings:			
Information:			
	Total Files Size (in bytes):	2239259	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
11/920,076	12/15/2008	

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY ☐ FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT 10/11/2010	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 51	Minus	** 51	= 0	X $ =		OR	X $52=	0
Independent (37 CFR 1.16(h))	* 5	Minus	***5	= 0	X $ =		OR	X $220=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/EFREM WARREN/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/920,076	12/15/2008	John Arpee	AND01 061 US	2431

79172 7590 07/12/2010

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EXAMINER	
SHIVERS, ASHLEY L	
ART UNIT	PAPER NUMBER
2477	
MAIL DATE	DELIVERY MODE
07/12/2010	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	11/920,076	ARPEE ET AL.	
	Examiner	Art Unit	
	ASHLEY L. SHIVERS	2477	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *08 November 2007*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-51* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-51* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *08 November 2007* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Drawings

1. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the antenna, radio receiver and microprocessor of claim 43, the microprocessor, database and memory of claim 44, the wireless location system of claim 45, the GPS of claim 46, and the antenna and signal detection circuit of claim 48 must be shown or the features canceled from the claims. No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the

examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Objections

2. Claims 1, 34-40 and 51 are objected to because of the following informalities:

--In claim 1, replace –the improvement comprising—with –the improvement comprises:--.

--In claim 8, remove one instance of –inter-symbol interference--.

--Claims 34-40 are dependent on claim 33 which is a system claim, but claims 34-40 are indicated as method claims. Please correct to indicate that they are dependent on the system of claim 33.

--Insert a period at the end of claim 51.

Appropriate correction is required.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1, 3-6 and 8-10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Walton et al. (**U.S. Patent No. 6,751,187**), hereinafter referred to as Walton in view of Agrawal et al. (**U.S. PGPub 2005/0271012**), hereinafter referred to as Agrawal.

Regarding claim 1, Walton teaches a method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan, wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device and disabling the interfering frequency channels within the wireless communication system (**See col. 28, lines 41-65**).

Walton fails to teach of using an active communication channel to determine the signal strength of the wireless device.

Agrawal teaches of using an active communication channel to determine the signal strength of the wireless device (**Receive the reverse link signal transmitted by the terminal at the serving and non-serving sectors; See Fig. 9, #912, [0011], [0029] and [0035]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include using an active communication channel to determine the signal strength of the wireless device taught by Agrawal in order to prevent the reduction of system capacity in the affected cells/sectors.

Regarding claim 3, Walton teaches the method of claim 1, but fails to teach of the active communication channel defining any frequency channel capable for a simplex communication.

Agrawal teaches the active communication channel defining any frequency channel capable for a simplex communication (**Communication with the base station; See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include the active communication channel defining any frequency channel capable for a simplex communication taught by Agrawal in order to prevent the reduction of system capacity in the affected cells/sectors.

Regarding claim 4, Walton teaches the method of claim 1, but fails to teach the active communication channel defines a communication channel within the frequency use plan.

Agrawal teaches the active communication channel defining a communication channel within the frequency use plan (**See [0010]-[0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include the active communication channel defining any frequency channel within the frequency use plan

taught by Agrawal in order to prevent the reduction of system capacity in the affected cells/sectors.

Regarding claim 5, Walton teaches the method of claim 1, but fails to teach of the active communication channel defining a reverse control channel.

Agrawal teaches of the active communication channel defining a reverse control channel (**See [0011]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include the active communication channel defining a reverse control channel taught by Agrawal in order to prevent the reduction of system capacity in the affected cells/sectors.

Regarding claim 6, Walton teaches the method of claim 1, but fails to teach of the active communication channel defining a forward control channel.

Agrawal teaches of the active communication channel defining a forward control channel (**See [0028]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include the active communication channel defining a forward control channel taught by Agrawal in order to prevent the reduction of system capacity in the affected cells/sectors.

Regarding claim 8, Walton teaches the method of claim 1, but fails to teach of interfering channels defining frequency channels causing at least one of adjacent channel interference, co-channel interference, inter- symbol interference and cross-rail interference.

Agrawal teaches of the interfering channels defining channels causing at least one of adjacent channel interference, co-interference, inter-symbol interference and cross-rail interference (**Interfering channels are allocated on orthogonal sub-bands; See [0006] and [0033]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton to include the interfering channels defining channels causing at least one of adjacent channel interference, co-interference, inter-symbol interference and cross-rail interference taught by Agrawal in order to indicate the types of communication that cause a reduction in successful data transmission.

Regarding claim 9, Agrawal further teaches the method of claim 1, wherein the improvement further comprises using an active communication channel without disabling any interfering channel (**Interfering channels are allocated on orthogonal sub-bands; See [0033]**).

Regarding claim 10, Agrawal further teaches the method of claim 1, wherein the improvement further comprises using an active channel without disrupting the frequency use plan (**Interfering channels are allocated on orthogonal sub-bands; See [0033]**).

5. Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Walton in view of Agrawal in further view of Moulsley (**U.S. PGPub 2002/0172160**), hereinafter referred to as Moulsley.

Regarding claim 2, Walton in view of Agrawal teaches the method of claim 1, but fails to teach of the active communication channel defining any frequency channel capable of a duplex communication.

Moulsley teaches of the channel being capable of duplex communication (**See [0025]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton in view of Agrawal to include the channel being capable of duplex communication taught by Moulsley in order to provide a reverse path for the monitoring an remote adjustment of equipment in the field.

6. Claim 7 is rejected under 35 U.S.C. 103(a) as being unpatentable over Walton in view of Agrawal in further view of Garceran et al (**U.S. Patent No. 6,522,888**), hereinafter referred to as Garceran.

Regarding claim 7, Walton in view of Agrawal teaches the method of claim 1, but fails to teach of calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel.

Garceran teaches of calculating path loss for the wireless device's location as a function of the transmission signal strength and the received signal strength on the active communication channel (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Walton in view of Agrawal to calculating path loss for the wireless device's location as a function of the transmission signal strength and the received signal strength taught by Garceran in order to determine how the wireless units communicate with the base stations so as to provide maximum performance for data transmission.

7. Claims 11-14, 16-44 and 46-51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Agrawal in view of Garceran.

Regarding claim 11, Agrawal teaches a method for where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel (**See Fig. 9 and [0029]**), the method comprising the steps of:

identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel (**See [0011], [0029] and [0035]**);

receiving at said receiver the signal transmitted from said wireless device on said first frequency channel (**Receive the reverse link signal transmitted by the terminal at the serving and non-serving sectors; See Fig. 9, #912**); and

measuring at said receiver the received signal strength of said signal (**sectors measure the received signal strength; See [0058]**).

Agrawal fails to teach of identifying a geographic area where the path loss is to be determined, receiving the transmit signal strength of said signal and determining path loss as a function of the transmission signal strength and the received signal strength.

Garceran teaches of determining a geographic area where the path loss is to be determined (**See col. 3, lines 25-45 and col. 11, lines 10-36**) and receiving the transmit

signal strength of said signal (**See Fig. 3C and col. 3, lines 40-45**) and determining path loss as a function of the transmission signal strength and the received signal strength (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Agrawal to include identifying a geographic area where the path loss is to be determined, receiving the transmit signal strength of said signal and determining path loss as a function of the transmission signal strength and the received signal strength taught by Garceran in order to determine how the wireless units communicate with the base stations so as to provide maximum performance for data transmission.

Regarding claim 12, Agrawal further teaches the method of claim 11, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel (**Interfering channels are allocated on orthogonal sub-bands; See [0033]**); and

reassigning a second signal using said second frequency channel to a third frequency channel (**Interfering channels are allocated on orthogonal sub-bands; See [0033]**).

Regarding claim 13, Agrawal further teaches the method of claim 11, but fails to teach of determining the path loss value for a plurality of geographic areas to compile a database.

Garceran teaches of determining the path loss value for a plurality of areas and compiling a database (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Agrawal to determining path loss to compile a database taught by Garceran in order to track how the wireless units communicate with the base stations so as to provide maximum performance for data transmission.

Regarding claim 14, Agrawal further teaches the method of claim 11, wherein the receiver is a base station (**See Fig. 10, #110x**).

Regarding claim 16, Agrawal further teaches the method of claim 11, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device,

portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager (**See [0028]**).

Regarding claim 17, Agrawal further teaches the method of claim 11, wherein the wireless device is engaged in one of a duplex or a simplex communication (**Communication with the base station; See [0011]**).

Regarding claim 18, Agrawal further teaches the method of claim 11, further comprising randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver (**Selection is made from the "restricted" set of frequency sub-bands; See [0011]**).

Regarding claim 19, Agrawal further teaches the method of claim 11, further comprising selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute (**Users with different channel conditions may be distributed throughout the system. The channel condition may be C/I, SINR, etc.; See [0032]**).

Regarding claim 20, Agrawal further teaches the method of claim 19, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-

interference ratio and carrier-to-interference ratio (**Users with different channel conditions may be distributed throughout the system. The channel condition may be C/I, SINR, etc.; See [0032]**).

Regarding claim 21, Agrawal further teaches the method of claim 11, further comprising identifying the location of the receiver and the wireless device (**GPS or A-FLT may be used to estimate the position of the user and base stations; See [0059]**).

Regarding claim 22, Agrawal further teaches a circuitry configured to implement the method of claim 11 (**ASIC; See [0096]**).

Regarding claim 23, Agrawal teaches a method where the wireless device and the receiver operate within a wireless communication system, the method comprising:

identifying a first frequency channel in an active communication between the wireless device and the receiver (**See [0011], [0029] and [0035]**);

geolocating the wireless device and the receiver (**GPS or A-FLT may be used to estimate the position of the user and base stations; See [0059]**);

receiving at the receiver the signal transmitted from said wireless device on said first frequency channel (**Receive the reverse link signal transmitted by the terminal at the serving and non-serving sectors; See Fig. 9, #912**); and

measuring at said receiver the received signal strength of said signal (**sectors measure the received signal strength; See [0058]**).

Agrawal fails to teach of receiving an indication of the transmitted signal strength of said signal and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

Garceran teaches of receiving the transmit signal strength of said signal (**See Fig. 3C and col. 3, lines 40-45**) and determining path loss as a function of the transmission signal strength and the received signal strength (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Agrawal to include receiving the transmit signal strength of said signal and determining path loss as a function of the transmission signal strength and the received signal strength taught by Garceran in order to determine how the wireless units communicate with the base stations so as to provide maximum performance for data transmission.

Regarding claim 24, Agrawal further teaches the method of claim 23, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel (**Interfering channels are allocated on orthogonal sub-bands; See [0033]**); and

reassigning a second signal using said second frequency channel to a third frequency channel (**Interfering channels are allocated on orthogonal sub-bands; See [0033]**).

Regarding claim 25, Agrawal teaches the method of claim 23, but fails to teach of determining the path loss value for a plurality of geographic areas to compile a database.

Garceran teaches of determining the path loss value for a plurality of areas and compiling a database (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Agrawal to determining path loss to compile a database taught by Garceran in order to track how the wireless units communicate with the base stations so as to provide maximum performance for data transmission.

Regarding claim 27, Agrawal further teaches the method of claim 23, wherein the first frequency channel in active communication is engaged in a simplex communication (**Communication with the base station; See [0011]**).

Regarding claim 28, Agrawal further teaches the method of claim 23, further comprising selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute (**Users with different channel conditions may be distributed throughout the system. The channel condition may be C/I, SINR, etc.; See [0032]**).

Regarding claim 29, Agrawal further teaches the method of claim 28, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio, inter-symbol interference and carrier-to-interference ratio (**Users with different channel conditions may be distributed throughout the system. The channel condition may be C/I, SINR, etc.; See [0032]**).

Regarding claim 30, Agrawal further teaches the method of claim 23, wherein the receiver is a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device (**See Fig. 1**).

Regarding claim 31, Agrawal further teaches the method of claim 23, wherein the receiver is a base station or a wireless location sensor ("WLS") or a combination of the base station and a WLS (**See [0028]**).

Regarding claim 32, Agrawal further teaches a circuitry configured to implement the method of claim 23 (**ASIC; See [0096]**).

Regarding claim 33, Agrawal teaches a system where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel (**See Fig. 9 and [0029]**), the system comprising:

a circuitry (**ASIC; See [0096]**) including a microprocessor and a memory (**See Fig. 10**) the circuitry configured with instructions to:

identify a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel (**See [0011], [0029] and [0035]**);

receive at said receiver the signal transmitted from said wireless device on said first frequency channel (**Receive the reverse link signal transmitted by the terminal at the serving and non-serving sectors; See Fig. 9, #912**); and

measure at said receiver the received signal strength of said signal (**sectors measure the received signal strength; See [0058]**).

Agrawal fails to teach of the circuitry for compiling a database and the circuitry configured to determine a geographic area where the path loss is to be determined, receive the transmit signal strength and determine the path loss as a function of the transmitted signal strength and received signal strength.

Garceran teaches of circuitry (**ASIC; See col. 15, line8-9**) for compiling a database for receiving the path loss (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36**), the circuitry configured to determine a geographic area where the path loss is to be determined (**See col. 3, lines 25-45 and col. 11, lines 10-36**) and receive the transmit signal strength of said signal (**See Fig. 3C and col. 3, lines 40-45**) and determine path loss as a function of the transmission signal strength and the received signal strength (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the system of Agrawal to include circuitry for compiling a database for receiving the path loss, the circuitry configured to identify a

geographic area where the path loss is to be determined, receive the transmit signal strength of said signal and determine path loss as a function of the transmission signal strength and the received signal strength taught by Garceran in order to determine how the wireless units communicate with the base stations so as to provide maximum performance for data transmission.

Regarding claim 34, Agrawal further teaches the method of claim 33, wherein the circuitry is further programmed with instructions to:

determine a second frequency channel which interferes with said first frequency channel (**Interfering channels are allocated on orthogonal sub-bands; See [0033]**); and

reassign a second signal using said second frequency channel to a third frequency channel (**Interfering channels are allocated on orthogonal sub-bands; See [0033]**).

Regarding claim 35, Agrawal teaches the method of claim 33, but fails to teach of the circuitry being further programmed with instructions to determine the path loss value for a plurality of geographic areas to compile a database.

Garceran teaches of determining the path loss value for a plurality of areas and compiling a database (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path**

loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Agrawal to determining path loss to compile a database taught by Garceran in order to track how the wireless units communicate with the base stations so as to provide maximum performance for data transmission.

Regarding claim 36, Agrawal further teaches the method of claim 33, wherein the receiver is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device, pager, base station and wireless location sensor (**See [0028]**).

Regarding claim 37, Agrawal further teaches the method of claim 33, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager (**See [0028]**).

Regarding claim 38, Agrawal further teaches the method of claim 33, wherein the wireless device is engaged in one of a simplex or a duplex communication area (**Communication with the base station; See [0011]**).

Regarding claim 39, Agrawal further teaches the method of claim 33, wherein the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic (**Selection is made from the "restricted" set of frequency sub-bands; See [0011]**).

Regarding claim 40, Agrawal further teaches the method of claim 33, wherein the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area (**Each base station provides communication coverage for a particular geographic area; See [0029]**) and having at least one desired attribute (**Users with different channel conditions may be distributed throughout the system. The channel condition may be C/I, SINR, etc.; See [0032]**).

Regarding claim 41, Agrawal teaches an apparatus (**See Fig. 10**) comprising:

means for identifying (**processor; See Fig. 10**) an active communication channel supporting at least one desirable attribute (**See [0011], [0029] and [0035]**);

means for identifying the wireless device and the receiver tasked to communicate on said active communication channel (**processor; See Fig. 10**);

means for locating said wireless device and said receiver (**GPS or A-FLT; See [0059]**); and

means for identifying a received signal strength for signaling on said active communication channel (**receivers of the sectors measure the received signal strength; See Fig. 10 and [0058]**).

While Agrawal teaches of a processor and receiver (**See Fig. 10**), it fails to teach of receiving the transmit signal strength of said signal and determining path loss as a function of the transmission signal strength and the received signal strength.

Garceran teaches of means for receiving (**base station**) the transmit signal strength of said signal (**See Fig. 3C and col. 3, lines 40-45**) and means for determining path loss (**RF coverage system**) as a function of the transmission signal strength and the received signal strength (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Agrawal to means for receiving the transmit signal strength of said signal and means for determining path loss as a function of the transmission signal strength and the received signal strength taught by

Garceran in order to determine how the wireless units communicate with the base stations so as to provide maximum performance for data transmission.

Regarding claim 42, Agrawal further teaches the apparatus of claim 41, wherein the desirable attribute comprises of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value (**Users with different channel conditions may be distributed throughout the system. The channel condition may be C/I, SINR, etc.; See [0032]**).

Regarding claim 43, Agrawal further teaches the apparatus of claim 41, wherein the means for identifying an active communication channel comprises an antenna, a radio receiver and a microprocessor (**See Fig. 10**).

Regarding claim 44, Agrawal teaches the apparatus of claim 41, wherein the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions associated with a memory (**See Fig. 10**), but fails to teach of searching a database stored in the digital memory.

Garceran teaches of compiling a database (**Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes; See col. 11, lines 10-36**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Agrawal to compiling a database taught by Garceran in order to track how the wireless units communicate with the base stations so as to provide maximum performance for data transmission.

Regarding claim 46, Agrawal further teaches the apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a geo-positioning system ("GPS") (**GPS or A-FLT may be used to estimate the position of the user and base stations; See [0059]**).

Regarding claim 47, Agrawal teaches the apparatus of claim 41, but fails to teach the transmitted signal strength defining the signal strength at the wireless device.

Garceran teaches of the transmitted signal strength being of the wireless device (**See Fig. 3C and col. 3, lines 40-45**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Agrawal to include the transmitted signal strength defining the signal strength at the wireless device taught by Garceran in order to determine how much interference is involved between transmission and reception.

Regarding claim 48, Agrawal further teaches the apparatus of claim 41, wherein the means for identifying a transmitted signal strength for signaling on said active communication channel comprises an antenna and a signal detection circuit (**See Fig. 10, #1052x and 1054x**).

Regarding claim 49, Agrawal further teaches the apparatus of claim 41, wherein means for identifying the wireless device and the receiver further comprises means for tasking the wireless device and the receiver to signal on said active communication channel (**processor; See Fig. 10**).

Regarding claim 50, Agrawal further teaches the apparatus of claim 41, further comprising means for detecting a second communication channel interfering with the active communication channel (**controller; See Fig. 10 and [0007] and [0033]**).

Regarding claim 51, Agrawal further teaches the apparatus of claim 50, further comprising means for reassigning the second communication channel to a third communication channel (**Interfering channels are allocated on orthogonal sub-bands; See [0033]**).

8. Claims 15 and 45 are rejected under 35 U.S.C. 103(a) as being unpatentable over Agrawal in view of Garceran in further view of Stilp (**U.S. PGPub 2002/0172223**), hereinafter referred to as Stilp.

Regarding claim 15, Agrawal in view of Garceran teaches the method of claim 11, but fails to teach of the receiver being a wireless location sensor.

Stilp teaches of the receiver being a wireless location sensor (**See [0017]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Agrawal in view of Garceran to include the receiver being a wireless location sensor taught by Stilp in order to make highly accurate TDOA and FDOA measurements.

Regarding claim 45, Agrawal in view of Garceran teaches the apparatus of claim 41, but fails to teach of the wherein the means for locating said wireless device and said receiver comprising a wireless location system.

Stilp teaches of the receiver being a wireless location sensor (**See [0017]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the apparatus of Agrawal in view of Garceran to include the receiver being a wireless location sensor taught by Stilp in order to make highly accurate TDOA and FDOA measurements.

9. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Agrawal in view of Garceran in further view of Moulsley.

Regarding claim 26, Agrawal in view of Garceran teaches the method of claim 23, but fails to teach of the first frequency channel in active communication is engaged in a duplex communication.

Moulsley teaches of the channel being engaged in a duplex communication (**See [0025]**).

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention, to modify the method of Agrawal in view of Garceran to include the channel being capable of duplex communication taught by Moulsley in order to provide a reverse path for the monitoring an remote adjustment of equipment in the field.

Conclusion

10. Any response to this action should be **faxed** to (571) 273-8300 or **mailed** to:

Commissioner of Patents,
P.O. Box 1450
Alexandria, VA 22313-1450

Hand delivered responses should be brought to:
Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ASHLEY L. SHIVERS whose telephone number is (571) 270-3523. The examiner can normally be reached on Monday-Friday 8:30-5:00 EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chirag Shah can be reached on (571) 272-3144. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/A. L. S./
Examiner, Art Unit 2477
7/3/2010

/Chirag G Shah/
Supervisory Patent Examiner, Art Unit 2477

Notice of References Cited	Application/Control No. 11/920,076	Applicant(s)/Patent Under Reexamination ARPEE ET AL.	
	Examiner ASHLEY L. SHIVERS	Art Unit 2477	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,751,187	06-2004	Walton et al.	370/210
*	B	US-2005/0271012	12-2005	Agrawal et al.	370/331
*	C	US-6,522,888	02-2003	Garceran et al.	455/456.3
*	D	US-2002/0172160	11-2002	Moulsley, Timothy J.	370/252
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

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*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
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	R					
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NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
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	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	Art Unit
	ASHLEY L SHIVERS	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/03/2010								
	1	✓								
	2	✓								
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	36	✓								

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	ASHLEY L SHIVERS	2477

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CLAIM		DATE								
Final	Original	07/03/2010								
	37	✓								
	38	✓								
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	40	✓								
	41	✓								
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	51	✓								

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

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Application Number	11920076
Filing Date	2008-12-15
First Named Inventor	ARPEE et al.
Art Unit	2477
Examiner Name	Ashley Shivers
Attorney Docket Number	AND01 061 US

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920076
	Filing Date	2008-12-15
	First Named Inventor	ARPEE et al.
	Art Unit	2477
	Examiner Name	Ashley Shivers
	Attorney Docket Number	AND01 061 US

	6	20080261614	A1	2008-10-23	Mia, et al.	
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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.S./

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Filing Date	2008-12-15
	First Named Inventor	ARPEE et al.
	Art Unit	2477
	Examiner Name	Ashley Shivers
	Attorney Docket Number	AND01 061 US

	17	20030064734	A1	2003-04-03	Stilp, et al.	
	18	20060003775	A1	2006-01-05	Bull, et al.	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		☐

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EXAMINER SIGNATURE

Examiner Signature	/Ashley Shivers/	Date Considered	07/02/2010

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	11920076
Filing Date	2008-12-15
First Named Inventor	ARPEE et al.
Art Unit	2477
Examiner Name	Ashley Shivers
Attorney Docket Number	AND01 061 US

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6952158	B2	2005-10-04	Kennedy, Jr.	
	2	6922170	B2	2005-07-26	Alexander, Jr.	
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	Attorney Docket Number	AND01 061 US

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear

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	1	06-347529	JP		1994-12-22	NEC Corp.		☐

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NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
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	Art Unit	2477
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	Examiner Name	Ashley Shivers
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EXAMINER SIGNATURE

Examiner Signature	/Ashley Shivers/	Date Considered	07/02/2010

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CONFIRMATION NO. 2431

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/920,076	12/15/2008	455	2477	AND01 061 US

APPLICANTS

John Arpee, Herndon, VA;
John Peter Carlson, Dulles, VA;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/US2006/017517 05/17/2006
which claims benefit of 60/681,475 05/17/2005

**** FOREIGN APPLICATIONS ***************************

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02/25/2009

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /ASHLEY L SHIVERS/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		VA	3	51	5

ADDRESS

Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004
UNITED STATES

TITLE

Method and Apparatus for Determining Path Loss by Active Signal Detection

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BIB (Rev. 05/07).

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	231	("20020058503" | "20020058503" | "20030129987" | "20030129987" | "20030139188" | "20030190919" | "20030203738" | "20040043775" | "20040132466" | "20040137912" | "20040137912" | "20040203921" | "20040218664" | "20040252752" | "20050058182" | "20050136945" | "20050164712" | "20050192026" | "20060003695" | "20060116130" | "20060125695" | "20060141998" | "20060154607" | "20060240836" | "20070087689" | "20070155401" | "20070202885" | "3150372" | "3659085" | "4814751" | "4845504" | "4891650" | "5056106" | "5218618" | "5317323" | "5365544" | "5404376" | "5423067" | "5497503" | "5506863" | "5506864" | "5508708" | "5512908" | "5515419" | "5519760" | "5559864" | "5592180" | "5614914" | "5675344" | "5736964" | "5815538" | "5825887" | "5862124" | "5870029" | "5920278" | "5952969" | "5960341" | "5973643" | "5987329" | "6014102" | "6047175" | "6049717" | "6097959" | "6138024" | "6144711" | "6188351" | "6191738" | "6201499" | "6201803" | "6212319" | "6233459" | "6236365" | "6236365" | "6246884" | "6295455" | "6311043" | "6363263" | "6363263" | "6407703" | "6470195" | "6477161" | "6501955" | "6519465" | "6526279" | "6526279" | "6546256" | "6553322" | "6556832" | "6556832" | "6563460" | "6571082" | "6603428" | "6603761" | "6640106" | "6646604" | "6661379" | "6765531" | "6771625" | "6771969" | "6782264" | "6834234" | "6839539" | "6845240" | "6845240" | "6853842" | "6853842" | "6859172" | "6871077" | "6873290" | "6876859" | "6920329" | "6922170" | "6952158" | "6987979" | "6996392" | "7023383" | "7167713" | "7271765" | "7340259" | "7427952" | "7440762" | "7593738").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/02 22:43
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L3	6989	(path near2 loss) and ((receive$1 near2 signal) or (receive$1 near2 power) or RSS or RSSI)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/02 22:55
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L10	26	l6 and duplex	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/03 00:07
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S11	51	S10 and (455/1,422.1,423,424,456.1,464,39,41.2,501,513,515,522,526,63.1,67.11,67.13,67.14,105,114.2,115.1,115.2,115.3,130,134-135,150.1,151.2,152.1,154.1,161.3,206,226.1,226.3,227,277.2,278.2,283,296,).ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/25 19:41
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S18	2	("6363263").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/25 20:32
S19	2	("6049717").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/25 20:34
S20	2	("6138024").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/25 20:35
S21	1	S7 and (forward near2 control) and (reverse near2 control)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/25 20:37
S22	583	(signal near2 strength) and channel$4 and frequenc$4 and (forward near2 control) and (reverse near2 control)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/25 20:38

S23	20	S22 and (drive near2 test$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/25 20:38
S24	585	((signal near2 strength) or RSSI) and channel$4 and frequenc$4 and (forward near2 control) and (reverse near2 control)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:12
S25	20	S24 and (drive near2 test$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:13
S26	19	S25 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:13
S27	2611	((signal near2 strength) or RSSI) and channel$4 and frequenc$4 and (path near2 loss)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:21
S28	73	S27 and ("wireless location system")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:22
S29	59	S28 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:22
S30	59	S29 and GPS	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:22
S31	59	S30 and (sector$1 or cell$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:24
S32	648	RSSI and channel$4 and frequenc$4 and (path near2 loss)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:26

S33	3	S32 and ("wireless location system")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:26
S34	1	S33 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:27
S35	184	S32 and GPS	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:29
S36	139	S35 and (sector$1 or cell$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:29
S37	109	S36 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:29
S38	515	(RSS or RSSI) and channel$4 and frequenc$4 and (path near2 loss) and (sector$1 or cell$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:46
S39	153	S38 and (GPS or geo$1locat$6)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:47
S40	113	S39 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:47
S41	32	S40 and (duplex or simplex)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 13:56
S42	145	S38 and (duplex or simplex)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 14:19

S43	94	S42 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 14:19
S44	173	((RSS or RSSI) same (path near2 loss)) and channel$4 and frequenc$4 and (sector$1 or cell$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 14:21
S45	97	S44 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/28 14:21
S46	4741	(path near2 loss) and ((base near2 station$1) or BTS or (wireless near2 location near2 system$1))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:18
S47	2221	S46 and (SNR or SIR or C$1I)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:19
S48	818	S47 and (RSS or RSSI or (receive$1 near2 signal$1 near2 strength$1))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:20
S49	697	S48 and (channel$4 or frequenc$4) and (sector$1 or cell$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:21
S50	611	S49 and (locat$6 or GPS or geo$1locat$6)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:21
S51	446	S50 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:22
S52	774	(path near2 loss) same (RSS or RSSI or (receive$1 near2 signal$1 near2 strength$1))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:26

S53	576	S52 and ((base near2 station$1) or BTS or (wireless near2 location near2 system$1))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:26
S54	418	S53 and (channel$4 or frequenc$4) and (sector$1 or cell$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:26
S55	376	S54 and (locat$6 or GPS or geo$1locat$6)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:26
S56	255	S55 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:27
S57	1579	(path near2 loss) with ((base near2 station$1) or BTS or (wireless near2 location near2 system$1))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:41
S58	1242	S57 and (channel$4 or frequenc$4) and (sector$1 or cell$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:41
S59	495	S58 and (RSS or RSSI or (receive$1 near2 signal$1 near2 strength$1))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:42
S60	419	S59 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:42
S61	385	S60 and interference	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:42
S62	237	S60 and (SNR or SIR or C$1I)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/29 19:42

S63	45	(path near2 loss) with (wireless near2 location near2 system$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 14:12
S64	44	S63 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 14:12
S65	59	(path near2 loss) same (wireless near2 location near2 system$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 14:34
S66	56	S65 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 14:34
S67	12	S66 not S64	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 14:34
S68	169	(path near2 loss) and (wireless near2 location near2 system$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:00
S69	129	S68 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:00
S70	117	S69 not S67	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:00
S71	0	S70 and (sector$1 and channel44)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:01
S72	69	S70 and (sector$1 and channel$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:01

S73	1670	(path near2 loss) with ((base near2 station$1) or BTS or transceiver$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:32
S74	509	S73 and (channel$4 same (cell$1 or sector$1) same frequenc$4)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:33
S75	386	S74 and (@ad<"20050517" or @rlad<"20050517" or @pd<"20050517" or @ptad<"20050517")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:33
S76	367	S75 and interference	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:34
S77	346	S76 and ("370" or "455").clas.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 15:34
S78	1	"20040152415".pn. and strength	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/06/30 18:11

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L17	0	((john near2 arpee) or (john near2 carlson)).in. and (active near2 channel$4) and (path near2 loss)	USPAT; UPAD	OR	OFF	2010/07/03 02:56

7/ 3/ 2010 2:56:59 AM
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	11920076
Filing Date	2008-12-15
First Named Inventor	ARPEE et al.
Art Unit	2477
Examiner Name	Ashley Shivers
Attorney Docket Number	AND01 061 US

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6920329	B2	2005-07-19	Kennedy, Jr. et al.	
	2	6987979	B2	2006-01-17	Carlsson	
	3	6859172	B2	2005-02-22	Powers et al.	
	4	6201803	B1	2001-03-13	Munday et al.	
	5	6097959	A	2000-08-01	Yost	
	6	5987329	A	1999-11-16	Yost	
	7	5952969	A	1999-09-14	Hagerman et al.	
	8	5423067	A	1995-06-06	Manabe	

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	9	5372144	A	1994-12-13	Mortier et al.	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20040132466	A1	2004-07-08	Kennedy, Jr. et al.	
	2	20040218664	A1	2004-11-04	Kennedy, Jr. et al.	
	3	20040252752	A1	2004-12-16	Kennedy, Jr. et al.	
	4	20040043775	A1	2004-03-04	Kennedy, Jr. et al.	
	5	20030190919	A1	2003-10-09	Niemenmaa	
	6	20050192026	A1	2005-09-01	Carlson, et al.	
	7	20050164712	A1	2005-07-28	Kennedy, Jr. et al.	
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	9	20050058182	A1	2005-03-17	Kennedy, Jr. et al.	
	10	20060003695	A1	2006-01-05	Kennedy, Jr. et al.	
	11	20060116130	A1	2006-06-01	Kennedy, Jr. et al.	
	12	20060125695	A1	2006-06-15	Kennedy, Jr. et al.	
	13	20060141998	A1	2006-06-29	Kennedy, Jr. et al.	
	14	20060154607	A1	2006-07-13	Kennedy, Jr. et al.	
	15	20060240836	A1	2006-10-26	Kennedy, Jr. et al.	
	16	20070202885	A1	2007-08-30	Kennedy, Jr. et al.	
	17	20070087689	A1	2007-04-19	Kennedy, Jr. et al.	
	18	20040203921	A1	2004-10-14	Bromhead, et al.	
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	20	20030139188	A1	2003-07-24	Chen, et al.	
	21	20030203738	A1	2003-10-30	Brown, et al.	

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Examiner Name	~~Unassigned~~ Ashley Shivers
Attorney Docket Number	AND01 061

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	1	1 081 972	EP	A2	2001-03-07	Lucent Technologies, Inc.		☐
	2	2 311 912	GB	A	1997-10-08	AT&T Wireless Services, Inc.		☐

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	Filing Date	2007-11-08
	First Named Inventor	Arpee, et al.
	Art Unit	2477
	Examiner Name	~~Unassigned~~ Ashley Shivers
	Attorney Docket Number	AND01 061

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	European Patent Office, European Search Report for related European Application No. 06770051.8, dated 18 April 2008.	☐

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11920076	ARPEE ET AL.
	Examiner	Art Unit
	ASHLEY L SHIVERS	2477

SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
(path near2 loss) and ((receive$1 near2 signal) or (receive$1 near2 power) or RSS or RSSI) and(455/1,422.1,423,424,456.1,464,39,41.2,501,513,515,522,526,63.1,67.11,67.13,67.14,105,114.2,115.1,115.2,115.3,130,134-135,150.1,151.2,152.1,154.1,161.3,206,226.1,226.3,227,277.2,278.2,283,296,).ccls. and (370/431,433,437,442-443,464,480).ccls	7/2/2010	Ashley Shivers
See EAST Search History	7/2/2010	Ashley Shivers
Performed Double Patenting Search	7/2/2010	Ashley Shivers

INTERFERENCE SEARCH

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(Not for submission under 37 CFR 1.99)

Application Number	11920076
Filing Date	2008-12-15
First Named Inventor	ARPEE et al.
Art Unit	2477
Examiner Name	Ashley Shivers
Attorney Docket Number	AND01 061 US

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6014102	A	2000-01-11	Mitzlaff et al.	
	2	3659085	A	1972-04-25	POTTER BASIL E et al.	
	3	3150372	A	1964-09-22	JR. EDWARD J. GROTH	

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U.S.PATENT APPLICATION PUBLICATIONS

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
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Filing Date	2007-11-08
First Named Inventor	Arpee, et al.
Art Unit	~~Unassigned~~ 2477
Examiner Name	~~Unassigned~~ Ashley Shivers
Attorney Docket Number	AND01 061

U.S.PATENTS

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	Examiner Name	~~Unassigned~~ Ashley Shivers
	Attorney Docket Number	AND01 061

	9	6853842	B1	2005-02-08	Wilson, et al.	
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	1	20020058503	A1	2002-05-16	Gutowski	
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	3	20040137912	A1	2004-07-15	Lin	

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	1	2003001742	WO	A1	2003-01-03	Altman		☐

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	2	1191804	EP	A2	2002-03-27	Gutowski		☐
	3	0213439	WO	A2	2002-02-14	Tanay		☐
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	9	6876859	B2	2005-04-05	Anderson et al.	
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	1	06088472	WO	A1	2006-08-24	Anderson et al.		☐

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	6	20080261614	A1	2008-10-23	Mia, et al.	
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	17	20030064734	A1	2003-04-03	Stilp, et al.	
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CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature		Date (YYYY-MM-DD)	2010-06-02
Name/Print	Mark C. Comtois	Registration Number	46,285

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	11920076
Filing Date	2008-12-15
First Named Inventor	ARPEE et al.
Art Unit	2477
Examiner Name	Ashley Shivers
Attorney Docket Number	AND01 061 US

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6920329	B2	2005-07-19	Kennedy, Jr. et al.	
	2	6987979	B2	2006-01-17	Carlsson	
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	4	6201803	B1	2001-03-13	Munday et al.	
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	6	5987329	A	1999-11-16	Yost	
	7	5952969	A	1999-09-14	Hagerman et al.	
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	9	5372144	A	1994-12-13	Mortier et al.	

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	3	20040252752	A1	2004-12-16	Kennedy, Jr. et al.	
	4	20040043775	A1	2004-03-04	Kennedy, Jr. et al.	
	5	20030190919	A1	2003-10-09	Niemenmaa	
	6	20050192026	A1	2005-09-01	Carlson, et al.	
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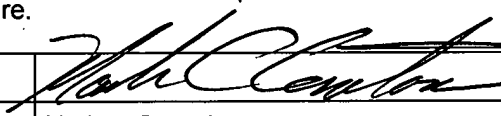
☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

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Signature		Date (YYYY-MM-DD)	2010-06-02
Name/Print	Mark C. Comtois	Registration Number	46,285

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	2	7440762	B2	2005-07-07	Maloney et al.	
	3	7427952	B2	2006-11-23	Bull et al.	
	4	7340259	B2	2008-03-04	Maloney	
	5	7271765	B2	2005-09-22	Stilp et al.	
	6	7167713	B2	2007-01-23	Anderson	
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	9	6876859	B2	2005-04-05	Anderson et al.	
	10	6873290	B2	2005-03-29	Anderson et al.	
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	12	6771625	B1	2004-08-03	Beal	
	13	6765531	B2	2004-07-20	Anderson	
	14	6661379	B2	2003-12-09	Stilp et al.	
	15	6646604	B2	2003-11-11	Anderson	
	16	6603428	B2	2003-08-05	Stilp	
	17	6563460	B2	2003-05-13	Stilp et al.	
	18	6546256	B1	2003-04-08	Maloney	
	19	6519465	B2	2003-02-11	Stilp et al.	

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	22	6463290	B1	2002-10-08	Stilp et al.	
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	27	6334059	B1	2001-12-25	Stilp et al.	
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	32	6285321	B1	2001-09-04	Stilp et al.	
	33	6281834	B1	2001-08-28	Stilp	
	34	6266013	B1	2001-07-24	Stilp et al.	
	35	6184829	B1	2001-02-06	Stilp	
	36	6172644	B1	2001-01-09	Stilp	
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	38	6119013	A	2000-09-12	Maloney et al.	
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	41	6101178	A	2000-08-08	Beal	

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	42	6097336	A	2000-08-01	Stilp	
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	44	6047192	A	2000-04-04	Maloney	
	45	5959580	A	1999-09-28	Maloney et al.	
	46	5608410	A	1997-03-04	Stilp et al.	
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U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20080160952	A1	2008-07-03	Bull, et al.	
	2	20080160953	A1	2008-07-03	Mia, et al.	

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	1	06088472	WO	A1	2006-08-24	Anderson et al.		☐

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	1	06-347529	JP		1994-12-22	NEC Corp.		☐

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	1	AMIR LESHEM, MATI WAX, "Array Calibration in the Presence of Multipath," IEEE Transactions on Signal Processing, Vol. 48, No. 1, pp.53-59, January 2000	☐
	2	XIN WANG, ZONGXIN WANG and BOB O'DEA, "A TOA-Based Location Algorithm Reducing the Errors Due to Non-Line-of-Sight (NLOS) Propagation," IEEE Trans. Vehicular Technology, Vol. 52, No.1, January 2003, pp.112–116	☐
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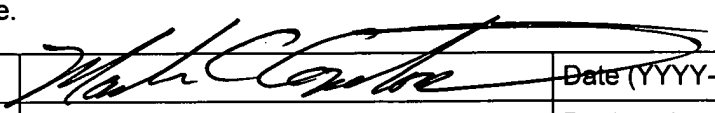
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U.S.PATENTS

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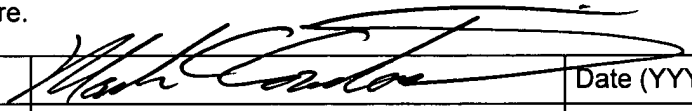
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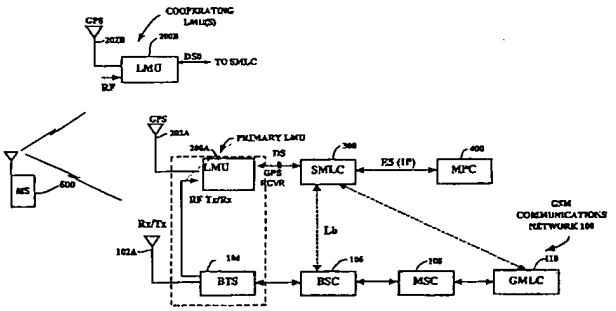
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(54) Title: BASE TRANSCEIVER STATION (BTS) SYNCHRONIZATION



(57) Abstract: In a network overlay wireless location solution for a GSM or UMTS communications network, spectrum utilization can be made far more efficient by synchronizing the BTSs, which can require distributing a timing signal to all BTSs, or installing a satellite-based timing unit in each site. The present invention provides an architecture in which Location Measurement Units (LMUs) are installed at some or all of the BTS sites for the purpose of locating wireless devices. The LMUs are used to measure the timing of various uplink and/or downlink signals in the cellular network in support of various location techniques. These LMUs may include a GPS-based timing reference module, which may be used to synchronize the time bases of all LMUs. To reduce the overall cost of BTS synchronization, the LMU distributes timing signals, including a periodic electrical pulse as well as time description information, on a serial or other interface, which is available for other nodes to use for synchronization. The format of the electrical pulse and time description information is modified through hardware and software to adapt to the various formats required by various BTS types. For example, the BTSs with co-located LMUs can receive a synchronization signal with little or no hardware cost. The External Interface Unit (EIU) described herein may be used to adapt to various BTS hardware formats. For BTS sites not equipped with an LMU, a Timing Measurement Unit (TMU) can be used. The TMU has the single function of providing BTS time signals in the same formats as provided by the LMUs. The time signals provided by the TMUs are synchronous to the signals provided by the LMUs. This timing-only TMU has a lower cost than the LMU because it does not support the uplink or downlink signal measurement functions. This approach allows a cellular operator to synchronize BTSs at a relatively low cost.

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BASE TRANSCEIVER STATION (BTS) SYNCHRONIZATION

CROSS REFERENCE

[0001] The present application claims priority to U.S. Provisional Application No. 60/652,265, filed on February 11, 2005, entitled "Base Transceiver Station (BTS) Synchronization," which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates generally to the field of wireless location and associated wireless communications systems, and more particularly, but not exclusively, to a system for synchronizing Base Transceiver Stations (BTSs) of a GSM or UMTS network coupled with an overlay wireless location system (WLS).

BACKGROUND OF THE INVENTION

[0003] The present invention is especially suited, but not necessarily limited to, use with GSM and UMTS systems and the like. GSM stands for Global System for Mobile communication and is a digital mobile telephone system widely used in Europe and other parts of the world, whereas UMTS stands for Universal Mobile Telecommunications System and is a third-generation (3G) broadband system based on the GSM standard. This specification describes systems and methods to provide Global Positioning System (GPS)-derived timing information to base stations of a wireless communications system, for the purposes of network synchronization. For example, GSM network synchronization can benefit a wireless carrier in several ways. In unsynchronized GSM networks, the co-channel interference created by frequency reuse can be reduced by synchronization. A reduced noise/co-channel interference level allows for tighter frequency reuse patterns, thus allowing the carrier to increase system capacity (e.g., Erlang capacity) or improve voice/data quality.

SUMMARY OF THE INVENTION

[0004] The following statements summarize several important aspects of the present invention, which are described in greater detail herein:

1. In a network overlay wireless location solution for a wireless communications system comprising a network of Base Transceiver Stations (BTSs),

for example GSM or UMTS communications network, a method and system of improving spectrum by synchronizing the BTSs.

2. A method and system as recited above, wherein a timing signal is provided to each BTS by either a Location Measurement Unit (LMU) or a Timing Measurement Unit (TMU).

3. A method and system as recited above, wherein each LMU and TMU comprises a GPS-based timing reference module and means for generating a periodic timing signal which is synchronized within a pre-specified degree of accuracy with the timing signals generated by each other LMU and TMU.

4. A method and system as recited above, wherein the LMUs are used to measure the timing of various uplink and/or downlink signals in the cellular network in support of various location techniques.

5. A method and system as recited above, wherein the LMUs and TMUs distribute timing signals, including a periodic electrical pulse as well as time description information.

6. A method and system as recited above, wherein the format of the electrical pulse and time description information are modified through hardware and software to adapt to the various formats required by various BTS types.

7. A method and system as recited above, wherein the BTSs with co-located LMUs receive a synchronization signal with little or no hardware cost, and wherein BTS sites not equipped with an LMU are equipped with TMU that has the single function of providing BTS time signals in the same formats as provided by the LMUs, wherein the time signals provided by the TMUs are synchronized to the signals provided by the LMUs and the timing-only TMU has a lower cost than the LMU because it does not support uplink or downlink signal measurement functions.

[0005] It should be noted that the concept of the time signals being "synchronized" is not limited to signals of substantially identical shape or occurring simultaneously. For example, two signals may be considered sufficiently synchronized, for the purposes of the present invention, where they are offset in time but have a known relationship.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Figure 1 schematically depicts an illustrative embodiment of an emergency-only overlay location solution.

[0007] Figure 2 depicts several ways of deploying base station synchronization products (LMUs and TMUs) in accordance with the present invention.

[0008] Figure 3 depicts an illustrative embodiment of a TMU's internal architecture and external interface.

[0009] Figure 4 depicts an illustrative relationship between a 1 PPS timing signal and synchronization data.

[0010] Figure 5 depicts an exemplary GSM/UMTS network including a mixture of synchronized/location-enabled BTSs and synchronized/not location-enabled BTSs.

[0011] Figure 6 depicts an exemplary architecture of an External Interface Unit (EIU).

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

1. Overview

[0012] The present invention is particularly suited for use in connection with a network overlay solution for a GSM communications network. The GSM network is specified by the European Telecommunications Standards Institute (ETSI) and extended by the 3rd Generation Partnership Project (3GPP). In a fully integrated, GSM specification-compliant Location Services solution, the SMLC (Serving Mobile Location Center) depends on the existing BSC (Base Station Controller) or PCU (Packet Control Unit) to provide RF assignment information for the MS (Mobile Station, i.e., the mobile unit to be located). By modifying the LMU to monitor the uplink and or downlink control channels, it is possible to implement an emergency-only overlay location solution that satisfies the FCC's E911 mandate and does not require any modifications to the existing GSM handsets or network. An exemplary architecture for such a solution is illustrated in Figure 1. (For further information about this architecture, see U.S. Patent Application No. 20040203429, filed on September 3, 2002 and published on October 14, 2004, "E911 Overlay Solution for GSM, for Use in a Wireless Location System.")

[0013] As shown in Figure 1, the E911 overlay solution comprises the following elements:

1. A GSM communications network 100, including receive/transmit antennae 102A coupled to a Base Transceiver Station (BTS) 104; a Base Station

Controller (BSC) 106; a Mobile Switching Center (MSC) 108; and a Gateway Mobile Location Center (GMLC) 110. All of these components and subsystems are well known in the art. See, e.g., 3GPP TS 03.71 V8.6.0 (2002-06).

2. A Location Measuring Unit (LMU) 200A, which as indicated by the dashed line may be co-located with the BTS 104, so as to share antennae 102A for receiving RF signals from the Mobile Stations. The LMU 202A may include an internal GPS receiver and so a GPS antenna 202A may also be provided. The LMU may also provide the ability to monitor and demodulate the forward channel signals transmitted by the BTS to the MS. This forward link monitor port may be connected to a separate antenna, or directly to the BTS forward link path. In addition, the system may be configured such that, for a given call, there will be a Primary LMU, in this case LMU 200A, and one or more Cooperating LMUs, e.g., the LMU designated 200B. The Cooperating LMUs are generally configured the same as the Primary LMU, and so they are coupled to a GPS antenna 202B and are typically co-located with a BTS.

3. The LMUs are coupled to a Serving Mobile Location Center (SMLC) 300, which in turn is coupled to a Gateway Mobile Location Center (GMLC) or Mobile Positioning Center (MPC) 400. The concept of the LMU, SMLC, GMLC, and MPC are well known, as can be seen from the above-cited GSM specification documents.

4. Figure 1 also shows a Mobile Station 500. Of course, there will typically be many such units in operation within a geographic region, and more than one may be engaged in an emergency call at a given time.

[0014] In a cellular/wireless system, such as GSM or UMTS system, spectrum utilization can be made far more efficient by synchronizing the BTSs. For example, 10-20% more voice calls per unit bandwidth can be achieved through BTS synchronization. Synchronizing a large number of BTSs in a network to an adequate level of accuracy is difficult and requires distributing a timing signal to all BTSs, or installing a satellite-based timing unit in each site. Satellite-based timing units are expensive and take up precious power and space at the BTS sites.

[0015] The present invention provides an architecture in which Location Measurement Units (LMUs) are installed at some or all of the BTS sites for the purpose of locating wireless devices. The LMUs are used to measure the timing of

various uplink and/or downlink signals in the cellular network in support of various location techniques. These LMUs may include a GPS-based timing reference module, which is used to synchronize the time bases of all LMUs. This allows relative time difference measurements to be made in support of location.

[0016] To reduce the overall cost of BTS synchronization, the LMU distributes timing signals, including a periodic electrical pulse as well as time description information, on a serial or other interface, which is available for other nodes to use for synchronization. The format of the electrical pulse and time description information is modified through hardware and software to adapt to the various formats required by various BTS types. For example, the BTSs with co-located LMUs can receive a synchronization signal with little or no hardware cost. The EIU described later is used to adapt to various BTS hardware formats.

[0017] Not all BTS sites will be equipped with the LMUs. For those sites without an LMU, a Timing Measurement Unit (TMU) can be used. The TMU has the single function of providing BTS time signals in the same formats as provided by the LMUs. The time signals provided by the TMUs are synchronous to the signals provided by the LMUs. This timing-only TMU has a lower cost than the LMU because it does not support the uplink or downlink signal measurement functions. This set of products allows a cellular operator (wireless carrier) to synchronize the BTSs at a relatively low cost.

2. BTS Synchronization

[0018] In accordance with the present invention, the LMUs may contain a high performance GPS receiver to provide a common high accuracy timing reference for all LMUs within the location system. The GPS receiver can provide a timing reference to a co-located base station for the purposes of synchronizing the base station network, i.e., to synchronize the BTSs to within a specified degree of precision. In one exemplary implementation of the invention, the LMU contains a network synchronization interface that may be adapted to be compatible with the corresponding interface on the associated BTS. Thus, through the addition of software modifications, the existing LMUs can be upgraded to a configuration compatible with the BTS interface. This software upgrade is termed the BSS Timing Option (BTO), and can be installed into existing LMU/ BTS installations and shipped with new LMUs.

[0019] For BTS sites without an installed LMU, a Timing Measurement Unit (TMU) may be employed. The TMU contains a GPS receiver and necessary software to conform to the BTS timing interface. A market can contain a mix of LMUs with BTO and TMU timing modules or the carrier may elect to use only the TMU to synchronize markets where LMUs are not yet installed.

[0020] The Timing Measuring Unit is a standalone product that can be deployed independent of the Wireless Location Systems. The TMU contains a built-in GPS receiver, including GPS antenna, for the purpose of establishing precise timestamps. The clocking output includes a 1 pulse per second (PPS) signal and timing information. The TMU provides data in a pre-specified ASCII format developed for use with the particular BTS equipment deployed.

[0021] TruePosition base station synchronization products can be employed in several ways, as recited below and depicted in Figure 2:

1. In green-field deployments which have neither location nor synchronization capability.
2. When upgrading an already synchronized BTS to include location capability.
3. When upgrading a location-enabled BTS to incorporate synchronization.

3. Timing Measurement Unit (illustrative embodiment)

[0022] To enable synchronized GSM operation by the wireless carrier, a TMU can be deployed to provide a periodic signal and related timing data information to the BTSs. The TMU preferably includes a GPS receiver designed to provide this periodic signal and related timing data information to the BTS over, e.g., an RS-422 communications interface.

[0023] In one exemplary embodiment, the TMU is a standalone device containing a GPS receiver/engine (GPS), an 80C51 microcontroller (C51), a serial interface for supplying timing information to a BTS, and a console interface. The purpose of the TMU is to obtain accurate time information from the GPS and supply it to the BTS. Timing is provided to the BTS in the form of a pulse per second (PPS) signal that is preceded by a serial message announcing the precise time at the rising edge of the pulse.

[0024] The TMU attempts to maximize the amount of time that it can supply accurate timing information to the BTS. To this end, the TMU takes measures to bring the GPS on-line as quickly as possible after a power outage and to keep it on-line whenever possible.

[0025] To support maintenance and test, the TMU has three modes of operation, boot mode, test mode and operational mode. Boot mode allows the TMU firmware to be updated after production. Test mode supports testing and diagnostics of the TMU hardware platform. Operational mode provides the primary TMU functionality of supplying timing to the BTS.

[0026] The TMU provides synchronization information as described above for two primary reasons:

1) When an LMU is not present in the BTS. When an LMU is present, synchronization information is provided by the LMU through an External Interface Unit (EIU). The External Interface Unit takes the 1 PPS signal and related timing information signal and converts both signals to an RS-422 communication format for interface to the BTS.
2) When an LMU is deployed with equipment already utilizing its signal output capability, such that is it unable to provide the timing signals.

[0027] Figure 3 shows an illustrative embodiment of the TMU internal architecture and external interfaces. The received GPS satellite signal is input to the TMU internal GPS receiver. An internal micro-controller provides the following capabilities:

1) Format GPS timing data in a serial format as may be required.
2) TMU firmware upgrade through the external RS-232 Console port.
3) Control the tri-colored LED that indicates TMU health, and synchronization status.
4) Reset capability through a front panel reset switch.

[0028] The 1 PPS signal output from the GPS receiver, and the formatted serial timing data signal output from the micro-controller are both converted to RS-422 signal levels, and output to the BTS. The 1 PPS and serial data signals are fanned out to 4 four ports that comprise a quad output connector. Each output port provides both a 1 PPS and a serial data output in RS-422 signal levels.

[0029] The TMU micro-controller firmware is capable of upgrade through the RS-232 console port.

[0030] The TMU will transmit the synchronization timing data messages, and the 1PPS signal to the BTS in RS-422 signal levels as shown in Figure 3. The synchronization timing data interface to the BTS may be a serial communications link.

[0031] The 1 PPS signals distributed by the TMU at each of the 4 output ports may have a frequency of 1 Hz and an accuracy 100 ns RMS with respect to UTC time.

[0032] The serial communications link physical layer is based on a RS-422 UART. Specific characteristics are as follows:

- RS-422 interface with 100 ohm termination in the BTS
- 9600 bits/s
- No parity
- One start bit
- 8 bits data length
- One stop bit

[0033] A RS-422 transmitter in the TMU drives the one PPS signal. The 10 – 90 % rise time may be less than 10 ns at each of the TMU output ports. The BTS may include a built in 100 ohm termination.

[0034] The synchronization data is preceding the one PPS pulse. See Figure 4 for timing details. The arrows in Figure 4 show the rising edge of the PPS pulse-pulse. The data signal containing the timing information is preceding the corresponding PPS-pulse.

[0035] Figure 5 is a schematic diagram showing a GSM or UMTS network in which the BTSs are synchronized using the timing information obtained from an LMU or a TMU. The LMUs may or may not require an EIU, depending on the BTS interface requirements as discussed herein.

TMU Operational Description (illustrative embodiment)

[0036] As discussed, the TMU provides timing for a BTS that will enable the BTS to synchronize its operation with other BTSs in its network. The TMU

derives timing information from its integral GPS receiver and provides the BTS with a PPS signal and *Periodic PPS Report* and *Position Data* messages. The TMU is deployed at locations where there is no LMU present or where timing signals are unavailable from the deployed LMU. Where the LMU is deployed, the LMU can supply the same timing functionality as the TMU by employing an EIU. Synchronized BTSs can increase network capacity through precise management of radio resources.

[0037] The TMU software, in a preferred implementation, supports three modes of operation: *boot mode*, *test mode* and *operational mode*. Although each mode provides a mechanism that allows switching to the others, each mode is independent and mutually exclusive. That is, boot mode does not support test mode functionality, test mode does not support boot mode functionality, neither boot nor test mode provide any operational functionality, and operational mode does not support any functionality of the other two modes.

[0038] To utilize the functionality of any mode, the TMU must first be switched to that mode by an appropriate mechanism (usually a console command). Once switched into a particular mode, it is understood that the functionality of the other modes is unavailable. For example, when switched to test mode, the time synchronization to the BTS is disabled since this functionality is only supported by operational mode. BTS timing synchronization cannot be resumed until the TMU is returned to operational mode.

[0039] Certain conditions can prevent the switching from one mode to another. For example, it is not possible to switch out of boot mode if a valid program image is not present. In addition, certain conditions can cause an automatic switch to a mode. For instance, the TMU will automatically switch to boot mode on reset if a valid program image is not present.

[0040] The current mode of the TMU may be identified by the console prompt. The console prompt enumerates the current mode as follows.

- "TMU>" for operational mode
- "Boot>" for boot mode
- "Test>" for test mode

Boot Mode

[0041] Boot mode allows the TMU software to be update in the field. In boot mode, a software image can be downloaded through the console port. The downloaded image will replace the image stored in flash memory. Only the test mode and operational mode portions of the image can be replaced using this method. The boot mode portion of the image can only be replaced during production or through a JTAG port.

[0042] Boot mode may be entered by console command or it may be automatically invoked following a reset if a valid program image is not found. Certain failure conditions, such as a watchdog timeout, can produce a reset that may then result in the boot mode being invoked. Boot mode is exited by a reset when a valid program image is present. Reset can be implemented by pushing the reset button, cycling power or by console command. Boot mode cannot be exited if a valid program image is not present. When boot mode is exited successfully, the TMU returns to the operational mode.

Test Mode

[0043] Test mode supports console commands that directly exercise the TMU hardware. Commands are generally either low-level commands or high-level commands. Low-level commands directly manipulate TMU hardware and provide little or no translation for the operator. Low-level commands are useful for board-level test and troubleshooting. High-level commands provide signal interpretation and manipulate combinations of signals to support interaction with the hardware by the operator. These commands are useful when diagnosing operational issues.

[0044] Test mode is intended for use during manufacturing testing, installation, diagnosing of field failures and repair. Test mode is intended for use by a trained technician. Test mode may be entered from operational mode by console command. Test mode is exited by any reset and the TMU returns to the operational mode (as long as a valid program image is present).

Operational Mode

[0045] Operational mode is the primary mode for the TMU. When in operational mode, the TMU functions autonomously toward its primary goal, supplying precise time synchronization information to the BTS. While in operational

mode, the TMU may send alarms and status information to the console port. In addition, operational mode supports console commands that allow query of operational conditions and manipulation of operational parameters.

[0046] Operational mode is entered automatically following any reset, if a valid program image is present. Operational mode may be exited by invoking test mode or boot mode via console command. Operational mode may be exited automatically if certain failure conditions are detected.

Operational States

[0047] The TMU's front panel status LED reflects the TMU's current state. The state of the TMU is determined by its mode of operation and the exiting conditions. Of the ten (10) possible LED states, only the following are defined as valid. LED states always indicate existing conditions.

- **SOLID RED** (failure) – This indicates a failure, such that the TMU is unable to function normally and must be replaced or repaired by a qualified technician.
- **FLASHING GREEN** (initializing) – This indicates that the TMU is operational and no unexpected conditions have been detected. This state may only exist immediately following reset and indicates that the conditions necessary to provide timing to the BTS have not yet been established. If the required conditions cannot be established within two minutes following reset, the state will proceed to **FLASHING AMBER**. Once this state has been exited, the TMU will not return to this state until it is again reset
- **SOLID GREEN** (full functionality) – This indicates that the TMU is operating normally, there are no outstanding alarm conditions, and the BTS is being supplied with accurate timing.
- **FLASHING AMBER** (impaired) – This indicates the TMU is completely functional but that there exist conditions or alarms that prevent the TMU from supplying the BTS with timing. This state is always the result of external influences, such that replacing the TMU itself will not circumvent the issue. When all outstanding conditions clear, the TMU will return to the **SOLID GREEN** state.

Alarms and Status Messages

[0048] In operational mode, the TMU monitors conditions that may affect its ability to provide accurate timing information to the BTS. In addition, it also notes exceptions or conditions that it encounters in the execution of its programming. Messages concerning these conditions will be sent to the console. These messages are either alarms or status. A *status* message is purely informative and can indicate anything of interest. The issuance of a status message has no effect on the TMU. *Alarms* indicate conditions that may impact the performance of the TMU. The existence of alarms may result in a change of the TMU state. When multiple alarms are indicated, the most severe state is assumed.

Table 1 - TMU Alarms

No.	Alarm	State	Description
1	CPU clock failure	Solid Red	The CPU external oscillator is not functioning **Raised:** During software initialization **Cleared:** Only be reset **Indication to BTS:** No messages
2	TMU Initialization failure	Solid Red	The TMU CPU has encountered an error during initialization **Raised:** During software initialization **Cleared:** Only be reset **Indication to BTS:** No messages **OR** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (1) GPS Receiver Faulty
3	GPS not detected	Solid Red	The CPU is unable to detect the presence of GPS. The GPS is assumed to be totally nonfunctional **Raised:** During software initialization if GPS fails to respond to initialization procedures **Cleared:** Only by reset **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (1) GPS Receiver Faulty
4	GPS comm. failure	Solid Red	The CPU is experiencing difficulty in communicating

No.	Alarm	State	Description
			with the GPS to the extent that the CPU is unable to control the GPS or to obtain the information necessary for the mandatory BTS reports **Raised:** The first time that a mandatory BTS report cannot be completed due to GPS communications **Cleared:** The first time that a mandatory BTS report is successfully accomplished **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (1) GPS Receiver Faulty
5	GPS Internal Failure	Solid Red	The GPS self-test has reported a failure of the GPS ROM and/or RAM. GPS self-test is run following CPU reset. **Raised:** Based on the self test results **Cleared:** Only by reset **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (1) GPS Receiver Faulty
6	GPS No satellites	Flash Amber (Flash Green[1])	There are no satellites available to the GPS receiver. **Raised:** When the *No. of satellites used for positioning* of the GPGGA sentence indicates 0 **Cleared:** When one or more satellites are indicated **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (0) GPS Receiver running
7	GPS PPS Not available	Flash Amber (Flash Green[1])	The GPS indicates that the PPS will not be output. **Raised:** When the *PPS Availability Status* field of the GPTps sentence indicates "PPS not output" **Cleared:** When PPS output is indicated **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (0) GPS Receiver running
8	GPS No UTC Parameter	Flash Amber (Flash Green[1])	The UTC parameter has not been obtained and PPS accuracy cannot be ensured. **Raised:** When the *Date/Time of UTC Parameter* field of

No.	Alarm	State	Description
			the GPTps sentence indicates "000000000000" **Cleared:** When a valid date/time stamp is indicated **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (0) GPS Receiver running
9	GPS Time Not valid	Flash Amber (Flash Green[1])	The GPS time has not been determined. **Raised:** When the *Validity Flag* field of the GPgpt sentence indicates "GPS Time not determined yet" **Cleared:** When "GPS Time valid" is indicated. **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (0) GPS Receiver running
10	GPS Position Mode, Not valid	Flash Amber (Flash Green[1])	The GPS indicates that the position data is not valid. **Raised:** When the *Position System Mode Indication* field of the GPGLL, GPRMC or GPVTG sentence indicates "Data not valid" or The *GPS Quality Indication* field of the GPGGA sentence indicates "0: Fix not available or invalid" **Cleared:** When "Autonomous mode" or "Differential mode" is indicated **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (0) GPS Receiver running
11	PPS not detected	Flash Amber (Flash Green[1])	Information from the GPS indicates that the PPS is being generated, but the PPS is not detected by the CPU. **Raised:** When PPS output is expected and PPS is not found for 2 seconds **Cleared:** When a PPS is detected **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (0) GPS Receiver running
12	GPS Navigation receiver warning	Flash Amber (Flash Green[1])	The GPS indicates a *Navigation receiver warning* in the *Status* field of the GPGLL, GPRMC, or GPRMC sentences.

No.	Alarm	State	Description
			Raised: When "Nav receiver warning" is indicated **Cleared:** When "Data Valid" is indicated **Indication to BTS:** GPSS Status = (3) PPS not Synchronized GPSS Faulty = (0) GPS Receiver running
13	GPS Sats less than 4	Solid Green	The *No of satellites used for positioning* field of the GPGGA or GPGSA sentence indicates that less than 4 satellites are available. **Raised:** When 1,2 or 3 satellites are indicated **Cleared:** When 4 or more satellites are indicated **Indication to BTS:** GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running
14	GPS PPS TRAIM Alarm	Solid Green	TRAIM is available and indicates a problem with the PPS timing. **Raised:** When the *PPS Output Result Status* field of the GPrrm sentence is "1" **Cleared:** When the a value other than "1" is indicated **Indication to BTS:** GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running
15	GPS Antenna Failure	Solid Green	The GPS self-test has reported a failure on the GPS antenna connection. GPS self-test is run following CPU reset. **Raised:** Based on the self-test results **Cleared:** Only by reset **Indication to BTS:** GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running
16	GPS Position Mode, Autonomous	Solid Green	The GPS is operating in stand-alone mode. **Raised:** When the *Position System Mode Indication* field of the GPGLL, GPRMC or GPVTG sentence indicates "Autonomous mode" **Cleared:** When "Autonomous mode" is not indicated **Indication to BTS:**

No.	Alarm	State	Description
			GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running
17	GPS Position Mode, Differential	Solid Green	The GPS is operating in differential mode. **Raised:** When the *Position System Mode Indication* field of the GPGLL, GPRMC or GPVTG sentence indicates "Differential mode" **Cleared:** When "Differential mode" is not indicated **Indication to BTS:** GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running
18	GPS DGPS not received	Solid Green	The GPS is not receiving DGPS data. **Raised:** When the *DGPS status* field of the GPdie sentence is "0" **Cleared:** When the *DGPS status* field of the GPdie sentence is non-zero **Indication to BTS:** GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running
19	GPS DGPS base station unhealthy	Solid Green	The GPS is receiving DGPS information but the DGPS base station is unhealthy, the GPS will operate stand-alone **Raised:** When the *DGPS Base station's Health Condition* field of the GPdie sentence indicates "unhealthy" **Cleared:** When "healthy" is indicated **Indication to BTS:** GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running
20	GPS DGPS Data Abnormal	Solid Green	The GPS is receiving DGPS information but the DGPS data is bad, the GPS will operate stand-alone **Raised:** When the *DGPS Data Status* field of the GPDie sentence indicates "Abnormal" **Cleared:** When "Normal" is indicated **Indication to BTS:** GPSS Status = (0) PPS Locked

No.	Alarm	State	Description
			GPSS Faulty = (0) GPS Receiver running
21	GPS DGPS Error	Solid Green	The GPS indicates that an error associated with the DGPS. **Raised:** When the *DGPS Error Code* field of the GPdie sentence is other than "0" **Cleared:** When "0" is indicated **Indication to BTS:** GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running
22	GPS TRAIM Detection Only	Solid Green	TRAIM is available but there are only enough satellites to detect alarm conditions, deletion of abnormal satellites is not possible **Raised:** When the *TRAIM Status* field of the GPrrm sentence is "1" **Cleared:** When the value is other than "1" **Indication to BTS:** GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running
23	GPS TRAIM Not Available	Solid Green	TRAIM is not available **Raised:** When *TRAIM Status* field of the GPrrm sentence is "2" **Cleared:** When the value is other than "2" **Indication to BTS:** GPSS Status = (0) PPS Locked GPSS Faulty = (0) GPS Receiver running

Operational Processes

[0049] This section describes the procedures followed by the illustrative TMU software. With the exception of the some of the initial startup processing, all procedures refer to operational mode.

Startup

[0050] The startup procedure is performed following any reset of the C51. The purpose of the startup process is to bring up the platform and establish an operational state. The startup procedure also performs a self-check of the TMU

platform and a software integrity test. If the software integrity test fails, the TMU enters boot mode.

Establish C51 Control

[0051] The first part of the startup procedures establishes the operation of the C51 and configures I/O for control of the TMU platform.

1. Check for the presence of a software image.
2. Check the integrity of the software image.
3. Configure the C51 I/O mapping
4. Disable PPS and Serial output to the BTS.
5. Configure the LED drive.
6. Check and switch to the external oscillator.
7. Configure the serial communications ports

Establish Control of the GPS

[0052] The second part of the startup procedure establishes control of the GPS. When establishing control of the GPS, the TMU may perform either a *warm* or a *cold* restart. A *cold restart* assumes that the GPS engine must be completely reinitialized and that all previous information is lost. Under these conditions, several minutes may be required before timing can be reestablished. A *warm restart* attempts to reestablish timing sooner by preserving the information stored in GPS. This is possible because the GPS is an independent subsystem of the TMU. Under some conditions, such as a button reset, the C51 is reset but the GPS is not. In addition, since no power interruption was experienced, the GPS is still operating normally. In these cases, a warm restart reestablishes control of the GPS without disrupting its operation.

[0053] A cold restart of the GPS will be performed if any of the following conditions exist, otherwise, a warm restart will be attempted.

- The C51 experienced a power-on-reset.
- A hard self-reset was commanded.
- The GPS does not respond to communications.
- The GPS self test indicates an error.
- The reset button was pushed while the LED state was other than **SOLID GREEN**.

Cold Restart

[0054] A cold restart of the GPS involves the following steps.

1. Give the GPS a hard reset by asserting its reset signal line.
2. Send the $PFEC,GPclr,1 command.
3. Stop all periodic report messages.
4. Perform a *Self-Test*.
5. Configure timing for periodic messages.
6. Configure PPS delay due to cable length.
7. *PPS Control Mode* is set to be output always.
8. Proceed to establishing position.

Warm Restart

[0055] A warm restart of the GPS involves the following steps.

1. Give the GPS a hard reset by asserting its reset signal line.
2. Send the $PFEC,GPclr,2 command.
3. Stop all periodic report messages.
4. If GPS fails to return response messages, perform Cold Restart.
5. Perform a *Self-Test*.
6. If *Self-Test* indicates that backed up data is bad, perform Cold Restart.
7. Configure timing for periodic messages.
8. Configure PPS delay due to cable length.
9. Configure *PPS Control Mode* to be output always.
10. Proceed to establishing position.

Establishing Position

[0056] Once the TMU has established control of the GPS, its next objective is to establish its position. The GPS must determine its position before it will be able to produce accurate time information. Following a warm restart, the TMU checks the GPS to determine if the position is already known and fixed (fixed observation mode) by the GPS. If the position is both known and fixed, the TMU reads the location from the GPS and proceeds as normal. If the position is known but not fixed, the TMU reads the location and proceeds with *self-survey* as described in the next section. If the position is unknown (or for the case of a cold start), the TMU proceeds with establishing its position.

[0057] The TMU can obtain its position information (latitude, longitude and altitude) from one of three sources, console input, nonvolatile memory or self-survey.

The TMU stores its last known location in its nonvolatile memory. To determine its current position, the TMU sets the GPS to the estimated observation mode and sets the initial position to its last know location. The TMU then proceeds with self-survey.

[0058] A position can be entered manually via console command. If this is done, the location replaces the location data stored in the nonvolatile memory, the GPS is set to the estimated observation mode and the specified location data is written to the GPS as the initial position. The TMU then proceeds with self-survey.

[0059] When position is unknown, there is no last location stored, and there is no console input, the TMU relies completely on the self-survey process. In this case, the GPS is set to the estimated observation mode, and the last known location is used as the initial position. The self-survey process is then allowed to correct the location information. If the last known location is very far from the actual location, it may require an extended amount of time for the TMU to establish its time synchronization.

Self Survey

[0060] The TMU utilizes the self-survey process to determine its exact position and, thereby, produce the most accurate timing. To determine location, the TMU places the GPS into the *estimated observation mode*. In this mode, the GPS will determine its location from the satellites that it can observe. While performing self-survey, the TMU will periodically read the location data from the GPS and compute an average location. Note that self-survey does not prevent the TMU from outputting time synchronization information once an initial location has been established by the GPS. The self-survey process will continue for up to12 hours. At the completion of the self-survey period, the GPS will be set to the *fixed observation mode* and the average location computed will be set. The location determined by self-survey will replace the last known location stored in the TMU nonvolatile memory.

Position Averaging

[0061] While performing self-survey, the TMU obtains the estimated location information once each minute in the **$GPGGA** message. The TMU implements independent averages for longitude, latitude and altitude parameters. The TMU implements a majority-voting algorithm on the *integer portion* of each parameter and an averaging of the *fractional portion*. The integer portion of latitude and longitude includes degrees and integer minutes. The integer portion of altitude is

the whole 100s of meters. The fractional portion is the fractional minutes of latitude or longitude and altitude modulo 100.

[0062] For integer portions, the majority-voting algorithm observes the current reported value; the two previously reported values and the *last known location* (LKL) value. If the integer portion of the three reported values agrees with each other but disagree with the LKL, the LKL is discarded and replaced with the agreed integer portion. For example, if the integer portion of the three most recent latitude values agree but disagree with the LKL, the integer portion of the LKL is replaced with the agreed upon value. The fractional portion of the LKL is replaced with the average of the fractional portion of the consenting values.

[0063] If the integer portion of all four values agrees, the fractional portion of the newest value is averaged into the LKL. If all values, except the newest value agree, the fractional portion of the newest value is not averaged into the LKL. The fractional portion is computed by a straight average of all of the contributions since the last time the LKL was replaced.

[0064] The majority-voting algorithm helps to protect the average from the influence of anomalous locations. Additional rules or algorithms may be employed in determining the stability of the location average and allow a more rapid change to fixed position mode.

Last Known Location

[0065] The TMU stores its last known location in its nonvolatile memory. This location is utilized to hasten the establishment the GPS time output. To minimize the wear on nonvolatile memory, the value will be updated only on one of the following conditions.

- When a manual location is entered via console command.
- On completion of the self-survey processing.
- Whenever, the self-survey average differs from the stored location by more than 1/100 minute of latitude or longitude, or more than 10 meters of altitude.

Antenna Cable Length

[0066] The length of the cable to the GPS antenna can affect the accuracy of the PPS. The TMU requires that this value be entered manually during installation. The POSITION console command is provided for this purpose. The cable length will

be stored to non-volatile memory and will be utilized every time the GPS is configured.

Initiating Output to BTS

[0067] The TMU configures the GPS to begin output of timing data immediately. The TMU configures the GPS to begin outputting the PPS signal immediately. If the GPS is in the fixed observation mode, the PPS will be accurate for as long as one satellite is available. If the GPS is in the estimated observation mode, the PPS will become accurate when 4 satellites are available to fix the position, the UTC parameter is available, ephemeris data for satellite is available, and the UTC computation completes.

[0068] The TMU will begin sending the *Periodic Pulse Report* (GPppr) and the *Position Data Report* (GPGGA) to the BTS immediately after initialization. As soon as the PPS signal is available from the GPS, the TMU will begin sourcing the PPS signal to the BTS as well. However, the *GPSS Status field* of the GPppr will indicate "PPS Not synchronized" until all alarm conditions in the above table marked *Flash Green* are clear.

Supporting Greater Timing Accuracy

[0069] The TMU attempts to support the greatest possible timing accuracy by allowing the GPS to utilize its DGPS and TRAIM features. These features are enabled by default.

Synchronization Loss

[0070] Once timing output has successfully commenced, the occurrence of any critical alarm will cause the *GPSS Status field* of the GPppr to indicate, "PPS Not synchronized" until the condition clears.

BTS Messages Supported

[0071] The TMU supports only the messages that are mandatory. In addition, only the mandatory fields within these messages are supported. These messages are:

1. Periodic PPS Report
2. Position Data Report

Periodic PPS Report ($PTP,GPppr)

[0072] The *GPS TOW Standard Deviation* field of the Periodic PPS Report will be populated as follows.

- If 5 or more satellites used for positioning, the field will be set to 50nsec
- If 4 or less satellites are used for positioning, the field will be set to 100nsec
- If no satellites cause are available, the *GPS Status* field will be set to (3) PPS not synchronized

Position Data (&GPGGA)

[0073] The optional fields; *DGPS Data Time*, *DGPS Station ID* and the *checksum* will not be provided. The fields; *DOP*, *Geoid of Altitude*, and *Unit of Geoid* are set to a blank.

Console Port Operation

[0074] The console port allows human interaction and monitoring of the TMU through an ASCII terminal or terminal emulation software. Following reset or by entering *escape* at the command prompt, the console interface enters *status display mode*. In this mode, alarms and other event driven status strings are sent to the console. The console can collect these strings to monitor the operation and health of the TMU.

[0075] When the *enter key* is pressed while in status display mode, the console interface changes to *command entry mode* and issues the command prompt. The command prompt reflects the current mode of TMU operation; boot, test or operational. Commands may then be entered and the results will be sent to the console. All spontaneous alarm and status string output will be inhibited while in command entry mode.

[0076] The commands available are limited by the TMU's mode of operation. An operator may change modes to obtain access to the desired commands. The operator should be aware of the consequences of invoking any TMU mode of operation.

4. External Interface Unit (EIU) (illustrative embodiment)

[0077] As discussed, to enable synchronized GSM operation, a 1 PPS signal may be provided to the BTSs. For sites that already have an LMU deployed with them, the 1 PPS signal may already be available on those existing LMUs (since the LMUs include built-in GPS receivers). However, for certain types of BTS equipment, the following may be true:

- The 1 PPS signal needs to be converted to RS-422 signal levels for this application.
- In addition to the 1 PPS conversion, the timing information related to 1 PPS signal also needs to be sent over the RS-422 interface using the proprietary protocol called for by the BTS equipment manufacturer (e.g., Ericsson).

[0078] The protocol conversion hardware unit that performs these two operations is called an EIU and is applicable to those cell sites that already have an LMU deployed there.

Impact on GBE and mE-board connectivity

- The EIU will be connected to the 9-pin RS-232 serial port on the LMU. This is the same port that is also used to connect the GBE (ground based electronics) in AOA deployments. Hence, in their present forms the GBE and EIU cannot be co-deployed. Therefore, installation of EIU precludes AOA deployment. The solution to this problem is to use a TMU instead of an EIU in cases where AOA is needed.
- Similar to the above problem is the case of using the environmental board (which is sometimes called the mini environmental board, or mE-board). It also uses the same port and cannot be deployed where an EIU is used.

Architecture

[0079] An exemplary architecture for an EIU is depicted in Figure 6, which shows the internal architecture and external interfaces of the EIU. It connects to the 9 pin serial port and the 1 PPS on the LMU side, and converts both of these interfaces to RS-422 signal levels for connection with the BTS. The 1 PPS and serial data signals are fanned out to 4 four ports that comprise a quad output connector. Each output port provides both a 1 PPS and a serial data output in RS-422 signal levels.

LMU-N Interface

[0080] The illustrative EIU receives timing messages from its LMU interface in RS-232 signal format/levels. The RS-232 signal connection pin outs will

be as shown in table 1. The EIU receives the 1 PPS signal from the LMU through its 1 PPS port. The 1 PPS EIU port appears as a 50-ohm load from outside.

Pin	Signal Name	Description
1,7,8,9	NC	
2	RX	Port 1 Receive, from the PC to the processor
3	TX	Port 1 Transmit, from the processor to PC
4	DTR	Data Terminal Ready – from PC
5	GND	Ground
6	DSR	Data Set Ready

Table: RS-232 Connector Pin Outs

BTS Interface

[0081] The EIU transmits the LMU synchronization data messages and the 1PPS signal to the BTS in RS-422 signal levels as shown in Figure 4. The synchronization data interface to the BTS is a serial communications link.

[0082] The 1 PPS signal will have a frequency of 1 Hz and an accuracy of 100ns RMS at the 1 PPS EIU output port with respect to UTC time.

[0083] The signal connection pin outs for each port will be as shown in the table below.

Pin	Signal Name	Description
1	TX+	Transmit
2	TX-	Transmit return
3	TX+	Transmit (optional)
4	1PPS	Pulse Per Second
5	1PPS-	Pulse Per Second Return
6	TX-	Transmit return (optional)
7,8	NC	
9,10	GND	

Table: RS-422 Single Port Pin Outs

Serial Communications Link

[0084] The serial communications link physical layer is based on a RS-422 UART. Specific characteristics are as follows:

- RS-422 interface with 100 ohm termination in the BTS
- 9600 bits/s
- No parity
- One start bit
- 8 bits data length
- One stop bit

One PPS

[0085] A RS-422 transmitter in the EIU drives the one PPS signal. The 10 – 90 % rise time will be less than 10 ns at the EIU output. The BTS has a built in 100 ohm termination.

5. Conclusion

[0086] The true scope the present invention is not limited to the illustrative and presently preferred embodiments disclosed herein. For example, the foregoing disclosure of a Wireless Location System uses explanatory terms, such as LMU, TMU, EIU, BTS, BSC, SMLC, and the like, which should not be construed so as to limit the scope of protection of the following claims, or to otherwise imply that the inventive aspects of the Wireless Location System are limited to the particular methods and apparatus disclosed. Moreover, as will be understood by those skilled in the art, many of the inventive aspects disclosed herein may be applied in location systems that are not based on TDOA techniques. In such non-TDOA systems, the SMLC described above would not be required to perform TDOA calculations. Similarly, the invention is not limited to systems employing LMUs constructed in a particular manner, or to systems employing specific types of receivers, computers, signal processors, etc. The LMUs, SMLC, etc., are essentially programmable data collection and processing devices that could take a variety of forms without departing from the inventive concepts disclosed herein. Given the rapidly declining cost of

digital signal processing and other processing functions, it is easily possible, for example, to transfer the processing for a particular function from one of the functional elements (such as the SMLC) described herein to another functional element (such as the LMU) without changing the inventive operation of the system. In many cases, the place of implementation (i.e., the functional element) described herein is merely a designer's preference and not a hard requirement. Accordingly, except as they may be expressly so limited, the scope of protection of the following claims is not intended to be limited to the specific embodiments described above.

[0087] In addition, any reference herein to control channels or voice channels shall refer to all types of control or voice channels, whatever the preferred terminology for a particular air interface. Moreover, there are many more types of air interfaces (e.g., IS-95 CDMA, CDMA 2000, and UMTS WCDMA) used throughout the world, and, unless the contrary is indicated, there is no intent to exclude any air interface from the inventive concepts described within this specification. Indeed, those skilled in the art will recognize other interfaces used elsewhere are derivatives of or similar in class to those described above.

CLAIMS

We claim:

1. In a network overlay wireless location solution for a wireless communications system comprising a network of Base Transceiver Stations (BTSs), a method of improving spectrum, comprising synchronizing a plurality of BTSs with a timing signal, wherein at least one BTS is provided with said timing signal by a Timing Measurement Unit (TMU).

2. A method as recited in claim 1, wherein said wireless communications system comprises a GSM communications network.

3. A method as recited in claim 1, wherein said wireless communications system comprises a UMTS communications network.

4. A method as recited in any of claims 1 - 3, wherein the timing signal is provided to each BTS by either a Location Measurement Unit (LMU) or a Timing Measurement Unit (TMU).

5. A method as recited in claim 4, wherein each LMU and TMU comprises a GPS-based timing reference module and means for generating a periodic timing signal which is synchronized within a pre-specified degree of accuracy with the timing signals generated by each other LMU and TMU.

6. A method as recited in claim 5, wherein the LMUs are used to measure the timing of uplink and/or downlink signals in the cellular network in support of location techniques.

7. A method as recited in claim 6, wherein the LMUs and TMUs distribute timing signals, including a periodic electrical pulse as well as time description information.

8. A method as recited in claim 7, wherein the format of the electrical pulse and time description information are modified through hardware and software to adapt to formats required by various BTS types.

9. A method as recited in claim 8, wherein the BTSs with co-located LMUs receive a synchronization signal with little or no hardware cost, and wherein BTS sites not equipped with an LMU are equipped with a TMU that has the single function of providing BTS time signals in the same formats as provided by the LMUs, wherein the time signals provided by the TMUs are synchronous to the signals provided by the LMUs and the timing-only TMU has a lower cost than the LMU because it does not support uplink or downlink signal measurement functions.

10. A network overlay wireless location system for use in association with a wireless communications system comprising a network of Base Transceiver Stations (BTSs), comprising a plurality of Location Measurement Units (LMUs) and at least one Timing Measurement Unit (TMU), and a mechanism for synchronizing a plurality of BTSs with a timing signal, wherein at least one BTS is provided with said timing signal by said at least one TMU.

11. A wireless location system as recited in claim 10, wherein said wireless communications system comprises a GSM communications network.

12. A wireless location system as recited in claim 10, wherein said wireless communications system comprises a UMTS communications network.

13. A wireless location system as recited in any of claims 10 - 12, wherein the timing signal is provided to each BTS by either a Location Measurement Unit (LMU) or a Timing Measurement Unit (TMU).

14. A wireless location system as recited in claim 13, wherein each LMU and TMU comprises a GPS-based timing reference module and means for generating a periodic timing signal which is synchronized within a pre-specified degree of accuracy with the timing signals generated by each other LMU and TMU.

15. A wireless location system as recited in claim 14, wherein the LMUs are used to measure the timing of uplink and/or downlink signals in the cellular network in support of location techniques.

16. A wireless location system as recited in claim 15, wherein the LMUs and TMUs distribute timing signals, including a periodic electrical pulse as well as time description information.

17. A wireless location system as recited in claim 16, wherein the format of the electrical pulse and time description information are modified through hardware and software to adapt to formats required by various BTS types.

18. A wireless location system as recited in claim 17, wherein the BTSs with co-located LMUs receive a synchronization signal with little or no hardware cost, and wherein BTS sites not equipped with an LMU are equipped with a TMU that has the single function of providing BTS time signals in the same formats as provided by the LMUs, wherein the time signals provided by the TMUs are synchronous to the signals provided by the LMUs and the timing-only TMU has a lower cost than the LMU because it does not support uplink or downlink signal measurement functions.

19. A wireless location system for use in association with a wireless communications system comprising a network of Base Transceiver Stations (BTSs), comprising a plurality of Location Measurement Units (LMUs) and at least one Timing Measurement Unit (TMU), wherein said LMUs and at least one TMU are operative for synchronizing a plurality of BTSs with a timing signal, wherein at least one of said BTSs is provided with said timing signal by said at least one TMU; and wherein each LMU and TMU comprises a GPS-based timing reference module and means for generating time description information and a periodic timing signal that is synchronized with the timing signals generated by each other LMU and TMU.

20. A wireless location system as recited in claim 19, wherein BTSs with co-located LMUs receive a synchronization signal with little or no hardware cost, and wherein BTS sites not equipped with an LMU are equipped with a TMU that has the single function of providing BTS time signals in the same formats as provided by the LMUs, wherein the time signals provided by the TMUs are synchronous to the signals provided by the LMUs and the TMU has a lower cost than the LMU because it does not support uplink or downlink signal measurement functions.

21. A wireless location system as recited in claim 20, wherein said wireless communications system comprises a GSM communications network.

22. A wireless location system as recited in claim 20, wherein said wireless communications system comprises a UMTS communications network.

23. A wireless location system as recited in claim 20, wherein the format of the timing signal and time description information are modified through hardware and software to adapt to formats required by various BTS types.

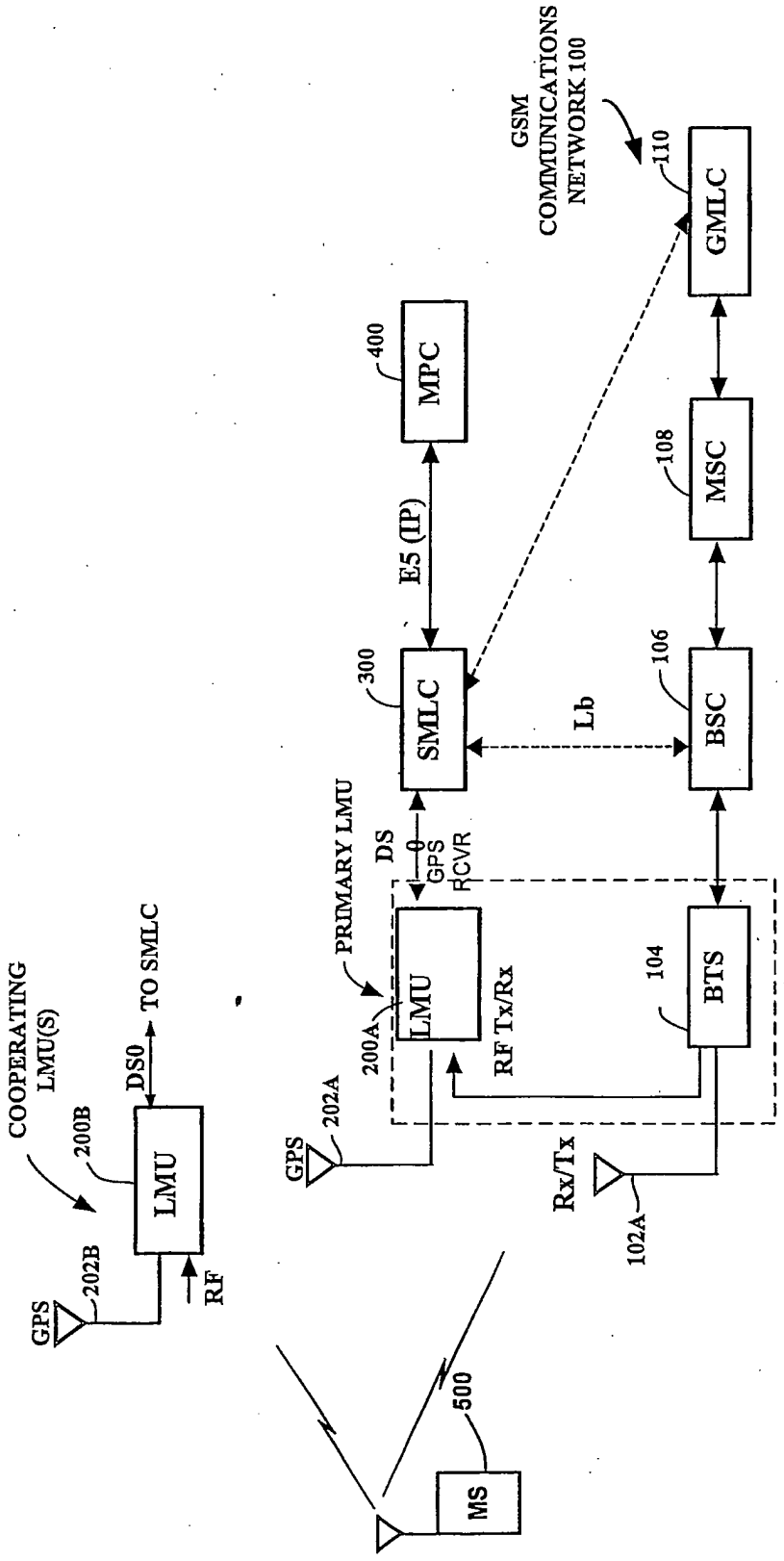

GSM COMMUNICATIONS NETWORK 100
110
GMLC
400
MPC
108
MSC
E5 (IP)
300
SMLC
Lb
106
BSC
PRIMARY LMU
DS
GPS RCVR
LMU
200A
RF Tx/Rx
104
BTS
202A
GPS
Rx/Tx
102A
500
MS
COOPERATING LMU(S)
200B
LMU
DS0
TO SMLC
202B
GPS
RF

FIGURE 1

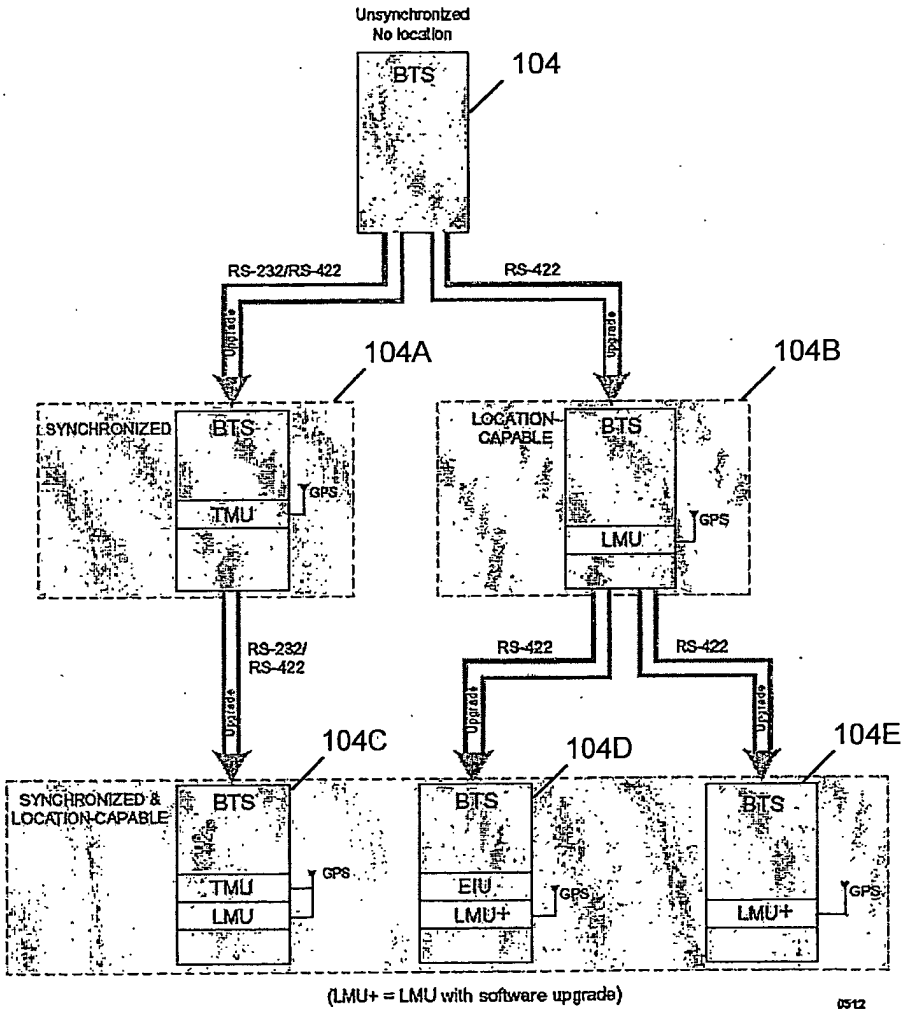

Unsynchronized
No location
BTS
104
RS-232/RS-422
RS-422
Upgrade
Upgrade
104A
104B
SYNCHRONIZED
BTS
GPS
TMU
LOCATION-CAPABLE
BTS
GPS
LMU
RS-232/
RS-422
RS-422
RS-422
Upgrade
Upgrade
Upgrade
104C
104D
104E
SYNCHRONIZED &
LOCATION-CAPABLE
BTS
GPS
TMU
LMU
BTS
GPS
EIU
LMU+
BTS
GPS
LMU+
(LMU+ = LMU with software upgrade)
0512

FIGURE 2

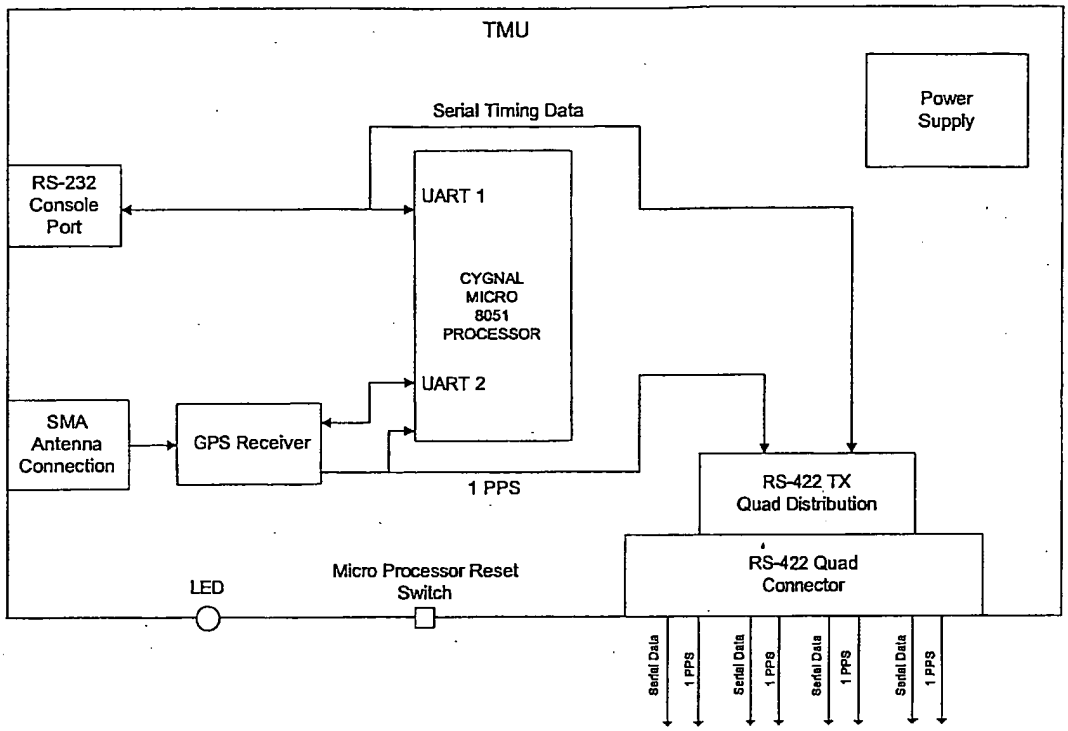


FIGURE 3

$a > 0$ ms
$b > 600$ ms
$2\ \mu s < c < 600$ ms

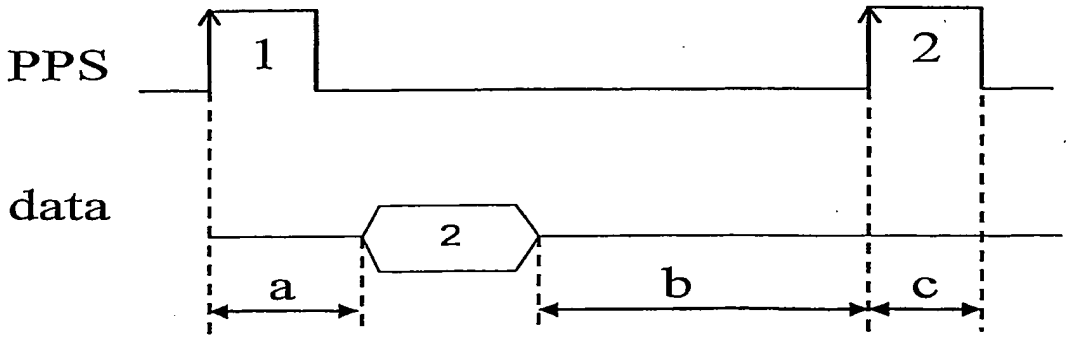


FIGURE 4

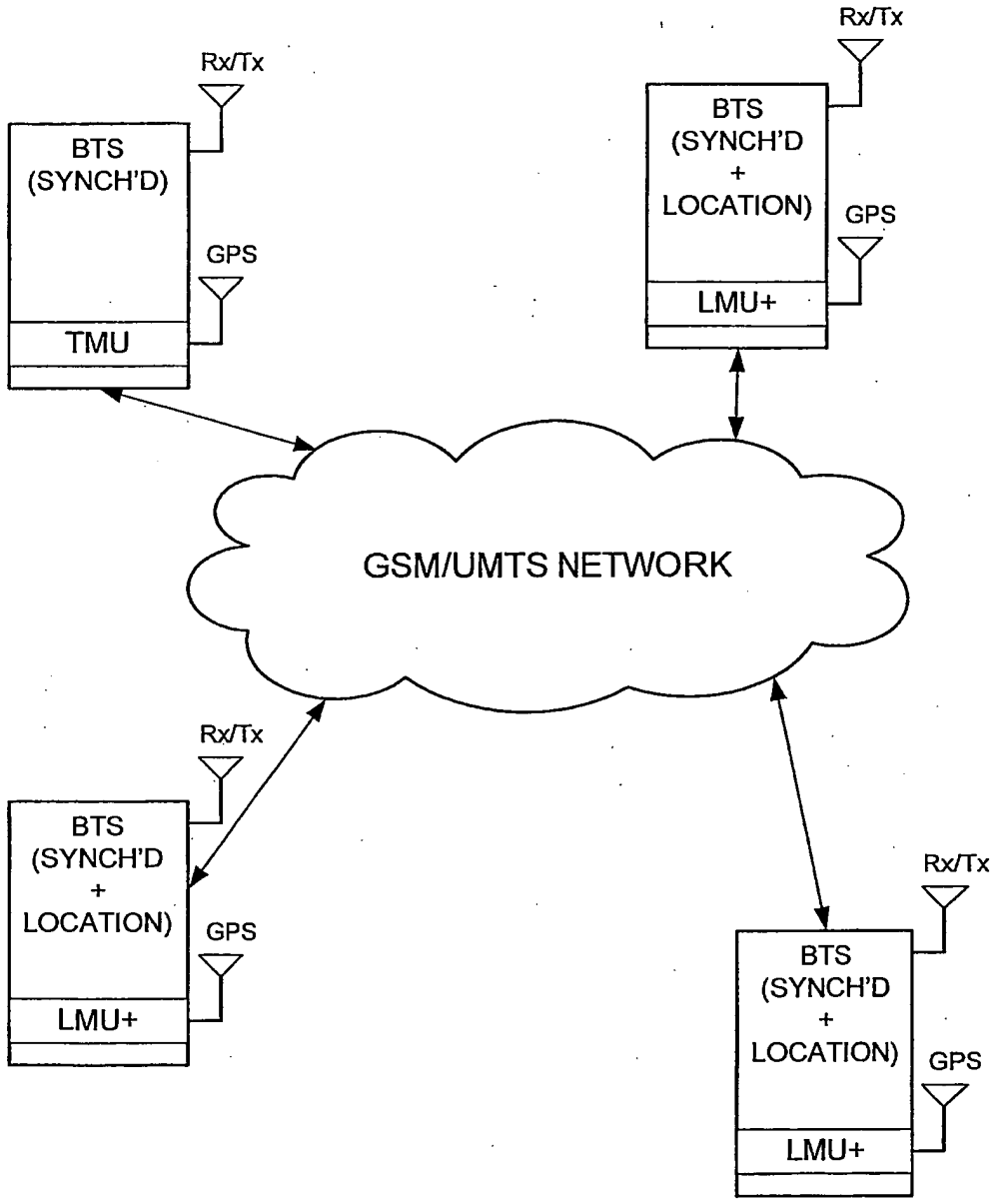

Rx/Tx
BTS
(SYNCH'D)
GPS
TMU
Rx/Tx
BTS
(SYNCH'D
+
LOCATION)
GPS
LMU+
GSM/UMTS NETWORK
Rx/Tx
BTS
(SYNCH'D
+
LOCATION)
GPS
LMU+
Rx/Tx
BTS
(SYNCH'D
+
LOCATION)
GPS
LMU+

FIGURE 5

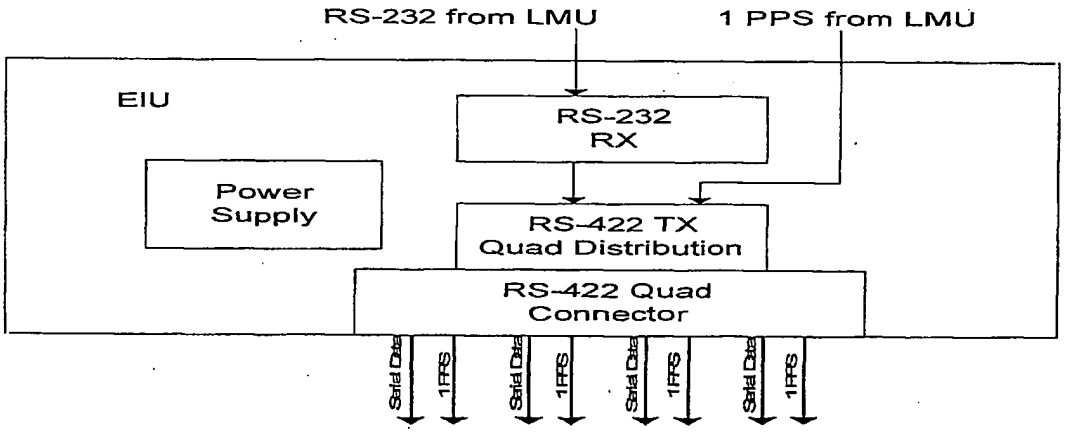

RS-232 from LMU
1 PPS from LMU
EIU
RS-232
RX
Power
Supply
RS-422 TX
Quad Distribution
RS-422 Quad
Connector
Serial Data
1PPS
Serial Data
1PPS
Serial Data
1PPS
Serial Data
1PPS

FIGURE 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US05/14188

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : H04Q 7/20
US CL : 455/456.1, 456.2,456.3,459
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 455/456.1, 456.2,456.3,459

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
None

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2004/0203865 A1 (Krasner) 14 Oct. 2004 (14.10.2004), fig. 11, pars. 0099-0117	1-23
A	US 2004/0092275 (Krasner et al) 13 May 2004 (13.13.2004), fig. 5A, pars. 0033-0038	1-23

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
22 August 2005 (22.08.2005)

Date of mailing of the international search report
23 SEP 2005

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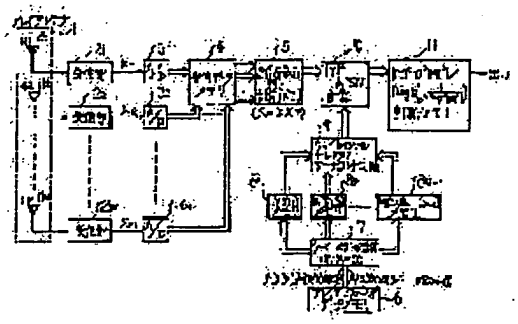
(71)Applicant : NEC CORP

(72)Inventor : TANAKA MOTOYASU
ATOKAWA AKIHISA
TERASAWA NOBUO

(54) METHOD AND DEVICE FOR MEASURING BEARING

(57)Abstract:

PURPOSE: To resolve and measure the bearing of interference wave including a coherent signal (also called as a multi-path signal), in which arrival wave are correlated with each other completely at the same frequency, by an array antenna having optional array elements and arrangement.



CONSTITUTION: The device is provided with an A/D converter 3 which divides receiving signals, that are received by an array antenna consisting of M pieces of array element, into real and imaginary parts to convert them into receiving data, a circuit 5 to find out a covariance matrix from the receiving data, and a circuit 11 to calculate an evaluation function relevant to inner noise in connection with the covariance matrix and array manifold, and it detects the combination of arrival bearings by which the evaluation function is minimized.

LEGAL STATUS

[Date of request for examination] 07.06.1993

://www19.ipdl.nciri.go.jp/PA1/result/detail/main/wAAAxIaWueDA406347529 9/27/2005

[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	2630200
[Date of registration]	18.04.1997
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the bearing measuring method equipment using the super RIZORYUSHON (superresolution) technique which decomposes and measures bearing of an interference wave where two or more incoming waves exist in the same frequency, and its equipment.
[0002]
[Description of the Prior Art] Bearing of an interference wave where two or more incoming waves exist in the same frequency was decomposed using the array component of arbitration, and the array antennas of an array array, and since the method of MUSIC (MUltiple SIgnal Classification) is very efficient as a ****** super RIZORYUSHON technique, it came to be put in practical use in recent years. The method of MUSIC was also called the "characteristic value part solution method" or "characteristic vector method", it was announced by 1981R.O.Schmidt, and research of relation has been made by the researcher of after that many. the following -- R. "O.Schmidt, MultipleEmitter Locaticn and Signal Parameter Estimation" (it is called IEEE TRANSACTION ON ANTENNA AND PROPAGATION, VOL.AP-34.NO, 3PP.276-280, MARCH 1986, and the following reference 1) -- reference -- carrying out -- MUSIC -- the bearing measuring method by law is explained.
[0003] The input signal received with the array antennas which consist of M array components serves as line type association with the input signal (an arrival fraction is assumed to be D) of D individual, and the internal noise of a receiver. It is as follows when this is expressed in procession.
[0004]

$$\begin{bmatrix} X_1 \\ X_2 \\ X_M \end{bmatrix} = \begin{bmatrix} a(\theta_1)\, a(\theta_2) \cdots a(\theta_D) \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \\ F_D \end{bmatrix} + \begin{bmatrix} N_1 \\ N_2 \\ N_M \end{bmatrix}$$

$$X = AF + N \qquad \cdots (1)$$

[0005] It is vector X=(X1 X2 -- XM) T here. They are M input signals (complex). Moreover, matrix A= (a(theta 1) a (theta 2) -- [a (thetaD) is called an array manifold (array manifold), and the column vector a(theta) =(a1 thetaa2 theta--aM theta) T is the response (complex) of the array antennas to Bearing theta, and is called a mode vector or a steering vector.]) When the linear independence of a (theta) is guaranteed at 0 degree < theta<360 degrees, it is equivalent to the ability of Bearing theta to be found that a (theta) can be found. Vector F=(F1 F2 -- FD) T It is the

input signal (complex) of D individual. Vector N=(N1 N2 -- NM) T It is the internal noise (henceforth a noise) of M receivers, and assumes [having not correlated mutually and]. Moreover, since it is easy, all of M noise power are sigma2 equally. It carries out and it is assumed by prior measurement etc. that it is known. Namely, [0006]

$$|\overline{N_1}|^2 = |\overline{N_2}|^2 = \cdots\cdots = |\overline{N_M}|^2 = \sigma^2 \text{ (既知)}$$

[0007] ** -- although assumed -- this assumption -- generality -- ****** -- it is not a thing. T expresses the transpose of a matrix and a bar expresses the average here. Next, it is [0008] when the covariance matrix (covariance matrix) of (1) type is set to S.

$$S = \overline{XX^H} = A\overline{FF^H}A^H + \overline{NN^H}$$

[0009] A next door, [0010]

$$S = APA^H + \sigma^2 I \qquad \text{--- (2)}$$

[0011] It is expressed. However, H expressed complex-conjugate transposition and assumes [having not correlated and] the input signal and the noise. Moreover, [0012]

$$P = \overline{FF^H} \qquad \text{--- (3)}$$

[0013] It is called a ****** matrix of correlation or the power matrix (power matrix) of an input signal, and becomes a positive-definite value (positive delinite). I is a unit matrix. Since the rank (rank: rank) of the signal matrix of correlation P will serve as D supposing it supposes that D<M, i.e., the number of input signals, is smaller than several M of an array component here and there is no perfect correlation between input signals, it is APAH. A rank also serves as D. It is [0014] when the characteristic value of M pieces of a covariance matrix S is arranged in order of magnitude at this time.

$$\underbrace{\lambda_1, \lambda_2, \cdots\cdots, \lambda_D}_{\text{入力信号の固有値}}, \underbrace{\lambda_{D+1}, \cdots\cdots, \lambda_M}_{\text{雑音の固有値}}$$

$$\text{---- (4)}$$

[0015] It becomes and is [0016] further.

$$\lambda_{D+1} = \lambda_{D+2} = \cdots = \lambda_M = \sigma^2 \text{ (最小固有値)}$$

$$\text{--- (5)}$$

[0017] It becomes. Moreover, characteristic vector E corresponding to such characteristic value is [0018].

$$\left.\begin{aligned} E &= (E_S\, E_N) \\ E_S &= (E_1\, E_2 \cdots\cdots E_D) \\ E_N &= (E_{D+1}\, E_{D+2} \cdots\cdots E_M) \end{aligned}\right\} \quad (6)$$

[0019] It becomes. However, ES lambda 1 - lambdaD The signal subspace of the measuring line type space E is stretched by the corresponding signal-space characteristic vector, and it is EN. lambdaD+1 - lambdaM The noise subspace of E is stretched by the corresponding noise space characteristic vector. Moreover, ES EN It is in orthogonality relation (EN is the orthocomplement of ES).

[0020]

$$E = Es \dotplus EN \quad (\dotplus : 直和(direct\ sum))$$

--- (7)

[0021] It becomes. This is based on the following reasons. Characteristic vector E SE=lambdaE (8)
It ****** and is especially lambda=sigma 2. At the time SEN =sigma2 EN (9)
It is [0022] when a next door and (2) types are substituted for (9) types.

$$(APA^H + \sigma^2 I)EN = \sigma^2 EN$$

$$APA^H EN = 0$$

$$EN^H APA^H EN = (A^H EN)^H P(A^H EN) = 0 \quad --- (10)$$

[0023] It becomes. (10) Set at a ceremony and the ** matrix A is a full rank (that all bearings of an incoming wave differ, and equivalence).
** Matrix P (positive-definite value) is a full rank (that there is no perfect correlation between input signals, and equivalence).
In the ** case AH EN =0 (11)
Since it is an array manifold (set of the mode vector of the incoming wave of D individual), a next door and Matrix A are the signal subspace ES. It belongs and is ES. EN It intersects perpendicularly. Therefore, characteristic vector [as opposed to / decompose the characteristic value of a covariance matrix S and / the minimum characteristic value] EN It asks and they are the mode vectors a (theta) and EN. The inverse number of the square of Euclidean distance
[0024]

$$\frac{1}{a^H(\theta)EN\,EN^H a(\theta)} \quad --- (12)$$

[0025] If consider a performance index, and take out the mode vector a of a certain bearing theta (theta), theta is changed over 0 degree - 360 degrees out of all 0<theta<360-degree array manifolds, (12) types are calculated and a peak (peak) is searched for, bearing of the interference wave of D individual can be decomposed and presumed. In addition, in displaying, when it takes the logarithm of (12) types, since it is convenient, it is [0026].

$$10\log_{10}\left(\frac{1}{a^H(\theta)EN\,EN^H a(\theta)}\right) \quad ---$$

[0027] ****** may be performed.
[0028] The configuration of the conventional example explained above is shown in drawing 2 . The signal received in two or more array antennas 1 (11 -1M) and receive sections (21 -2M) by drawing 2 is changed into the digital data of real part and imaginary part with A/D converter 3 (31-3M), and is stored in the receiving data memory 4. The received data read from memory 4 are sent to covariance-matrix count / memory circuit 5, and a covariance matrix S is called for. The characteristic value / characteristic vector count / memory circuit 12 which receives this process (4), (5), (6), and (7) types, and asks for a characteristic vector. This output is sent to the circuit 14 which asks for (12) evaluation-of-expression function, and the performance index for bearing measurement is searched for.
[0029]
[Problem(s) to be Solved by the Invention] MUSIC by the reference 1 mentioned above -- there are the following troubles in law. That is, when it includes the coherent signal (or multi-pass signal) which has perfect correlation in the part between the input signals of D individual, the rank of the signal matrix of correlation P becomes smaller than D, and it becomes impossible to

decompose the characteristic value of the input signal of a covariance matrix S into D individual therefore, and it is the signal-space characteristic vector ES. And ES Noise space characteristic vector EN which has the relation of orthocomplement Asking correctly becomes impossible. Even if (11) types stop realizing and calculate (12) types, it becomes impossible therefore, to presume bearing of an incoming wave at this time. As an approach improved so that bearing of an interference wave including such a coherent signal might be decomposed and bearing could be presumed correctly, there is an approach of "tooth-space SHARU smoothing (Spatial Smoothing)." this approach -- MUSIC of drawing 2 -- in the example of law, when array antennas 1 are made into a regular-intervals linear array, application in the case where a coherent signal is included is enabled. "**** Tie-Jum shan and Mazi Wax, AND Thomas Kajlath and On Spatial Smoothing for Direction of-Arrival Estimation of Coherent Signals" () [IEEE TRANSACTION] ON Acastcs, SPEECH, AND SIGNAL PROCESING, VOL.ASSP-33, NO.4, pp 806-811, AUGUST It depends for calling it 1985 and the following reference 2. However, there is a trouble that the number of incoming waves inapplicable to the array component and array array of (1) arbitration in which (2) presumption is possible becomes M/2 (MUSIC about [in the case of law] 1/2) or less in SUPESHARU smoothing.

[0030]

[Means for Solving the Problem] This invention is for decomposing and presuming bearing of a total input signal between input signals also in the case of an interference wave including a coherent signal with perfect correlation, it can apply to the array component and array array of arbitration, and the number of the maximum presumption incoming waves maintains an individual (M-1) (MUSIC law and the same number). Even if the coherent signal was intermingled in order to take the process which decomposes the characteristic value of a covariance matrix S by the MUSIC method, and asks for a characteristic vector, it diagonalized S when the signal matrix of correlation P stopped having been a full rank, and it calculated characteristic value, since it was no longer what decomposed the input signal correctly, it became presumed impossible.

[0031] Even when it does not take but a coherent signal is intermingled with the following means, the process which this invention asks for characteristic value and a characteristic vector decomposes the arrival bearing of total ******, and makes presumption possible. In this invention, in order to solve a problem, the following wait vectors W are introduced. W=(W1 W2 -- WM) T (13)

The multiplication of the ********** value of W is carried out to an input signal X. If a multiplication result is set to Y Y=WH X (14)

It becomes. Furthermore, it is the square average of Y [0032]

$\overline{|Y|^2}$

[0033] It is [0034] when it carries out.

$$\overline{|Y|^2} = \overline{YY^*} = \overline{W^H X X^H W} = W^H \overline{XX^H} W = W^H S W$$

(*は複素共役を表わす) ---(15)

[0035] It becomes. It is [0036] when (2) types are substituted for (15) types here.

$$\overline{|Y|^2} = W^H (APA^H + \sigma^2 I) W$$

$$= W^H APA^H W + \sigma^2 \|W\|^2$$

$$= (A^H W)^H P (A^H W) + \sigma^2 \|W\|^2$$

ただし ||W|| は Wのノルム(norm)を表わす。

----(16)

[0037] It becomes. Moreover, if (16) types are transformed, the following performance indices can be acquired.
[0038]
$$|Y|^2 - \sigma^2\|W\|^2 = (A^HW)^HP(A^HW) \quad \text{---- (17)}$$

[0039] (17) From a formula AH W=0 (18)
the wait vector W with which like fills [****** primary] a formula -- MUSIC from contrast of (11) types -- noise space characteristic vector EN to the minimum characteristic value in law It turns out that it is equivalent. It is EN to calculate the characteristic value of a covariance matrix S in this invention without carrying out. Performance index which solves the simultaneous equation of (18) equations, searches for the equivalent wait vector W directly, and is calculated from a covariance matrix S and the wait vector W ((15) equations and (17) equations)
[0040]
$$|Y|^2 - \sigma^2\|W\|^2 = W^HSW - \sigma^2\|W\|^2 \quad \text{---(19)}$$

[0041] It is characterized by using and presuming arrival bearing. Therefore, since this invention does not need the full rank conditions of the signal matrix of correlation P, even when a coherent signal is intermingled, it can decompose and presume the arrival bearing of a total input signal. Moreover, it sets at (19) ceremony and the internal-noise power of a receiver is [0042] in a sigma12, sigma22 --, and sigmaM2 and barrack case.
$\sigma^2\|W\|^2$

[0043] It is [0044] to instead of.
$(\sigma_1^2|W_1|^2 + \sigma_2^2|W_2|^2 + \text{----} + \sigma_M^2|W_M|^2)$

[0045] What is necessary is just to use.
[0046]
[Function] Although the wait vector W searched for from the simultaneous equation of (18) equations in this invention is determined only from the element of the array manifold (theta) A a, i.e., a mode vector, since the arrival fraction D is strange, the number of incoming waves needs to ask for W about each case to 1- (M-1). Namely, [0047]

到来波数が1の場合 : $W(\theta_1)$
到来波数が2の場合 : $W(\theta_1, \theta_2)$
⋮ ⋮
到来波数が(M-1)の場合 : $W(\theta_1, \theta_2, \cdots \theta_{M-1})$
$(0° \leq \theta_1, \theta_2, \cdots, \theta_{M-1} < 360°)$ } (20)

[0048] Moreover, the reason the number of the maximum presumption incoming waves is set to (M-1) is the array manifold AH. It is because the maximum of D for having a solution effective [the matrix AH W of (18) types] except becoming Dx1 matrix and all the elements of W being set to 0 (zero) since a DxM matrix and the wait vector W are Mx1 matrices is set to (M-1). (20) Since wait ** KUTORU W is the combination (combination) of arrival bearing as shown in a formula, bearing of a total input signal will be presumed to coincidence. For example, when D is (M-1), it is theta 1, theta 2, --thetaM-1. Only when combination is presumed correctly, with regards to the rank of the signal matrix of correlation P, there is nothing and a performance-index (19) type can be made into minimum [0(zero)]. On the contrary, when arrival bearing is able to be investigated in combination [it is called a combination search (combination search) below] and (19) evaluation-of-expression function is able to be made into min, it means that the arrival

http://www4.ipdl.ncipi.go.jp/cgi-bin/tran_web_cgi_ejje 9/27/2005

bearing (put together) of a total input signal was called for.
[0049]
[Example] Next, this invention is explained to **** with reference to a drawing. Drawing 1 is the block diagram showing the configuration of the example of this invention. In drawing 1, array antennas 1, a receive section 2, the A/D-conversion section 3 that has the function which decomposes an input signal into real part and imaginary part, the receiving data memory 4, the S (covariance matrix) count / memory circuit 5, and the array manifold data memory 6 are provided, and this is as common as the conventional example. That is, the input signal to array antennas 1 to the process of this invention and the MUSIC method which asks for a covariance matrix S using configuration blocks 2, 3, 4, and 5 is the same. However, unlike the MUSIC method, this invention is [0050] by the wait vector W which is the output of a covariance matrix S, and the wait vector selector / search control circuit 9 which count of the characteristic value decomposition / characteristic vector by the characteristic value / characteristic vector count / memory circuit of drawing 2 is not performed, but is an output of 5 to (15) type count circuit 10.

$$|\overline{Y}|^2 = W^H S W \qquad \text{--- (15)}$$

[0051] It calculates. boil a circuit 9 memory 6 -- [0052] which is calculated by the wait calculus-of-vectors circuit 7, and is stored in the wait vector memory 8 from all the stored 0 degree - 360 degrees array manifold data

$$W(\theta_1),\ W(\theta_1, \theta_2), \cdots, W(\theta_1, \theta_2, \cdots, \theta_{M-1})$$

[0053] Drawing and a combination search are performed for a ** wait vector. Next, the output of the count circuit 10 is [0054].

$$\left|\,|\overline{Y}|^2 - \sigma^2\|W\|^2\,\right| \ /\ 10\log_{10}\left(\frac{1}{\left|\,|\overline{Y}|^2 - \sigma^2\|W\|^2\,\right|}\right)$$

[0055] It is sent to count / memory circuit 11, and is [0056].

$$\left|\,|\overline{Y}|^2 - \sigma^2\|W\|^2\,\right|$$

(絶対値をとるのは土の符号は評価上不要のため)

[0057] And it is [0058] for a display.

$$10\log_{10}\left(\frac{1}{\left|\,|\overline{Y}|^2 - \sigma^2\|W\|^2\,\right|}\right)$$

[0059] It calculates and stores. It is [0060] by combination search.

$$10\log_{10}\left(\frac{1}{|\overline{Y}|^2 - \sigma^2\|W\|^2}\right)$$

[0061] theta 1 used as a ** peak, theta 2, --thetaD It becomes the combination of the arrival bearing for which combination asks, and the arrival bearing of the interference wave on which a coherent signal is intermingled can be decomposed and presumed. moreover, the array component and array array of arbitration -- applicable -- the number of the maximum presumption incoming waves -- MUSIC -- law -- being the same (M-1) -- it becomes.
[0062]
[Effect of the Invention] Also in the case of an interference wave including the coherent signal which has perfect correlation in a feeling of an incoming wave, according to this invention, bearing of them can be decomposed and presumed as explained above. Moreover, in the array component of arbitration, and an array array, it can apply, and the bearing measuring device with which the number of incoming waves which can be presumed turns into (the array element

number M-1) can be realized.

[Translation done.]

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IFW

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ENCLOSURES *(Check all that apply)*

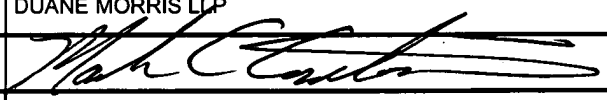
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2 Foreign Patent Documents

37 Non-Patent Literature Documents

Remarks

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Duane Morris LLP
505 9th Street, N.W.
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U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
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NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as a Designated / Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is ACCEPTED for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above and the relevant dates are:

12/15/2008	12/15/2008
DATE OF RECEIPT OF 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) REQUIREMENTS	DATE OF COMPLETION OF ALL 35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE " FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1), (c)(2) and (c)(4) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

The following items have been received:

- Copy of the International Application filed on 11/08/2007
- Copy of the International Search Report filed on 11/08/2007
- Preliminary Amendments filed on 11/08/2007
- Information Disclosure Statements filed on 02/08/2008
- Oath or Declaration filed on 12/15/2008
- Copy of references cited in ISR filed on 02/08/2008
- U.S. Basic National Fees filed on 11/08/2007
- Assignment filed on 12/11/2007
- Priority Documents filed on 11/08/2007
- Power of Attorney filed on 12/15/2008

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CONFIRMATION NO. 2431

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FILING RECEIPT



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Applicant(s)

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Assignment For Published Patent Application

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Title

Method and Apparatus for Determining Path Loss by Active Signal Detection

Preliminary Class

455

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For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as

set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

COMBINED DECLARATION AND POWER OF ATTORNEY FOR UTILITY PATENT APPLICATION

As a below named inventor, I hereby declare:

that my residence, post office address and citizenship are as stated below next to my name;

that I verily believe that I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the invention which is the subject of an application entitled: METHOD AND APPARATUS FOR DETERMIING PATH LOSS BY ACTIVE SIGNAL DETECTION; said invention being described and claimed [X] in the attached specification [ ] in the specification of application Serial No. 11/920,076 filed November 8, 2007; that I have reviewed and understand the content of said specification including the claims; that I do not know and do not believe the said invention was ever known or used in the United States before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to said application; that said invention was not in public use or on sale in the United States more than one year prior to said application; that said invention has not been patented or made the subject of an inventor's certificate issued before the date of said application in any country foreign to the United States on an application filed by me or my legal representatives or assigns more than twelve months prior to said application; that I acknowledge my duty to disclose information of which I am aware which is material to patentability as defined in 37 CFR 1.56; and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States prior to said application by me or my legal representatives or assigns, except as follows:

COUNTRY/INTERNATIONAL	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. 119/36
			YES___ NO__
			YES___ NO__

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application listed below:

60/681,475 filed 17 May 2005.

I hereby appoint Mark C. Comtois, Reg. No. 46,285; Joseph English, Reg. No. 42,514; Patrick D. McPherson, Reg. No. 46,255 and attorneys associated with Customer No.39290 to prosecute said application and to transact all business in the Patent and Trademark Office connected therewith and to file, prosecute and transact all business in connection with international applications directed to said invention:

Address all correspondence to: Duane Morris LLP
505 9th Street, N.W., Suite 1000
Washington, DC 20004

Direct all telephone calls to (202) 776-7800

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

John Arpee — SIGNATURE — 12/11/08
FULL NAME OF INVENTOR — DATE

13595 Dulles Technology Drive — US
RESIDENCE — CITIZENSHIP

Herndon, Virginia 20171
POST OFFICE ADDRESS

DM2/1630228.v1

John Peter Carlson
FULL NAME OF INVENTOR

X [signature] 12/15/08
SIGNATURE DATE

43479 Ogden Road
RESIDENCE

US
CITIZENSHIP

Dulles, Virgina 20166
POST OFFICE ADDRESS

Electronic Patent Application Fee Transmittal

Application Number:	11920076
Filing Date:	
Title of Invention:	Method and Apparatus for Determining Path Loss by Active Signal Detection
First Named Inventor/Applicant Name:	John ARPEE
Filer:	Mark Charles Comtois/Josh Staples
Attorney Docket Number:	AND07 061 US

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Oath/decl > 30 months from priority date	1617	1	130	130
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**130**

Electronic Acknowledgement Receipt

EFS ID:	4458274
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and Apparatus for Determining Path Loss by Active Signal Detection
First Named Inventor/Applicant Name:	John ARPEE
Customer Number:	79172
Filer:	Mark Charles Comtois/Josh Staples
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND07 061 US
Receipt Date:	15-DEC-2008
Filing Date:	
Time Stamp:	17:30:12
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$130
RAM confirmation Number	3047
Deposit Account	041679
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	poa1241.pdf	303883 64b1e7c63596b939399a1242499aa3c412297ea6	no	2
Warnings:					
Information:					
2	Fee Worksheet (PTO-06)	fee-info.pdf	29894 9f3eed1756331ec57a72ebe86fbe32c8519a1384	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	333777		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 November 2006 (23.11.2006)

PCT

(10) International Publication Number
WO 2006/124341 A2

(51) International Patent Classification:
H04J 1/16 (2006.01)

(21) International Application Number:
PCT/US2006/017517

(22) International Filing Date: 17 May 2006 (17.05.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/681,475 17 May 2005 (17.05.2005) US

(71) Applicant *(for all designated States except US)*: **ANDREW CORPORATION** [US/US]; 3 Westbrook Corporate Center, Suite 900, Westchester, IL 60154 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **ARPEE, John** [US/US]; 13595 Dulles Technology Drive, Herndon, VA 20171 (US). **CARLSON, John, Peter** [US/US]; 12006 Trossack Road, Herndon, VA 20170 (US).

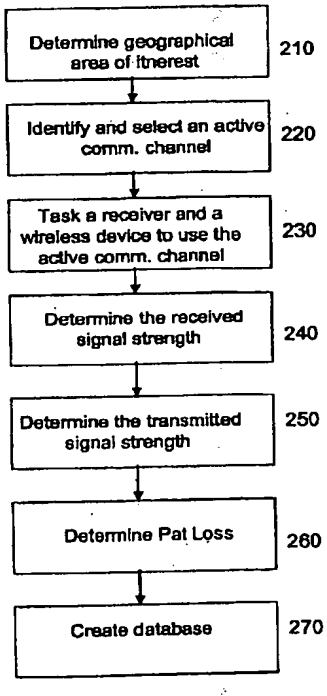
(74) Agent: **COMTOIS, Mark, C.**; DUANE MORRIS LLP, 1667 K STREET, N.W., Suite 700, Washington, DC 20006 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION



(57) Abstract: In one embodiment, the disclosure relates to a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel. The method includes: (i) identifying a geographic area where the path loss value is to be determined; (ii) identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; (iii) receiving at said receiver the signal transmitted from said wireless device on said first frequency channel; (iv) receiving at said receiver an indication of transmission signal strength of said signal; (v) measuring at said receiver the received signal strength of said signal; and (vi) determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

WO 2006/124341 A2

U.S. Appl. No. 11/920076 5/3 International Appl No. US 06/017517

Application filed by: ☐ 20 months ☑ 30 months

INTERNATIONAL APPLICATION PAPERS IN THE APPLICATION FILE:

- ☑ International application (RECORD COPY)
- ☐ Article 19 amendments
- ☐ PCT/IB/331
- → ☐ PCT/IPEA/409 IPER 237 (PCT/IPEA/416 on front)
- ☐ Annexes to 409
- ☑ Priority document(s) No. 1
- ☐ INTERNATIONAL APPLICATION ON DOUBLE SIDED PAPER (COPIES MADE)
- ☐ Request form PCT/RO/101
- ☐ PCT/IB/302
- ☑ PCT/ISA/210-Search Report
- ☑ Search Report references
- ☐ Other _____

RECEIPTS FROM THE APPLICANT: (other than checked above)

- ☑ Basic National Fee (paid or authorized to charge)
- Translation of international application as filed:
  - ☑ Description
  - ☑ Claims
  - ☑ Words in the drawing figure(s)
  - ☐ Article 19 amendments
  - ☐ Annexes to 409
- ☑ Oath / Declaration
- ☐ DNA diskette
- ☐ Preliminary amendment(s) filed
- ☑ Information Disclosure Statement
- ☑ Assignment document
- ☑ Power of attorney/Change of address
- ☐ Substitute specification
- ☐ Verified small status claim
- ☐ Other _____

Notes: Use IA from IB

35 U.S.C. 371 - Receipt of Request (PTO-1390)	08 Nov '07
Date acceptable oath / declaration received	15 DEC '08
Date complete 35 U.S.C 371 requirements met	
102(e) Date	
Date of completion of DO/EO 906 - Notification of Missing 102(e) Requirements	
Date of completion of DO/EO 907 - Notification of Acceptance for 102(e) date	
Date of completion of DO/EO 911 - Application accepted under 35 U.S.C. 1.11	
Date of completion of DO/EO 905 - Notification of Missing Requirements	14 Oct '08
Date of completion of DO/EO 916 - Notification of Defective Response	
Date of completion of DO/EO 903 - Notification of Acceptance	25 Feb '09
Date of completion of DO/EO 909 - Notification of Abandonment	

WIPO Publication
Publication No.
WO 06/124341 A2

Publication Date
23 Nov '06

Publication Language
English

Not Published
☑ U.S. only Designated
☐ EP request

Screening done by: SA

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
11/920,076	John ARPEE	AND07 061 US

79172
Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

INTERNATIONAL APPLICATION NO.	
PCT/US2006/017517	
I.A. FILING DATE	PRIORITY DATE
05/17/2006	05/17/2005

CONFIRMATION NO. 2431
371 FORMALITIES LETTER

OC000000032575225

Date Mailed: 10/14/2008

NOTIFICATION OF MISSING REQUIREMENTS UNDER 35 U.S.C. 371 IN THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

The following items have been submitted by the applicant or the IB to the United States Patent and Trademark Office as an Elected Office (37 CFR 1.495):

- Priority Document
- Copy of the International Application filed on 11/08/2007
- Copy of the International Search Report filed on 11/08/2007
- Preliminary Amendments filed on 11/08/2007
- Information Disclosure Statements filed on 02/08/2008
- Copy of references cited in ISR filed on 02/08/2008
- U.S. Basic National Fees filed on 11/08/2007
- Assignment filed on 12/11/2007
- Priority Documents filed on 11/08/2007

The applicant needs to satisfy supplemental fees problems indicated below.

The following items **MUST** be furnished within the period set forth below in order to complete the requirements for acceptance under 35 U.S.C. 371:

- Oath or declaration of the inventors, in compliance with 37 CFR 1.497(a) and (b), identifying the application by the International application number and international filing date.
- To avoid abandonment, a surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.492(h) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fees required for this application is $**130** for a Large Entity:
- $**130** Surcharge.

ALL OF THE ITEMS SET FORTH ABOVE MUST BE SUBMITTED WITHIN TWO (2) MONTHS FROM THE DATE OF THIS NOTICE OR BY 32 MONTHS FROM THE PRIORITY DATE FOR THE APPLICATION, WHICHEVER IS LATER. FAILURE TO PROPERLY RESPOND WILL RESULT IN ABANDONMENT.

The time period set above may be extended by filing a petition and fee for extension of time under the provisions of 37 CFR 1.136(a).

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web.
https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

SHAKEEL AHMED

Telephone: (703) 308-9140 EXT 208

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	PATENT NUMBER	GROUP ART UNIT	FILE WRAPPER LOCATION
11/920,076		2617	

Correspondence Address / Fee Address Change

The following fields have been set to Customer Number 79172 on 06/11/2008

- Correspondence Address

The address of record for Customer Number 79172 is:
Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington,DC 20004

PTO/SB/08a (05-07)
Approved for use through 09/30/2007. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920076
	Filing Date	2007-11-08
	First Named Inventor	Arpee, et al.
	Art Unit	
	Examiner Name	Unassigned
	Attorney Docket Number	AND01 061

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	1 081 972	EP	A2	2001-03-07	Lucent Technologies, Inc.		☐
	2	2 311 912	GB	A	1997-10-08	AT&T Wireless Services, Inc.		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920076
	Filing Date	2007-11-08
	First Named Inventor	Arpee, et al.
	Art Unit	
	Examiner Name	Unassigned
	Attorney Docket Number	AND01 061

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	European Patent Office, European Search Report for related European Application No. 06770051.8, dated 18 April 2008.	☐

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920076
	Filing Date	2007-11-08
	First Named Inventor	Arpee, et al.
	Art Unit	
	Examiner Name	Unassigned
	Attorney Docket Number	AND01 061

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/mcc/	Date (YYYY-MM-DD)	2008-05-28
Name/Print	Mark C. Comtois	Registration Number	46,285

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

(19) European Patent Office
Office européen des brevets

(11) EP 1 081 972 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
07.03.2001 Bulletin 2001/10

(51) Int. Cl.[7]: **H04Q 7/34**, H04Q 7/36

(21) Application number: **00307190.9**

(22) Date of filing: **21.08.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **31.08.1999 US 387604**

(71) Applicant:
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Murray Hill, New Jersey 07974-0636 (US)

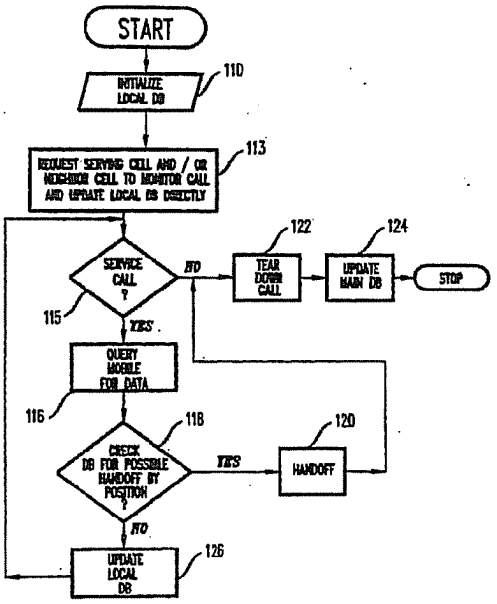
(72) Inventors:
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  Lincroft, New Jersey 07738 (US)
- **Matusevich, Alex**
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(54) System for determining wireless coverage using location information for a wireless unit

(57) A system for determining coverage in a wireless communications systems uses location information for a wireless unit and collects information on communications between the wireless unit and the wireless communications system in association with the location information. The wireless communications system determines and/or receives location information for the wireless unit along with other information associated with the location information. The information by location can be used to represent the coverage of a geographic region. For example, during communications between a serving base station and a wireless unit, the serving base station could receive and/or determine signal quality measurements of a forward link and/or of a reverse link at a particular location. Additionally, neighboring base stations can monitor the communications and determine and/or receive location information for the location of the wireless unit along with the information associated with or corresponding to the location of the wireless unit. The associated information can be linked with additional parameters, such as wireless unit type, wireless unit identity, frequency, operating conditions and/or base station identity. In accordance with other aspects of the present invention, the information and/or measurements stored by location can be used to derive additional and/or different information by location or determine how the wireless communications system communicates with a wireless unit at a location, for example the base station to service the wireless unit at the location. A wireless unit in a location or range of location(s) could be served by a serving base station(s) at a certain transmit power and frequencies given certain operating conditions or parameters, such as time, weather, traffic load, path loss and/or interference level. A change in operating condition could trigger a dynamic change in the RF coverage provided by the serving base station(s) and/or neighboring base stations to the wireless unit(s) in the location or range of locations.

FIG. 5



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Description

BACKGROUND OF THE INVENTION

1. Field of The Invention

[0001] This invention relates to wireless communications and, more particularly, to a system for determining cell coverage in a wireless communications system using location information for a wireless unit.

2. Description of Related Art

[0002] FIG. 1 depicts a schematic diagram of a wireless communications system 10 which provides wireless communications service to a wireless unit 12 that is situated within a geographic region 14. A Mobile Switching Center 18 is responsible for, among other things, establishing and maintaining calls between wireless units and calls between a wireless unit and a wireline unit (e.g., wireline unit 20). As such, the MSC interconnects the wireless units within its geographic region 14 with a public switched telephone network (PSTN) 22. The geographic area serviced by the MSC is divided into spatially distinct areas called "cells." As depicted in FIG. 1, each cell is schematically represented by one hexagon in a honeycomb pattern; in practice, however, each cell has an irregular shape that depends on the topography of the terrain surrounding the cell. Typically, each cell contains a base station (e.g. base stations 24a-g), which comprises the radios and antennas that the base station uses to communicate with the wireless units in that cell. The base stations also comprise the transmission equipment that the base station uses to communicate with the MSC 18 in the geographic area 14 via communication links 26a-g. One cell site may sometimes provide coverage for several sectors. In this specification, cells and sectors are referred to interchangeably.

[0003] In a wireless cellular communications system, a base station and a wireless unit communicate voice and/or data over a forward link and a reverse link, wherein the forward link carries communication signals over at least one forward channel from the base station to the wireless unit and the reverse link carries communication signals on at least one reverse channel from the wireless unit to the base station. Within the geographic region 14, the MSC 18 switches a call between base stations in real time as the wireless unit 12 moves between cells, referred to as a handoff. There are many different schemes for determining how wireless units and base stations communicate in a cellular communications system. For example, wireless communications links between the wireless units and the base stations can be defined according to different radio protocols, including time-division multiple access (TDMA), Frequency Division Multiple Access (FDMA), code division multiple access (CDMA) and others.

[0004] Currently, in FDMA, TDMA, CDMA and Global System for Mobile Communications (GSM), cell site planning is required to determine the geographic coverage for a cell. Cell site planning is a manually intensive task that needs constant adjustment. In planning a cell, the topology of the geographic area and a suitable antenna site is selected based on availability and zoning rules. Such a selection is typically not optimal but adequate. Drive tests and manually collecting signaling data are then performed mostly on the perimeter of the coverage area. Transmit and receive antennas and power are then adjusted in a manually iterative manner to improve the call quality. Sometimes, frequencies are swapped with neighbor cells and/or transmit power is readjusted to improve the coverage. Over time, the cell site engineers review customer complaints and cell site dropped call reports and again try to manually optimize the RF performance.

SUMMARY OF THE INVENTION

[0005] The present invention involves a system for determining coverage in a wireless communications systems using location information for a wireless unit and collecting information on communications between the wireless unit and the wireless communications system in association with the location information. The wireless communications system determines and/or receives location information for the wireless unit along with other information associated with the location information. The information by location can be used to represent the coverage of a geographic region. For example, during communications between a serving base station and a wireless unit, the serving base station could receive and/or determine signal quality measurements of a forward link and/or of a reverse link at a particular location. Additionally, neighboring base stations can monitor the communications and determine and/or receive location information for the location of the wireless unit along with the information associated with or corresponding to the location of the wireless unit. The associated information can be linked with additional parameters, such as wireless unit type, wireless unit identity, frequency, operating conditions and/or base station identity. In accordance with other aspects of the present invention, the information and/or measurements stored by location can be used to derive additional and/or different information by location or determine how the wireless communications system communicates with a wireless unit at a location, for example the base station to service the wireless unit at the location. A wireless unit in a location or range of location(s) could be served by a serving base station(s) at a certain transmit power and frequencies given certain operating conditions or parameters, such as time, weather, traffic load, path loss and/or interference level. A change in operating condition could trigger a dynamic change in the RF coverage provided by the serving

base station(s) and/or neighboring base stations to the wireless unit(s) in the location or range of locations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Other aspects and advantages of the present invention may become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIG. 1 shows a general diagram of a wireless communications system;

FIGs. 2 shows a diagram of a wireless communications system incorporating an embodiment of the handoff system according to certain principles of the present invention;

FIGs. 3A-C show information by location of the wireless unit in different forms;

FIG. 4 shows a general block diagram of a wireless unit which can provide location information according to certain aspects of the present invention;

FIG. 5 shows a flow diagram of an embodiment of a system for using and updating an RF coverage database according to certain principles of the present invention; and

FIGs. 6A and 6B show an example of how the coverage system using location information can be used in a portion of a wireless communications system;

FIGs. 7A and 7B show an example of how the coverage system can be used to change the coverage for a particular location or range of locations based on a change in traffic load; and

FIG. 8 shows an example of how the coverage system using location information can be used in a portion of a wireless communications system.

DETAILED DESCRIPTION

[0007] An illustrative embodiment of a system for determining coverage using location information for the wireless unit according to the principles of the present invention is described below. FIG. 2 shows a portion of a wireless communication system 50 which incorporates a system for determining radio frequency (RF) coverage using location information for a wireless unit communicating with at least one serving base station. The RF coverage system obtains location information for the wireless unit, which includes position, such as latitude/longitude, and can include time, speed, distance and/or direction. While a wireless unit is communicating with a base station, the RF coverage system can dynamically determine RF coverage using the location information from the wireless unit in association with additional information and/or measurements, such as signal quality measurements which can include received signal strength (RSSI), bit error rate (BER) and/or frame error rate (FER), made at the wireless unit and/or at the receiving base station(s), and/or other information or parameters, such as operating conditions, mobile identity, traffic load, frequency, speed, direction, time and/or mobile type.

[0008] For example, using the location of the wireless unit and collecting associated or corresponding data for the wireless unit at that location, the wireless communications system 50 can produce an RF database or storage 52 to represent or provide an RF coverage map for a geographic region serviced by a serving base station(s) and/or neighboring base stations. In one embodiment, during a call established between the wireless unit 54 and the serving base station 56, the serving base station periodically requests/receives/determines the wireless unit's position and receives associated information from the wireless unit 54, such as wireless unit type, wireless unit identity, radio signal strength (RSSI), bit error rate (BER), frame error rate (FER) or other signal quality measurements, of the base station's transmit signal at a known frequency, such as on the forward link traffic channel. At the same time, the base station 56 can perform measurements, such as RSSI, BER, FER or other signal quality measurements, of the received signal at the transmit frequency from the wireless unit 54, such as on the reverse link traffic channel.

[0009] By storing the information by position in the RF coverage database, the information can be analyzed and used to determine RF coverage for a particular location, such as forward link and/or reverse link frequency, the serving base station(s), handoff candidates, signal power(s). The request from the serving base station 56 can be periodically sent, triggered by a change in the position of the wireless unit, triggered by a signal quality threshold(s) being met, or triggered by a location trigger for which the wireless communications system desires information associated with that location. The wireless unit can determine and/or send the location information or the associated information continuously, periodically, triggered by position changes, triggered by a signal quality threshold(s) being met, triggered by location trigger(s) and/or in response to a request from a base station. The serving base station(s) can request the sending of or determine the location information for a wireless unit using other triggers, for other reasons and/or at different rates, and/or the wireless unit can request /send/determine location information or associated information using other triggers, for other reasons and/or at different rates.

[0010] The location information and/or associated information transmitted to the serving base station from the wireless unit can be sent as part of a location message or report to the serving base station on a reverse channel, for example on the reverse setup channel or in the SACCH or FACCH on the reverse voice or traffic channel. The transmitted location information can include current position measurements and/or previous position measurements. The location information can

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also include other information or parameters, such as signal quality measurements, operating conditions, wireless unit identity, wireless unit type, direction, speed, time and/or distance associated with the current position and/or previous position(s).

[0011] FIG. 3A shows an example of a location message sent from a wireless unit to a at least one serving base station. In this embodiment, the location is determined at the wireless unit along with signal quality measurements RSSI, BER and FER of the transmit frequency for the serving base station(s), wireless unit type, wireless unit identity and time or reference. The time or reference field can be used to ensure that measurements made at the serving base station on the wireless unit transmit frequency, at other locations or at other wireless units in the same location can be associated with measurements of the base station transmit frequency made at the same time for the particular location.

[0012] In addition to the serving base station's receiver measurements and the wireless unit's receiver measurements being stored by position, the MSC 58 and/or the serving base station 56 can send a message to neighboring base station(s) 60a-h to monitor the wireless unit 54 at the transmit frequency of the wireless unit 54 and collect receiver measurements at the neighboring base station(s) 60a-h for the location of the wireless unit. For example, during a call, unused radio(s) in the neighboring cell(s) 60a-h could monitor the call and receive and/or determine radio signal measurements by location and store the measurements by location. In this example, the neighboring base stations 60a and b are in an N= 7 cell cluster adjacent to the N=7 cell cluster of base stations 56 and 60c-h. The information can be stored in a location or RF database or storage 52 by location and another parameter(s), such as base station identity to identify the measurements by the particular base station 56 and 60a-h, to provide different sets of information by position. Additionally, information, such as base station transmit frequency and information, can be stored in the database 52 for different base stations by using neighboring base station(s) 60a-h to service or monitor a wireless unit 54 in a particular location.

[0013] The measurements or information can be stored by location with entries having different fields for the different forms of information or parameters. For a particular location, the information can be stored by particular base station(s) and further fields designating time period, date, traffic density, weather, mobile type, mobile identity, signal quality measurements, certain operating conditions, frequency and/or other parameters. The information can be stored in different manners, and entries can be updated in different ways. For example, for a given base station and mobile type, the information could be stored in the database 52 as individual measurements for a location within a window, for example all measurements in the last seven days for a particular location.

[0014] To analyze, process or use the information, the window can be narrowed to search by using different parameters, for example entries in the last month for a location by base station and/or particular wireless unit. The information by location can be manipulated over time or used to derive additional information by location, such as an average or weighted average of certain measurements over time or for a particular times during the day and/or under different parameters or operating conditions. An average, weighted average, cumulative average or a function of the measurements for a particular location and time period and/or other parameter(s), such as traffic density, can be maintained. For example, an average or weighted average of measurements for the location by base station can be stored based on measurements which are over a month old which are made between 3PM and 6PM and when traffic density is above a certain threshold level. These measurements can be continuously or recursively updated or maintained using the current measurements.

[0015] The information can be stored by location and linked to a particular base station(s) to determine the RF coverage at particular frequencies and at a particular locations. A window of time could be used to analyze, retrieve or store information associated with a particular geographic location and particular base station(s). The window for measurement entries of a location can be based on a variety of parameters. For example, the window for storing, analyzing or updating the database can be determined by time and traffic density at that point. As such, the database 52 is kept current and any analysis or examination by location to determine RF coverage can be narrowed to a particular set of factors or window of entries defined by particular parameter(s)which are fields of a particular entry, such as location, traffic density, weather, time, date, signal level or interference level, or by parameters or information derived from or a function of different fields in different entries, such as changes in path loss, interference and/or signal level.

[0016] The information for a particular location can be obtained, manipulated, stored and used in a variety of ways depending on the embodiment, and the corresponding location information can also be obtained and associated with a particular location in different ways. For example, FIG. 3B shows example entries in a coverage database for a location 'X'. The location 'X' can be designated by latitude and longitude and include a certain tolerance, for example a radius of 50 meters. Other tolerances or ways to measure tolerances can be used, such as an area encompassing a certain latitude and longitude coordinate or a fraction(s) of a latitude and longitude coordinate depending on the location resolution. In this embodiment, the information in the entries is shown with a variety of parameters, such as base station transmit frequency F_B, wireless unit transmit frequency F_W, corresponding signal quality measurements

$RSSI_{Fb}$, BER_{Fb}, FER_{Fb}, $RSSI_{Fw}$, BER_{Fw} and FER_{Fw} for communications between the wireless unit identified in the wireless id field of the wireless type identified in wireless type field with corresponding transmit power P_{Fw} and the identified base station under the traffic load conditions designated in the traffic load field at a particular time or time period with a corresponding transmit power P_{Fb}. Depending on the embodiment, the signal quality measurements or other parameters can be averages, weighted averages or a function of measurements over a time period or during the time a wireless unit is communicating with the base station at that location. Alternatively, an entry can reflect an individual measurement, and multiple entries can be made for communications between the base station and the wireless unit for a time period at the location.

[0017] Depending on the implementation, the number of entries or parameters for a location given a particular set of parameters or windows can be different or change, and the number of parameters per entry associated with and/or stored with a location can change or be different. For example, in the entries of FIG. 3B, certain signal quality measurements, such as BER, need not be made, or other parameters can be included, such as weather or speed. Additionally, the coverage database can have different informational structures (for example separate entries can be provided for base station transmit frequencies and wireless unit transmit frequencies) and/or include various databases in which the information associated with location is processed, manipulated, changed or used to derive other information by location depending on a particular purpose for the information by location. For example, FIG. 3C shows information associated with a location 'X' and another parameter, such as the identity of the wireless unit 'Z', which provides information or parameters for the particular wireless unit 'Z' by location, such as the transmit powers P_{Fb} and P_{Fw} for the base stations identified in the base station field and the wireless unit Z for designated transmit frequencies F_B and F_W at designated traffic loads during designated time periods. Such information by location can be derived or processed from or can be a function of the information by location in entries such as those shown in FIG. 3B. Furthermore, individual measurement entries can be stored and later processed to provide more useable information by location. Alternatively, individual measurements can be processed to dynamically update certain information by location entries. The individual measurement entries can be stored separately, such as in a local database, then processed to update information by location in the local and/or in a main database.

[0018] In certain embodiments, the wireless unit determines and sends the location information and associated information to the serving base station(s) and/or neighboring base station(s). With particular reference to FIG 4, a wireless unit 70 includes GPS receiver circuitry 72 which receives GPS signals from a duplexer 74 which is connected to the antenna 76 of the wireless unit 70. Alternatively, the GPS receiver could use its own dedicated antenna and/or receive circuitry. Through interaction with a GPS system of satellites and control centers as would be understood by one of skill in the art, the GPS receiver circuitry 72 provides a location information which can include time, speed, distance and/or direction for the wireless unit to the processing circuitry 78 of the wireless unit 70. The processing circuitry 78 can receive the location information in alternative ways. For example, the processing circuitry 78 can periodically or continuously monitor the location information from the GPS processing circuitry. The processing circuitry 78 can manipulate the location information into an appropriate format and store any portion of the location information in a storage or memory. For example, the location information can be stored as a position for the wireless unit, such as the latitude and longitude coordinates, in association with the time, direction and/or speed of the wireless unit at the particular position. Location information can be stored along with signal quality measurements of channel(s) to/from the serving base station as well as signal quality measurements for channel(s) to/from other base stations.

[0019] Depending on the embodiment, the wireless unit 70 can transmit the location information and associated signal quality or other information to a serving base station 54 (FIG. 2) over a channel on the reverse link. Depending on the radio protocol used to communicate with the serving base station, the forward and reverse links established between the base station and the wireless units have different structures. In North American TDMA as defined by TIA/EIA-136 ("IS-136"), the forward link is composed of a forward voice channel and a forward setup channel, and the reverse link is composed of a reverse voice channel and a reverse setup channel. The location and associated information can be sent from the wireless unit to the serving base station over the forward voice channel, for example in a slow associated control channel (SACCH) portion of a voice frame or in a fast associated control channel (FACCH) of a voice frame. To do so, the location information and associated information can be provided to a signal processing /coding block which processes the location information along with the digital voice signals from an analog to digital converter (A/D) 82, for example, by performing speech coding, channel coding interleaving, encryption and/or multiplexing depending on the embodiment. The analog voice signal to be transmitted originate from a microphone 84. As would be under stood by one of skill in the art, the signals to be transmitted are provided to modulator 86 which modulates the signals, for example using differential quadrature phase shift keying (DQPSK), and converts the signals to analog radio frequencies (RF) for transmission. The radio frequency (RF) signals are amplified at amplifier 88 and transmitted using the antenna 76 after passing through the duplexer 74. The location informa-

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tion or other information used by the handoff system can be transmitted over the forward setup channel using the coder 80, modulator 86, amplifier 88, the duplexer 74 and the antenna 76.

[0020] To receive location information requests, the RF signals are received at the antenna 76 and pass through the duplexer 74 to RF receiver and demodulator 90. The RF receiver and demodulator circuitry 90 receives the RF signals and demodulates the signals, for example using DQPSK. The demodulator 90 extracts the encoded, encrypted and/or interleaved information from the signals on the reverse setup channel or in the reverse voice channel and provides the information in digital form to a decoder block 92. The processing/decoder block 92 performs any interleaving, decrypting, channel decoding, speech decoding and/or de-multiplexing of the information signals from the demodulator 90 as would be understood by one of skill in the art. The voice signals are converted from digital to analog at block 94, amplified at block 96 and output to the user at speaker 98. Data signals, such as location information requests from the serving base station can be provided to the processing circuitry which can act on the request. Other data can be displayed on a display 100 or accessed by the user interfacing with a keypad 102.

[0021] FIG. 5 shows a flow diagram of one embodiment of a system for storing location and associated information in the RF coverage storage or database 52 (FIG. 2) sent from the wireless unit 54 (FIG. 2) to the serving base station 56 (FIG. 2) and/or determined at the serving base station 56 (FIG. 2) according to the principles of the present invention. At block 110, a local storage or database 112 (FIG. 2 is initialized from a main database 52 (FIG. 2) connected to the MSC 58 (FIG. 2). The data is received and stored by position (latitude and longitude coordinate) with some tolerance (+/- distance or area encompassed by the latitude and longitude coordinate). The positions in the local database 112 can designate the positions making up the coverage area(s) for the serving base station for a particular set(s) of parameters or information. Additionally, for a position, the manner in which the serving base station services the wireless unit at that position can be determined, for example the transmit powers for the serving base station and the wireless unit at the designated frequencies using information by location structured as in FIG. 3C.

[0022] In certain embodiments, when a wireless unit registers or is to initiate a call or receive a call, the wireless unit 54 (FIG. 2) transmits location information to the wireless communications system, and based on the location information and a comparison of the local database 112 for the serving base station, the main database 112 of the MSC 58 (FIG. 2), or information derived therefrom, the serving base station 56 is determined which currently services the particular location for the wireless unit 54 (FIG. 2) given the particular conditions or parameters, such as the date, the weather, the particular mobile identification number, and/or traffic load of the candidate base station(s). For example, when a wireless unit registers with the local base station upon powering up, the wireless unit sends location information and wireless unit identification information. When the wireless unit detects a stronger base station, the wireless unit again registers and provides location information and wireless unit identification. The local base station can forward this information to the MSC 58 such that the location of the particular wireless unit 54 (FIG. 2) is known at the MSC 58 and the number of pages, time and processing required to locate a wireless unit and determine the serving base station(s) for an incoming call is reduced. Additionally, if the wireless unit is terminating or originating a call, the wireless unit can send location information in a setup message over a setup channel to local base station(s), and the local base station(s) can examine the location information and through a comparison with the local database(s), the main database(s) and/or information derived therefrom, the serving base station is determined and/or the forward link and/or reverse link frequencies for the wireless unit at that location and given any additional parameters.

[0023] Some of the entries from the main database 52 (FIG. 2) can be ignored, discarded, de-emphasized or altered by the main database or the receiving base station as not falling within the window set due to when the entry was made and/or the current parameters or information used to select the entries per location. Accordingly, in this embodiment, given a window or operating parameters or conditions, a local database 112 in the serving base station can be initialized with at least location entries for locations in the coverage area of the serving database corresponding to the current set of conditions or parameters. Given a change in the window or operating conditions, the local database can be initialized with information by location corresponding to the new set of parameters or a subset of the location by information corresponding to the new set of parameters in the local database can be used. If wireless unit identity is a parameter, a coverage area of locations could be established for each wireless unit.

[0024] At block 113, the MSC 58 (FIG. 2) requests the serving base station 56 (FIG. 2) and/or any neighboring cells 60a-h to monitor the call and directly update or supplement the local database 112 of the serving base station and/or the local database(s) 114a-h of the neighboring base station 60a-h with information by location of the wireless unit 54 (FIG. 2) and other parameters if desired, such as type of wireless unit, the wireless unit identification information and/or the transmit frequency. During the call or if the call is active at block 115, the serving base station 56 (FIG. 2) and/or the neighboring base station(s) 60a-h can query the wireless unit 54 at block 116 for data, such as location information and associated information or measure-

ments. The serving cell can send signal quality measurements which can be associated with the location information and other parameters, such as the wireless unit identification, time period, date, forward or downlink traffic frequency, reverse or uplink traffic frequency or other channel frequency. The signal quality measurements of any reverse link frequencies can be made at the serving base station while signal quality measurements for any forward link frequencies can be performed at the wireless unit and transmitted back to the serving base station.

[0025] The neighboring base stations 60a-h can be requested by the serving base station through the MSC 58 (or the request can be made directly if a link exists between base stations) or by the MSC 58 to monitor the wireless unit transmit frequency for location information, and the neighboring base station(s) 60a-h makes signal quality measurements of the received signal from the wireless unit by location. Depending on the embodiment, the wireless unit could also perform signal quality measurements by location of a received signal from the neighboring base station(s) 60a-h. For example, the serving base station can send to the wireless unit forward link channel(s) to monitor the forward link channel(s) by location. The wireless unit measures the signal quality, such as received signal strength, of the forward link channel(s) in association with location. The measurements by location could be sent to the serving base station and/or directly to the corresponding neighboring base station(s) 60a-h to be stored in or processed at the serving base station, the MSC and/or neighboring base station(s).

[0026] Depending on the implementation, the wireless unit 54 can periodically send a location message or autonomously send a location message, for example based on a change in location, to the serving base station and/or the neighboring base station(s). Alternatively, the serving and/or neighboring base station(s) can send trigger positions to the wireless units or send requests to the wireless unit based on trigger positions which trigger the wireless unit to send location information with associated information or measurements to the serving and/or neighboring base station(s). The position triggers could correspond to locations for which the RF coverage system has determined information is desired, for example locations which correspond to a "hole" in the RF coverage. When a wireless unit is near a hole in the RF coverage, a position trigger can be tripped by the location information for the wireless unit, and the wireless unit can collect information by location and transmit the information by location back to the serving and/or neighboring base stations 60a-h in location messages. Depending on the embodiment, if a location trigger is matched by the location information or for other reasons, the location information and associated information can be collected at a higher rate. The location information and the associated measurements or information can be stored in the wireless unit and subsequently sent to the serving and/or neighboring base station in case of an interruption in the call while the wireless unit is in the hole. In fact, the information by location can be stored in the wireless unit and sent to the serving base station and/or another base station in the form of location messages or a location report when the wireless unit is subsequently connected with the wireless communications system. The receiving base station can store the location messages in the local database 112 and/or forward the location messages to the appropriate MSC or serving base station depending on the location.

[0027] When a location message, including location information (which can include information to determine wireless unit location) and associated measurement or other information, is received, the serving base station 54 updates the local database 112 and checks at block 118 for a possible handoff to a neighboring cell 60a-h. If a handoff is necessary, the current serving cell can handoff the call to a neighbor cell 60a-h at block 120, tear down the call at block 122 and update the main database 52 (FIG. 2) at block 124 with the information obtained during the call and stored in the local database 112. If no handoff is required, the serving base station updates the local database 112 at block 126 and continues monitoring the active call by querying the wireless unit for data at block 116. If the call is over at block 115, the serving base station can tear down the call at block 122 and update the main database 52 (FIG.2) using the entries in the local database(s) 112 or 114a-h.

[0028] Depending on the implementation, the serving base station 56 which hands off the call to become a neighboring base station can continue to monitor the call as a neighboring base station. Additionally, when the call is complete or when desired, for example if the local database is full, the local database(s) 112 and 114 a-h (FIG. 2), can transfer the local database entries to update the main database 52 (FIG. 2).

[0029] To perform a handoff by checking the location information in the location message, a handoff can be performed using location information according to U.S. patent application Ser. No. XX/XXX,XXX filed concurrently with this application, assigned to the same assignee and entitled "System for Performing Handoffs Using Location Information For the Wireless Unit," herein incorporated by reference. For example, the location information for the wireless unit can be examined relative to location information in the main and/or local database or information derived therefrom where entries for a particular location include entries from neighboring base stations which are candidates to service the particular location or which are candidates to be handed off to depending on the set of operating parameters and information or measurements made at the location relative to the candidate base stations. Alternatively, depending on how the information by location is processed or structured, information by location can include a field identifying a candidate base station(s) to

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which a wireless unit at a particular location is handed off.

[0030] In some embodiments, the MSC uses the location information to determine whether the wireless unit is to be handed off and a best candidate for the wireless unit to be handed off. The MSC can determine which base station to handoff to by examining a handoff location information for the serving base station. The handoff location information can include different positions or regions within the serving cell and for the different positions or regions, the corresponding best candidate or candidate base station to be handed off to for a wireless unit in the particular position. The handoff location information can be derived from the measurements or information made by wireless unit location and relative to the serving and candidate or neighboring base stations. The MSC can examine the capacity of the handoff candidates in determining which is the best candidate for the wireless unit in the particular position. Additionally, depending on the embodiment, the speed and/or direction of the wireless unit can be included in the location information and be used by the MSC in determining which is the best candidate to handoff the wireless unit at the particular position traveling at a particular speed and/or direction.

[0031] Alternatively, the determination of the best candidate to handoff the wireless unit to can be performed at the wireless unit, serving base station and/or at the MSC. For example, the serving base station can provide the best candidate after examining the location information relative to the measurements or information made by location and relative to the serving base station and candidate base stations or provide a plurality of candidates from which the MSC chooses the best candidate. Alternatively, the MSC can receive the location information and make the determination of whether to handoff the wireless unit and to which candidate base station using the location information and information associated with the location for the candidate or neighboring base stations. Furthermore, the handoff system can determine that more location information is desired to select the best candidate base station. If the wireless unit is to determine whether a handoff is to be made and/or the best candidate base station, handoff location information can be provided to the wireless unit which monitors its location relative to the handoff location information.

[0032] In accordance with an aspect of the present invention, the information by location in the RF coverage database is manipulated, analyzed and/or used to change the RF coverage for a location or particular locations. For example, to correct path loss changes at certain locations or poor service locations which are being detected, the transmit power of the serving cell and/or neighbor cells could be adjusted when communicating with wireless units in those locations. Signal path loss could increase or decrease at a slow or fast rate. Path loss changes occur when objects are in the line-of-sight between the transmit and receive antennas and can occur for example due to building construction or destruction or due to highway traffic which is present or absent. The RF coverage system can record path loss as a field for a location and be used to react to the path loss changes. A determination of the base station(s) to service a particular location and how, for example the transmit power used, can be based on or a function of the information stored by location in the RF coverage system. As such, if a location is subject to high path loss, the transmit power for the serving base station can be determined using information by location. If a location(s) within a cell is determined to be better served by a neighbor base station, the wireless unit(s) in a location or range of locations within a serving cell could be serviced by a neighbor base station and/or transmit powers adjusted for the serving base station and/or the neighbor base station(s) accordingly.

[0033] FIGs. 6A and 6B show an example of how the system using the RF coverage database can provide correction of poor service resulting from an increase in path loss in a particular coverage area. For example, if location information with associated information is collected over a period of time, an RF coverage database or map is generated which includes an RF coverage area 130. In this embodiment, the base station for sector or face 1 of Cell A uses frequency F1 in the RF coverage area 130. Although Cell B does not use frequency F1, the base station(s) for Cell B has been collecting data on frequency F1 in the RF coverage area 130. As shown in FIG. 6B, as time passes a building or obstruction 132 is erected at position P1 which changes the RF coverage for frequency F1 from Cell A because the obstruction 132 interferes with the signals at frequency F1 in the geographic region 133. The obstruction 132 could also be a cluster of trees in the spring and summer which have grown leaves. Since the RF database is constantly being updated with serving cell and wireless unit signal information by location, at some point the coverage area 130 for Cell A at frequency F1 changes to the RF coverage area 134. A call being established at a position in the coverage area 130 but falling out of the new coverage area 134 would be handled by a neighbor cell, such as Cell B, which has monitored the RF coverage area 130, and the MSC 58 has determined based on an analysis of the measurements by location between Cells A and B that Cell B should handle calls established at positions within the coverage area 130 but outside the new coverage area 134. For example, for a given set of parameters, the positions in the area 133 can be designated as being covered by Cell B rather than Cell A if the signal quality measurements for Cell B in the area 133 are consistently greater than a threshold and/or than the signal quality measurements of the Cell A in the area 133 or if the path loss from Cell B to the positions in area 133 is determined to be less than the path loss from Cell A to the positions in area 133. Alternatively, by analyzing the

information by position and another parameter, such as frequency, the MSC 56 can determine a frequency F2 at which the Cell A and/or Cell B can service wireless units in the positions 133 within the coverage area 130 but outside the coverage area 134.

[0034] If the traffic load and/or interference level for a serving base station increases, the RF coverage system can be used to change the RF coverage by providing information by location which can be used to derive or determine RF coverage for a location. FIGs. 7A and 7B show an example of how the system using the RF coverage database can provide dynamic or automatic determination of RF coverage between particular base stations 140 and 142. For example, if location information with associated information is collected over a period of time, an RF coverage database or map is generated which provides an RF coverage area 144 for a base station 140 and a RF coverage area 145 for the base station 142 depending on certain parameters, such as traffic load(s) for the base station(s) 140 and/or 142. Given the traffic load and any other parameter(s), the MSC 58 (FIG. 2) determines the corresponding coverage areas 144 and 145 for the base stations 140 and 142 respectively. The MSC 58 (FIG. 2) can send the corresponding positions to the local databases of the base stations 140 and 142. If the traffic load measurements of the base station 140 and the base station 142, which can be measured by interference levels within the geographic area 144 and/or 145, remain at that particular level, a wireless unit 146 on a highway 147 or a wireless unit 148 on a road 150 within the geographic area 144 establishes a call with the serving base station 140. The wireless unit 146 or 148 accomplishes this by sending a location message used to locate the wireless unit 148 or 148. Given the location of the wireless unit 146 or 148, the serving base station 140 and/or the MSC determines that the base station 140 acts as the serving base station for the current set of parameters or operating conditions.

[0035] If the traffic load increases, for example the traffic on the highway 147 increases dramatically as shown in FIG. 7B, the coverage area 144 corresponding to the base station 140 is reduced or changed as reflected by the information in the local database of the serving base station 140 or the information in the local database is updated from information in the main database of the MSC 58 (FIG. 2), or the information in the main database which the MSC 58 maintains to dynamically change the coverage of base stations 140 and 142. Additionally, the coverage area 145 for the base station 142 is increased to encompass the position of the wireless unit 148 on the road 150. Alternatively, the coverage area can automatically change during certain times, for example from 3PM to 6PM, or due to anticipated changes in the operating conditions. Depending on the embodiment, an existing call established between the wireless unit 148 and the base station 140 can be handed off to the base station 142 or the call is allowed to end with the serving base station and any new calls initiated or terminated within the new coverage area 145 are established through the base station 142 as the serving base station.

[0036] In another application, the RF coverage system can be used in conjunction with a dynamic channel allocation scheme to determine the appropriate coverage for a geographic area and/or a particular location. Dynamic channel allocation refers to the borrowing of carriers or frequencies by base stations needing additional capacity. When a base station borrows the frequency from another base station, the local RF coverage is affected by this additional frequency through co-channel interference and adjacent channel interference. As such, the borrowed frequency might bring it close to the use of the same frequency in a different cluster of cells (thereby causing co-channel interference) and may affect carriers used by other base stations with frequencies close to the borrowed frequency (thereby causing adjacent channel interference). The power used at the location of a wireless unit for the borrowed carrier also has a significant effect on the level of co-channel or adjacent channel interference.

[0037] FIG. 8 shows how the RF coverage system can be used to select a frequency and a power to transmit at the frequency for a location in a geographic area covered by overlapping coverage areas 160 and 162. For example, the coverage area 160 is defined as a set of positions for which the base station of sector 1 in Cell A provides coverage over a set of frequencies, and the coverage area 162 is defined as a set of positions for the base station of sector 2 in Cell B over a different set of frequencies. In this example, Cell A is one of a cluster of N=7 field of cells which supports frequencies F1, F2, F3 and F4 in sector 1 in geographic region 160. Cell B is in a different cluster of N=7 cells which supports frequencies F5, F6, F7 and F8 on sector 2 in geographic coverage area 162. The cells A and B have a dynamic channel allocation feature where a frequency can be moved from another cell if capacity is needed. Accordingly, if the traffic demand in Cell B increases, Cell B can borrow frequency F1 and transmit on frequency F1 on sector 2 of cell B. As such, a co-channel interference is caused in the geographic coverage area 160 which degrades the quality of frequency F1 being used by Cell A for locations in the area 164 created by the intersection of area 160 and area 162. Since the RF coverage database is constantly updated, the coverage area for sector 1 of Cell A taking the additional parameter of frequency F1 is determined using the information by location to exclude the locations in the area created by the intersection 164 of area 160 and 162. Thus, the base station for cell A or sector 1 does not use frequency F1 for locations in area 164.

[0038] Furthermore, using the example of FIG. 8, if the coverage area 160 for sector 1 of Cell A intersects with the coverage area 162 of sector 2 in Cell B, the base station for Cell A could send a message to the

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base station of Cell B (through the MSC or directly depending on the embodiment) requesting the base station for Cell B to lower the transmit power of frequency F1 a small amount at a time until the co-channel or adjacent channel interference disappears from the geographic area 160. As such, the coverage area for sector 1 of Cell A for frequency F1 can be the same as the coverage area 160 and the coverage area for frequency F1 in sector 2 of cell B can be the same as the geographic area 162. Thus, frequencies borrowed for a particular location can be transmitted at a power determined to provide an adequate level of signal quality while reducing the co-channel or adjacent channel interference produced by the borrowed frequency.

[0039] In addition to the embodiment described above, alternative configurations of the RF coverage system according to the principles of the present invention are possible which omit and/or add components and/or use variations or portions of the described system. The manner of measuring, determining, monitoring, transferring, storing and/or sending location information and/or associated information depends on the particular embodiment. Additionally, once the information associated with the position of the wireless unit is stored, the resulting RF coverage database can be manipulated, analyzed and/or used in different ways within the wireless communication system depending on the particular application. The location information can be stored in a variety of manners and locations, and in being used by the wireless communications system to determine RF coverage, the manner in which the information is stored manipulated, augmented and deployed within the wireless communications systems can also vary.

[0040] For example, if the RF coverage system stores information by location and wireless unit type, such as vendor type and/or model, the RF coverage system can be used to identify the service quality of wireless units by vendor. As such, information in the RF coverage system can be used to derive or determine how a wireless unit of a certain type is to be serviced at a particular location. If the embodiment of the RF coverage system obtains information by location and wireless unit identity, such as a wireless unit identification number, electronic serial number or phone number, the information obtained by the RF coverage system can be used to derive or determine how a particular wireless unit is to be serviced at a particular location. Additionally, if the RF coverage system obtains information by location and wireless unit identity, the information obtained by the RF coverage system can be used to identify a rogue wireless unit. A rouge wireless unit is a wireless unit that is not operating properly, for example transmitting at a higher power level than provided for in the wireless communications system. The subscriber is unaware of any service problem, but the wireless unit causes other wireless units to lose signal quality. By storing the wireless unit identity in association with signal quality measurements for the wireless unit and/or time, the identity of the rogue wireless unit could be determined.

[0041] Depending on the embodiment, components of the RF coverage system and/or the wireless communications system can be added, moved, changed or omitted. For example, the RF coverage system as described can be implemented in a TDMA system, but the RF coverage system can be used with other wireless communications systems based on other radio protocols, such as CDMA, Global System for Mobile Communications (GSM), and/or Advanced Mobile Phone System (AMPS). The RF coverage system and portions thereof can be distributed at different locations throughout the wireless communication system, such as the wireless unit, the serving base station, the MSC and/or the neighboring base stations. An embodiment of the RF coverage system has been described with a GPS system to determine location information at the wireless unit. Any other method to determine the location of the wireless unit can be used, such as differential GPS or triangulation methods in which signals from the wireless unit are received at different base stations and the delays between the received signals enable the location of the wireless unit to be determined through triangulation. Moreover, location has been given in terms of latitude and longitude, but other ways to designate location or an area can be used.

[0042] As would be understood by one of ordinary skill in the art, different forms and kinds of location information can be used in the RF coverage mapping process to link or associate a particular location with associated information, such as signal quality information, and other parameters, such as a particular base station, traffic load and frequency. Additionally, the location information and associated information stored in the wireless communications system can be manipulated or updated. Moreover, the location information and associated information can be modified or provided to the wireless communications system in different form so long as the location information and associated information is derived from the corresponding location information and associated information. Furthermore, the RF coverage system can be implemented in different configurations and portions thereof can be implemented in application specific integrated circuits, software-driven processing circuitry, firmware or other arrangements of discrete components as would be understood by one of ordinary skill in the art with the benefit of this disclosure. What has been described is merely illustrative of the application of the principles of the present invention. Those skilled in the art will readily recognize that these and various other modifications, arrangements and methods can be made to the present invention without strictly following the exemplary applications illustrated and described herein and without departing from the spirit and scope of the present invention.

Claims

1. A method of determining coverage for a particular geographic area, said method CHARACTERIZED BY:

   determining a location for a wireless unit (54);
   obtaining information associated with said location; and
   sending said location and said information associated with said location to a base station (56).

2. The method of claim 1 CHARACTERIZED IN THAT said determining and sending includes:

   determining said location at said wireless unit (54); and
   sending said location and said information from said wireless unit (54) to said base station (56).

3. The method of claim 2 CHARACTERIZED IN THAT obtaining includes:

   using a GPS receiver (72) integrated with said wireless unit (70) to obtain said location at said wireless unit (54).

4. The method of claim 1 CHARACTERIZED IN THAT obtaining information includes:

   performing by a wireless unit (54) at said location at least one signal quality measurement on at least one signal received from said base station (56).

5. The method of claim 1 further CHARACTERIZED BY:

   receiving by a base station (56) said location from said wireless unit (54).

6. The method of claim 1 CHARACTERIZED BY:

   receiving by a base station (56) information from said wireless unit (54) resulting from a measurement of at least one signal quality measurement on at least one signal received from said base station (56).

7. The method of claim 1 CHARACTERIZED BY:

   performing by said base station (56) at least one signal quality measurement from at least one signal received from said wireless unit (54) at said location.

8. The method of claim 1 CHARACTERIZED BY:

   storing said information in association with said location.

9. The method of claim 8 CHARACTERIZED IN THAT said storing includes:

   storing said information by location and wireless unit identity.

10. The method of claim 8 CHARACTERIZED IN THAT said storing includes:

    storing said information by location and traffic load for a base station.

11. The method of claim 1 CHARACTERIZED BY:

    providing a location trigger; and
    performing said steps of determining and obtaining in response to said location trigger.

12. A method of determining radio frequency coverage for a particular geographic area, said method comprising:

    determining a location for a wireless unit (54); and
    obtaining by a base station (56) information associated with said location.

13. The method of claim 12 CHARACTERIZED IN THAT said determining includes:

    receiving said location from said wireless unit.

14. The method of claim 12 CHARACTERIZED IN THAT obtaining information includes:

    receiving from a wireless unit (54) information resulting from a measurement of at least one signal quality measurement on at least one signal received from a base station (56).

15. The method of claim 12 CHARACTERIZD IN THAT obtaining information includes:

    performing at least one signal quality measurement from at least one signal received from said wireless unit at said location.

16. The method of claim 12 including:

    storing said information by said location information.

17. The method of claim 16 CHARACTERIZED IN THAT said storing includes:

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storing said information by location and wireless unit identity.

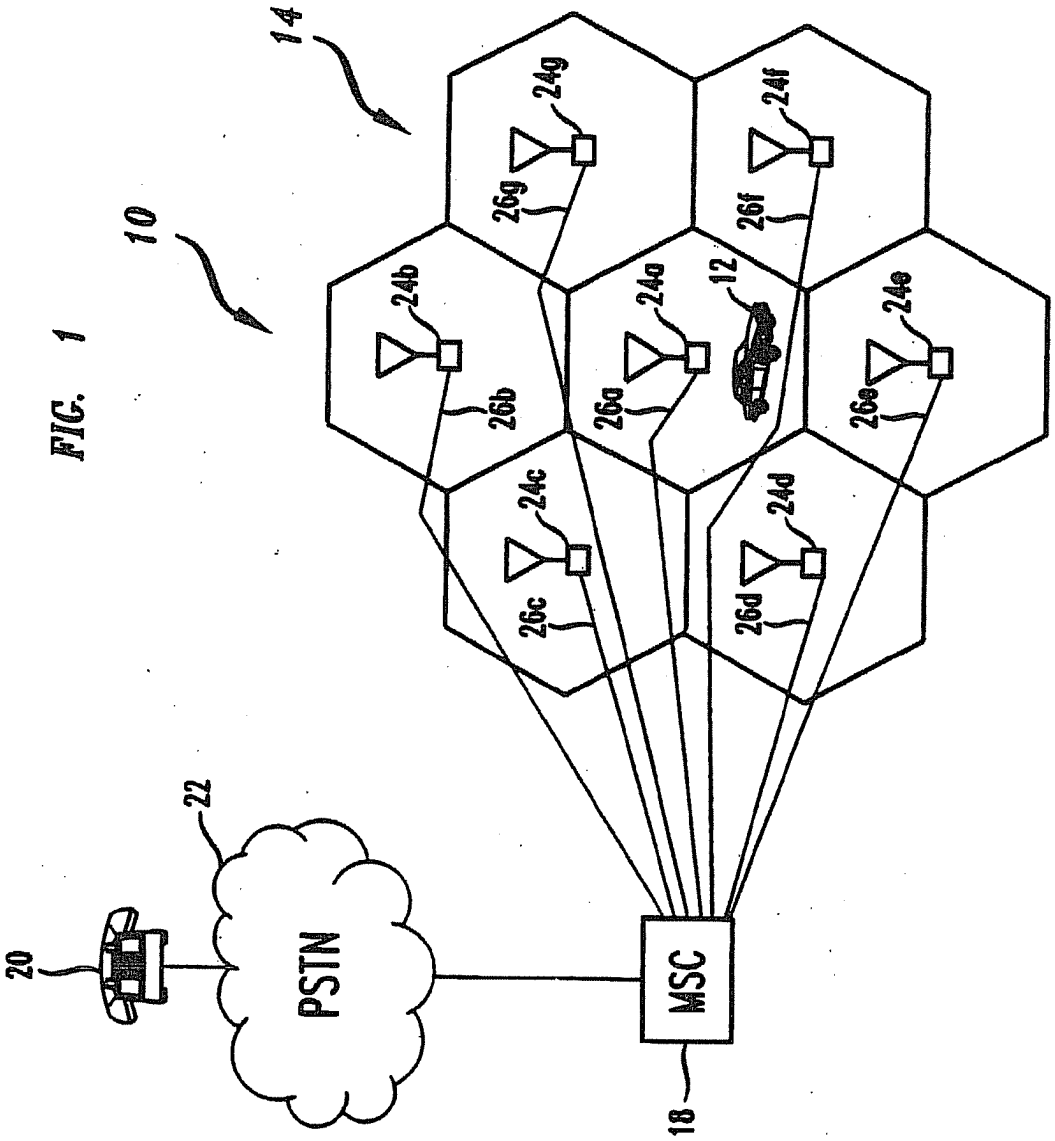
18. The method of claim 16 CHARACTERIZED IN THAT said storing includes:

storing said information by location and traffic load for a base station.

19. A method of determining radio frequency coverage for a particular geographic area, said method CHARACTERIZED BY:

determining a location for a wireless unit (54);
retrieving stored information by said location of a wireless unit (54); and
using said stored information by location to determine how said wireless unit (54) at said location communicates with said wireless communications.

FIG. 1



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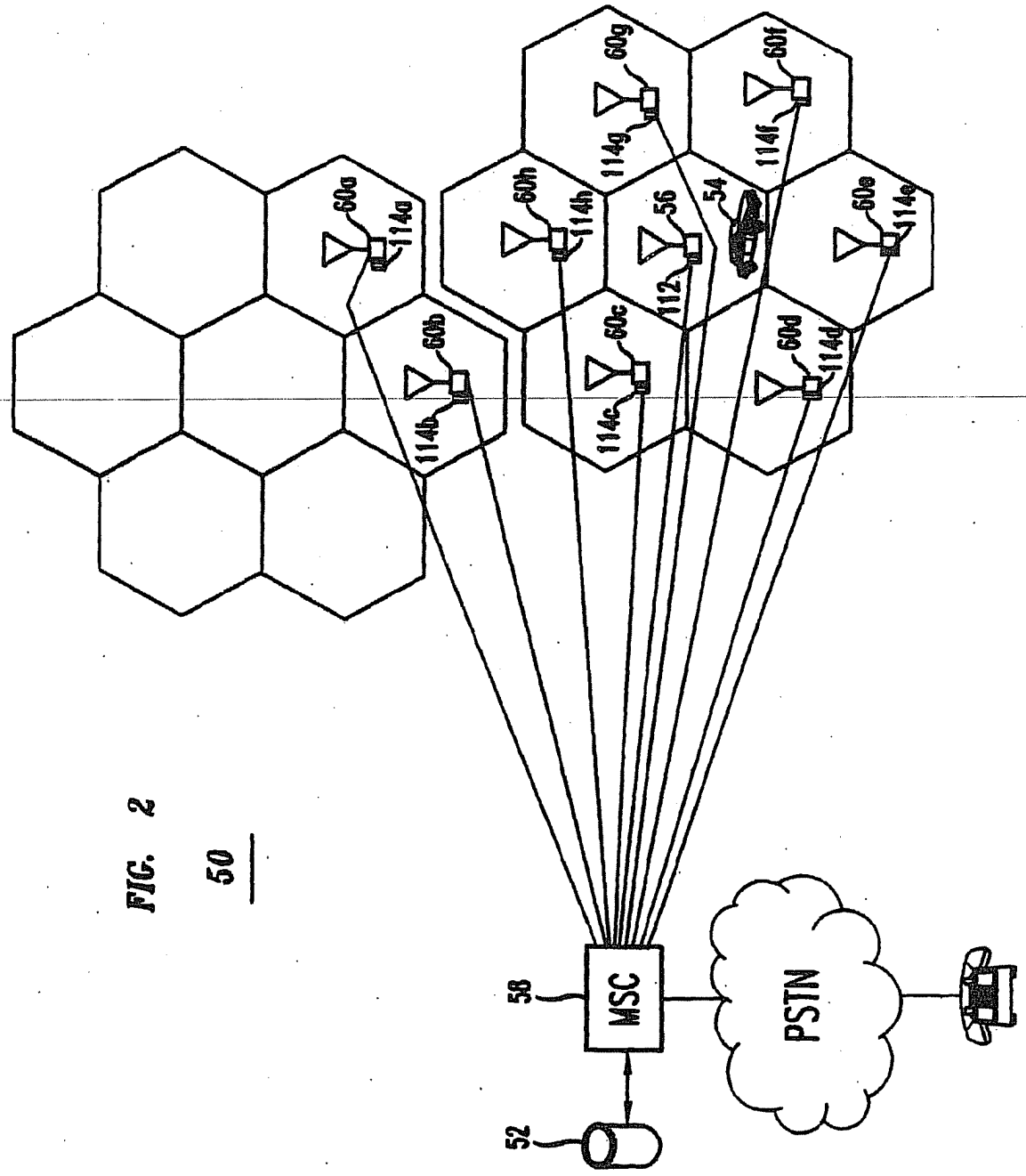

60a
114a
60b
114b
60c
114c
60d
114d
60e
114e
60f
114f
60g
114g
60h
114h
56
112
54
58
MSC
PSTN
52

FIG. 2

50

FIG. 3A

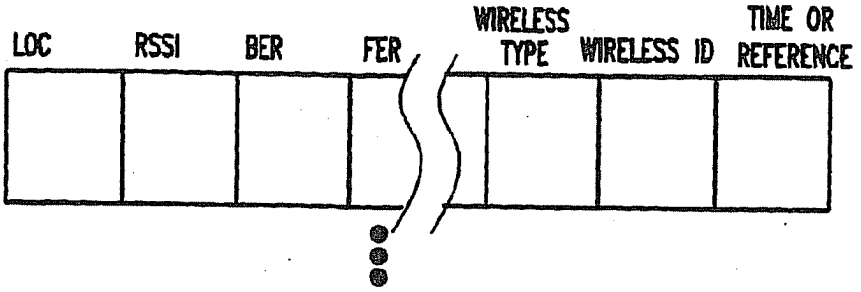


FIG. 3B

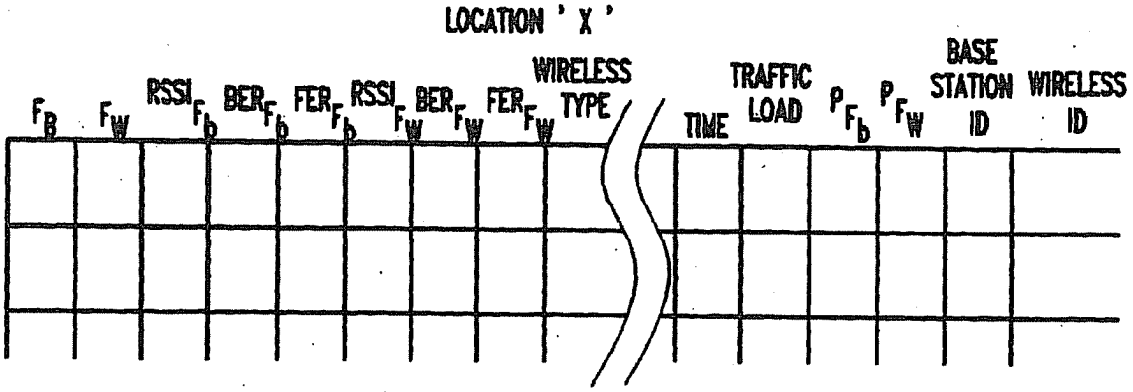


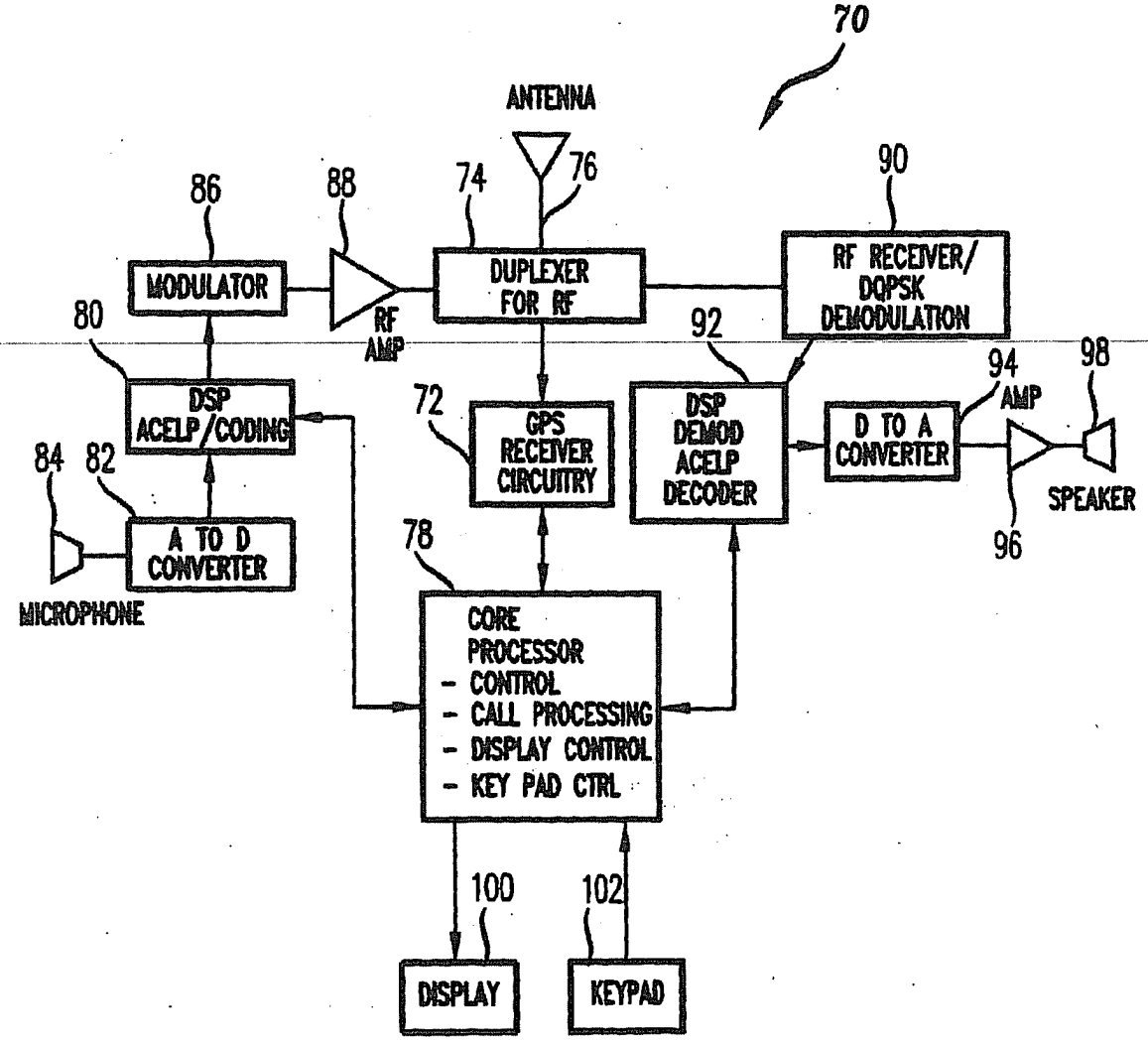
FIG. 3C

LOCATION ' X ' + WIRELESS UNIT ' Z '

F_B	F_W	P_{F_b}	P_{F_W}	TRAFFIC LOAD	TIME PERIOD	BASE STATION

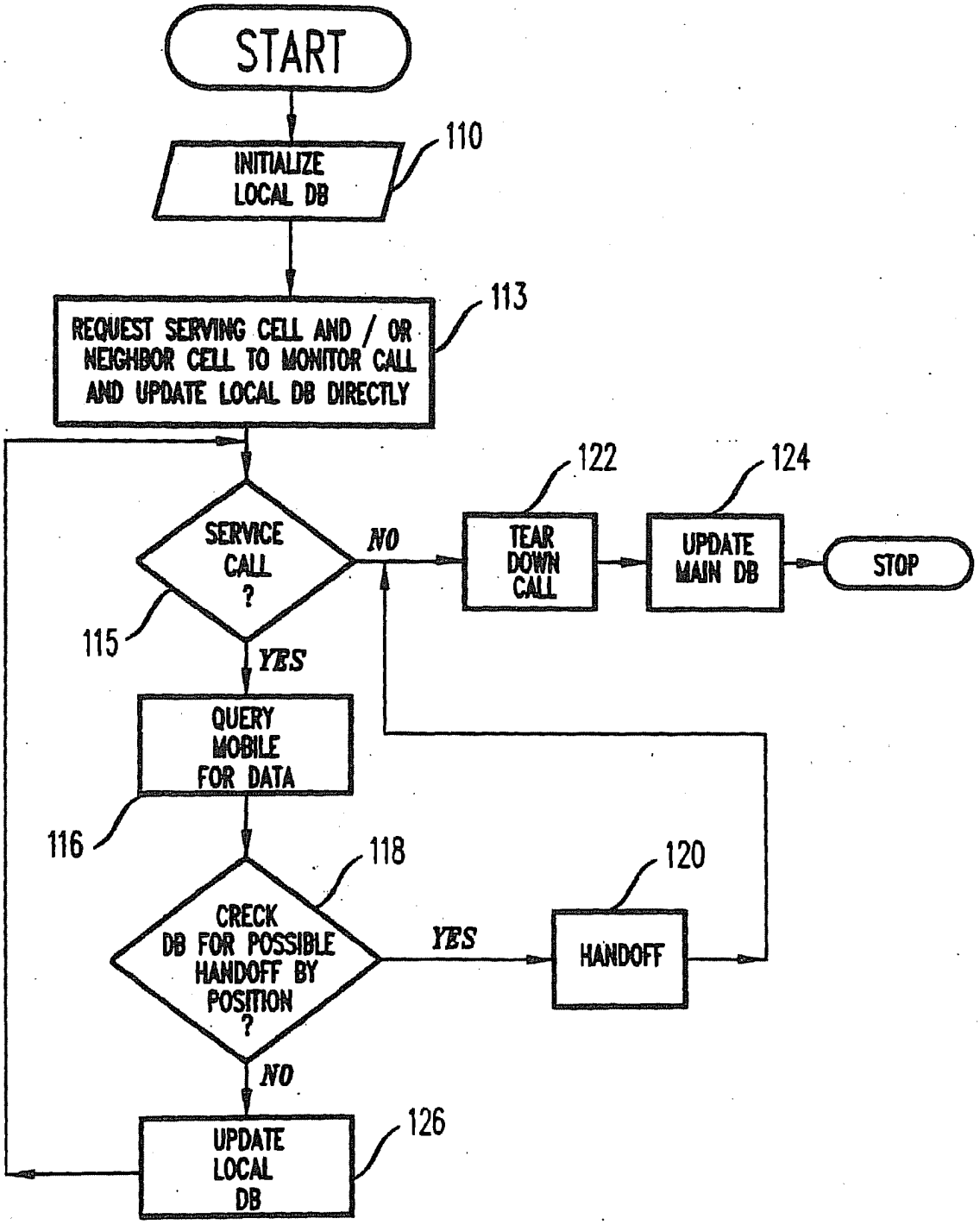
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FIG. 4



MOBILE WITH GPS RECEIVER

FIG. 5



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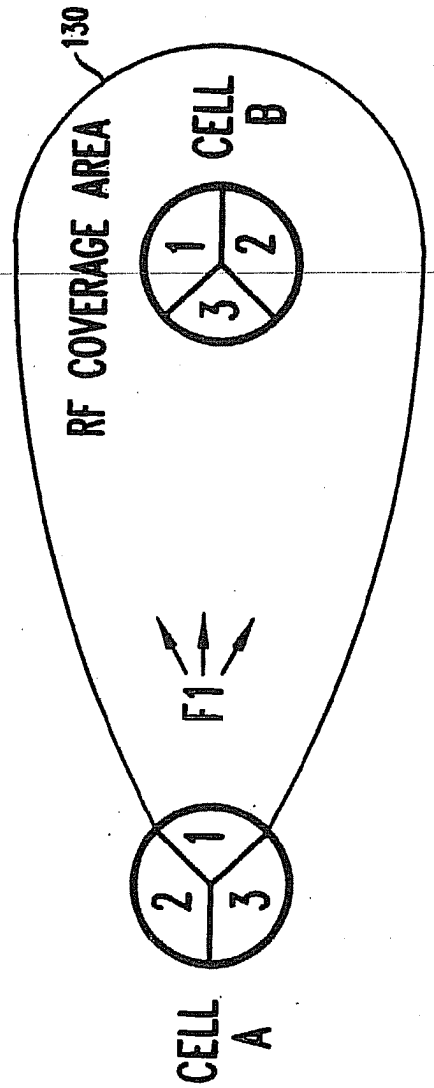

130
RF COVERAGE AREA
CELL B
1
2
3
F1
2
1
3
CELL A

FIG. 6A

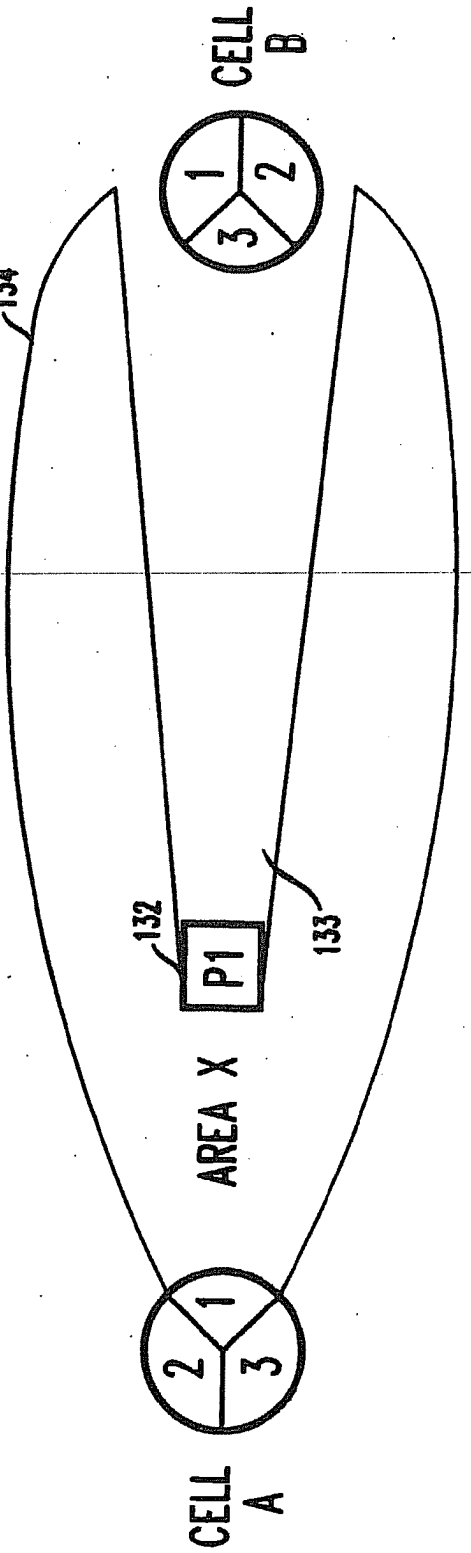

134
CELL B
1
2
3
132
P1
133
AREA X
2
1
3
CELL A

FIG. 6B

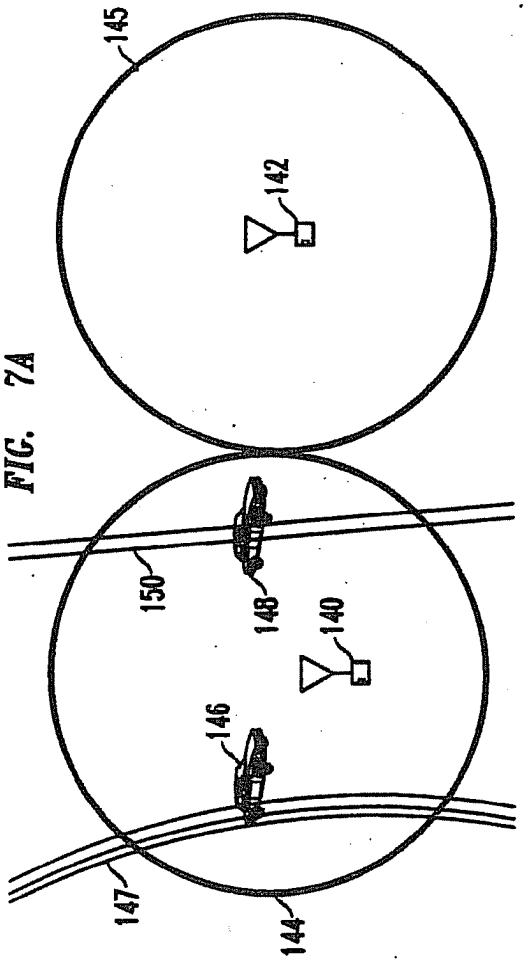


FIG. 7A

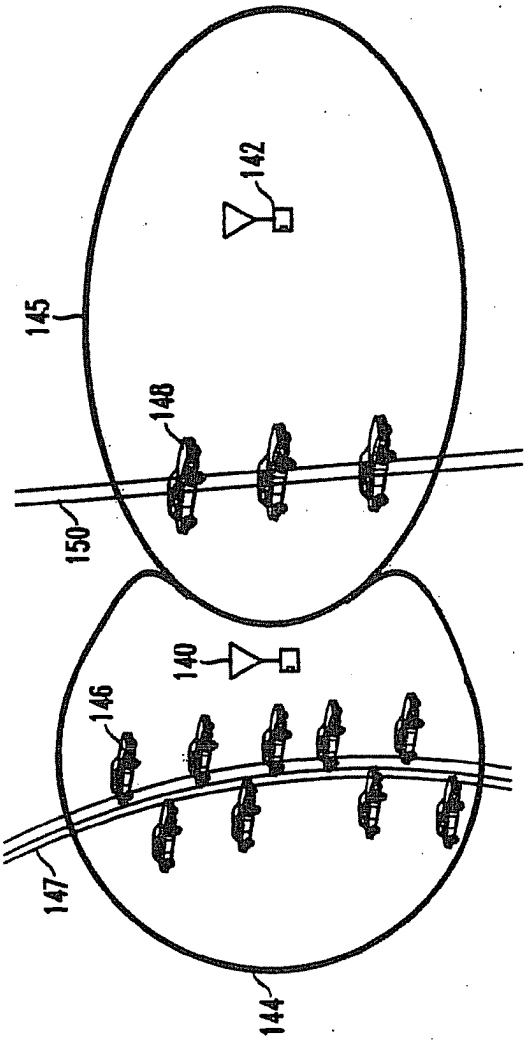


FIG. 7B

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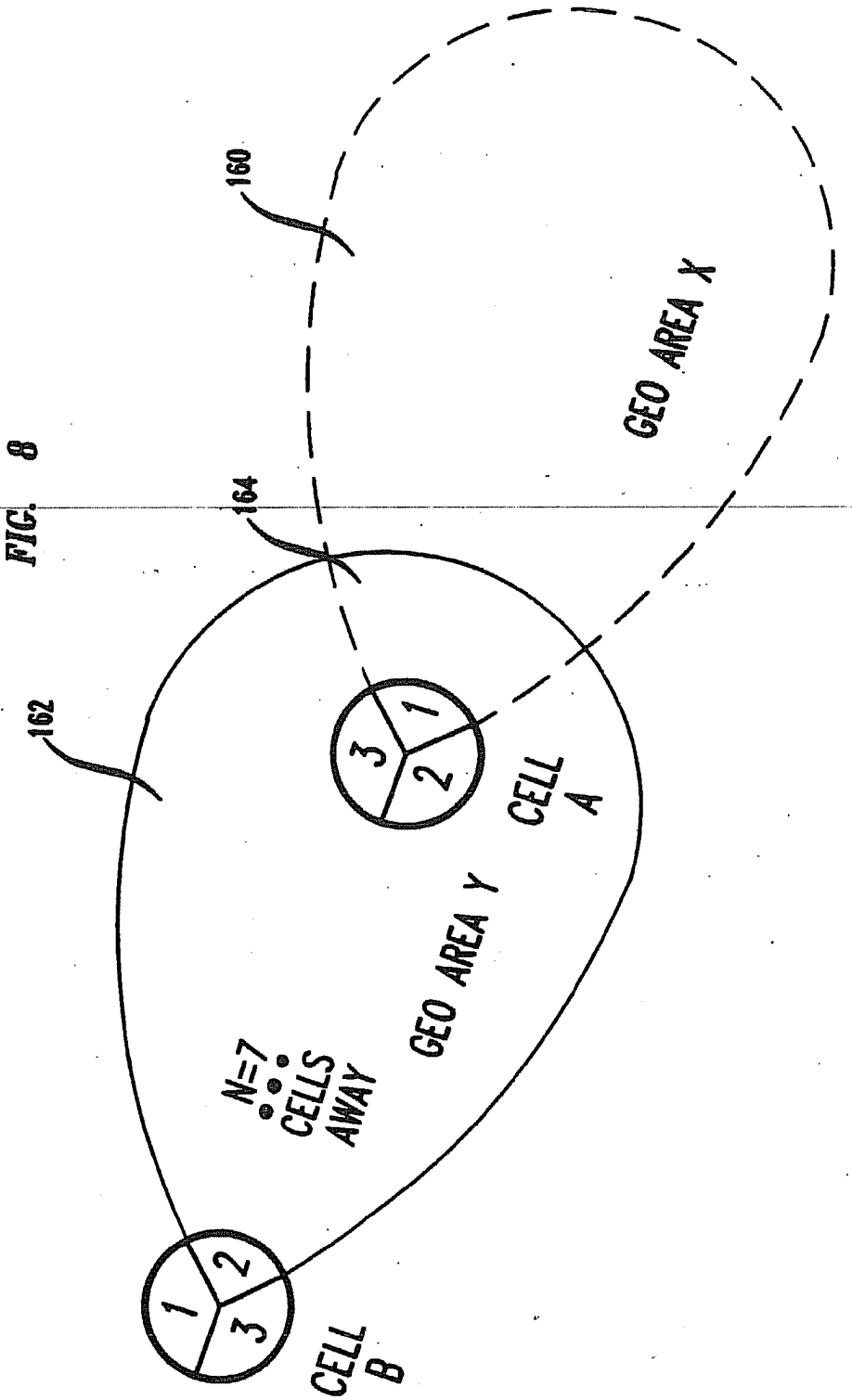

160
GEO AREA X
164
162
3
1
2
CELL
A
GEO AREA Y
N=7
CELLS
AWAY
1
2
3
CELL
B

FIG. 8

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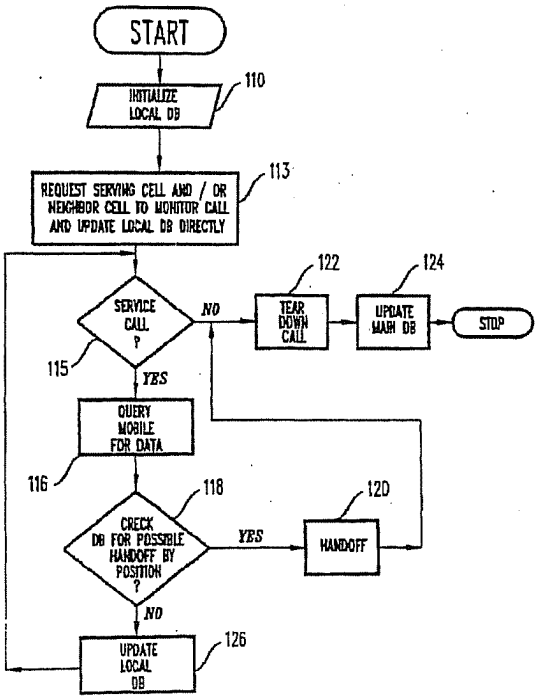
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(54) System for determining wireless coverage using location information for a wireless unit

(57) A system for determining coverage in a wireless communications systems uses location information for a wireless unit and collects information on communications between the wireless unit and the wireless communications system in association with the location information. The wireless communications system determines and/or receives location information for the wireless unit along with other information associated with the location information. The information by location can be used to represent the coverage of a geographic region. For example, during communications between a serving base station and a wireless unit, the serving base station could receive and/or determine signal quality measurements of a forward link and/or of a reverse link at a particular location. Additionally, neighboring base stations can monitor the communications and determine and/or receive location information for the location of the wireless unit along with the information associated with or corresponding to the location of the wireless unit. The associated information can be linked with additional parameters, such as wireless unit type, wireless unit identity, frequency, operating conditions and/or base station identity.

FIG. 5



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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 30 7190

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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X	EP 0 431 956 A (MOTOROLA INC) 12 June 1991 (1991-06-12) * column 2, line 54 - column 3, line 30 * * column 5, line 42 - column 8, line 2 * * column 8, line 29 - line 44 *	1,7-12, 15-18	
X	MOULY M ET AL: "COMMUNICATION MANAGEMENT" GSM SYSTEM FOR MOBILE COMMUNICATIONS, LASSAY-LES-CHATEAUX, EUROPE MEDIA, FR, 1993, pages 500-565, XP000860008 * page 510, line 12 - page 513, line 4 *	19	
X	BECK R ET AL: "Strategies for handover and dynamic channel allocation in micro-cellular mobile radio systems" 39TH IEEE VEHICULAR TECHNOLOGY CONFERENCE (IEEE CAT. NO.89CH2739-1), SAN FRANCISCO, CA, USA, 1-3 MAY 1989, pages 178-185 vol.1, XP010086252 1989, New York, NY, USA, IEEE, USA * page 185, left-hand column, line 1 - line 15 *	19	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H04Q

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	16 January	Palencia Gutiérrez,C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 30 7190

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	16 January 2002	Palencia Gutiérrez,C

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 30 7190

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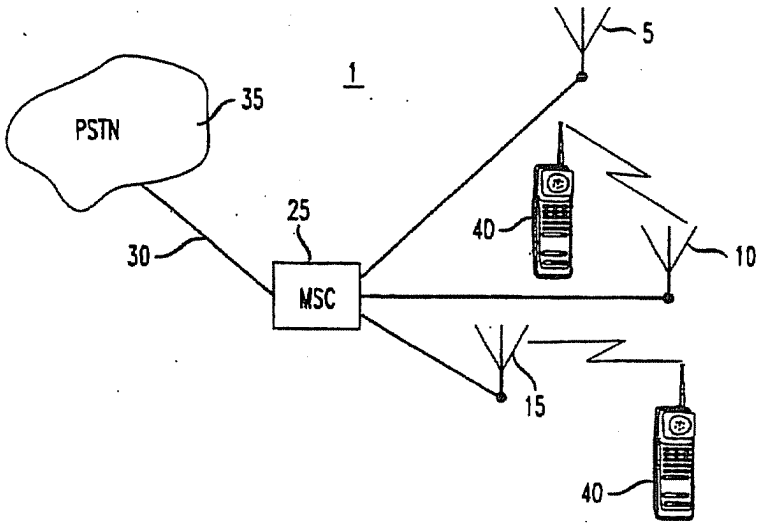
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(54) Method for determining organization parameters in a wireless communication system

(57) A wireless communication system automatically adjusts its organisation parameters using a characterization of signal propagation in the system's coverage area. This characterization involves measuring path loss-related characteristics by the system's base stations and wireless terminals. The path loss-related characteristic may be the wireless terminals' received signal strengths (RSS), based on signals transmitted at known powers by a plurality of the system's base stations. It is possible for the wireless terminals to take measurements while operating in the coverage area, whether idle or during communication with the system, and for such terminals to be associated with the system's subscribers. A resulting characterization of signal propagation, based upon the measured path loss-related characteristic, can then be used to determine parameter settings such as base station transmission power settings, wireless terminal access parameters, neighbour lists, sets of base stations that can reuse channels and base station transmission power settings when base stations are added to or removed from the system.

FIG. 1



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FIG. 1

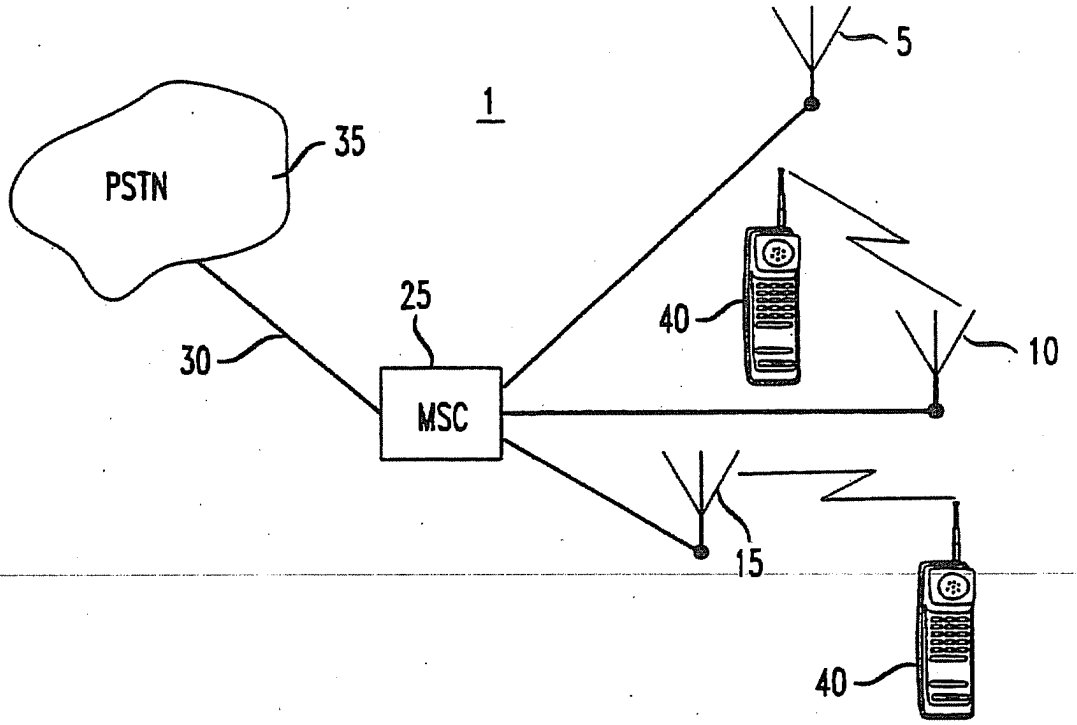


FIG. 2

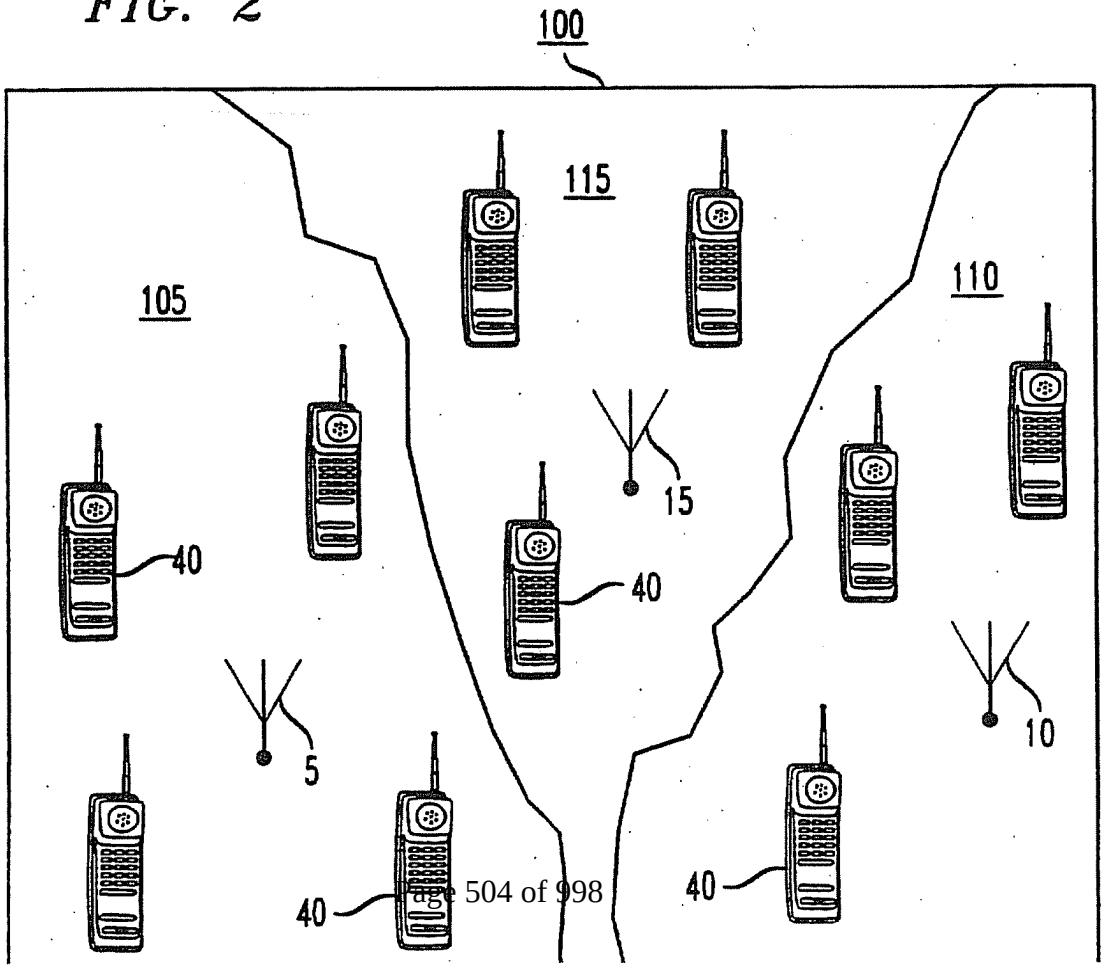


FIG. 3

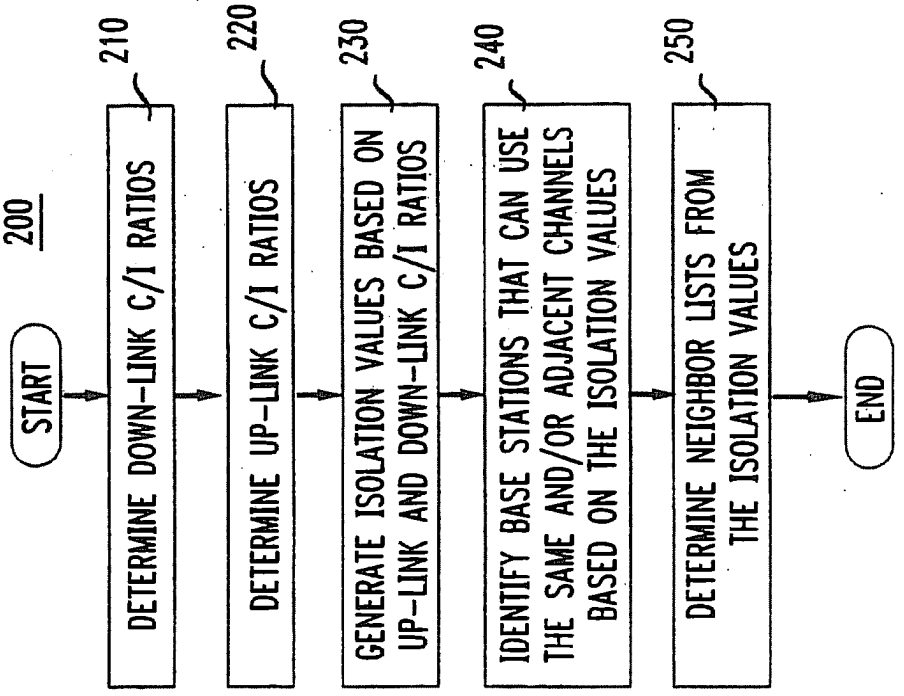
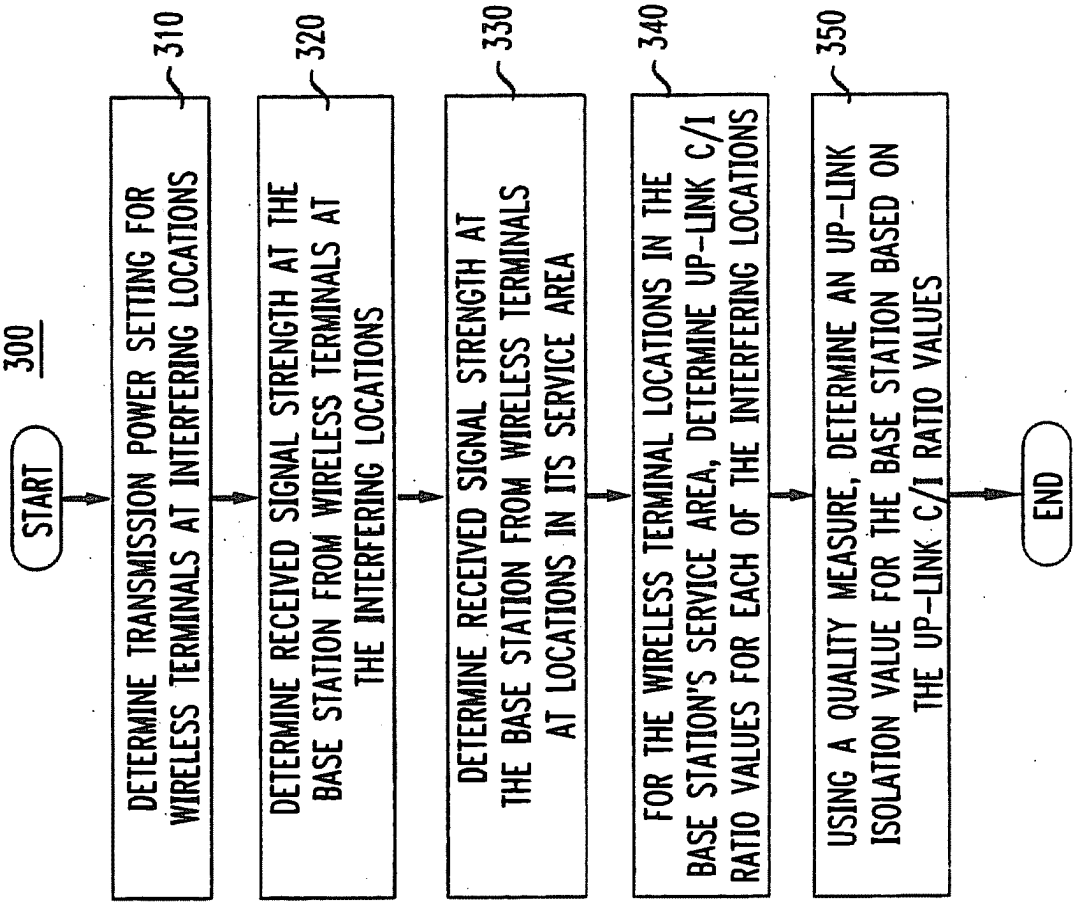


FIG. 4



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METHOD FOR DETERMINING ORGANIZATION PARAMETERS IN A WIRELESS COMMUNICATION SYSTEM

Cross-Reference to Related Case

This application is related to commonly assigned pending U.S. Patent Application Serial No. 08/575,974, filed December 21, 1995, entitled "Method and Apparatus for Wireless Communication System Organization", which is incorporated by reference herein.

Field of the Invention

The invention relates to wireless communication systems in general and more particularly to the organization of such systems.

Background of the Invention

Conventional radio telephone systems such as cellular systems use cell-sites having co-located transmitters and receivers to cover geographical regions referred to as cells. Several cell-sites disposed within a particular geographic area are coupled to a master controller called a mobile telephone switching office (MTSO). The MTSO controls the cell-sites and provides an interface connection to the public switched telephone network (PSTN).

Each conventional cell-site uses pre-assigned channel sets to communicate with mobile units in a service area covered by the cell-site. Each channel set typically includes a pair of carrier frequencies with each carrier frequency being used for respective up-link or down-link communications with a mobile unit. Neighboring cell-sites use different channel sets to avoid interference on the same channel and adjacent channels between adjacent service areas.

Conventional cellular systems provide mobility to a subscriber through a procedure referred to as hand-off. According to this procedure, geographically adjacent cell-sites are considered to be neighbor cell-sites. A neighbor cell-site is the cell-site to which a call can be transferred as a mobile unit traverses a current cell-site boundary. A data table called a neighbor list specifies the cell-sites that can receive a hand-off from a particular cell-site. In addition, to increase the simultaneous communication capacity of a system, channel reuse is employed where two sufficiently distant base stations simultaneously use the same channel.

The channel sets and neighbor lists assigned to particular cell-sites as well as cell-site transmission powers are examples of system organization parameters that define the

operating characteristics of the system. Such parameters are typically determined using propagation models prior to installation of a system. After installation, the system coverage area produced by the determined parameter settings is verified by field testing. During a typical field test, a mobile test unit is moved throughout the service area while the base stations and test unit transmit respective test frequencies. As the test unit is moved from one sampling location to the next, the respective signal strength of the test frequencies and the corresponding geographic location is detected at the respective base stations and test unit to verify that the system can provide service to the intended coverage area.

Typical wireless communication systems do not have the capability to automatically identify and adapt parameter settings to such changes. Environmental changes that often require parameters setting adjustments include the construction of structures in the coverage area, such as a building in an outdoor cellular system or a added walls in an indoor system, or the installation of another wireless communication system in close proximity to the current system. Such changes could degrade system performance and often require an installer to perform computer modeling of the coverage area again to determine the proper parameters settings.

A method that possesses the limited ability of determining frequency channels used by respective cell-sites is described in M. Almgren et al., "Adaptive Channel Allocation in TACS", *IEEE Global Telecommunication Conference Record*, pp. 1517-1521 (1995), which is incorporated by reference herein. According to this method, each cell-site monitors received signal strength (RSS) on respective sets of channels over time and uses the channels for establishing communications that have the lowest interference.

Also, some time division multiple access (TDMA) systems, such as those adhering to the Telecommunication Industry Association Interim Standard 136 (TIA IS-136 standard), have the limited ability to dynamically allocate channels during operation of the systems to achieve greater spectral efficiency and communication capacity. In such systems, a cell-site can request an idle mobile unit to measure the RSS or bit error rate of different communication channels and transmit the measurement information back to the cell-site. Such RSS or bit error rate information indicates the interference on the respective channels. Communication can then be established with the mobile unit using the channel with the lowest interference. However, such a dynamic allocation technique is limited to channel allocation for the respective mobile unit that provides the RSS information.

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Thus, a need exists for a radio telephone system having enhanced spectral efficiency that employs a substantially automated determination of system organization parameters and that is capable of adjusting for environmental changes.

Summary of the Invention

The invention provides a level of automation in determining system organization parameters in a wireless communication system by advantageously determining a signal propagation characterization of the system's coverage area. This signal propagation characterization is based on measurements of a path loss-related characteristic between the system's base stations and a plurality of wireless terminals operating throughout the coverage area. Path loss-related characteristic refers to a measurable characteristic that is partially or fully based on path loss and includes, for example, path loss, bit error rate, word error rate and frame error rate. Path loss refers to the reduction in power of a signal transmitted between two locations. Coverage area refers to the geographic area in which a wireless terminal can communicate with the base stations without substantial interruption.

In accordance with the invention, it is possible for the wireless terminals associated with subscribers located within the coverage area to provide the measurements for the path loss-related characteristic. Such a characteristic can be path loss determined by the wireless terminals measuring received signal strength (RSS) of signals transmitted at known power levels by the system's base stations. Since the base stations are transmitting at known power levels, the path losses between the base stations and the respective locations of the measuring wireless terminals can be determined based on the differences between the known transmission powers and the RSS measurements. The determined path losses are used to form the signal propagation characterization which can be used to predict the signal strength received at locations of the measuring wireless terminals based on a corresponding increase or decrease in base station transmission power. Moreover, the individual and cumulative interference characteristics of signals transmitted on the same or adjacent communication channels between the respective base stations and the locations of the measuring wireless terminals can also be obtained from such a characterization.

Although some conventional systems posses the limited capability of identifying a single particular parameter setting with respect to specific mobile unit, the novel and unobvious use of the signal propagation characterization of the coverage area in this invention advantageously enables the determination of a variety of important system-based settings which can affect multiple wireless terminals. Such a signal propagation characterization can be determined from measurements taken over an extended period of

time. Exemplary parameter settings that can be determined from this characterization include neighbor lists, the sets of base stations which can reuse channels and base station transmission power settings including such settings upon the addition or removal of base stations. For example, base station transmission power settings can be determined directly using the path loss characteristics. The determination of neighbor lists, and those base stations that can efficiently reuse the same or adjacent channels can be performed using isolation values derived from the predicted cumulative interference effects. Isolation values characterize the relative signal isolation of signals originating from a particular base station or its service area from interfering signals originating from another base station and service area.

Since the path loss-related characteristic measurements can be obtained during normal operation of a wireless communication system, the parameter settings can advantageously be updated automatically. Thus, the system does not require costly re-modeling and field testing as changes occur in the coverage area or system that effect the signal propagation. The invention also avoids the complex and labor intensive recording of geographic location information that is typically required during the field testing of conventional installation techniques.

Additional features and advantages of the present invention will become more readily apparent from the following detailed description and accompanying drawings.

Brief Description of the Drawings

FIG. 1 illustrates a schematic block diagram of an exemplary wireless communication system having at least one system organization parameter determined in accordance with the invention;

FIG. 2 illustrates a schematic block diagram of base stations in FIG. 1 arranged to provide service to a coverage area;

FIG. 3 illustrates a flow diagram of an exemplary process in accordance with the invention for determining frequency reuse schemes and neighbor lists based on isolation values for the system arrangement of FIG. 2; and

FIG. 4 illustrates a flow diagram of determining up-link isolation values for a base station in the system arrangement of FIG. 2.

Detailed Description

The invention concerns a technique for determining a system organization parameter setting in a wireless communication system using a characterization of signal propagation of the system's coverage area. The signal propagation characterization is

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based on measurements of a path loss-related characteristic between the system's base stations and wireless terminals operating within the coverage area. System organization parameter refers to a system characteristic that can be determined during the operation of the communication system including wireless terminal access parameters.

Exemplary system organization parameters that can be determined according to the invention include neighbor lists, base stations that can reuse channels, wireless terminal access parameters such as wireless terminal transmission power settings, and base station transmission power settings including such settings upon the addition or removal of base stations from the system. Upon determining a parameter setting, the setting can be used by the system in establishing communications with wireless terminals in the coverage area. However, it should be readily understood that the parameter determination need not be made prior to the establishment of each communication, but can be made at the time of the system installation or intermittently during the operation of the system.

The signal propagation characterization used to determine the parameter settings can be in the form of a table, two or multi-dimension matrix or other mathematical expression of a plurality of the path loss-related characteristics that facilitates prediction of, for example, received signal strength or interference at locations throughout the coverage area. Path loss-related characteristic refers to a measurable characteristic that is partially or fully based on path loss and includes, for example, path loss, bit error rate, word error rate and frame error rate. Path loss refers to the reduction in power of a signal transmitted between two locations. Coverage area refers to the geographic area in which a wireless terminal can communicate with the base stations of the system without substantial interruption. In determining the signal propagation characterization, the path loss related characteristic measurements can be taken over an extended period of time during operation of the system. Path loss, an exemplary path loss-related characteristic, can be determined from the difference between known transmission powers of a plurality of the system's base stations and the corresponding received signal strengths measured by a plurality of wireless terminals at different locations in the coverage area.

An exemplary wireless communication system 1 having a system organization parameter determined in accordance with the invention is shown in FIG. 1. The system includes three base stations 5, 10 and 15 (5-15) connected to a mobile switching center (MSC) 25. The MSC 25 is connected to a public switched telephone network (PSTN) 35 by a suitable trunk 30. If the system 1 is an indoor or outdoor system with a relatively small coverage area, such as in an office building or a campus, then the MSC 25 can alternatively be connected to the PSTN via a private branch exchange (PBX).

The MSC 25 is responsible for routing calls between wireless terminals 40 and the respective base stations 5-15 and to the PSTN 35. For small coverage area applications, suitable MSC's and base stations include, for example, small MSC devices manufactured by Celcore and microcells produced by Lucent Technologies, Inc., respectively. For larger coverage area applications, exemplary MSC and base stations include those manufactured by wireless infrastructure manufacturers such as Lucent Technologies, Inc. The method of wireless communication is not critical to practicing the invention and can be, for example, digital communications techniques including code division multiple access (CDMA) schemes or time division multiple access (TDMA) schemes such as a TDMA scheme in accordance with the Telecommunication Industry Association Interim Standard 136 (IS-136) as well as conventional analog techniques.

FIG. 2 shows the base stations 5-15 of FIG. 1 arranged to provide service to an intended rectangular coverage area 100. It is possible for such a system coverage area to be, for example, 100 m by 200 m to provide wireless communication, such as cellular communication service, to a floor of an office building. The size and shape of the coverage area and the number of positioned base stations is not critical to practicing the invention. Although the depicted coverage area 100 could represent an office building floor, it should be readily understood that the technique of the invention is useful in a variety of wireless systems including, for example, other indoor systems such as those providing service to multiple floors of an office building, airport facilities or shopping malls, and in outdoor systems providing service to a campus or larger systems such as conventional cellular telephone systems as well as PCS systems.

Each of the base stations 5, 10 and 15 provides communications to the wireless terminals 40 in respective service areas 105, 110 and 115 (105-115). The size of the exemplary service areas 105-115 are different due to the respective transmission powers of the base stations 5-15 and the environment in which the base stations 5-15 are operating. Overlap regions (not shown) exist between the service areas 105-115 to enable hand-offs between adjacent base stations to provide substantially uninterrupted communications of a wireless terminal as it travels across service area boundaries. Suitable overlap regions include those used in conventional wireless systems and have not been shown for ease of illustration.

An exemplary method for determining system organization parameters for the system 1 of FIGS. 1 and 2 in accordance with the invention, will be described with respect to path loss based on received signal strength (RSS) measurements taken by the wireless terminals 40 of signals transmitted at a known power by the base stations 5-15. Such path-loss related characteristic measurements are for illustration purposes only, and

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it is alternatively possible in accordance with the invention, to employ other path loss-related characteristics measurements, including bit, word or frame error rates, or for such measurements to be taken by the base stations 5-15 based on signals transmitted by the wireless terminals 40.

According to the exemplary method, RSS measurement data is collected by wireless terminals 40 based on signals transmitted by the respective base stations 5-15. Such collected data can then be transmitted to at least one of the base stations 5-15. It is possible for a wireless terminal 40 to transmit data regarding a RSS measurement to the corresponding base station that provides service to that terminal's location. The RSS data can be transmitted by the wireless terminals 40 at times, for example, when the terminal is activated and registers with the base station, responds to a page, originates a call, and/or intermittently during a call or otherwise. Several current digital communication standards include provisions for wireless terminals to make such measurements, such as the mobile assisted hand-off (MAHO) and mobile assisted channel allocation (MACA) features of IS-136. It is possible for a wireless terminal 40 to be, for example, mobile units, such as cellular or PCS telephones or portable wireless modems for laptop computers or personal digital assistants (PDA's), or stationary units, such as wireless modems associated with desktop computers.

It is possible for the base stations 5-15 to transmit test signals at respective beacon frequencies to provide the reference signals for the RSS measurements taken by the wireless terminals 40. The beacon frequencies employed by the base station 5-15 are frequencies not used by other base stations in the vicinity, and correspondingly, provide identification of the source base stations for the test signals used for RSS measurements. In the alternative, a single beacon frequency can be employed for the test signal by the base stations which transmit the signal at respective timing intervals and in a particular sequence to indicate the identities of the respective source base stations. The use of beacon frequency signals for RSS measurements is not meant to be a limitation on the invention and other techniques can be employed to differentiate the sources of the signals to be detected by the wireless terminals 40.

Provided in the following Tables 1-1 to 1-3 are lists of exemplary signal strength measurements reported by the wireless terminals 40 to the corresponding servicing base stations 5-15 servicing their location. A wireless terminal reference number appears in the left column of Tables 1-1 to 1-3 for ease of discussion but such reference numbers are not required for operation of the invention. The data in Table 1-1 corresponds to RSS data from 18 different wireless terminals 40 which are not all depicted in the service area

105 in FIG. 2 for ease of illustration. The RSS data in Tables 1-2 and 1-3 are from 18 and 26 other wireless terminals 40 located in the corresponding service areas.

Table 1-1

RSS Report From Wireless Terminals in Service Area 105

Location of Wireless Terminal Ref. No.	RSS from base station 5 (dBm)	RSS from base station 10 (dBm)	RSS from base station 15 (dBm)
1	-60	-114	-100
2	-32	-109	-95
3	-32	-103	-90
4	-60	-97	-86
5	-77	-88	-83
6	-77	-88	-72
7	-60	-97	-76
8	-32	-103	-83
9	-32	-109	-90
10	-60	-114	-96
11	-70	-115	-93
12	-60	-110	-86
13	-60	-105	-76
14	-69	-98	-65
15	-76	-107	-72
16	-77	-112	-83
17	-81	-116	-92
18	-90	-118	-92

Table 1-2

RSS Report From Wireless Terminals in Service Area 110

Location of Wireless Terminal Ref. No.	From base station 5 (dBm)	From base station 10 (dBm)	From base station 15 (dBm)
19	-88	-77	-83
20	-97	-60	-86
21	-103	-32	-90
22	-109	-32	-95
23	-114	-60	-10
24	-114	-60	-96
25	-109	-32	-90
26	-103	-32	-83
27	-97	-60	-76
28	-88	-77	-72
29	-98	-70	-65
30	-105	-60	-76
31	-110	-60	-86
32	-115	-70	-93
33	-116	-81	-92
34	-112	-77	-83
35	-107	-77	-72
36	-118	-92	-93

Table 1-3

RSS Report From Wireless Terminals in Service Area 115

Location of Wireless Terminal Ref. No.	RSS from base station 5 (dBm)	RSS from base station 10 (dBm)	RSS from base station 15 (dBm)
37	-77	-88	-83
38	-88	-77	-83
39	-88	-77	-72
40	-77	-88	-72
41	-70	-98	-65

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42	-81	-91	-55
43	-91	-81	-55
44	-98	-70	-65
45	-112	-77	-83
46	-107	-77	-72
47	-101	-81	-55
48	-95	-88	-27
49	-88	-95	-27
50	-81	-101	-55
51	-77	-107	-72
52	-77	-112	-83
53	-88	-114	-83
54	-88	-109	-72
55	-91	-105	-55
56	-95	-100	-27
57	-100	-95	-27
58	-105	-91	-55
59	-109	-88	-72
60	-114	-88	-83
61	-91	-118	-92
62	-118	-91	-92

Actual received power measurements by a wireless terminal 40 would be limited by the detection capabilities of that wireless terminal. Thus, high power readings would be clipped to the upper limit of the receiver measurement range and, likewise, the lower power levels would be limited by the "noise floor" of the terminal.

Each row in the Tables 1-1, 1-2 and 1-3 corresponds to measurements that are substantially taken at a location in the coverage area by a respective wireless terminal 40. It is possible for the location to be a respective region of a size that is partially based on the size of the base station service areas. For instance in a large outdoor system, such as a conventional cellular telephone system, the location can be as large as ten's of square meters, while in an indoor system, such as in an office building, a location can be as small as approximately a quarter of a square meter.

Moreover, it is not critical that all RSS measurements made by a particular wireless terminal 40 include data for signals transmitted by all the respective base stations. It is possible for RSS data to be collected at a particular wireless terminal location from less than the total number of base stations. The number of RSS measurements that should be used in determining a system organization parameter is partially based on the parameter to be determined and is described in greater detail below.

The RSS data contained in Tables 1-1, 1-2 and 1-3 along with the known base station transmission power settings provide a characterization of the path loss between the wireless terminal locations where the measurements were collected and the base stations that generated the signals being measured. A path loss L can be determined from the signal power S_1 received by a wireless terminal 40 according to equation (A): $L = S_2 - S_1 + G_{base} + G_{term}$, wherein S_2 is the base station transmission power and G_{base} and G_{term} are the base station and wireless terminal nominal antenna gains, respectively. Antenna gains

G_{term} of conventional wireless terminals are typically in the range of approximately 0 to 3 dB for omni-directional antennas, and antenna gains for conventional cellular telephone base stations G_{base} are often on the order of 10 dB. Base station antenna gain G_{base} for smaller wireless communication systems such as indoor systems can, for example, be in the range of approximately 0 to 3 dB.

The path loss information enables the prediction of signal strengths that would be received by a wireless terminal location based on different base station transmission power settings. Moreover, the cumulative predictions of received signal strengths at a location from different base stations enable the determination of interference characteristics in the coverage area 100 as is described in greater detail below with regard to FIG. 3.

The Tables 1-1, 1-2 and 1-3 include data for 62 locations in the coverage area for discussion purposes only. However, a sufficiently large number of RSS readings from different locations should be taken in accordance with the invention to provide a substantially accurate representation of the path losses between the base stations 5-15 and regions of the coverage area 100 to enable determination of the system parameter. If too few RSS measurements were used in determining a parameter, then an inadequate characterization of the coverage area could result which can lead to an inaccurate parameter setting determination. It is possible for the number of RSS readings taken at corresponding locations in a base station service area to be, for example, on the order of several hundreds to several thousands.

Thus, in an exemplary outdoor system with relatively high communication traffic, it is possible to take a sufficiently large number of RSS data measurements for determination of a parameter setting approximately every few minutes or hours. In contrast, in an exemplary indoor system with a limited number of users, such as less than ten, it can take on the order of several days to obtain a sufficient number of RSS data measurements to adequately characterize the signal propagation in the coverage area to determine a parameter setting or adjustment. Further, it is advantageous to collect RSS data intermittently, whether, periodically or otherwise, during system operation to detect and adjust a parameter setting as required.

The unique path loss characterization obtained from the RSS measurements enables determination of a variety of important parameter settings including transmission power, isolation values, neighbor lists, the base stations that can reuse channels, wireless terminal access parameters and the transmission power for the addition or removal of base stations in the system 1. A description of the determination of the previously listed parameters follows. However, these parameter determinations are representative of the

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parameters that can be determined in accordance with the invention and not exhaustive and are not intended to be a limitation of the invention.

I. Base Station Power Level Settings

The signal strength that would be received at a coverage area location from a signal transmitted by one of the base stations 5-15 can conveniently be determined based on equation (B) : $S_1 = S_2 - L + G_{base} + G_{term}$. Since the nominal antenna gains G_{base} + G_{term} and path loss L can be considered constant, then the received signal strength S_1 at a location in a service area by a wireless terminal 40 is directly proportional to the transmitted signal power S_2.

According to equation (B), a relative change in transmission signal power S_2 will result in a corresponding change in the received signal strength S_1 at that location. Thus, the signal strength S_{1New} that would be received at a location for a new base station transmission power S_{2New} is as follows: $S_{1New} = S_{1RSS} + (S_{2New} - S_{2RSS})$, wherein S_{1RSS} is an RSS value from the Table 1-1, 1-2 or 1-3 obtained during the collection of the RSS data and S_{2RSS} is the known base station transmission power used during the collection of the RSS data.

For instance, if an exemplary base station transmission power setting S_2 of 10 dBm was used for the base station 10 to generate the RSS data in Tables 1-1, 1-2 and 1-3, then an increase in transmission power of the base station 10 to 15 dBm would produce a corresponding increase in the received signal strength at the measured locations of 5 dBm over the RSS values listed in the second column of the Tables 1-1, 1-2 and 1-3. For instance, the received signal strength at the location of the wireless terminal reference no. 1 in Table 1-1 from the base station 5 would be -55 dBm or 5 dBm more than the corresponding listed RSS value of -60 dBm.

Thus, in accordance with the invention, it is possible to determine the base station power level settings such that, for example, 95% of the locations in the coverage area 100 would receive a threshold signal strength of at least -90 dBm. Such a constraint is for explanation purposes only and it is possible to employ other constraints for determining the required coverage area according to the invention. For ease of discussion, the base stations 5-15 are limited to transmitting signals having power levels in the range of 0 dBm to 20 dBm in steps of 5 dBm.

For the following examples, it is assumed that the transmission power settings of the base stations 5, 10 and 15 that produced the RSS data listed in Tables 1-1, 1-2 and 1-3, is 10, 10, 15 dBm, respectively, unless stated otherwise. At such transmission power settings, 17 of the 18 measurement locations in the service area of base station 5 would

satisfy the RSS threshold requirement for signals transmitted by the base station 5 as indicated in column 1 of Table 1-1. The location of wireless terminal reference no. 18 would receive a signal strength of -91 dBm which is the only measured location that would fail to meet this threshold requirement. As a consequence, a coverage percentage of 94% (17/18 x 100%) is achieved for the service area of base station 5 transmitting at 10 dBm. Thus, increasing the transmission power of base station 5 by one step to 15 dBm would result in the location of the wireless terminal no. 18 receiving a 5 dBm increase in signal strength to -86 dBm.

In a similar manner, the service area of base station 10 also has a coverage percentage of 94% because 17 of the 18 locations where wireless terminal measurements were taken meet or exceed the -90 dBm threshold requirement with that base station transmitting at 10 dBm as shown in the second column of Table 1-2. The location of wireless terminal reference no. 36 receives a signal strength of -92 dBm which does not satisfy the threshold requirement. Accordingly, as in the case of the base station 5, by increasing the transmission power of the base station 10 by 5 dBm to 15 dBm, a 100% coverage area is achieved.

However, as the base station transmission power settings are increased or decreased a corresponding change occurs in the relative size of the service areas as is described in the following example. In the service area of base station 15, 24 of the 26 locations at which RSS measurements were taken meet the received signal strength requirement with signals transmitted by the base station 15 at 15 dBm. Specifically, wireless terminal reference nos. 61 and 62 receive signal strengths of -92 dBm from signals generated by the base station 15. Thus, only 92 % (24/26 x 100%) of the locations in the service area meet the threshold from base station 15.

Nevertheless, no change is required in the transmission power of base station 15 because the increase in transmission powers of the base stations 5 and 10 resulted in an increase in the service areas size of the base stations 5 and 10 which will cover the two locations in Table 1-3 not covered by the base station 15. In particular, the location where the wireless terminal reference no. 61 took its measurements would receive a signal strength of -86 dBm from base station 5 transmitting at 15 dBm, and the location at which the wireless terminal reference no. 62 took its measurements would also receive a signal strength of -86 dBm from base station 10 transmitting at 15 dBm. Since the relative size of the service areas provide by the respective base stations varies with transmission power, it is often desirable to use RSS measurements from a relatively greater number of locations in the coverage area than those listed in Tables 1-1, 1-2 and 1-3.

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In addition, if a coverage percentage of 100% is detected for an existing power level setting, it is often advantageous to determine whether the corresponding base station transmission powers can be decreased while still meeting the coverage area threshold requirement. It is desirable to use the substantially lowest transmission power settings to obtain coverage of a given service area to avoid interference in neighboring service areas and facilitate channel reuse.

The following Table 2 lists the expected received signal strengths at the locations where the wireless terminals 40 took the RSS measurements listed in Tables 1-1, 1-2 and 1-3 with the transmission power level of each base station 5, 10 and 15 set to 15 dBm. The values in the first and second columns of Table 2 correspond to a 5 dBm increase over the values in the respective first and second columns of Tables 1-1, 1-2 and 1-3 because of the increase of 5 dBm in the transmission powers of base stations 5 and 10 from 10 dBm to 15 dBm. However, the entries in the third column of Table 2 are identical to the respective third columns of Tables 1-1, 1-2 and 1-3 as both concern the transmission power of base station 15 set to 15 dBm. A fourth column has been added in Table 2 indicating the respective base stations that would provide the substantially strongest signals to corresponding wireless terminal locations for the table entries.

Table 2

Received Signal Strength with at the locations of the wireless terminals with the base stations transmitting signals at 15 dBm

Location of Wireless Terminal Ref. No.	RSS from base station 5 (dBm)	RSS from base station 10 (dBm)	RSS from base station 15 (dBm)	Covered by Base Station
1	-55	-109	-100	5
2	-27	-104	-95	5
3	-27	-98	-90	5
4	-55	-92	-86	5
5	-72	-83	-83	5
6	-72	-83	-72	5
7	-55	-92	-76	5
8	-27	-98	-83	5
9	-27	-104	-90	5
10	-55	-109	-96	5
11	-65	-110	-93	5
12	-55	-105	-86	5
13	-55	-100	-76	5
14	-64	-93	-65	5
15	-71	-102	-72	5
16	-72	-107	-83	5
17	-76	-111	-92	5
18	-85	-113	-92	5
19	-83	-72	-83	10
20	-92	-55	-86	10
21	-98	-27	-90	10
22	-104	-27	-95	10
23	-109	-55	-10	15
24	-109	-55	-96	10
25	-104	-27	-90	10
26	-98	-27	-83	10

27	-92	-55	-76	10
28	-83	-72	-72	10
29	-93	-65	-65	10
30	-100	-55	-76	10
31	-105	-55	-86	10
32	-110	-65	-93	10
33	-111	-76	-92	10
34	-107	-72	-83	10
35	-102	-72	-72	10
36	-113	-87	-93	10
37	-72	-83	-83	5
38	-83	-72	-83	10
39	-83	-72	-72	15
40	-72	-83	-72	15
41	-65	-93	-65	15
42	-76	-86	-55	15
43	-86	-76	-55	15
44	-93	-65	-65	15
45	-107	-72	-83	10
46	-102	-72	-72	15
47	-96	-76	-55	15
48	-90	-83	-27	15
49	-83	-90	-27	15
50	-76	-96	-55	15
51	-67	-102	-72	5
52	-72	-107	-83	5
53	-83	-109	-83	15
54	-83	-104	-72	15
55	-86	-100	-55	15
56	-90	-95	-27	15
57	-95	-90	-27	15
58	-100	-86	-55	15
59	-104	-83	-72	15
60	-109	-83	-83	10
61	-86	-113	-92	5
62	-113	-86	-92	10

II. Base Station Service Area Coverage And Overlaps

Overlaps of base station service areas permit hand-offs of communications with a wireless terminal 40 that is moving from one service area to the other. One method for establishing the overlaps is to employ a hand-off hysteresis limit. A hand-off hysteresis limit establishes overlaps in service areas as regions that can receive signal strengths from two or more base stations that all satisfy a threshold RSS criteria as well as being within a particular limited range of one another, such as, for example, 15 dB. Thus, for example, communication between the system 1 in FIG. 2 and a wireless terminal 40 is provided by a first base station if that base station provides the substantially strongest received signal strength at the wireless terminal and if the received signal strength satisfies a threshold requirement of -85 dBm. This same wireless terminal location can also be covered by a second base station if the signal strength received at the location is at least -85 dBm as well as within the hand-off hysteresis of 15 dB of the signal strength received from the

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first base station. As a result, a wireless terminal 40 traversing that location can have its communication with the first base station handed-off to the second base station.

Table 3 is based on the signal strengths listed in Table 2 and includes the base stations that cover the respective regions assuming a hysteresis hand-off limit of 15 dB. In Table 3, a "1" denotes that the corresponding region is covered by a particular base station and a "0" denotes that no coverage is provided to the region by the particular base station. For instance, at the location of wireless terminal reference no. 14 in Table 2, the received signal strength from base station 10 is -93 dBm which is below -85 dBm and therefore, this base station would not cover the location of wireless terminal reference no. 14 as indicated by the "0" in Table 3. However, the received signal strengths from base station 5 and 15 are -64 and -65 dBm, respectively, which are both above the threshold -85 dBm and within 15 dBm of one another. Thus, base stations 5 and 15 would cover the region 24 as indicated by the "1's" in Table 3.

Conversely, Table 2 shows that at the location of the wireless terminal no. 30, the received signal strength is greater than -85 dBm from base stations 10 and 15. However, only base station 10 is considered to service that location because the difference in the received power from base stations 10 and 15 is 21 dB which is greater than the 15 dB limit. Thus, in Table 3, location of the wireless terminal no. 30 is indicated as serviced only by the base station 10.

Table 3

Location coverage by base stations 5, 10 and 15

Location of Wireless Terminal Ref. No.	5	10	15
1	1	0	0
2	1	0	0
3	1	0	0
4	1	0	0
5	1	1	1
6	1	1	1
7	1	0	0
8	1	0	0
9	1	0	0
10	1	0	0
11	1	0	0
12	1	0	0
13	1	0	0
14	1	0	1
15	1	0	1
16	1	0	1
17	1	0	0
18	1	0	1
19	1	1	1
20	0	0	1
21	0	0	1
22	0	1	0
23	0	0	1
24	0	1	0
25	0	1	0
26	0	1	0
27	0	1	0

28	1	1	1
29	0	1	1
30	0	1	0
31	0	1	0
32	0	1	0
33	0	1	0
34	0	1	1
35	0	1	1
36	0	1	0
37	1	1	1
38	1	1	1
39	1	1	1
40	1	1	1
41	1	0	1
42	0	0	1
43	0	0	1
44	0	1	1
45	0	1	1
46	0	1	1
47	0	0	1
48	0	0	1
49	0	0	1
50	0	0	1
51	1	0	1
52	1	0	1
53	1	0	1
54	1	0	1
55	0	0	1
56	0	0	1
57	0	0	1
58	0	0	1
59	0	1	1
60	0	1	1
61	1	0	0
62	0	0	0

The percentage of the coverage area 100 serviced by the respective base stations as well as the service area overlap between a pair of base stations can also be determined from Table 3. The coverage area percentage can be determined by the number of locations of the coverage area that are indicated as serviced by a particular base station. For instance, the number of regions serviced by the base station 5 in Table 3 is 17. Thus, the coverage area percentage serviced by the base station 5 is 48% (30 regions / 62 total locations).

In a similar manner, the service area overlap percentage between base stations can be determined. Thirteen locations of the 30 regions covered by base station 5 are covered by other base stations yielding a coverage overlap percentage of 43% (13/30 x 100%). Likewise, the coverage overlap percentage between base stations 5 and 10 occur at seven locations, which is 11% (7/62 x 100%) of the coverage area 100.

The coverage area percentage and coverage overlap indicate the effectiveness of each base station in providing service to the coverage area. For the example, the coverage area and overlap percentages are contained in the following Table 4.

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Table 4

base stations	locations covered	overlap locations	Coverage area (%)	Coverage overlap(%)
5	30	13	48	43
10	26	14	41	53
15	37	24	59	64

III. Removal of Base Stations from a System

Although Table 3 illustrates that service can be provided to the coverage area 100 using three base stations, it is possible to determine whether such coverage or a lesser acceptable coverage could be provided using a smaller number of base stations in the event that a base station becomes inoperative whether for routine maintenance, repair, reduction in the number of base stations in the coverage area or otherwise. Such a determination can be made from the RSS measurements taken by wireless terminals 40 for the three base stations 5-15 listed in Table 1. It is possible to perform the determination without the need for additional collection of RSS measurements using the smaller number of base stations.

The determination of whether the communication system 1 of FIG. 2 can operate with a reduced number of base stations can be performed by determining the required transmission power of the remaining base stations, if any, that could provide coverage to the service area of the base station to be removed. Moreover, such a determination would also have to include whether the required transmission powers would produce unacceptable interference in the other regions of the coverage area 100.

An exemplary method for determining whether the system 1 can operate with a reduced number of base stations is to perform the previously described method for adjusting the base station transmission power level in Section I excluding the RSS measurements of signals transmitted by the particular base station to be removed. This transmission power determination should be made such that the remaining base stations can provide an acceptable level of service coverage to the desired coverage area 100. In addition, this method can also be performed for each base station to test the resulting coverage with each of the base stations 5-15 individually removed to identify if the coverage area 100 can be serviced with a smaller number of base stations in the system. After a base station has been removed and the system is operating with a reduced number of base stations, it may be desirable to further obtain intermittent RSS measurements to determine if further transmission power adjustment of the remaining base stations would be advantageous. At such time, it would be further advantageous to update the neighbor lists and isolation values as is described in detail below in Section V.

IV. Addition of Base Stations to a System

It is desirable to add a new base station to an existing wireless communication system when, for example, the average number of wireless communications in the coverage area 100 approaches or exceeds the systems call capacity. The addition of a new base station in the system would provide an increase in call capacity. The position of a new base station can be proximate to those base station's which handle relatively high call traffic. The transmission power settings of such a new base station as well as the existing base stations can then be determined by a method in accordance with the invention. Moreover, at such time, it would be also desirable to update the neighbor lists and isolation values for the system 1 with the added base station, as described below in Section V.

An exemplary technique to make the transmission power determination includes the transmission power adjustment method previously described in Section I. According to this technique, a new base station is allowed to transmit a signal having a beacon frequency without handling any calls for an initial period of time. During this initial period, the other base stations maintain their existing transmission power settings. Also, during this initial period, RSS measurements are obtained from the wireless terminals 40 including measurements regarding the beacon signal of the new base station.

After a sufficient number of RSS measurements are collected to characterize the signal propagation in the coverage area with the new base station, the base station transmission power settings including that for the new base station are adjusted to establish coverage of respective service areas by the previously described method in Section I. The new base station is then activated for completing calls. Thus, a new base station can advantageously be incorporated into an existing system without substantially disrupting the operation of that system and without requiring costly system modeling and field testing by installers.

The duration of the initial period and the number of RSS measurements required to sufficiently characterize the coverage area for incorporating a base station is significantly dependent on the type of system, whether an indoor or outdoor system, and the coverage area environment. However, an exemplary number of RSS measurements that could be used to adjust the base station transmission power settings when a new base station is installed is on the order of hundreds of measurements.

An alternative method for determining the transmission power of the added base station is to provide a frequency assignment for the new base station and allow it to establish communications with wireless terminals in the area using a relatively low transmission power. As RSS data is collected for the new base station and the

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corresponding interference effects caused to neighboring base stations is determined, its power level can be adjusted accordingly. Such a technique is advantageous in that it allows a newly installed base station to provide communications without the previously described initial non-communication period. The initial relatively low power setting employed for a new base station is substantially dependent on the type of system and its proximity to neighboring base stations, however, such powers can be on the order of 20 dBm for an exemplary outdoor system and 1 dBm for an exemplary indoor system.

V. Isolation Values, Neighbor Lists and Channel Reuse

The RSS measurements and location coverage indicated in the respective Tables 1-1 to 1-3 can be used to generate isolation values in accordance with the invention. Isolation values are a measure of radio frequency isolation on a channel at a base station, or a wireless terminal at a location, from other signals from other base stations or wireless terminals that would interfere if they were permitted to transmit on the same channels. In other words, isolation values indicate channel interference by the strength of a received signal at a base station, or a wireless terminal at a location, relative to an interfering signal strength from other base stations or wireless terminals that would occur if they used the same channels.

Such channel interference can be up-link or down-link interference or a combination of these interferences. Down-link interference is channel interference received at locations serviced by a first base station caused from signals transmitted by other base stations. Up-link interference is interference at the base stations caused from signals transmitted by wireless terminals in locations of the coverage area that are not serviced by that base station.

FIG. 3 illustrates an exemplary method 200 for determining base station isolation values based on up-link and down-link isolation values. The up-link and down-link isolation values determined according to the method 200 are further based on carrier-to-interference (C/I) ratios. A large C/I ratio indicates a signal that is substantially isolated from channel interference while a small C/I ratio indicates a signal experiencing substantial channel interference. Thus, large C/I ratio values between conventional cellular base stations that are, for example, greater than approximately 18 dB, indicates that such base stations can use the same channel while small C/I ratio values between base stations, such as, for example, less than approximately 0 dB, indicate that the base stations are neighbors as is described below with regard to Table 8. It should be readily understood that carrier and interference signals for this discussion occur on the same channel or frequency.

The method 200 is described with respect to the system of FIGS. 1 and 2 with the transmission power settings of 10, 10 and 15 dBm for the base stations 5, 10 and 15, respectively. As previously described, the locations of the wireless terminals 40 where the RSS measurements were collected that are in the service area 105 of the base station 5 are listed in Table 1-1. Likewise, the measurement locations listed in Tables 1-2 and 1-3 are serviced by the base stations 10 and 15, respectively.

Referring to FIG. 3, down-link isolation values, such as service area down-link C/I ratio values, are determined in step 210. A service area down-link C/I ratio is a measure of interference on a down-link portion of a channel at locations serviced by a particular base station from signals transmitted on that channel by other base stations. An exemplary method for determining a service area down-link C/I ratio value includes: 1) determining down-link C/I ratios for the individual locations in a base station service area; and 2) using a particular quality measure, determining the service area down-link C/I ratio value based on these identified ratios.

An exemplary technique for determining the down-link C/I ratio for an individual location serviced by a first base station with interference from a second base station is to compute the difference in signal strengths S_2 from the first and second base stations at the location. For instance, Table 5 gives an interference distribution of the C/I ratios that would occur at locations in the service area of base station 5 if the base stations 10 and 15 transmitted on the same channel. Table 5 lists only those locations that are serviced by base station 5 as indicated in Table 1-1.

Table 5

Down-link C/I ratios at locations serviced by the base station 5

Location of Wireless Terminal Ref. No.	Int. from base station 10 (dB)	Int. from base station 15 (dB)
1	54	40
2	77	63
3	71	58
4	37	26
5	11	6
6	11	-5
7	37	16
8	71	51
9	77	58
10	54	36
11	45	23
12	50	26
13	45	16
14	28	-5
15	30	-5
16	35	6
17	35	10
18	27	1

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A suitable quality measure for determining the service area down-link C/I ratio value is, for example, the fifth percentile of the interference distribution. The fifth percentile of the distribution refers to 5% of the locations in the service area that have the lowest determined C/I ratios which corresponds to approximately one location in the 18 locations serviced by base station 5 (1/18 x 100% ≈ 5%). Accordingly, the service area down-link C/I ratio value for the base station 5 would be 11 and -5 dB for interference from the base stations 10 and 15, respectively. In particular, the substantially lowest single down-link C/I ratio that would be caused by the base station 10 is 11 dB at locations of wireless terminal reference nos. 5 or 6. Likewise, the substantially lowest single down-link C/I ratio caused by the base station 15 is -5 dB at locations of wireless terminal location nos. 6, 14 or 15.

The service area down-link C/I ratio values or down-link isolation values for the base stations 10 and 15 service areas can be obtained in a substantially identical manner as that previously described for the base station 5. Table 6 provides a correlation of the down-link C/I ratio values for the respective base station service areas in this example.

Table 6

Down-link C/I ratios for the locations serviced by the respective base stations (dB)

Base stations	5	10	15
5	0	11	-5
10	11	0	-5
15	-6	-6	0

Referring back to FIG. 3, after the service area down-link C/I ratio values are obtained in step 210, the method 200 obtains the up-link base station isolation or C/I ratio values in step 220. An up-link base station C/I interference ratio measures the channel interference to a signal from a wireless terminal in a location serviced by a first base station caused by wireless terminals in locations serviced by a second base station. Such a determination can be made for each location in the first base station's service area. For this example, up-link interference ratios for each of the 18 locations serviced by the base station 5 are determined based on the interference that would be caused by wireless terminals in each of the 18 locations serviced by the base station 10. A suitable method to obtain the cumulative up-link C/I ratios is substantially similar to the method used to obtain the cumulative down-link C/I ratios and is described in greater detail below with regard to FIG. 4. Table 7 lists the up-link C/I interference ratio values for each of the base stations' service areas.

Table 7

Up-link C/I ratios for the base stations (dB)

Base stations	5	10	15
5	0	17	-6
10	17	0	-6
15	0	0	0

After the up-link C/I ratio values are determined in step 220, the method 200 of FIG. 3 generates the base station isolation values based on the determined down-link and up-link C/I values, in step 230, using a quality measure. A suitable quality measure for generating the isolation values is, for example, to use the substantially minimum entry of the down-link and up-link C/I values listed in Tables 6 and 7 to yield the following isolation values Table 8.

Table 8

Isolation values for the base stations (dB)

Base stations	5	10	15
5	0	11	-6
10	11	0	-6
15	-6	-6	0

After the isolation values are generated in step 230, the neighbor lists and channel reuse determinations are performed in steps 240 and 250. With regard to channel reuse in step 240, if a substantially minimum isolation value is, for example, 10 dB to permit two base stations to use the same channel, then base stations 5 and 10 can use the same channel as their isolation value indicating the C/I ratio between them and their locations is 11 dB. However, if the requirement were 18 dB, then no channel reuse would be permitted in the system 1. In a similar manner, if a requirement of approximately 1 dB is used in order for two base stations to use adjacent frequency channels, then the base stations 5 and 10 can use adjacent channels. With regard to determining neighbor lists in step 250, if an isolation or C/I requirement of, for example, 0 dB is used then base stations 5 and 10 are neighbors of base station 15 for hand-off but base stations 5 and 10 are not neighbors to each other, as is seen in Table 8.

The previously described quality measures chosen to generate the C/I ratio values and the isolation values are representative and not intended to be a limitation of the invention. It should be readily understood that other quality measures can be employed in accordance with the invention including averaging of all or a portion of the C/I values. Moreover, numerous other methods of manipulating the individual C/I ratio values of the locations can be used in determining the isolation values in accordance with the invention including the use of just up-link or down-link C/I ratio values. In addition, more intricate combinations of the resulting isolation values than is represented in Table 8 can also be used such as employing separate isolation values representing the up-link and down-link interference. It is also possible to include criteria in addition to the isolation values for

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allocating channels such as, for example, a bias to communicate with a local private wireless communication system that is nearby a macro-cellular system.

An exemplary method 300 for determining an up-link C/I ratio value for a first base station is shown in FIG. 4. Referring to FIG. 4, interfering wireless terminal transmission powers in a second base station's service area are determined in step 310. Transmission power can be determined for each measurement location in the service area. It is possible for a wireless terminal to transmit at a fixed power, such as 0.6 W in conventional portable cellular telephones. However, also in conventional systems, such as those conforming to the previously mentioned TIA IS-136 standard, the wireless terminal transmission power can be controlled with control signals from the base station to which the wireless terminal is communicating. The base station controls the wireless terminals power in this manner such that it receives a substantially constant signal strength as the wireless terminal moves within the service area.

Thus, an exemplary technique for determining the wireless terminal transmission powers at the locations in the second base station's service area is to compute the transmission power required to provide the second base station with a particular signal strength such as, for example, -90 dBm based on a path loss between the location and the base station. For such a computation, it is possible to determine path loss as the difference between the base station's transmission power and the measured received signal strengths S_1 which are listed in the Tables 1-1, 1-2 and 1-3. If the path loss is substantially low, such as when the location is in close proximity to the base station, a lower limit of the wireless terminal's transmission power is reached and a minimum power of, for example, -4 dBm can be used.

After the interfering wireless terminal transmission powers are determined in step 310, the corresponding received signal strengths at the first base station from those transmission powers are determined in step 320. This determination is based on the computed path losses from those locations to the first base station in Table 1 in a similar manner to that used for interfering transmission powers as determined in step 310. Then, in step 330, the signal strength that would be received by the first base station from wireless terminals at locations within its own service area is determined.

If the wireless terminals are power controlled, then the first station would receive a signal strength of substantially constant power, such as -90 dBm. However, if the transmission power to provide such a signal strength is less than the minimum wireless terminal transmission power or if the wireless terminals are transmitting at a constant power, then the power reaching the base station can be determined in substantially the same manner as described above with regard to step 320. Such a determination would be

based on the transmission power and the measured path loss between the locations and the first base station.

After the signal strengths are determined in steps 320 and 330, then, for each location in the first base station's service area, up-link C/I ratio values are computed based on interfering signals that would be generated by interfering wireless terminals from each of the locations in the second base station's service area. This computation is performed in step 340. For instance, if base station 5 services the 18 locations for which RSS data was collected was the first base station and base station 10 that services the 18 other locations for which RSS data was collected was the second base station, then, in step 340, 18 up-link ratio values would be determined for each of the 18 locations in the service area of base station 5 for a total of 324 (18 x 18) values. Then, in step 350, a quality measure is used to determine a single up-link base station C/I ratio or up-link isolation value for the first base station's service area based on the up-link C/I ratio value computations of step 350. The method 300 can be repeated for each base station in the communication system.

In the example, if the quality measure of the fifth percentile is used then the determined base station up-link isolation values for each of the three base stations 5, 10 and 15 would be those listed in Table 7. In a substantially similar manner to the service area down-link C/I values, the particular quality measured used to generate the up-link C/I values is not critical to practicing the method of the invention. Accordingly, it should be readily understood that many other types of data manipulations can be performed to generate the up-link C/I and isolation values and that more than one value can be used to represent interference from base station service areas. In particular, unlike the down-link C/I values, the up-link C/I values need not correlate interference from wireless terminals based on the base station service areas in which they would be operating.

Although several embodiments of the invention have been described in detail above, many modifications can be made without departing from the teaching thereof. All of such modifications are intended to be encompassed within the following claims. For instance, it is possible to use other methods and techniques than those previously described to determine system organization parameters in accordance with the invention based on path loss-related characteristic measurements from the base stations and/or wireless terminals.

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CLAIMS

1. A method of communicating between (A) at least one wireless terminal and (B) a wireless communication system having at least one base station that services a geographic area, the method comprising:

establishing communication over at least one channel between the wireless terminal and said base station based on at least one system organization parameter, wherein the parameter is determined according to a method comprising:

measuring a path-loss related characteristic between each one of a plurality of wireless terminals and said base station;

based on said measurements, establishing a characterization of signal propagation for signals generated within said geographic area; and

determining the system organization parameter based on said characterization.

2. The method of claim 1 wherein said characteristic is based on measurements taken over a period of time.

3. The method of claim 1 wherein the measuring step comprises measuring respective signal strengths received by said wireless terminals from signals transmitted by said base station.

4. The method of claim 1 wherein the signal propagation characterization is a characterization of path loss.

5. The method of claim 1 wherein the step of measuring the path loss-related characteristic is performed intermittently.

6. The method of claim 1 wherein said system comprises a plurality of said base stations.

7. The method of claim 6 wherein said parameter is a transmission power setting for said base station.

8. The method of claim 7 wherein said transmission power parameter is determined based upon a deactivation of one of the other base stations.

9. The method of claim 7 wherein said transmission power parameter is determined based upon an addition of a base station to the system.

10. The method of claim 6 wherein the base stations provide service to respective service areas of said geographic area and wherein said parameter is a determination of an overlap of the service areas.

11. The method of claim 6 further comprising:

for at least one base station, determining an isolation value for said base station based on up-link interference that would be caused by at least one interfering wireless terminal in a coverage area not serviced by said base station based on said measurements from said interfering wireless terminal; and

determining said system organization parameter based on said isolation value.

12. The method of claim 11 wherein said isolation value for said base station is further based on measurements corresponding to at least one wireless terminal in a coverage area serviced by said base station.

13. The method of claim 11 wherein the isolation value is based on said measurements for a plurality of interfering wireless terminals in locations of a particular coverage area serviced by another base station.

14. The method of claim 11 wherein the system organization parameter is related to identifying channels useable by the respective base stations.

15. The method of claim 11 wherein the system organization parameter is a determination of a neighbor base station which is operable to receive communication hand-offs from a particular base station.

16. The method of claim 11 wherein the isolation value is based on at least one up-link carrier-to-interference ratio value.

17. The method of claim 6 further comprising:

for at least one base station, determining a first isolation value for a coverage area of said base station based on down-link interference that would be caused by another base station in said system based on said path loss-related characteristic measurements

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between at least one wireless terminal in said coverage area and said base station as well as between said wireless terminal and said other base station; and

determining said system organization parameter based on said first isolation value.

18. The method of claim 17 wherein said parameter is related to identifying channels useable by the respective base stations.

19. The method of claim 17 wherein said parameter is a determination of at least one neighbor base station operable to receive communication hand-offs from a particular base station.

20. The method of claim 17 wherein the first isolation value is based on at least one down-link carrier-to-interference ratio value.

21. The method of claim 17 further comprising determining a second isolation value for said base station based on up-link interference that would be caused by at least one interfering wireless terminal in a coverage area serviced by said other base station based on said path loss-related characteristic measurements between said interfering wireless terminal, wherein said parameter is determined based on said first and second isolation values.

22 The method of claim 21 wherein said isolation value for said base station is further based on measurements corresponding to at least one wireless terminal in a coverage area serviced by said base station.

23. The method of claim 21 wherein the isolation value is based on at least one up-link carrier-to-interference ratio value.

24. A method for determining at least one system organization parameter for a wireless communication system having at least one base station arranged to serve at least one wireless terminal in a particular geographic area, the method comprising:

measuring a path-loss related characteristic between each one of a plurality of wireless terminals and said base station;

based on said measurements, establishing a characterization of signal propagation for signals generated within said geographic area; and

determining the system organization parameter based on said characterization.

25. The method of claim 24 wherein said characteristic is based on measurements taken over a period of time.

26. The method of claim 24 wherein the measuring step comprises measuring respective signal strengths received by said wireless terminals from signals transmitted by said base station.

27. The method of claim 24 wherein the signal propagation characterization is a characterization of path loss.

28. The method of claim 24 wherein the step of measuring the path loss-related characteristic is performed intermittently.

29. The method of claim 24 wherein said system comprises a plurality of said base stations.

30. The method of claim 29 wherein said parameter is a transmission power setting for at least one of said base stations.

31. The method of claim 30 wherein said transmission power parameter is determined based upon a deactivation of one of the other base stations.

32. The method of claim 30 wherein said transmission power parameter is determined based upon an addition of a base station to the system.

33. The method of claim 29 wherein the base stations provide service to respective service areas of said geographic area and wherein said parameter is a determination of an overlap of service areas.

34. The method of claim 29 further comprising:

for at least one base station, determining an isolation value for said base station based on up-link interference that would be caused by at least one interfering wireless

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terminal in a coverage area not serviced by said base station based on said measurements from said interfering wireless terminal; and

determining said system organization parameter based on said isolation value.

35. The method of claim 34 wherein said isolation value for said base station is further based on measurements corresponding to at least one wireless terminal in a coverage area serviced by said base station.

36. The method of claim 34 wherein the isolation value is based on respective measurements between said base station and a plurality of interfering wireless terminals located in a particular coverage area serviced by another base station.

37. The method of claim 34 wherein the system organization parameter is related to identifying channels useable by the respective base stations.

38. The method of claim 34 wherein the system organization parameter is a determination of at least one neighbor base station operable to receive communication hand-offs from a particular base station.

39. The method of claim 34 wherein the isolation value is based on at least one up-link carrier-to-interference ratio value.

40. The method of claim 29 further comprising:

for at least one base station, determining a first isolation value for a coverage are of said base station based on down-link interference that would be caused by another base station in said system based on said measurements between at least one wireless terminal in said coverage area and said base station as well as between said wireless terminal and said other base station; and

determining said system organization parameter based on said first isolation value.

41. The method of claim 40 wherein said parameter is related to identifying channels useable by the respective base stations.

42. The method of claim 40 wherein said parameter is a determination of at least one neighbor base station operable to receive communication hand-offs from a particular base station.

43. The method of claim 40 wherein the first isolation value is based on at least one down-link carrier-to-interference ratio value.

44. The method of claim 40 further comprising determining a second isolation value for said base station based on up-link interference that would be caused by at least one interfering wireless terminal in a coverage area serviced by said other base station based on said path loss-related characteristic measurements between said interfering wireless terminal and said base station, wherein said parameter is determined based on said first and second isolation values.

45. The method of claim 44 wherein the isolation value is based on at least one up-link carrier-to-interference ratio value.

46. The method of claim 44 wherein said isolation value for said base station is further based on measurements corresponding to at least one wireless terminal in a coverage area serviced by said base station.

47. A method of communicating between (A) at least one wireless terminal and (B) a wireless communication system having at least one base station that services a geographic area, substantially as hereinbefore described with reference to the accompanying drawings.

48. A method for determining at least one system organization parameter for a wireless communication system having at least one base station arranged to serve at least one wireless terminal in a particular geographic area, substantially as hereinbefore described with reference to the accompanying drawings.

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The Patent Office

Application No: GB 9706533.8
Claims searched: 1 to 48

Examiner: Mr Jared Stokes
Date of search: 16 May 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4L (LDH, LDSE, LFM)

Int Cl (Ed.6): H04B (7/005, 17/00)
H04Q (7/34, 7/36)

Other: On-Line - WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X,P	EP 0 752 766 A1 (NTT) See column 8 lines 13-55 & column 10 lines 11-20	1 & 24 at least
X	WO 96/09696 A2 (Nokia) See abstract, page 6 lines 11-27	1 & 24 at least
X	WO 95/26598 A2 (Philips) See page 6 line 15-page 8 line 27	1 & 24 at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier

Electronic Acknowledgement Receipt

EFS ID:	3368606
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and apparatus for determining path loss by active signal detection
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	39290
Filer:	Mark Charles Comtois/Jacquetta McBee
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND07 061 US
Receipt Date:	28-MAY-2008
Filing Date:	
Time Stamp:	16:36:23
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	AND01_061_IDS.pdf	8527503 a051ed6126c9970e1e2c990d6655e28703fc3c6d	no	67

Warnings:	
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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

ATTORNEY DOCKET NO. AND01 061

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of John ARPEE, et al.

Serial No.: 11/920,076 Art Unit: Unassigned

Filed: 08 November 2007 Examiner: Unassigned

Title: **METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION**

REQUEST FOR DELETION OF IMAGE FILE WRAPPER ENTRIES

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

On February 8, 2008, two Information Disclosure Statements were filed in the above-referenced application. One of the Information Disclosure Statements (although identical) was inadvertently filed.

Applicants respectfully request that Item 4, Item 5 and Item 6 be deleted from the Image File Wrapper on EFS ID No. 2836510 (Application No. 11/920,075, Attorney Docket No. AND01 062), because they were inadvertently filed under the wrong Application Number.

No fees are believed to be due with this submission. However, should any fees be required, the Commissioner is hereby authorized to charge such required fees to **Deposit Account No. 04-1679.**

Respectfully submitted,

/mcc/

Mark C. Comtois Reg. No. 46,285

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Dated: February 14, 2008

Electronic Acknowledgement Receipt

EFS ID:	2858336
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and apparatus for determining path loss by active signal detection
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	39290
Filer:	Mark Charles Comtois/Jacquetta McBee
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND07 061 US
Receipt Date:	14-FEB-2008
Filing Date:	
Time Stamp:	10:45:55
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	AND01_061_Deletion.pdf	97068 4f94f882c1902f65244c39047275007d9841cb03	no	1

Warnings:	
Information:	

Total Files Size (in bytes):	97068

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of John ARPEE, et al.

Serial No.: 11/920,076 Art Unit: Unassigned

Filed: 08 November 2007 Examiner: Unassigned

Title: **METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION**

TRANSMITTAL

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith is an Information Disclosure Statement pursuant to 37 CFR §1.56 in connection with the above-identified application .

[X] No fee required:

[ ] Filed within three months of filing application, or

[ ] Certification made.

[X] Filed prior to first Office Action.

No fees are believed to be due with this submission. However, should any fees be required, the Commissioner is hereby authorized to charge such required fees to **Deposit Account No. 04-1679.**

Respectfully submitted,

/mcc/
Mark C. Comtois Reg. No. 46,285

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Dated: February 8, 2008

PTO/SB/08a (05-07)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920076
	Filing Date	2007-11-08
	First Named Inventor	Arpee, et al.
	Art Unit	Unassigned
	Examiner Name	Unassigned
	Attorney Docket Number	AND01 061

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6236365	B1	2001-05-22	LeBlanc, et al.	
	2	6556832	B1	2003-04-29	Soliman	
	3	6526279	B1	2003-02-25	Dent	
	4	6138024		2000-10-24	Evans, et al.	
	5	6845240	B2	2005-01-18	Carlson, et al.	
	6	5862124		1999-01-19	Hottinen, et al.	
	7	6363263	B1	2002-03-26	Reudink, et al.	
	8	6049717		2000-04-11	Dufour, et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920076
	Filing Date	2007-11-08
	First Named Inventor	Arpee, et al.
	Art Unit	
	Examiner Name	Unassigned
	Attorney Docket Number	AND01 061

	9	6853842	B1	2005-02-08	Wilson, et al.	
	10	6047175		2000-04-04	Trompower	
	11	5497503		1996-03-15	Rydberg, et al.	

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20020058503	A1	2002-05-16	Gutowski	
	2	20030129987	A1	2003-07-10	Tanay, et al.	
	3	20040137912	A1	2004-07-15	Lin	

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2003001742	WO	A1	2003-01-03	Altman		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920076
	Filing Date	2007-11-08
	First Named Inventor	Arpee, et al.
	Art Unit	
	Examiner Name	Unassigned
	Attorney Docket Number	AND01 061

	2	1191804	EP	A2	2002-03-27	Gutowski		☐
	3	0213439	WO	A2	2002-02-14	Tanay		☐
	4	1999027737	WO	A1	1999-06-03	Desgagne, et al.		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920076
	Filing Date	2007-11-08
	First Named Inventor	Arpee, et al.
	Art Unit	
	Examiner Name	Unassigned
	Attorney Docket Number	AND01 061

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature		Date (YYYY-MM-DD)	2008-02-08
Name/Print	Mark C. Comtois	Registration Number	46,285

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

(19) Europäisches Patentamt
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(12) EUROPEAN PATENT APPLICATION

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(51) Int Cl.[7]: **H04Q 7/34**

(21) Application number: **01122871.5**

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(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
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(30) Priority: **26.09.2000 US 235435 P**
14.09.2001 US 951504

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Herndon, Virginia 20171 (US)

(72) Inventor: **Gutowski, Stanley J.**
Arlington, Virginia 22201 (US)

(74) Representative: **Prato, Roberto et al**
STUDIO TORTA S.r.l.,
Via Viotti 9
10121 Torino (IT)

(54) Path loss data normalization for growth management of a cellular system

(57) The RF propagation of a wireless system is normalized to remove the directionality, orientation and gain characteristics of the antennae deployed in the system to allow for enhanced growth management of a wireless system. RF propagation data for a wireless system is gathered by any collection method. For example, drive test of the cellular system can be performed to receive and measure the signal strength throughout the system to determine the receive power of signals from cell sites in the system. Other methods such as uplink collection, E911 data can be used. After measurements of the system are collected, the data is post-processed to remove the effective gain achieved by each antenna associated with each of the signals to normalize the signals to a conceptual antenna having an isotropic radiation pattern. A database of the antenna gain and deployment patterns of the actual antennae in the system is used to normalize the data. The expected receive power of the conceptual antennae signals at the locations throughout the cellular system are determined using a propagation model. The modeled conceptual signals correspond to the measured signals and the characteristics of the conceptual antennae substituted to model the conceptual signals. The Propagation modeling can be revised through analysis of the correlation with the measured data. Once the system has been normalized and the propagation model is acceptably accurate, the system designer can model data corresponding to a variety of antenna gain, directionality and orientation choices to effectively enhance growth management through effective redeployment and specification of antennae without the need to physically experiment with antenna of varying characteristics and perform numerous data collections after antennae substitutions or reconfigurations. A final data collection such as a final drive test can be performed after implementation of a new antenna deployment.

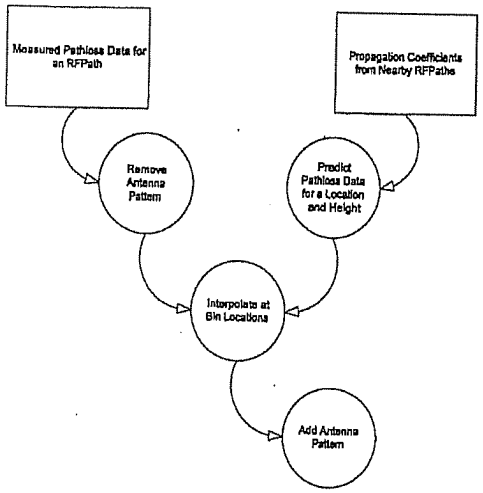


Figure 1

EP 1 191 804 A2

Description

REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of provisional patent application 60/235,435, filed September 26, 2000.

FIELD OF THE INVENTION

[0002] This invention relates to the management of channel interference in a cellular telephone systems and, more particularly, to a the improved analysis of the RF propagation in a cellular system for improved deployment of antenna designs, configurations and orientations.

BACKGROUND OF THE INVENTION

[0003] Present day commercial mobile communication systems typically have a plurality of fixed-location base stations arranged in patterns in which each base station has a plurality of antennae divided among a number of sectors, to transmit and receive on a number of frequencies. The distribution of antennae, sectors and assignment of frequencies as well as the selection of antennae is intended to be optimize coverage. The channels used by a base station are separated from one another in frequency sufficiently that signals on any channel do not interfere with signals on another channel from that base station.

[0004] However, in order to allow mobile units to transmit and receive telephone communications over a wide area, each cell is normally positioned with its area of coverage adjacent and overlapping the areas of coverage of a number of other cells. When a mobile unit moves from an area covered by one base station to that covered by another, the communication is transferred from the former station to the latter in an area where the coverage from the different cells overlaps. Because of this overlapping coverage, the channels allotted to the cells are carefully selected so that adjoining cells do not transmit or receive on the same frequencies. The channels used by adjoining base stations are also supposedly separated from one another in frequency sufficiently that signals from any base station do not interfere with signals from another nearby base station. This is typically accomplished by assigning channels to some central cell, which are widely separated in frequency in the manner described above, and then assigning channels to the cells surrounding that central cell using a pattern to optimize coverage and minimize interference. The pattern of channel assignments continues similarly in the other cells adjoining the central cell. It will be noted that the technique of separating each channel assigned to any cell from the next channel assigned to that cell allows a number of cells having entirely different frequencies to be positioned in a system before any frequency must be repeated. The pattern is often called a frequency reuse pattern and may vary in many ways.

[0005] In some systems, especially those with cells in urban areas carrying heavy traffic, each cell is further divided into three sectors each of which includes assignment of channels. The antennas of each sector are typically arranged to provide 120 degrees of coverage within the cell. With slightly over four hundred channels available, a repeating pattern may be achieved in a hexagonal arrangement, using seven cells that each have three sectors.

[0006] In theory, this form of cell arrangement and the channel assignment scheme allow the frequency reuse pattern to be repeated at distances sufficiently separated to minimize interference between mobile units.

[0007] Unfortunately, interference does occur for a number of reasons. Antenna patterns, power levels, scattering, and wave diffraction differ from cell to cell. Buildings, hills, mountains, foliage, and other physical objects cause the transmitted signal strength to vary over the region covered by a cell. Consequently, the boundaries at which the signal strength of a channel falls below a level sufficient to support communications with a mobile unit vary widely from cell to cell. For this reason, cells adjacent to one another do not, in fact, typically form the precise geometric boundaries suggested above and coverage gaps can occur. Since cell boundaries must overlap to provide complete coverage of an area and the boundaries of cells are imprecisely defined, overlapping coverage often occurs between channels. As a result, channels having an overlapping coverage area may interfere with each other.

[0008] The odd-shaped boundaries of the cells and the necessity that the cells have overlapping coverage areas increases the likelihood that multiple signals on the same channel will interfere with each other, even though they are generated by non-adjacent or widely separated cells. This is especially true when a sectored cell pattern is used because the cells are much closer to each other than in a simple cell pattern. A signal originating from a remote cell (sometimes referred to as an interferor I) may interfere with a second stronger signal carrying a mobile transmission (sometimes referred to as the carrier signal S), on the same channel, when the difference in signal strength between the two signals is less than some threshold level (typically measured in decibels as the S/I ratio). Moreover, signals on adjacent channels are carried by abutting cells in accordance with the above-described frequency reuse pattern. Typically, frequency filtering is insufficient to eliminate the reception of adjacent frequencies entirely. Consequently,

there may be adjacent channel interference. A signal on an adjacent frequency may interfere with a communication link when the difference in signal strength between the two signals is less than some second, usually lower, threshold level. Normally an adjacent channel may have a signal strength closer to that of the communication link without causing significant interference because the frequency filtering of the receivers eliminates a substantial portion of the adjacent channel's signal strength.

[0009] In order to optimize coverage and to overcome interference when designing or reconfiguring the coverage of a mobile cellular system, a cellular system operator uses predictive software to determine what signal strength may be expected at locations throughout the cellular system from each of a particular set of cells. This software can utilize data describing the physical characteristics of the terrain surrounding each cellular site and the physical characteristics of the cellular station to plot predicted signal strengths around the cellular site. These signal strength predictions are then overlaid on a graphical plot to determine where antennas should be placed to provide optimum coverage, with appropriate overlapping areas for hand-offs. Once the antenna sites have been determined, the operator assigns channel groups to the cells in accordance with the technique described above.

SUMMARY OF THE INVENTION

[0010] It is common that coverage cannot be optimized and the expected interference among signals cannot be eliminated using predictive software alone. To discover the differences between the predicted system and realized system characteristics, it may be necessary to perform data collection to measure the signal strength of each sector at multiple points within the region of interest and compare these measurements with the predicted characteristics. Data collection can be accomplished by a number of methods which measure the signal strength of channels.

[0011] During the data collection to determine RF signal strengths, indication of RF signal strength at a plurality of locations throughout the system is collected. In one form of collection, referred to as a drive test, a mobile unit with a scanning receiver drives over the roads of the test region. The scanning receiver scans, receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system. For each measurement point, this provides a strength measurement of the signal generated by each cell. These strength signals are recorded for the cells and sectors from which they emanate. The collected data indicates RF coverage for the system. Also, by comparing the relative signal strengths of signals originating from different sectors and measured at a common point, it is possible to determine which sectors may potentially interfere with each other in the event they use a common or adjacent channel frequency. Thus, the effective coverage pattern may be used to optimize coverage and the actual interference points may be used to determine whether sufficient interference exists to change the channel group assigned to the particular area. The collected data can also be used for a number of other analysis or implementation applications. The present invention does not rely on any particular data collection nor is the present invention limited to particular analysis application. The present invention is a post-processing technique which can be widely applied to enhance network growth management.

[0012] If the geographic region of interference is sufficiently great, the channel assignment pattern for the system may be changed. That is, a frequency or a frequency group assigned to an antenna, a sector or a cell (or cells) is typically changed in its entirety to another non-interfering frequency group. Sometimes, interference may be eliminated by changing the cell characteristics (such as antenna tilt or power used in particular cells) without changing the channel assignment.

[0013] The present invention processes collected data after collection and prior to additional analysis. The present invention overcomes the problems of the prior art when designing or reconfiguring antenna gain patterns, directionality, orientation and selection, by using both measured and predicted signal level data for a system to characterize interference between cellular channels. The invention characterizes the expected interference based upon dynamic information corresponding to in-use performance. The method of the present invention also analyses and normalizes reception data to remove the effect of antenna directionality from the measured and modeled propagation profile of a cellular system. Moreover, the invention may be used to adaptively reassign radio frequency (RF) channels and power settings based upon the measured system performance and prospective parametric variations, to maximize capacity while minimizing overall interference within the system. The analysis method herein also allows for system expansion planning and for determination of optimum antenna gain pattern selection.

[0014] When collecting data for analysis and optimization of a wireless system, measured path loss data may be used as the foundation for analyzing cellular systems. Path loss is defined as the attenuation between a source antenna (sector) and a point on the terrain of the wireless system. The path loss is measured by subtracting the Received Signal Strength Indicator (RSSI) of a signal, at a location on the terrain, from a known transmitted signal level for the received signal.

[0015] The path loss equation may be expressed as:

$$\text{Path Loss [dB]} = P_{tx}\text{ [dBm]} - \text{RSSI [dBm]}$$

where,

P_{tx} is the transmitted power

[0016] RSSI values can be obtained at various locations of a cellular system by any desired method or means.

[0017] Once data has been collected, it is post processed. The post processing involves associating each measurement with a sector transmission so that the path loss may be calculated. The association includes matching a measured RF channel with an RF channel used in a sector. The path loss calculation requires knowledge of at least one reference RF channel used in a sector and its transmit power.

[0018] To completely analyze a cellular system, it is necessary to have path loss information, at each measurement location, for sectors that may serve and sectors that may interfere at the particular location. For example, if a system requires a Signal to Interference ratio (S/I) of 20 dB for interference-free communication, the collection must obtain measurements of sector signals that are discernable at the location and have RSSI power levels within 20 dB of the serving signal level. With this information, it is possible to automate optimization tasks, such as determining frequency and power assignments that provide a desired quality of service.

[0019] In reality, it is not always possible to acquire measured path loss information at every potential measurement point. Therefore, the present invention can augment the acquirable measured path loss information with predicted path loss information obtained using a propagation model. A linear regression analysis can also be applied to the preliminary results provided by the propagation model to better match the propagation model to the realized cellular system. Other techniques such as geostatistical analysis can also be used, as can interactive interpolation of weighted measured and propagation data. Once the propagation model is refined, the expected path loss information produced by the model is integrated with the measured information. Thereafter, the combined information may be used to improve or model the performance of the cellular system.

[0020] As described above, the path loss is measured by subtracting the Received Signal Strength Indicator (RSSI) of a signal, at a location on the terrain, from a known transmitted signal level for the received signal and may be expressed by the equation:

$$\text{Path Loss [dB]} = P_{tx}\text{ [dBm]} - \text{RSSI [dBm]},$$

where P_{tx} is the transmitted power

[0021] Since P_{tx} is the transmitted power radiated by the transmission antenna, the path loss equation expressed above does not provide the propagation path loss. Instead, the equation provides the combined path loss for the RF link comprising the transmission antenna and the propagation medium, assuming the loss of the receiver system has been factored into the value for RSSI. The propagation path loss may be obtained from the above-described equation by factoring out the gain provided by the transmission antenna. Once the antenna gain is removed from the path loss calculation for the RF link, the resulting propagation path loss value may be used to model the propagation characteristics of a signal communicated between the transmit and receive points without regard to the gain or beam pattern of the transmission antenna.

[0022] An embodiment of the invention is a process for optimizing the performance of a wireless communication system, employing a number of techniques for determining improved antenna distribution and orientation, including: identifying a drive test region; measuring a signal from each of a plurality of sectors of a plurality of cell sites for the drive test region, to determine the receive power of the measured signals; removing the effective antenna gain associated with each of the measured signals to normalize each of the measured signals to a conceptual antenna having an isotropic radiation pattern; correlating each of the measured signals with the corresponding modeled conceptual signal; revising the propagation model, based on the correlation between each measured signal with the corresponding modeled conceptual signal, to create a revised propagation model that better predicts an expected path loss of the conceptual signal; applying the revised propagation model to the conceptual signal from each sector of the plurality of sectors to determine the predicted path loss to a number of additional non-overlapping spatial bins; planning antenna variations, changes and substitutions based on the conceptual model to enhance coverage through increased effective use of directional antennas, antenna gain patterns and antenna orientation; applying the revised propagation model to a planned signal from each sector of a planned plurality of sectors to determine the expected path loss of the planned signal to each of the plurality of bins; and/or repeating the steps a number of times to improve a co-channel signal-to-noise ratio for the planned signal in each of the bins.

[0023] The present invention can utilize a database containing antenna specification data corresponding to the antennae deployed throughout the system to remove antenna effects to normalize data. The data base can contain additional information about other antennae so that the system can implement a plurality of propagation analysis

through substitution of antennae with known properties into cell site locations to determine enhanced system coverage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Figures 1 through 3 are logical flow diagrams illustrating the overall flow of the process of the present invention.
[0025] Figure 4 illustrates a representative three-dimensional gain pattern;
[0026] Figure 5 illustrates a receiver point located of the horizontal and vertical planes of the gain pattern shown in Figure 4;
[0027] Figure 6 illustrates a plane orthogonal to the boresight containing the ellipse formed by horizontal and vertical plane intersection points for the receiver;
[0028] Figure 7 illustrates a graphical means for determining the angle in the horizontal plane between the antenna boresight and the receiver point;
[0029] Figure 8A and 8B illustrate a graphical means for determining the angle in the vertical plane between the antenna's effective boresight and the receiver point;
[0030] Figure 9 illustrates a graphical means for determining the angle of intersection between the ellipse of Figure 5 and a radial drawn from the boresight to the receiver point;
[0031] Figure 10 illustrates typical antenna specification data.
[0032] Figure 11 illustrates the parameters used to calculate pathloss values for new pathloss points along a ray using the designated radials method;
[0033] Figure 12 illustrates the created pathloss points uniformly distributed along numerous radials of an inscribed arc using the designated radials method;
[0034] Figure 13 illustrates an example of calculating the effective antenna height using the height above average terrain (HAAT) method;
[0035] Figure 14 illustrates the static method for computing average terrain elevation;
[0036] Figure 15 illustrates a representative Picquenard model;
[0037] Figure 16 illustrates the measured pathloss points assigned to numerous radial regions;
[0038] Figure 17 illustrates the radial regions of Figure 16 divided into sections having a uniform step size; and
[0039] Figure 18 graphically illustrates a method for calculating diffraction in each section of Figure 17.
[0040] Figure 19 illustrates the measurement of radiation center offsets of modeled antennae in a system.

DETAILED DESCRIPTION OF THE INVENTION

[0041] This section defines the nomenclature used in this specification. The following properties of a cellular system refer to a set of attributes that describe some physical characteristic of the system.
[0042] Location - the set of attributes describing a cell site's position on the earth.
[0043] RFMount - the set of attributes describing the position of an antenna above some point on the earth.
[0044] RFPath - the set of attributes describing the directional mounting of an antenna at an RFMount. More specifically, the physical information needed to determine how the cell site antenna focuses energy over a geographical area.
[0045] Pathloss Point - the set of attributes describing the pathloss value and associated geographic information for a particular point in space.
[0046] When one of these properties is referenced in the specification, the set of attributes defining this property is being referenced, also. The set of attributes associated with each property are summarized in Table 1.

Table 1

Attributes	Location	RFMount	RFPath	Pathloss Point
Longitude	X	X	X	X
Latitude	X	X	X	X
Elevation	X	X	X	X
Radiation Center		X	X	
Orientation			X	
Electrical Tilt			X	
Mechanical Tilt			X	
Antenna			X	

Table 1 (continued)

Attributes	Location	RFMount	RFPath	Pathloss Point
Path Loss				X
Variance				X

[0047] The attributes listed in Table 1 have the following meanings in this specification, however, the physical characteristics of a cellular system may vary greatly from the exemplary system described herein without departing form the scope of the invention.

[0048] Longitude: Earth coordinate position in centiseconds. Positive for the Eastern hemisphere.

[0049] Latitude: Earth coordinate position in centiseconds. Positive for the northern hemisphere.

[0050] Elevation: Height from mean sea level to ground level in meters.

[0051] Radiation Center: Height from the ground to the center of an antenna in meters. Sometimes abbreviated as radctr.

[0052] Orientation: Physical direction of an antenna in the horizontal plane of the earth. Units are degrees with respect to true north. Orientation increases clockwise from north.

[0053] Mechanical Tilt: Physical direction of an antenna in the vertical plane of the earth. Units are degrees with respect to the horizon. Tilt has a positive value for an angle below the horizon and a negative value for an angle above the horizon. This parameter is sometimes abbreviated as mtilt.

[0054] Electrical Tilt: Shift in the main lobe of the antenna pattern in the vertical plane of the earth. Units for electrical tilt are in degrees and follow the same representation as mechanical tilt. This parameter is sometimes abbreviated as etilt.

[0055] Antenna: This is a reference to a set of attributes describing the characteristics of an antenna.

[0056] Pathloss: The difference in signal level, in dB, between transmit power and receive power.

[0057] Variance: The range in ± dB about the recorded pathloss value, an actual measured value may vary for a given confidence level.

[0058] The invention generates predicted pathloss values from normalized measured pathloss values, producing a set of data for an analysis of differing antenna gain configurations. The process for creating predicted pathloss values and generating interference patterns for a variety of antenna specifications allows for enhanced cellular system coverage.

[0059] The overall process of the system of the present invention is illustrated in Figure 1. A cellular system analysis program, capable of executing the inventive method described herein, is executed by a computer to evaluate the qualitative and quantitative aspects of a cellular system. When the analysis program requests data for an RFPath, both measured and predicted values are merged by an interpolation process to produce binned pathloss values. The interpolation process uses pathloss values containing no antenna effects. The antenna effects are absent either because they have been removed from the measured pathloss values or because they were not initially added to the predicted pathloss values. When the gain characteristics of the RFPath's antenna are needed in the system analysis, they are additively incorporated into the binned pathloss values.

[0060] An RFMount concept is introduced by this invention and is used to describe the attributes of all RFPaths originating at the same location and height, with their respective antenna effects omitted. Measured RFPath data is converted to RFMount data by removing the gain provided by the antenna pattern. Predicted data is generated for an RFMount using the gain characteristic of an isotropic radiation source in the propagation model. After both types of RFMount information are developed, they are combined by an interpolation process to produce binned RFMount data.

[0061] The process of removing the antenna gain from measured data converts RFPath pathloss data to RFMount pathloss data by making an adjustment to the calculated pathloss value. The overall flow of this process is illustrated in Figure 2. This permits the grouping of data by an RFMount, which is more easily combined with predicted data, and more easily adjusted when small changes to RFPath configurations occur. The process used to negate the effect of an antenna gain from a measured RFPath pathloss value is also used to quantify the environmental propagation characteristics of the RFPath and modify the variance attribute of the pathloss value in accordance with the propagation characteristics.

[0062] Predicted pathloss data is generated for an RFMount using a propagation model. The resulting values are easily merged with measured RFMount data by considering the relative variance value of the sources. Predicted values are generated using factors derived from measured values of nearby RFPaths. Each value either measured or predicted has an associated variance value which reflects the confidence in the value. Measured values are generally assigned greater confidence than predicted values. The confidence of a measured value can vary depending on the distance between the measured location and the antennae cell and dependant on the orientation of the antennae as well as other factors.

[0063] It is difficult to determine the relative numbers of measured and predicted pathloss values that may be required to accurately characterize a particular region of a cellular system. For this reason, variance attributes are attached to each pathloss value. The interplay of confidence of predicted and measured data is illustrated in Figure 3. A relatively high variance value is assigned to predicted pathloss values and a relatively low variance is assigned to measured pathloss values because of the greater confidence in measured data over predicted data. Since the interpolation can ignore high-variance predicted values when enough measured data is available in an area, it can be preferred to include the predicted values and let the interpolation process decide whether to use them. Therefore, pathloss interpolation can accommodate both measured values and predicted values, allowing variance to guide the interpolation algorithm in choosing and weighting the significance of the source data.

[0064] The variance assigned to measured data will be influenced by the confidence in the antenna manufacturing specifications. Antenna specifications have greater accuracy in the main frontal lobes than in ancillary side or back lobes, which can be greatly affected by antenna mounting. When the antenna gain pattern is removed in the present invention post-processing of the collected data, the inaccuracy can be compounded by the antenna confidence factor especially in side or back lobes. Therefore, the variance of measured values can vary due to antenna variance factors.

[0065] To better understand the purpose and means for negating the effects of antenna gain for each binned pathloss value, this section identifies the attributes that describe an antenna. Of primary interest are the attributes describing the electrical properties. The electrical properties are supplied by the antenna manufacturer and identify the antenna's ability to focus RF energy in three dimensions. This information is defined by the maximum gain and two sets of gain offset values surrounding the antenna. The gain offset values identify the difference in maximum gain for points along the horizontal and vertical planes, forming a horizontal and vertical gain (offset) patterns.

[0066] The gain pattern is represented by an array of 360 gain offset values having units of decibels (dB). A gain offset value represents the difference in gain from the maximum gain point of the antenna to some gain pattern point associated with an angle in degrees {0° ... 359°} from the boresight of the antenna. Therefore, the gain offset value is zero for the horizontal and vertical gain patterns at the maximum gain point of the antenna and must be negative or zero for all other points of the gain pattern.

[0067] The antenna's boresight refers to the physical direction (aim) of the antenna. The boresight corresponds to the angles 0°,0° in the horizontal and vertical planes. Note that the boresight is not necessarily the point of maximum gain on the gain pattern. A gain pattern is a complex three-dimensional shape. To represent this shape, the manufacturer provides a cross section of the gain pattern in the horizontal and vertical planes. The three-dimensional gain pattern can be constructed by combining these horizontal and vertical cross sections. Figure 4 depicts a three dimensional gain pattern for a simplified antenna pattern.

[0068] The gain offset for a receiver point in space is determined by the angle between the antenna and a receiver point. When the receiver point is located on the vertical or horizontal planes, the gain offset is obtained by calculating the angle on the respective gain pattern and retrieving the gain offset value. In most cases, the receiver point is not located on these planes, so an interpolation is required to determine the gain offset. Figure 5 illustrates a receiver point located off the horizontal and vertical planes.

[0069] To interpolate the gain offset for a receiver point in space, a line is constructed from the antenna to the receiver point. Next, the intersection points of this line with the horizontal and vertical gain patterns are determined. The gain offset values form two points on an elliptical curve joining the intersection points and the plane of this elliptical curve is orthogonal to the boresight of the antenna, as illustrated in Figure 6.

[0070] The antenna gain associated with the RFPath pathloss to the binned receiver point, is determined by the following steps of:

1) calculating the horizontal angle between the binned receiver point and the antenna to determine the horizontal gain offset;
2) calculating the vertical angle between the binned receiver point and the antenna to determine the vertical gain offset;
3) calculating the angle between the binned receiver point and the antenna, on the plane orthogonal to the boresight, to interpolate the spatial gain offset; and
4) calculating the antenna gain by subtracting the spatial gain offset from the maximum antenna gain.

[0071] Referring now to Figure 7, to determine the horizontal gain offset from the horizontal antenna pattern, the angle θ between the antenna boresight and the binned receiver point must first be determined. In practice, this requires calculating the angle from true north to the binned receiver point and then subtracting from this angle the angle between true north and the boresight orientation. These calculations are performed in the following way. The angle between the binned receiver point and true north is given by atan(dX/dY), where $dX = X_p - X_s$, $dY = Y_p - Y_s$, X_p and Y_s are the planar coordinates of the binned receiver point, and X_s and Y_s, are the planar coordinates of the source antenna. Angle θ may be determined from the equation:

$$\theta = \text{atan}(dX/dY) - \text{RFPath.orientation},$$

where RFPath.orientation is the angle between the antenna boresight and true north. With θ known, the antenna's horizontal gain offset, $G_{ant,hor}[\theta]$, may be obtained by examination of the antenna's horizontal gain pattern.

[0072] Referring now to Figures 8A and 8B, to determine the vertical gain offset from the vertical antenna pattern, the angle σ between the antenna's effective boresight and the binned receiver point must first be determined. In practice, this requires calculating the angle between the RFPath horizon and the path loss data point, and subtracting from this value the RFPath mechanical and electrical tilt angles (i.e., the effective boresight angle). These calculations are performed in accordance with the following equations:

$$dZ = Z_p - (Z_s + \text{RFPath.radctr})$$

$$dX = X_p - X_s$$

$$dY = Y_p - Y_s$$

$$dist = (dX^2 + dY^2)^{1/2}$$

$$\sigma = \text{atan}(-dZ/dist) - (\text{RFPath.etilt} + \text{RFPath.mtilt})$$

where,

X_p, Y_p, and Z_p are the coordinates of the binned receiver point;
X_s, Y_s, and Z_s are the coordinates of the source antenna;
RFPath.etilt is the angle of electrical tilt forming the angle between the effective boresight and the actual boresight; and
RFPath.mtilt is the angle between the horizon and the actual boresight.

[0073] With σ known, the antenna's vertical gain offset, $G_{ant,ver}[\sigma]$, may be obtained by examination of the antenna's vertical gain pattern. The horizontal and vertical gains pattern is stored in a database which has information on each of the antennae deployed in the system. The database can also have information on a number of alternative antennae for use later in the process for proposed antennae substitutions. Figure 10 is an illustrative example of a typical antenna pattern data. Although the determination of $G_{ant,ver}[\sigma]$ must consider whether the binned receiver point is in front of or behind the antenna, this consideration has been omitted for clarity of discussion. One of ordinary skill in the art would understand how to incorporate the consideration of whether the binned receiver point is in front of or behind the antenna.

[0074] After ascertaining the horizontal and vertical gain offset values, an elliptical approximation is used to interpolate the gain offset. To perform this interpolation, it is necessary to calculate the angle, φ, from the antenna boresight to the path loss data point. Figure 9 illustrates this angle in the plane lying orthogonal to the boresight and containing the ellipse.

[0075] The equations to calculate the angle φ are as follows:

$$dZ = \sin(\sigma);$$

$$dR = \sin(\theta);$$

and

$$\varphi = \text{atan}(dZ/dR).$$

Calculating the gain offset requires solving for the radius of the ellipse at the angle φ. The equation for an ellipse is:

$$((i/a)^2 + (j/b)^2)^{½} = 1$$

Substituting:

$$i = r * \sin(\varphi)$$

$$j = r * \cos(\varphi)$$

provides the equation:

$$((r * \cos(\varphi)/a)^2 + (r)* \sin(\varphi)/b)^2)^{½} = 1$$

Solving for r:

$$r = ((\cos(\varphi)/a)^2 + (\sin(\varphi)/b)^2)^{-½}$$

and substituting:

$$a = G_{ant,hor}[\theta]$$

$$b = G_{ant,ver}[\sigma]$$

provides the equation:

$$G_{offset}[\varphi] = ((\cos(\varphi)/G_{ant,hor}[\theta])^2 + (\sin(\varphi)/G_{ant,ver}[\sigma])^2)^{-½}$$

Finally, the antenna gain is calculated as:

$$G_{ant}[\varphi] = G_{ant,max} - G_{offset}[\varphi]$$

[0076] When including the effects of an antenna in the pathloss value, we subtract the antenna gain from the path loss data point;

$$PL_{new} = PL_{original} - G_{ant}$$

[0077] When removing the effects of an antenna in the pathloss value, we add the antenna gain to the path loss data point, as described in the equation:

$$PL_{new} = PL_{original} + G_{ant}$$

In both cases, the pathloss has a positive value.

[0078] Variance is additive since the antenna pattern variance is independent of the path loss data point variance. Therefore, the variance of the antenna pattern is added to the variance of the path loss data point. The process for calculating the antenna variance uses the same procedure as calculating the gain offset. In particular, the process has the steps:

1) Calculate $VAR_{ant,hor}[\theta]$;
2) Calculate $VAR_{ant,ver}[\sigma]$;
3) Calculate $VAR_{ant}[\varphi]$; and
4) $VAR_{new} = VAR_{original} + VAR_{ant}[\varphi]$.

[0079] Path Loss Data Normalization (PLDN) provides the ability to add or remove the effects of an antenna from a set of path loss data. This process involves offsetting the path loss value, for each path loss data point, with the antenna gain relative to each path loss data point location. In addition, the variance associated with each path loss data point may be adjusted by the variance associated with the corresponding point on the antenna pattern.

[0080] At a typical cellular tower, there are three sectors that are each served by a different transmit antenna. Each antenna forms a unique RFPath. Measured pathloss data is recorded separately for each RFPath. In order to combine the data from all three RFPaths into a single data set, it is necessary to normalize the data by removing the antenna effects from each pathloss point measurement.

[0081] RFPath data is translated to RFMount data for several reasons:

1) to combine measured data from multiple RFPaths into a single RFPath.
2) to combine measured data with modeled data; and
3) to model new RFPaths for an existing RFMount.

[0082] PLDN is initialized by submitting a desired RFPath. PLDN works with a single pathloss point at a time. Each pathloss point is submitted individually for processing by the computer. Using the procedures described above, the horizontal and vertical offset angles, $\{\theta, \sigma\}$, to the pathloss point are calculated. Next, the horizontal and vertical offset gain values are retrieved from an antenna database. The antenna database contains the same offset gain information as the horizontal and vertical gain pattern graphs, but in the database the antenna values will be loaded numerically in one-degree increments. The horizontal and vertical gain offsets are used to interpolate the gain, $G_{ant}[\varphi]$, of the antenna at some angle φ in three dimensional space, where $\varphi = \text{atan}(\sin(\sigma)/\sin(\theta))$. Once the offset gain is calculated, the RFMount pathloss value may be calculated.

[0083] For example, suppose the RFPath pathloss for a pathloss point is derived from a measurement at the point and found to have a value of 102 dB. Further suppose that the RFPath antenna gain, $G_{ant}[\varphi]$, for the relevant value of angle φ has a value of 5.2 dB. The RFMount pathloss is calculated as the sum of the RFPath pathloss and the RFPath antenna gain and has a value of 107.2 dB. Although the gain of the antenna does not, in fact, affect the pathloss of a propagation link in any way, summing the RFPath pathloss with the antenna gain provides a convenient way to characterize the propagation loss of an RF link. This propagation loss is characterized as though the RF transmission originated from an isotropic radiator and is commonly referred to as the free space loss. The RFPath pathloss contains the propagation effects of both the free space loss and the antenna gain. Translating RFMount data to RFPath data simply reverses the process described above.

[0084] The gain patterns provided by a manufacturer represent the theoretical gain performance of an antenna model. These gain patterns are normally measured in a lab environment under controlled conditions.

[0085] When an antenna is deployed at a cell site, the actual gain pattern is affected by mounting conditions, near field objects, and frequency. These effects cause the actual gain pattern to differ from the theoretical gain pattern reported by the manufacturer. In particular, the gain pattern outside the main beam of the antenna (side lobes) is most likely to be different in the real environment. Within the main beam of the antenna, the gain pattern typically remains consistent with the theoretical gain pattern.

[0086] The variance pattern identifies the confidence associated with the gain pattern. This variance can be included when adding or removing the gain pattern from a set of pathloss data points, thus incorporating the confidence of the gain pattern in the data. The variance pattern is represented by an array of 360 decimal values in dB corresponding with the horizontal and vertical gain patterns.

[0087] Variance is additive, since the antenna pattern variance is independent of the pathloss point variance, and is calculated from the equation:

$$VAR_{new} = VAR_{original} + VAR_{ant}[\theta,\sigma]$$

where,

$VAR_{ant}[\theta,\sigma]$ = variance value in the direction of the pathloss point using elliptical approximation not separate variance for horizontal and vertical antennae patterns

[0088] Since variance increases with each PLDN translation, it will be important to use the minimum number of translations to model a particular RFPath or RFMount. For example, if ten different RFPaths are modeled for the same

RFMount, then the original measured data should be used as the input for all ten models rather than using the output of each model as the input to the succeeding model.

[0089] The propagation model calculates pathloss between an RFMount and a pathloss point. A number of different propagation models have been developed to capture different propagation effects. Since all the factors that influence pathloss can not be modeled, a calculated value can only estimate the pathloss within a statistical variance. One generic propagation model has the form:

$$PL_{RFMount} = w_0 (c_0 - c_1 \log_{10} (h)) + w_1 (c_2 - c_3 \log_{10} (h) \log_{10} (r)) + w_2 (\text{diffraction}) + w_3$$

(local effects)

where,

h is the effective height of the RFMount in meters;
r is the distance between the RFMount and the pathloss point in meters;
c_0, c_1, c_2, and c_3 are constants;
diffraction is the diffraction component;
local effects is a correction factor to adjust for local terrain type; and
w_0, w_1, w_2, and w_3 are weighting factors, having a default value of one.

In the free space pathloss model:

$$c_0 = 32.4 + 20 \log_{10} (\text{frequency}) - 60;$$

$$c_1 = 0;$$

$$c_2 = 20;$$

$$c_3 = 0;$$

and

$$\text{pathloss} = 32.4 + 20 \log_{10} (\text{frequency}) + 20 \log_{10} (r) - 60$$

In the Okamura-Hata pathloss model:

$$c_0 = 69.55 + 26.16 \log_{10} (\text{frequency});$$

$$c_1 = 13.82;$$

$$c_2 = 44.9;$$

$$c_3 = 6.55;$$

and

$$\text{pathloss} = 69.55 + 26.16 \log_{10} (\text{frequency}) - 13.82 \log_{10} (h) + (44.9 - 6.55 \log_{10}$$

$(h))\log_{10}(r)$

The generic equation can be expanded as follows:

$$PL_{RFMount} = w_0 c_0 + w_1 c_2 - w_0 c_1 \log_{10}(h) + w_1 c_3 \log_{10}(h) \log_{10}(r) + w_2 (\text{diffraction}) + w_3 (\text{local effects})$$

Combining common terms provides the equation:

$$PL_{RFMount} = b_0 + b_1 \log_{10}(h) + b_2 \log_{10}(h) \log_{10}(r) + b_3 (\text{diffraction}) + b_4 (\text{local effects})$$

where;

$b_0 = w_0 c_0 + w_1 c_2$;
$b_1 = - w_0 c_1$;
$b_2 = -w_1 c_3$;
$b_3 = w_2$; and
$b_4 = w_3$.

In this final form of the generic equation, b_0 through b_4 are the pathloss coefficients.

[0090] Pathloss data generation can be performed for a single pathloss point or a series of pathloss points, if the locations of the pathloss points are already known. One application of the generation process is used for pathloss coefficient generation, when modeled pathloss values must be calculated for each measured pathloss point used in the coefficients regression.

[0091] To perform pathloss data generation, information concerning the following features is required for each pathloss point:

RFMount;
Receiver Height (meters);
Signal Frequency (MHZ);
Propagation Coefficents (b_0 - b_4); and
pathloss Variance (dB).

[0092] The propagation coefficients and pathloss variance are calculated during the generation of pathloss coefficients. During initial modeling, all coefficient values are set to one. Diffraction values are calculated for segmented areas, as described later.

[0093] Pathloss data generation can be used to calculate pathloss for new pathloss points that are uniformly distributed along a ray, or for multiple rays uniformly distributed within an azimuthal angle. To perform the pathloss data generation using the designated radials method, the following information is required:

RFMount;
Receiver height (float meters);
Signal frequency (float MHZ);
Propagation coefficients (float b_0 - b_4);
pathloss variance (float dB);
Number of radials (int);
Radial length (int meters);
Step size along radial (int meters);
Starting azimuth (int degrees); and
Inscribed arc angle (int degrees).

[0094] Figure 11 provides a graphical display of the input parameters. An initial radial is constructed using the radial length and azimuth values. Pathloss point locations along the radial are determined using the step size value. Each pathloss point location along the radial is translated into a latitude and longitude. Elevation is extracted from the terrain

database. Propagation and diffraction losses are sequentially calculated for each pathloss point.

[0095] The orientation of the second and succeeding radials are calculated by dividing the inscribed arc angle by the number of radials, and adding this value to the previous radial's orientation.

[0096] Figure 12 shows the resulting output. Pathloss points are uniformly distributed along each radial and the radials are uniformly distributed within the inscribed arc.

[0097] Note that there are three variables that describe a radial: total length, step size, and number of steps. There are three variables that describe the inscribed arc: total arc span, angular spacing, and number of radials. As shown in the following table, these values may be expressed in nine different ways to describe the same distribution of pathloss points.

	Radial Description		Inscribed Arc Description	
1	total length	step size	total arc span	no. of radial
2	total length	step size	total arc span	angular spacing
3	total length	step size	no. of radial	angular spacing
4	total length	no. of steps	total arc span	no. of radial
5	total length	no. of steps	total arc span	angular spacing
6	total length	no. of steps	no. of radial	angular spacing
7	step size	no. of steps	total arc span	no. of radial
8	step size	no. of steps	total arc span	angular spacing
9	step size	no. of steps	no. of radial	angular spacing

[0098] A preferred embodiment of the invention uses the first set of inputs to describe the distribution of pathloss points. Other input sets can be implemented, as well.

[0099] In propagation modeling, the height of the transmit and receive antennas has a direct effect on the total path loss for a given link. Increasing antenna height generally reduces pathloss. In a flat earth model, antenna height is an easily determined attribute. In a real world scenario with variable terrain, there are different techniques for dealing with antenna height, as illustrated in Figure 13. Most treatments of antenna height neglect the mobile antenna height. The mobile antenna height is typically in the range of 1.5-2.0 meters. The base station antenna height has considerably more variation.

[0100] In the pathloss data generation, effective antenna height is used in the generic propagation model. The diffraction algorithm uses an actual antenna height rather than an effective antenna height. However, the diffraction algorithm directly calculates the terrain effects on propagation and is a more precise measure.

[0101] For the generic propagation model, the effective antenna height is calculated as height above average terrain (HAAT). Average terrain elevation is extracted from the terrain database. Figure 13 shows an example of calculating effective antenna height using HAAT.

[0102] The FCC has defined a standard method for computing average terrain to be used by public mobile services in all application filings. With this method, eight uniformly distributed radials are drawn from the RFMount starting with true north (0°). A minimum of fifty evenly spaced elevation points are collected between 3 km and 16 km (2 to 10 miles) along each radial. An average elevation is computed for each radial. Then, the radial elevations are averaged to produce a final average terrain elevation. Figure 14 shows the static method for computing average terrain elevation.

[0103] As illustrated in Figure 15, the diffraction algorithm of the propagation model calculates how obstructions interfere with the signal path between the RFMount and pathloss point. The diffraction algorithm employs the Picquenard model. In this model, the effective height of a first obstacle is measured from the baseline formed by a segment connecting the transmitter and the receiver. The effective height of each succeeding obstacle is measured from a baseline segment drawn from the top of the previous obstacle to the receiver.

[0104] Diffraction values are calculated for measured pathloss points during coefficient generation. A particular RFMount may be associated with 40,000 or more measured pathloss points. Calculating a separate elevation profile for each pathloss point is computationally inefficient.

[0105] As illustrated in Figure 16, an alternative approach divides the region around the RFMount into segmented areas. A single diffraction value is calculated for each area and assigned to all pathloss points within the area. To implement the segmented area approach, the diffraction algorithm requires the following inputs:

RFMount;

Receiver height (float meters);
Signal frequency (float MHZ);
Number of radials (int); and
Step size along radial (int meters).

[0106] Using the number of radials, the area around the RFMount is divided into radial regions with uniform angular spacing. Each pathloss point is assigned to a particular radial region based on its location. The length of each radial region is set equal to the distance to the furthest pathloss point in that region (each radial region can have a different length). Figure 16 shows the measured pathloss points assigned to radial regions.

[0107] Next, each radial region is divided into concentric sections using the uniform step size as shown in Figure 17. Finally, a diffraction value is calculated in the center of each section of each region. The calculated diffraction value is assigned to all pathloss points in the section of each region. Figure 18 shows the final configuration.

[0108] Generic propagation models are based on best-fit calculations of measured field data. When applying a generic model to a different location, the accuracy of the results will depend on how closely the characteristics of the new location match those of the location where the model was derived. In accordance with the present invention, measured data for each location is compared to the path loss values calculated by the pathloss data algorithm. Based on this comparison, new coefficient values are calculated to minimize the variance between the measured and modeled values. The comparison can be accomplished in any of a number of manners, including simple substitution, iterative convergence or regression analysis. Once the propagation model has been optimized, new pathloss points may be modeled.

[0109] Coefficient generation is used to determine the set of weighting factors that minimizes the variance between the propagation model and the measured value. The equation for the generic propagation model:

$$PL_{RFMount} = w_0 c_0 + w_1 c_2 - w_0 c_1 \log_{10}(h) + w_1 c_3 \log_{10}(h) \log_{10}(r) + w_2 (\text{diffraction}) + w_3 (\text{local effects})$$

Combining common terms provides the equation:

$$PL_{RFMount} = b_0 + b_1 \log_{10}(h) + b_2 \log_{10}(h) \log_{10}(r) + b_3 (\text{diffraction}) + b_4 (\text{local effects})$$

where,

$b_0 = w_0 c_0 + w_1 c_2$;
$b_1 = - w_0 c_1$;
$b_2 = -w_1 c_3$;
$b_3 = w_2$; and
$b_4 = w_3$;
h = the effective height of the RFMount in meters;
r = the distance between the RFMount and the pathloss point in meters;
diffraction = diffraction component; and
local effects = a correction factor to adjust for local terrain type.

[0110] In this final form of the generic equation, b_0 through b_4 are the pathloss coefficients.

[0111] The pathloss equation fits the regression model, where:

$x_1 = \log_{10}(h)$
$x_2 = \log_{10}(h)\log_{10}(r)$
x_3 = diffraction
x_4 = local_effects

[0112] An analysis with measured data is required to confirm that the pathloss varies linearly with the diffraction and local effects values. To perform pathloss coefficients generation for an existing RFMount, the following inputs are required:

RFMount;
Receiver Height (meters); and
Signal frequency (MHZ).

[0113] For each point in the pathloss point list, the pathloss coefficients generator algorithm calculates values for x_1 through x_4. Each set of x's and the measured pathloss (y_i) form a row in the observations matrix. When all of the pathloss points are processed, the least-squares matrix is formed. The pathloss coefficients are calculated through the solution of the least-squares matrix.

[0114] To be useful, the coefficient generator must indicate how closely the modeled propagation values match the measured values. The resulting pathloss values must also include a variance value describing the expected bounds for pathloss at a given pathloss point. Regression analysis provides a number of methods for interpreting the results that are calculated along with the estimated coefficients. The coefficient generator will provide the following values for analysis of variance:

Variance: The variance of the modeled pathloss value; and
Variance and Standard deviation apply to the resulting pathloss value.

[0115] The same variance calculated in the coefficients generator algorithm applies to all pathloss points modeled with the same coefficients. Since the variance of measured values changes as a function of the measurement environment, it is possible that on a point-by-point analysis, the modeled variance will be less than the measured variance. Variance must be analyzed based on complete sets of data in order to be valid.

[0116] The coefficient generator algorithm is also used to calculate propagation components for a new (or simulated) RFMount, such as illustrated in Figure 19, having no measured data. In this case a new regression model is needed that determines the effects of antenna height, elevation, effective antenna height, and the distance between an existing RFMount and the modeled RFMount.

[0117] There are several methods that can be used to estimate values, and each has merits under different evaluation conditions. Kriging is an estimation method associated with spatial data that has several beneficial properties and can be used to calculate coefficient values for the modeled RFMount.

[0118] Although the present invention has been described in terms of a preferred embodiment, it will be appreciated that various modifications and alterations might be made by those skilled in the art without departing from the spirit and scope of the invention. The invention should therefore be measured in terms of the claims which follow.

Claims

1. A method for collecting and processing received signal level data from the individual sectors of a cell site, comprising the steps of:

   gathering signal level data at a known location within a wireless system;
   differentiating individual signals within said signal level data;
   determining the sector of origin of individual signals;
   determining the path loss of individual signals;
   retrieving a set of antenna parameters for antenna corresponding to said sector determinations; and
   normalizing the path loss value for each signal based upon said retrieved antenna parameters.

2. A method according to claim 1, wherein said antenna parameters include:

   directionality of the antenna design for the sector corresponding to the signal; and
   said normalization is a correction based upon the relative position of the known location with respect to the cellular site to compensate for error introduced into the gathered data.

3. A method of refining the determination of the quality of signal coverage in a wireless system, comprising the steps of:

   measuring actual path loss data at a plurality of locations within said wireless system;
   obtain predicted path loss data from a propagation model applied to said wireless system;
   combining said measured data and said predicted data to augment said measured path loss data with predicted path loss data to determine data for locations without measured data.

4. The method of claim 3, wherein:

   said combination is a weighted combination wherein said measured data and said predicated are assigned confidence indicators to determine the optimal weighting of each of said data.

5. The method of claim 3, further comprising:

assigning a confidence factor to each value within each set of data wherein said confidence factor is greater for measured data and is based upon the relationship between the data for a particular location and the data for proximate locations.

6. A method of managing the growth of a wireless system, comprising the steps of:

sub-dividing a drive test region into a plurality of spatial bins;
within each of said plurality of bins, measuring a signal from each of a plurality of sectors, which are within a region of examination that is at least partially co-extensive with or within propagation distance of said drive test region, to determine the receive power of said measured signal;
removing the effective gain achieved by an antenna associated with each of said measured signals to normalize each of said measured signals to a conceptual antenna having an isotropic radiation pattern;
applying a propagation model to a conceptual signal from each sector of said plurality of sectors to determine the predicted receive power of the conceptual signal within each of said plurality of bins, wherein each of said modeled conceptual signals corresponds to a different one of said measured signals and the characteristics of said conceptual antenna are used to model said conceptual signals; and
correlating each of said measured signals with said corresponding modeled conceptual signal.

7. The method of claim 6, further comprising the step of:

revising said propagation model, based on said correlation between each measured signal with said corresponding modeled conceptual signal, to create a revised propagation model that better predicts an expected path loss of said conceptual signal.

8. The method of claim 7, further comprising the step of:

applying said revised propagation model to said conceptual signal from each sector of said plurality of sectors to determine the expected path loss to a number of additional spatial bins.

9. The method of claim 7, further comprising the step of:

applying said revised propagation model to a planned signal from each sector of a planned plurality of sectors to determine the expected path loss of said planned signal to each of said plurality of bins.

10. The method of claim 9, further comprising the step of:

varying a propagation parameter value of said planned signal;
applying said revised propagation model to said planned signal and each of said plurality of bins; and
identifying an improved overall co-channel signal-to-noise ratio for said system based upon a revised propagation corresponding to a set of varied propagation parameters.

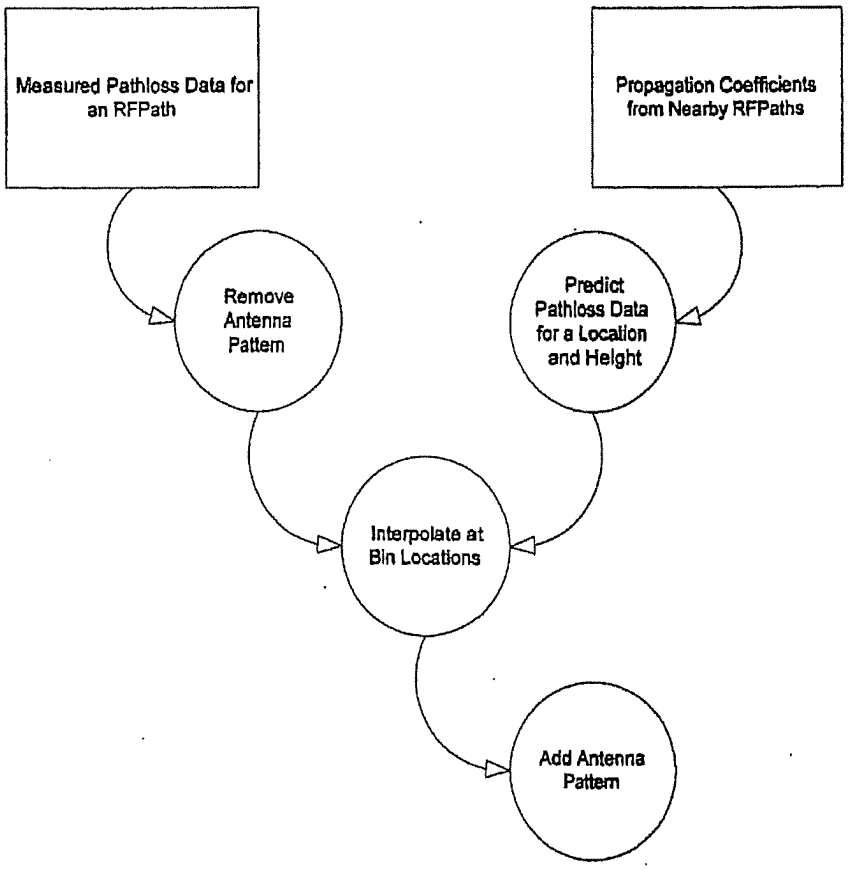

Measured Pathloss Data for an RFPath
Propagation Coefficients from Nearby RFPaths
Remove Antenna Pattern
Predict Pathloss Data for a Location and Height
Interpolate at Bin Locations
Add Antenna Pattern

Figure 1

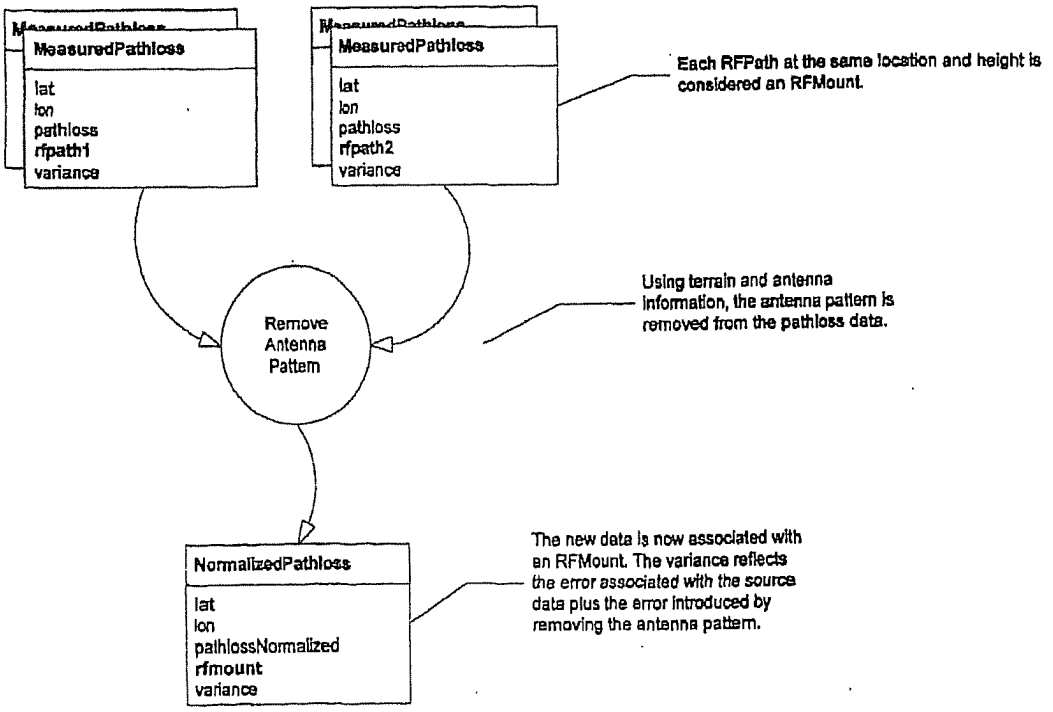

MeasuredPathloss
lat
lon
pathloss
rfpath1
variance
MeasuredPathloss
lat
lon
pathloss
rfpath2
variance
Each RFPath at the same location and height is considered an RFMount.
Remove Antenna Pattern
Using terrain and antenna information, the antenna pattern is removed from the pathloss data.
NormalizedPathloss
lat
lon
pathlossNormalized
rfmount
variance
The new data is now associated with an RFMount. The variance reflects the error associated with the source data plus the error introduced by removing the antenna pattern.

Figure 2

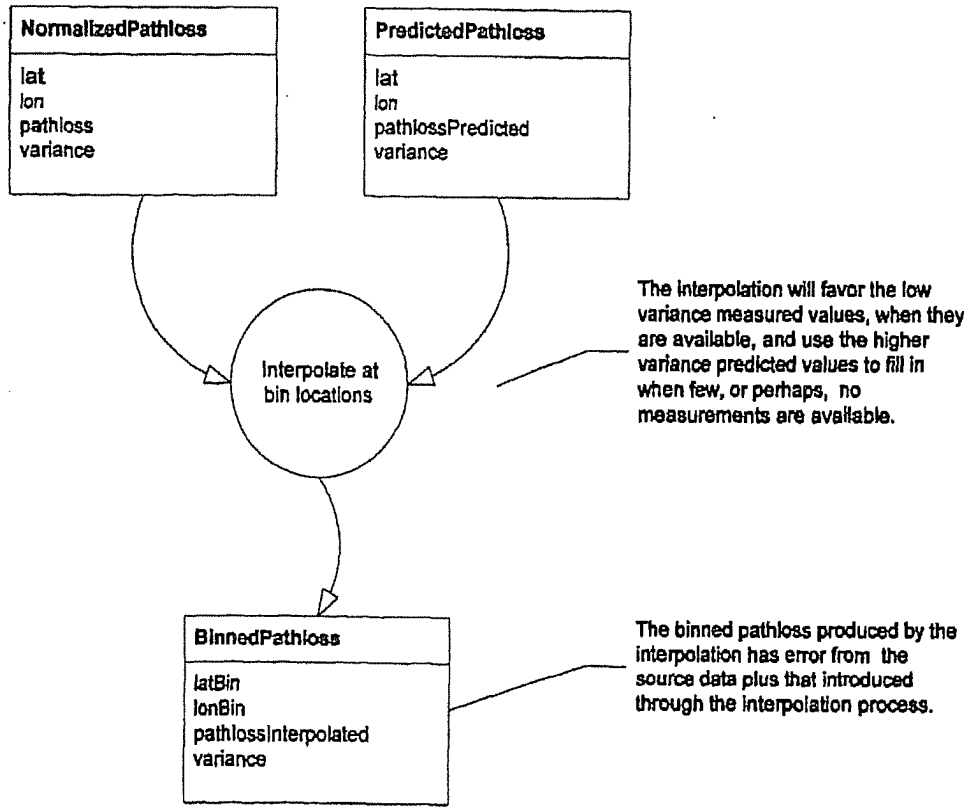

NormalizedPathloss
lat
lon
pathloss
variance
PredictedPathloss
lat
lon
pathlossPredicted
variance
Interpolate at bin locations
The interpolation will favor the low variance measured values, when they are available, and use the higher variance predicted values to fill in when few, or perhaps, no measurements are available.
BinnedPathloss
latBin
lonBin
pathlossInterpolated
variance
The binned pathloss produced by the interpolation has error from the source data plus that introduced through the interpolation process.

Figure 3

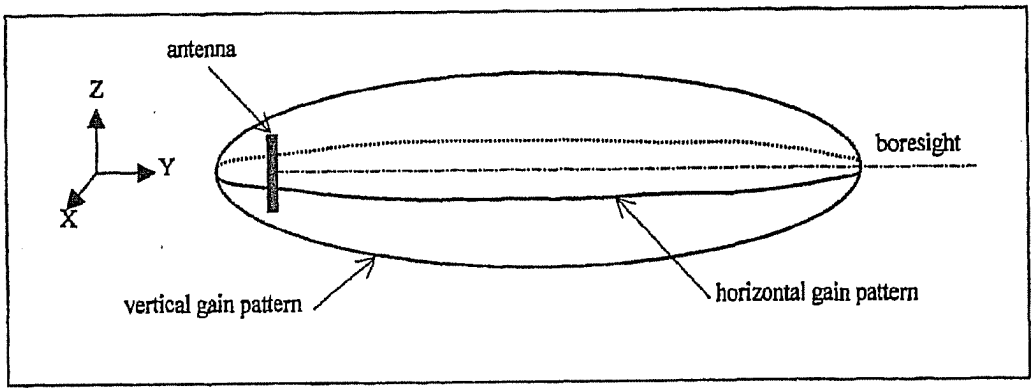


Figure 4

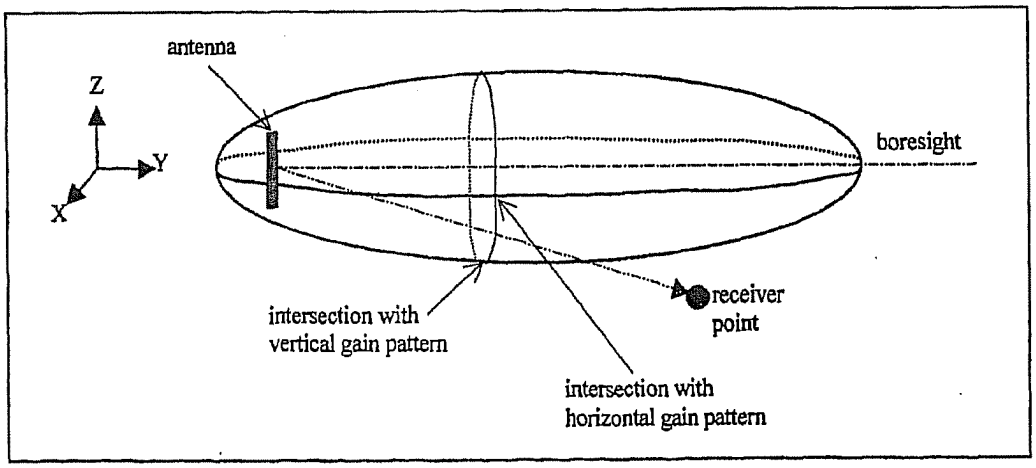


Figure 5

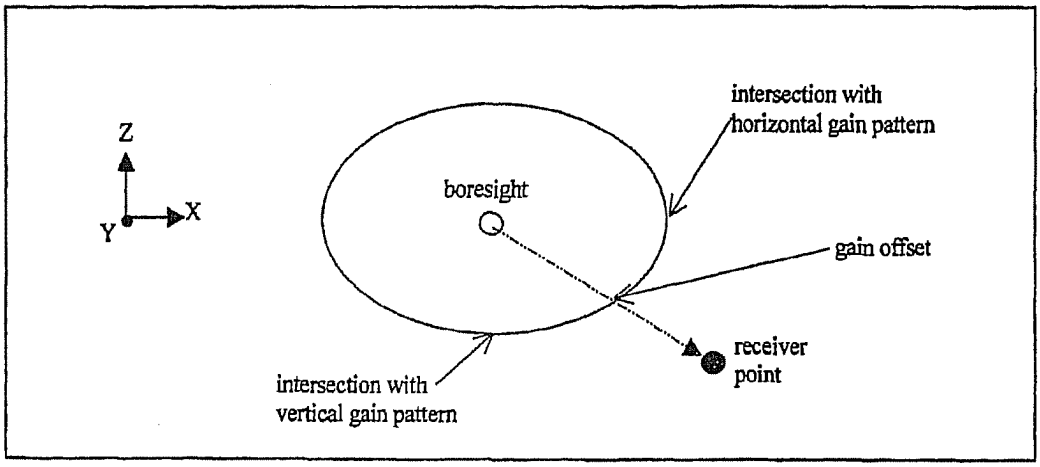


Figure 6

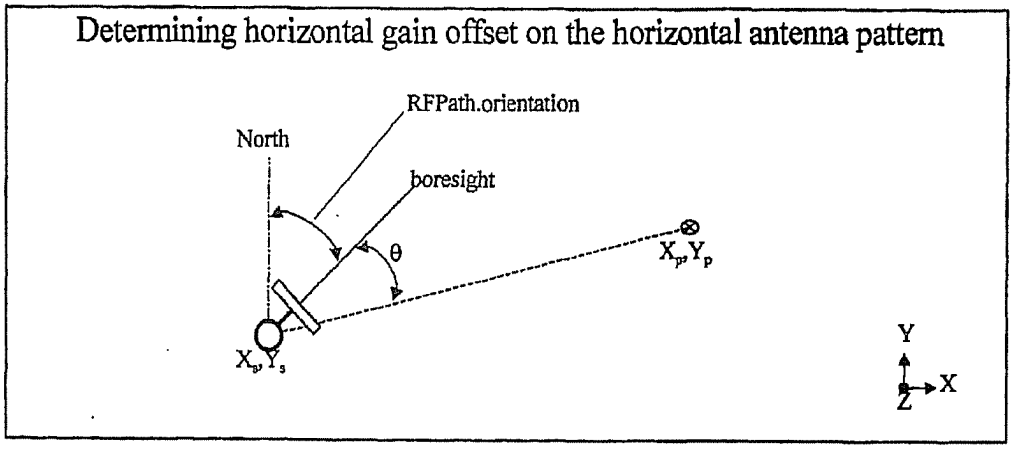


Figure 7

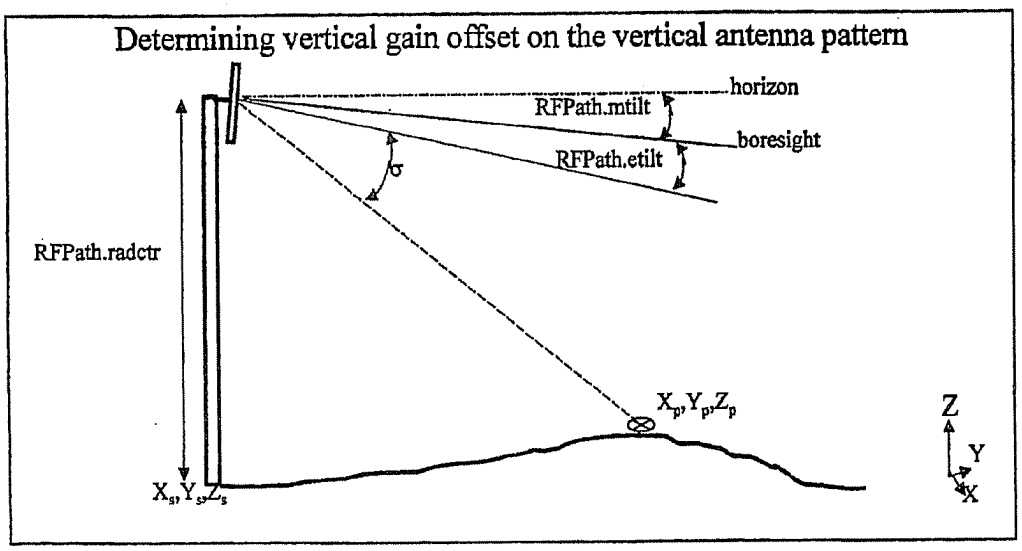


Figure 8A

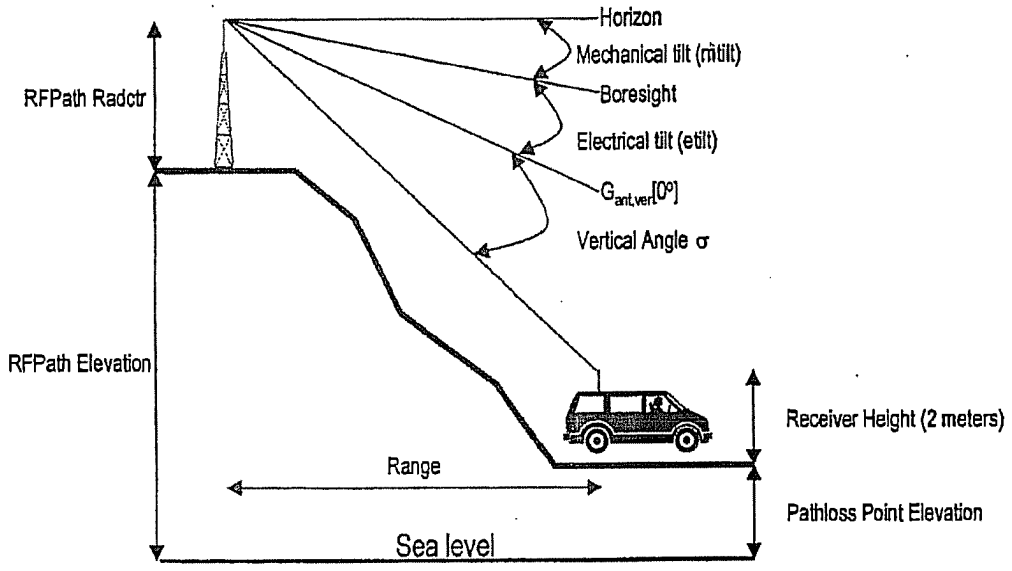


Figure 8B

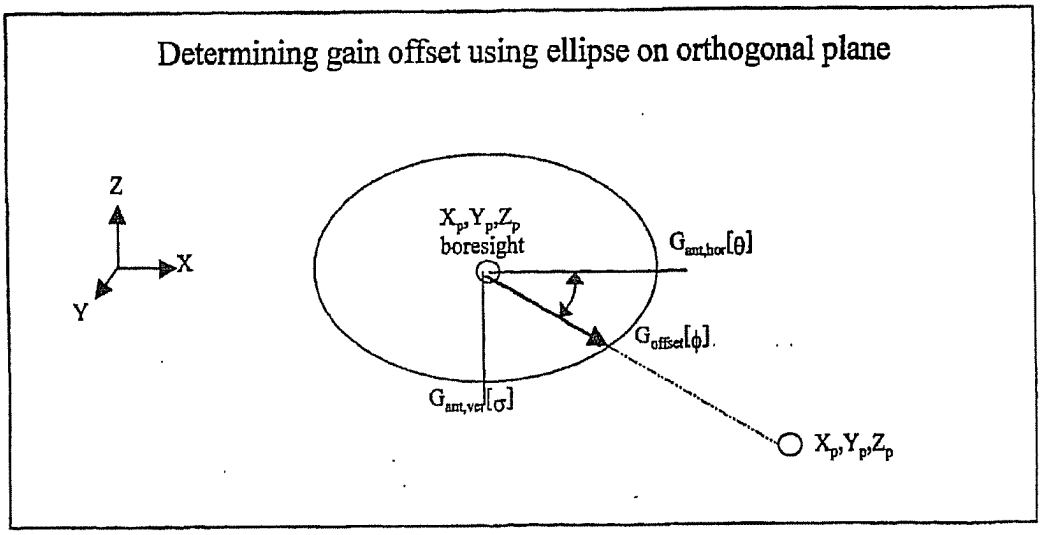


Figure 9

Manufacturer: TASC, Industries
Model: Glla2000
Date: October 2, 2000
Min Frequency: 880 MHz
Max Frequency: 960 MHz
Front-to-Back: 14 dB
Max Gain: 7.2 dB
Horizontal Beamwidth: 80 degrees
Vertical Beamwidth: 60 degrees
Electrical Tilt: 0 degrees

$G_{ant}[h,v] = G_{ant,max} + G_{ant,hor}[55] + G_{ant,ver}[40]$
$= 7.2 + (-2) + 0$
$= 5.2$ dB (Total Gain)

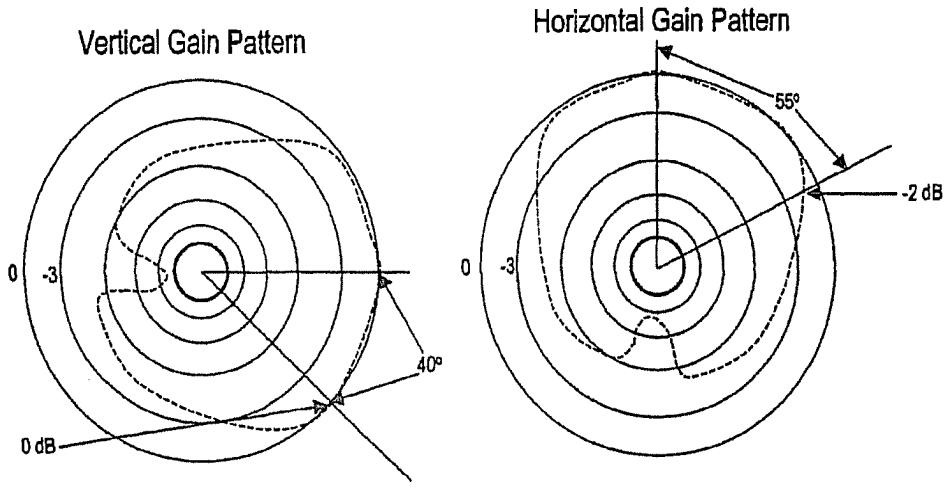


Figure 10

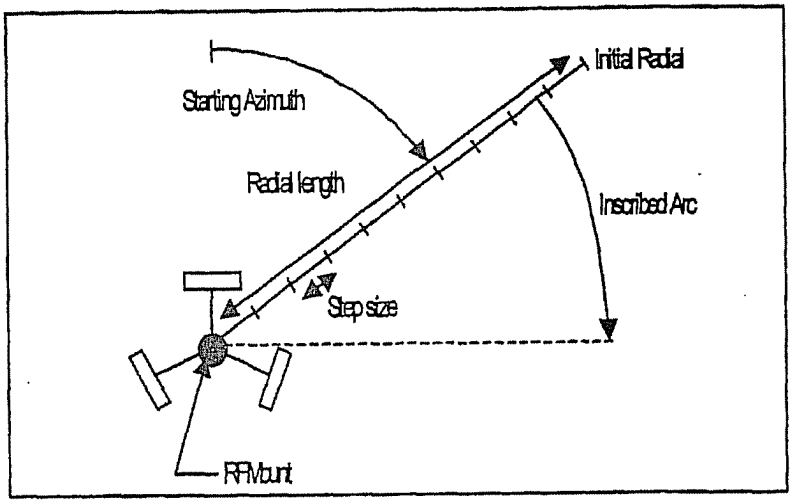


Figure 11

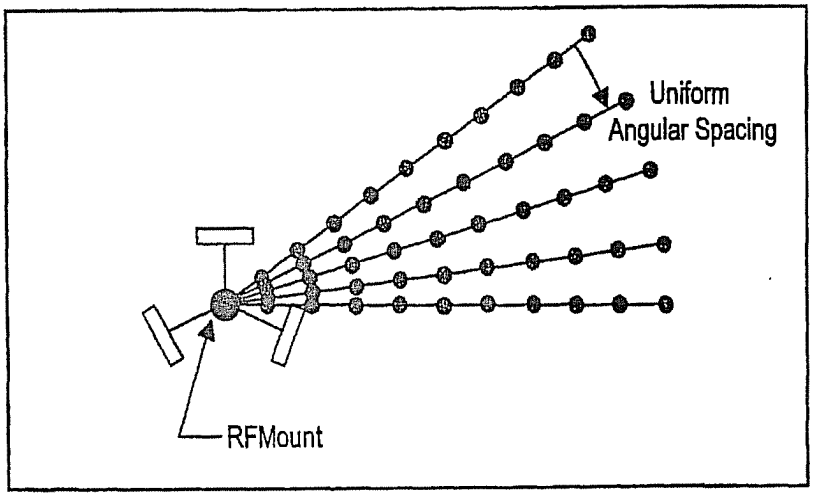


Figure 12

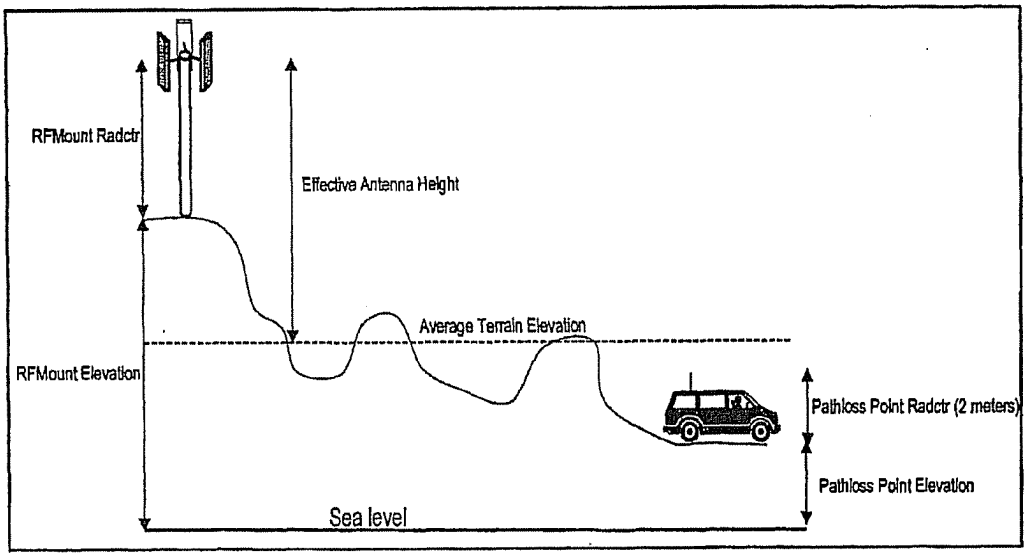


Figure 13

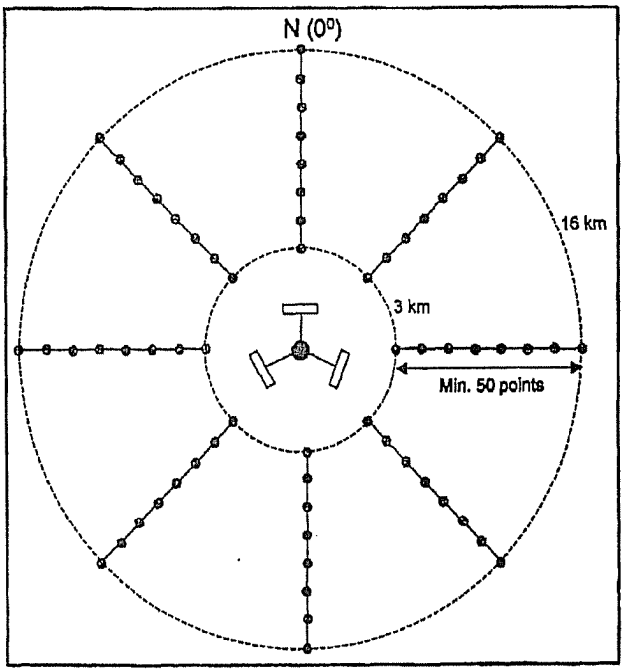


Figure 14

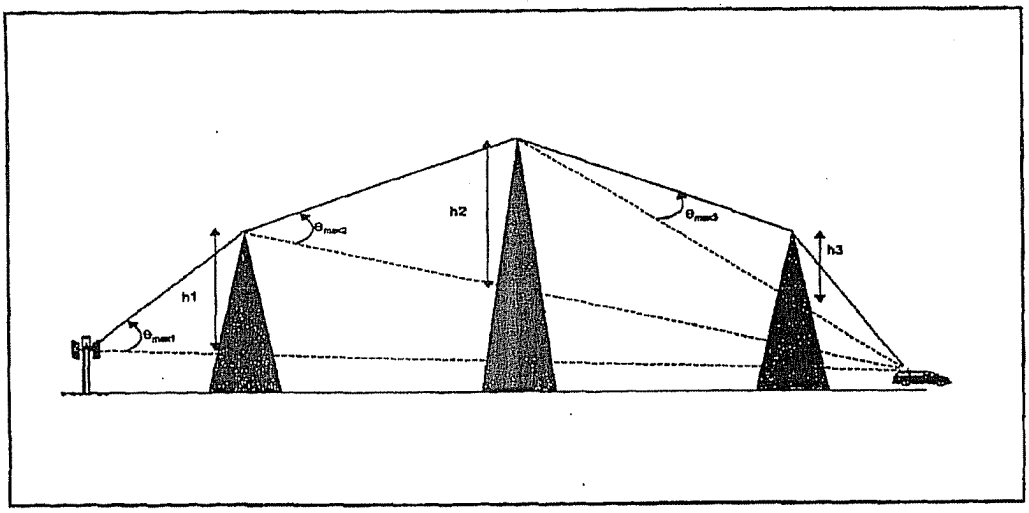


Figure 15

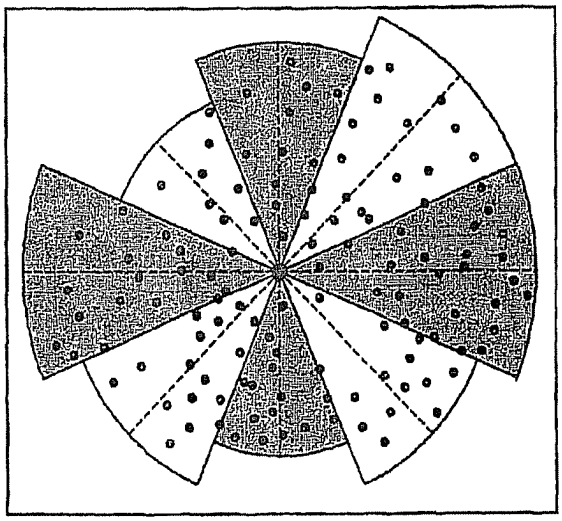


Figure 16

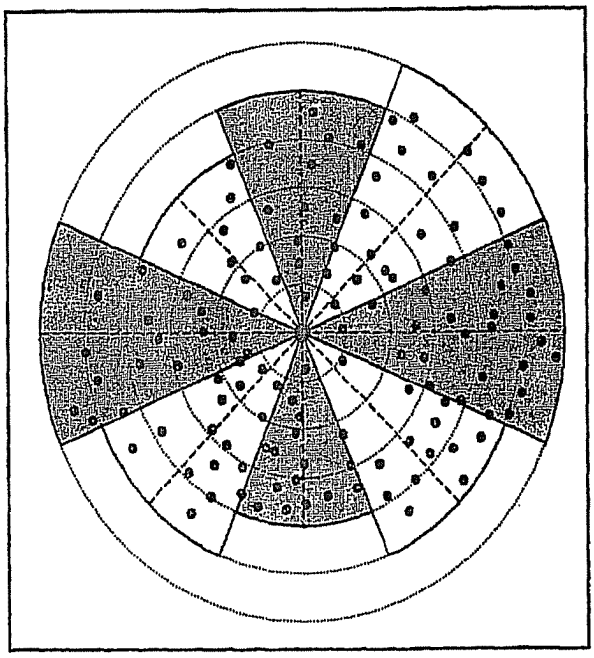


Figure 17

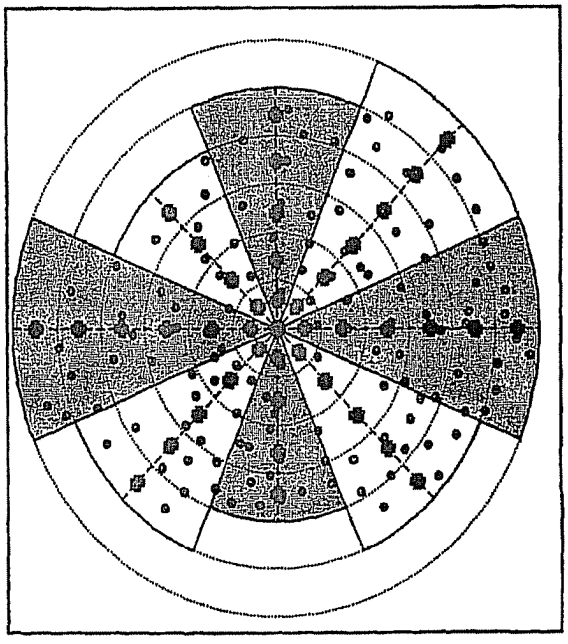


Figure 18

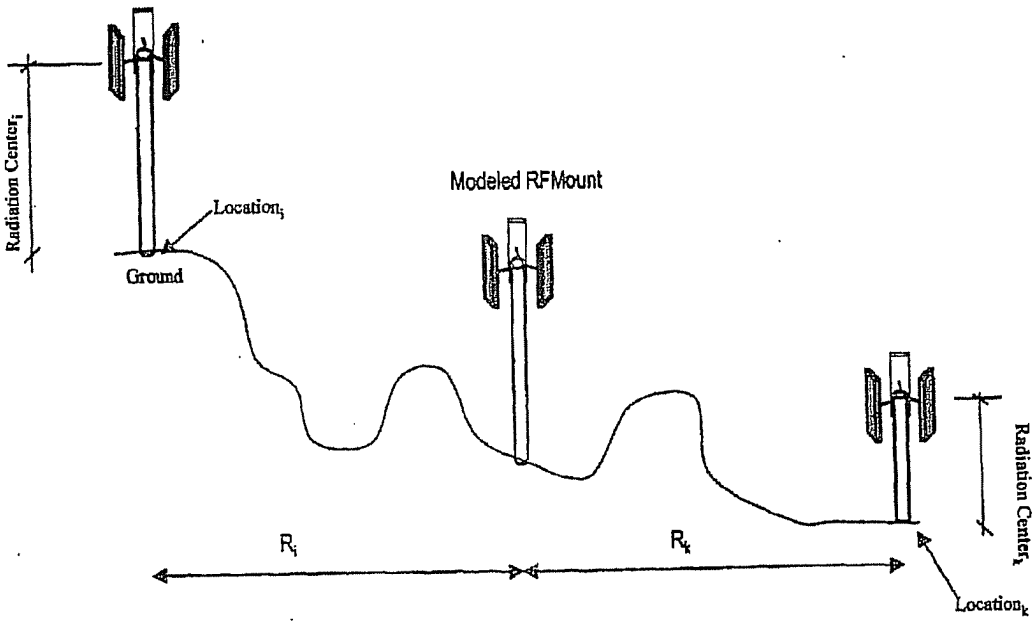

Radiation Center$_i$
Location$_i$
Ground
Modeled RFMount
Radiation Center$_k$
R_i
R_k
Location$_k$

Figure 19

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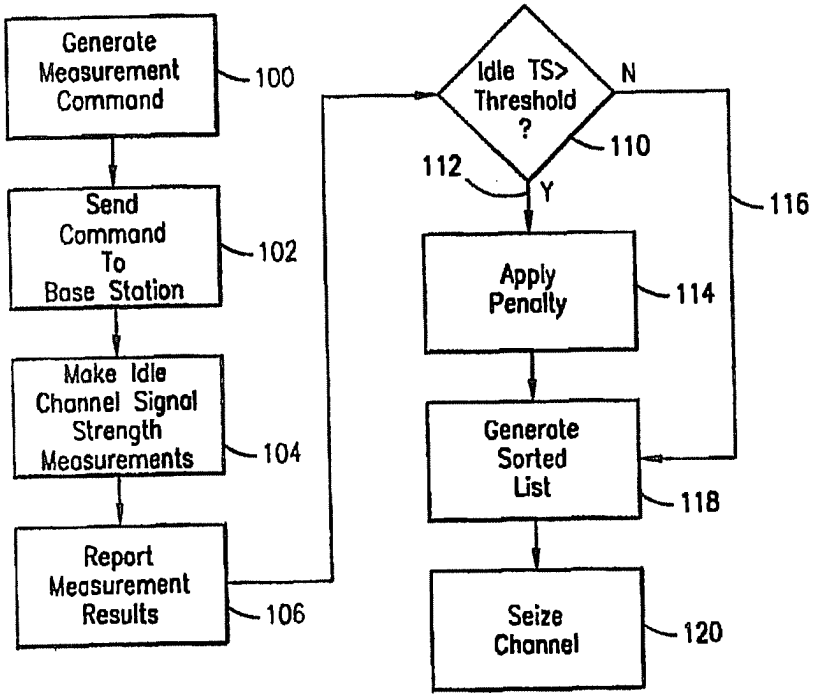
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(54) Title: TRAFFIC CHANNEL ASSIGNMENT IN A CELLULAR TELEPHONE SYSTEM USING AN UPLINK INTERFERENCE DRIVEN FREQUENCY PACKING METHOD

(57) Abstract

Each base station (14) in a cellular telephone system includes a signal strength measurement device (30, 32) operable to tune to and make signal strength measurements on not only the frequencies allocated to other cells, but also on its own allocated frequencies. Measurements (104) are made by the device on those of its own frequencies having idle traffic channels to obtain an indication of injected uplink interference. An interference penalty is then assessed (114) against the measured uplink interference for those frequencies having more than a threshold number (110) of idle traffic channels. The adjusted measurements for the frequencies allocated to the cell are then sorted (118) in relative order of idle traffic channel (adjusted) measured uplink interference from a least (adjusted) interfered frequency to a most (adjusted) interfered frequency. An idle traffic channel is then selected for assignment (120) at either call set–up or hand–off from the least (adjusted) interfered frequency.



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TRAFFIC CHANNEL ASSIGNMENT IN A CELLULAR TELEPHONE SYSTEM USING AN UPLINK INTERFERENCE DRIVEN FREQUENCY PACKING METHOD

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to cellular telephone systems and, in particular, to a method and apparatus for selection and assignment of a traffic channel during call set-up and hand-off by evaluating uplink signal strength measurements combined with frequency packing analysis.

Description of Related Art

Cellular telephone systems divide a large service area into a number of smaller discrete geographical areas called "cells" each typically ranging in size from about one-half to about twenty kilometers in diameter. Each cell is contiguous with multiple adjacent cells to provide continuous coverage throughout the service area. A base station including a plurality of transceivers capable of operating independently on different radio frequencies is provided for each of the cells. Via the transceivers, the base stations engage in simultaneous communications with plural mobile stations operating within the area of the associated cell. The base stations further communicate via data links (and voice trunks) with a central control station, commonly referred to as a mobile switching center, which functions to selectively connect telephone calls to and from the mobile stations through the base stations and, in general, control operation of the system.

Each cell is allocated the use of a predetermined set of frequencies, wherein each frequency comprises a physical channel supporting a plurality of logical channels (i.e., time slots) therein. The availability of multiple frequencies per cell, with multiple logical channels per frequency, permits base stations to simultaneously handle many telephone conversations with many mobile stations. The frequencies allocated to a cell are preferably spaced apart across the frequency spectrum of the cellular band. This serves to minimize the instances of adjacent channel interference.

Because only a limited number of frequencies are available in the cellular band, allocation of the same frequencies is repeated (i.e., reused) in other cells in a distant part of large service areas with many cells. No adjacent cells, however, are assigned the same frequency. Furthermore, the power levels of the signal transmissions on any given frequency are limited in strength. The foregoing precautions serve to minimize the likelihood of co-channel interference caused by reuse of that same frequency in a distant cell.

In spite of the precautions taken by service providers, it is known that instances of adjacent channel and co-channel interference do occur. This interference often adversely affects system operation by, for example, degrading voice or data quality on the traffic channels or interfering with the transmission and reception of control signals on the control channels.

The mobile switching center functions to dynamically assign the traffic channels available in any one cell among the plurality of mobile stations located within the cell area that desire communications. In this regard, the traffic channels comprise time slots in digital time division multiple access (TDMA) formatted frequencies which are allocated to the cell. Commands that assign for mobile station use a certain digital traffic channel assigned to a given cell are transmitted from the mobile switching center to the base station for that cell. The commands are then relayed by the base station to the certain mobile station over one of the channels to direct mobile station selection of the assigned traffic channel for handling the call.

Assignment by the mobile switching center of a particular digital traffic channel in a cell to a particular mobile station for carrying a cellular communication (i.e., a call) primarily occurs in two instances. The first instance is at call set-up when the subscriber activates the mobile station to initiate a call and the system selects for assignment the traffic channel to carry that new call. The second instance is at call hand-off when the subscriber, while engaged in a call, moves from one cell in the service area to another cell, and the system selects for assignment the traffic channel in the new cell that will continue the handling of the on-going call. In either case, it is important that the traffic channel selected for assignment at call set-up or hand-off be of the highest quality possible.

Conventionally, the selection and assignment by the system of a traffic channel to carry a call is performed by randomly choosing a logical channel from the available (idle) digital traffic channels allocated to the cell currently serving the mobile station. Alternatively, the system maintains a record of historic traffic channel use for each cell (normally in the form of a FIFO queue), and the traffic channel selected to carry the call is the channel allocated to that cell which has not been assigned for mobile station calling use in the longest period of time. While each of these selection methods is successful in assigning a traffic channel in a cell to a mobile station for carrying the call, the selection fails to take into consideration whether the traffic channel is the best quality (i.e., least interfered) channel available to carry the call. The prior art selection methods further fail to take into account concerns over minimizing the interference that may subsequently arise following the assignment of the traffic channel, and minimizing the number of frequencies simultaneously in use. In many instances there may be significant interference (often comprising adjacent channel or perhaps more frequently co-channel interference) on the randomly or queue selected traffic channel, or unacceptable interference may result following assignment due to inefficient simultaneous use of frequencies, and another one of the available idle traffic channels in the cell would have been a more appropriate assignment selection for use in carrying the call.

A need then exists for an improved method for assigning traffic channels to carry a call in response to either a call set-up or hand-off occurrence. This method should give consideration not only to whether the traffic channel is the best quality (i.e., least interfered) channel available to carry the call, but also whether a minimum required number of frequencies are being used as is possible to handle traffic needs.

SUMMARY OF THE INVENTION

Signal strength measurements are made by a signal strength measurement device in each cell base station on those frequencies allocated to that cell which have idle traffic channels. From these measurements, the injected uplink interference (comprising either adjacent channel, co-channel, or other type of interference) on the frequencies for each of the idle traffic channels is determined and reported to the mobile switching center. The reported uplink interference measurements are then

adjusted by a predetermined interference penalty if the frequency allocated to the cell presently includes more than a predetermined number of idle traffic channels. The adjusted measurements for all the frequencies are then sorted in relative order of idle traffic channel (adjusted) measured uplink interference from a least (adjusted) interfered frequency to most (adjusted) interfered frequency. The sorted list is then used by the system in selecting, for a base station, a traffic channel from the least (adjusted) interfered frequency for assignment at either call set-up or hand-off.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be obtained by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

FIGURE 1 is an exemplary cell diagram schematically illustrating a frequency reuse cellular telephone system wherein the present invention is implemented;

FIGURE 2 is a simplified block diagram of a base station in accordance with the present invention for use in the frequency reuse cellular telephone system of FIGURE 1; and

FIGURES 3A and 3B are flow diagrams illustrating alternative methods of operation for the channel selection process of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

There are a plurality of radio frequencies in the cellular band available to cellular telephone system providers for use in communicating with mobile stations. These radio frequencies support both traffic channels and control channels. The traffic channels are used for carrying telephone voice or data conversations. The control channels are used for carrying system operation control signals (commands). Such control signals include page signals, page response signals, location registration signals, traffic channel assignments, maintenance instructions, and cell selection or re-selection instructions.

A cellular service area can cover a large geographic area, and in many instances there will be a need for a large number of cells that often exceeds in number the number of cells provided by dividing the available radio frequencies in such a

manner as to handle expected subscriber usage. Accordingly, in order to provide sufficient call handling capacity throughout the service area, the cells are grouped into clusters of cells and the radio frequencies in the cellular band are reused in each of the clusters.

Reference is now made to FIGURE 1 for an illustration of an example of the frequency reuse concept commonly utilized in cellular systems. An arbitrary geographic area (hereinafter "the service area") is divided into a plurality of contiguous cells 10 schematically represented by hexagons. The cells 10 are then grouped into clusters 12 (outlined in bold to ease recognition), which in the present example comprise seven cells 10(1)-10(7) in each cluster. Assume for this example that there are a total of twenty-eight frequencies fn (wherein n=1 to 28) available in the cellular band. It will of course be understood that each frequency actually comprises a paired uplink and downlink frequency. The frequencies f1-f28 are divided equally amongst the cells 10(1)-10(7) to provide four frequencies per cell. Thus, each of the cells 10(1) in the service area is allocated frequencies f1, f8, f15 and f22 for carrying its traffic and control channels. Similar assignments are made for each of the remaining cells 10, with the frequencies also being reused across each of the included clusters 12. The complete allocation of the frequencies f1-f28 to the cells 10(1)-10(7) in each cluster 12 in accordance with this example of cellular frequency reuse is illustrated in detail in FIGURE 1 with respect to cluster 12(1).

It is noted in this frequency reuse scheme that in no instance have adjacent cells been allocated use of the same frequency. Reuse of an identical frequency in the service area at a minimum requires a separation of at least one cell 10 along with a regulation of broadcast power from each cell to constrain radio propagation substantially within the cell area. Furthermore, it is noted that in no instance does any one cell 10 utilize adjacent frequencies in the cellular band. Adjacent frequencies should exist no closer than one cell 10 away from each other. By arranging the cells 10 in clusters 12 as shown in the figure, regulating broadcast power of communications within the cell, and further by allocating frequencies in the fashion described above and shown in the figure, the likelihood of interference is minimized while simultaneously providing effective and efficient cellular communications services across a very large service area.

In spite of the precautions taken to avoid interference, it is known that interference does occur in cellular systems like that previously described. One aspect of this interference originates from communications occurring in the cells of other clusters 12 on the same frequency (i.e., co-channel interference). To understand this phenomena, assume the existence of concurrent voice communications using frequency f10 (and perhaps individual time slots therein) in each of the cells 10(3) in each of the clusters 12(2), 12(3) and 12(4) as shown in FIGURE 1. In spite of any imposed broadcast power limitations, a certain amount of the radio frequency energy of those voice communications propagates beyond the respective cell boundaries and is injected as interference into frequency f10 in cell 10(3) of cluster 12(1).

Another aspect of this injected interference originates from communications occurring in other cells on adjacent frequencies (i.e., adjacent channel interference). To understand this phenomena, assume the existence of concurrent voice communications on frequency f8 in cell 10(1) and frequency f9 in cell 10(2), and perhaps individual time slots therein, of cluster 12(1) as shown in FIGURE 1. In spite of any regulations on broadcast power and the presence of guard bands around each of the frequencies, improper transceiver broadcasts around one frequency (for example, f8) may be injected as interference into the adjacent frequency f9. It should be recognized that adjacent channel interference is not nearly as common an occurrence as co-channel interference in well regulated and stable communication systems.

Because this injected interference may adversely affect cellular voice communications over a given frequency, it would be unwise for the system to act during certain times of high interference by assigning that given frequency (or channel therein) to a mobile station at either call set-up or hand-off to carry a cellular voice communication. Unfortunately, the prior art random or queued channel selection methods fail to obtain knowledge of and consider such injected interference and its adverse effects in selecting and assigning a voice channel (comprising a time slot within the frequency) during either call set-up or hand-off. There would be a great advantage to system operation if voice channel quality measurements could be made and evaluated prior to system voice channel selection and assignment.

The concerns over co-channel interference extend down to the time slot level within each frequency. It is recognized that at times of light or moderate loading, not every frequency (or every time slot therein) is needed for assignment to handle voice communications. Situations arise then where not every one of the plural time slots associated with a single frequency are used. Some injected co-channel interference arises from this use. At the same time, none of the plural time slots in another frequency may be used. No injected co-channel interference arises from this use. When a traffic channel assignment is then subsequently made, the prior art random or queued channel selection methods fail to obtain knowledge of and consider time slot usage between the allocated frequencies in a cell before selecting and assigning a voice channel (comprising a time slot within the frequency) during either call set-up or hand-off. There would be a great advantage to system operation if efforts were made to minimize the number of frequencies actively being used to carry communications prior in connection with system voice channel selection and assignment.

Each of the cells 10 in a cellular system such as that illustrated in FIGURE 1 includes at least one base station (BS) 14 configured to facilitate radio frequency communications with mobile stations 16 roaming throughout the service area. The base stations 14 are illustrated as being located at or near the center of each of the cells 10. However, depending on geography and other known factors, the base stations 14 may instead be located at or near the periphery of, or otherwise away from the centers of, each of the cells 10. In such instances, the base stations 14 may broadcast and communicate with mobile stations 16 located within the cells 10 using directional rather than omni-directional antennas. The base stations 14 are connected by communications links (illustrated schematically by arrow 17) to at least one mobile switching center (MSC) 18 operating to control the operation of the system for providing cellular communications with the mobile stations 14.

Reference is now additionally made to FIGURE 2 wherein there is shown is a simplified block diagram of a base station 14 used in the system of FIGURE 1 in accordance with the present invention. The base station 14 includes a plurality of transceivers (Tx/Rx) 20(1) through 20(N), wherein N is the number of frequencies allocated to the cell 10 served by the base station. In the exemplary system shown in FIGURE 1, N=4 wherein seven cells 10 are included in each cluster 12 and a total of

twenty-eight available radio frequencies in the cellular band. The transceivers 20 have a configuration known in the art that includes a transmitter and a receiver tuned to operate on one of the frequencies allocated to the base station 14 for its traffic and/or control channels. Each allocated frequency provides a plurality of digital TDMA channels for mobile station use.

The base station 14 also includes a signal strength measurement device 22 that is used in one mode known in the art during hand-off to measure the signal strength of communications on the voice frequencies assigned to and used by other cells. In accordance with the present invention, the operation of the signal strength measurement device 22 of each base station 14 is controlled in an additional operating mode by received mobile switching center commands and/or the base station programming to measure the signal strength of communications on each of the frequencies supporting idle traffic channels allocated to the base station. These measurements are made at selected times or are made periodically in accordance with system specifications. The results of the measurements provide an indication of the amount of injected uplink interference caused by same or adjacent channel communications occurring simultaneously within the system, or caused by any other interference source. The idle traffic channel signal strength measurements comprising the measured uplink interference (on either a frequency or time slot basis) are reported by the signal strength measurement device 22 of the base station 14 to the mobile switching center 18 (perhaps along with the hand-off traffic channel signal strength measurements made on the frequencies/channels allocated to other cells) and considered in connection with the process for selecting and assigning a voice channel at either call set-up or hand-off. Alternatively, a processor 24 within the base station 14 may receive the measured uplink interference (on either a frequency or time slot basis) for processing to select and assign a voice channel at either call set-up or hand-off.

In one embodiment of the present invention, the signal strength measurement device 22 comprises a locating verification module (LVM) 30 including a receiver and frequency synthesizer for selectively tuning to any one of the frequencies available in the cellular band. As each of the frequencies allocated to a cell 12 is subdivided into a plurality of time slots comprising the traffic channels, the locating verification

module 30 further includes a circuit (not explicitly shown) for synchronizing operation of the module to the TDMA communications protocol being implemented by the system so that the signal strength measurements on a selected frequency may be made during each of the plurality of included time slots therein. This would include not only the frequencies/time slots allocated to and used by other cells, but also the frequencies/time slots allocated to and used by the cell served by the base station 14. The signal strength measurements made by the locating verification module 30 are then filtered by an infinite impulse response filter (IIRF) 34 before being subsequently processed in accordance with the present invention. The filtering removes fast changes in the measured interference levels to provide a stable estimate for output and subsequent processing. With respect to the implementation of the present invention, the locating verification module 30 makes and reports measurements made on the frequencies/time slots associated with idle traffic channels in order to supply uplink interference measurement data.

In another embodiment of the present invention, the signal strength measurement device 22 comprises an idle channel supervision (ICS) functionality 32 associated with each transceiver 20. The idle channel supervision functionality 32 advantageously uses the receiver portion of the transceiver 20 to make the uplink signal strength measurements. This idle channel supervision functionality 32 may include a circuit (not explicitly shown) for synchronizing measurement operation to the TDMA communications protocol being implemented by the system so that the signal strength measurements on a selected frequency may be made during each of the plurality of included time slots therein. The selected frequencies upon which measurements are made comprise the frequencies/time slots allocated to and used by the cell served by the base station 14. With respect to the implementation of the present invention, the locating verification module 30 makes and reports measurements made on the frequencies/time slots associated with idle traffic channels in order to supply uplink interference measurement data. The signal strength measurements made by the idle channel supervision functionality 32 are then filtered by an infinite impulse response filter (IIRF) 34 before being subsequently processed in accordance with the present invention. The filtering removes fast changes in the

measured interference levels to provide a stable estimate for output and subsequent processing.

In one embodiment of the present invention, the base stations report signal strength measurements on a per idle time slot basis to either the processor 24 or the mobile switching center for processing. For this embodiment, the processing means comprising either the processor 24 or the mobile switching center may make intelligent time slot specific channel assignments with respect to minimizing interference concerns (for example, by choosing a least interfered time slot within a selected frequency). In another embodiment, the base stations process the signal strength measurements made on a per idle time slot basis to obtain an interference measure for the frequency (i.e., the carrier). It is this carrier based interference measurement that is reported to the processing means comprising either the processor 24 or the mobile switching center. For this embodiment, the processor 24 or mobile switching center does not possess per time slot interference information from which to make an intelligent assignment selection. Instead, the processor 24 or mobile switching center makes the decision as to which time slot channel to assign based on a random selection among the idle time slots in the least interfered carrier. More information on the processes implemented in accordance with the present invention is provided herein.

Reference is now made to FIGURE 3A wherein there is shown a flow diagram illustrating one manner of operation of the channel selection process of the present invention. In step 100, at a designated point in time the mobile switching center of the cellular telephone system generates a message commanding certain ones of the base stations to make idle traffic channel signal strength measurements. This command message is sent to the designated base stations in step 102. At each of the receiving base stations, the command message is implemented in step 104 by configuring the signal strength measurement device of the base station to tune to the base station's own allocated frequencies and make signal strength measurements (i.e., uplink interference measurements) on the frequencies with idle traffic channels that have been allocated to the cell served by the particular measuring base station. If possible, these measurements are made on a per idle time slot basis. It should be understood that this is an operating mode in addition to the conventional operating mode of making

measurements on neighboring cell voice channels in response to a hand-off request and the determination of a target cell.

The results of the uplink interference (signal strength) measurements on the frequencies with idle traffic channels are reported by the signal strength measurement device back to the mobile switching center in step 106. Again, alternatively, the measurements are reported to the processor 24 of the base station. This report also may be made upon receipt of a request from the mobile switching center. The report comprises either the measurements on a per idle time slot basis, or the accumulated measurement for a frequency (carrier). If the report is time slot specific, appropriate accumulation processing is performed at the processing means comprising either the processor of the base station or the mobile switching center to make a per frequency interference calculation. A determination is then made in step 110 as to the relative loading on each frequency having an uplink interference measurement reported in step 106. This loading determination evaluates, in general, the number of idle time slots within each measured frequency. If the number of idle time slots exceeds a predetermined threshold number (see, path 112), an interference penalty is assessed against the measured uplink interference for that frequency/carrier (step 114). If the threshold number is not exceeded (see, path 116), no penalty is applied. Although not specifically illustrated, it is understood that the process of steps 110 and 114 is performed, as needed, with respect to each of the frequencies having a step 106 reported uplink interference measurement. Following the adjustment (if any) applied in step 114 to the reported uplink interference measurements, the (adjusted) measurements in step 118 are processed to generate a sorted list of measured frequencies having idle traffic channels that are candidates for selection and assignment at either call set-up or hand-off. The generated list is sorted from the reported measurements in relative order of idle traffic channel measured (adjusted) uplink interference (e.g., from the least interfered (adjusted) frequency to the most interfered (adjusted) frequency). At an instance of traffic channel seizure (step 120), an idle one of the traffic channels within the least interfered (adjusted) frequency on the re-sorted list is randomly selected and assigned for either call set-up or hand-off. Alternatively, if individual time slot interference information is available, the least interfered time slot within that least interfered (adjusted) frequency is selected.

Referring now to FIGURE 3B, there is shown a flow diagram illustrating an alternative method of operation in accordance with the present invention wherein loop 122 and step 104 concern the programming of the base station to periodically measure signal strength on frequencies having idle voice channels that have been assigned to the cell served by the particular measuring base station. If possible, these measurements are made on a per idle time slot basis. At step 124 in loop 122, the base station programming tests for the occurrence of a reporting event. By this it is meant some cellular system event in response to which the measurements are to be reported to the mobile switching center or the base station processor. One such event comprises receipt of a command from the mobile switching center specifying the transmittal of the latest measurements. Another such event comprises receipt of a command from the mobile switching center directing the signal strength measuring device to make measurement on the traffic channels of other neighboring cells in preparation for hand-off and the selection of a target cell. In that case, the measurements relating to the own traffic channels are appended to the message reporting on the measurements made of the traffic channels for the neighboring cells. Yet another such event comprises a time out occurrence, thus effectuating periodic reporting of the traffic channel signal strength measurement information. Still further, the reporting event comprises a change in measured interference greater than a certain hysteresis value.

Once the reporting event occurs, the measurements are reported in step 106 to the mobile switching center. Again, alternatively, this measurement report may be made to the processor 24 of the base station. The report comprises either the measurements on a per idle time slot basis, or the accumulated measurement for a frequency (carrier). If the report is time slot specific, appropriate accumulation processing is performed at the processor of the base station or mobile switching center to make a per frequency interference calculation. Preferably, no report 106 is made if the most recent previous report was sent within a predetermined time threshold. A determination is then made in step 110 as to the relative loading on each frequency having an uplink interference measurement reported in step 106. This loading determination evaluates, in general, the number of idle time slots within each frequency. If the number of idle time slots exceeds a predetermined threshold number

(see, path 112), an interference penalty is assessed against the measured uplink interference for that frequency (step 114). If the threshold number is not exceeded (see, path 116), no penalty is applied. Although not specifically illustrated, it is understood that the process of steps 110 and 114 is performed, as needed, with respect to each of the frequencies having a step 106 reported uplink interference measurement. Following the adjustment (if any) applied in step 114 to the reported uplink interference measurements, the (adjusted) measurements in step 118 are processed to generate a sorted list of frequencies having idle traffic channels that are candidates for selection and assignment at either call set-up or hand-off. The generated list is sorted from the reported measurements in relative order of idle traffic channel measured (adjusted) uplink interference (e.g., from the least interfered (adjusted) frequency to the most interfered (adjusted) frequency). At an instance of traffic channel seizure (step 120), an idle one of the traffic channels within the least interfered (adjusted) frequency on the re-sorted list is randomly selected and assigned for either call set-up or hand-off. Alternatively, if individual time slot interference information is available, the least interfered time slot within that least interfered (adjusted) frequency is selected.

The particular penalty applied in step 114 against the previously made and sorted uplink interference measurements when the number of idle traffic channels exceeds the threshold may differ depending on the precise number of idle traffic channels that are present. For example, in a commonly implemented TDMA communications system, each frequency includes three time slots. The predetermined threshold in such a situation may require that two or more idle time slots be found with respect to a given frequency before applying the penalty. Then, if two idle time slots are found, the penalty that is applied to the uplink interference measurement is X dB. If, on the other hand, three idle time slots are found, the penalty that is applied to the uplink interference measurement is X+Y dB. A similar penalty scheme is implemented with respect to the eight time slots (resulting in seven penalty levels) associated with a Global System for Mobile (GSM) communications system. In any case, the object of applying the penalty to make the associated frequency having such a large number of idle time slots less attractive when the seizure of step 120 is performed. Conversely, for the frequency having only a single idle time slot, no

penalty is applied in order to continue making its lone idle time slot an attractive candidate for seizure.

With respect to the sorted (step 118) list, all frequencies allocated to a cell having idle time slots may be included on a single, comprehensive list. Alternatively, multiple lists may be generated in step 118 to account, for example, for differences that may need to be considered when the seizure of step 120 is performed. For example, it is known that the cellular frequency band includes both a basic band and an extended band. It is possible for separate step 118 sorted lists to be generated, one list for the frequencies having idle traffic channels in the basic band, and one list for the frequencies having idle traffic channels in the extended band. In another example, one list may be provided for data calls only, one list for voice calls only, and one list for either data calls or voice calls. At the time of seizure (step 120), an appropriate one (or perhaps more than one) of the re-sorted lists is then evaluated in connection with randomly or intelligently choosing an idle traffic channel for call set-up or hand-off assignment.

Although a preferred embodiment of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A cellular telephone system, comprising:

a base station allocated use of a plurality of frequencies, each frequency including a plurality of time slot traffic channels, comprising:

a signal strength measuring device selectively tunable to make signal strength measurements on the frequencies allocated to the base station having idle time slot traffic channels and obtain uplink interference measurements on those measured frequencies; and

processing means connected to receive the uplink interference measurements, the processing means operating to:

apply an interference penalty against the received uplink interference measurements if the measured frequency includes more than a threshold number of idle time slot traffic channels;

sort the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties from a least uplink interfered frequency to a most uplink interfered frequency; and

select for assignment by the base station at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency.

2. The system as in claim 1 wherein the signal strength measuring device comprises a base station locating verification module.

3. The system as in claim 1 wherein the signal strength measuring device comprises a base station idle channel supervision functionality provided by a base station transceiver.

4. The system as in claim 1 wherein the signal strength measuring device makes signal strength measurements for each idle time slot.

5. The system as in claim 1 wherein the processing means sorting operation sorts the measured frequencies by their uplink interference measurements

adjusted by any applied interference penalties into plural lists, each list ordered from a least uplink interfered frequency to a most uplink interfered frequency.

6. The system as in claim 5 wherein the processing means selecting operation selects from a certain one or ones of the plural lists for assignment at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency contained on that certain list.

7. The system as in claim 1 wherein the processing means applying operation applies an increasing interference penalty against the received uplink interference measurements corresponding to when an increasing number of idle time slot traffic channels are included within the frequency.

8. The system as in claim 1 wherein the processing means comprises a mobile switching center connected to the base station.

9. A method for use in a cellular telephone system for assigning traffic channels, comprising the steps of:

making signal strength measurements on frequencies allocated to a base station, wherein each frequency includes a plurality of time slot traffic channels, the measurement made on those frequencies having idle time slot traffic channels to obtain uplink interference measurements;

applying an interference penalty against the made uplink interference measurements if the measured frequency includes more than a threshold number of idle time slot traffic channels;

sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties from a least uplink interfered frequency to a most uplink interfered frequency; and

selecting for assignment by the base station at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency.

10. The method as in claim 9 wherein the step of making signal strength measurements comprises the step of making signal strength measurements for each idle time slot.

11. The method as in claim 9 wherein the step of sorting comprises the step of sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties into plural lists, each list ordered from a least uplink interfered frequency to a most uplink interfered frequency.

12. The method as in claim 11 wherein the step of selecting comprises the step of selecting from a certain one or ones of the plural lists for assignment at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency contained on that certain list.

13. The method as in claim 9 wherein step of applying comprises the step of applying an increasing interference penalty against the received uplink interference measurements corresponding to when an increasing number of idle time slot traffic channels are included within the frequency.

14. The method as in claim 9 wherein the step of selecting comprises the step of randomly selecting an idle time slot traffic channel included within the least uplink interfered frequency.

15. The method as in claim 9 wherein the step of selecting comprises the step of selecting an idle time slot traffic channel having a lowest interference included within the least uplink interfered frequency.

16. A cellular telephone system having a plurality of frequencies available for carrying cellular communications, each frequency including a plurality of time slot traffic channels, comprising:

a plurality of base stations distributed across a service area, each base station being allocated to use a subset of the plurality of frequencies wherein each base station includes:

a signal strength measuring device selectively tunable for making signal strength measurements on any of the plurality of frequencies in the system; and

processing means:

connected to receive a report from a given base station of measurements made by the signal strength measuring device on selected ones of the subset of frequencies allocated to that given base station which include idle traffic channels, the measured signal strengths indicative of uplink interference; and

operating to process uplink interference signal strength measurements for the selected frequencies and select for assignment by the given base station an idle traffic channel on as little an interfered one of selected frequencies as possible while simultaneously using as few of the frequencies allocated to that given base station as possible.

17. The system of claim 16 wherein the signal strength measuring device comprises a locating verification module.

18. The system of claim 16 wherein the signal strength measuring device comprises an idle channel supervision functionality provided by a base station transceiver.

19. The system as in claim 16 wherein the signal strength measuring device makes signal strength measurements for each idle time slot.

20. The system as in claim 16 wherein the processing means operates to process and select by:

applying an interference penalty against the received uplink interference measurements if the measured frequency includes more than a threshold number of idle time slot traffic channels;

sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties from a least uplink interfered frequency to a most uplink interfered frequency; and

selecting for assignment by the base station at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency.

21. The system as in claim 20 wherein the processing means performs the sorting operation to sort the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties into plural lists, each list ordered from a least uplink interfered frequency to a most uplink interfered frequency.

22. The system as in claim 21 wherein processing means performs the selecting operation to select from a certain one or ones of the plural lists for assignment at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency contained on that certain list.

23. The system as in claim 20 wherein the processing means performs the applying operation to apply an increasing interference penalty against the received uplink interference measurements corresponding to when an increasing number of idle time slot traffic channels are included within the frequency.

24. The system as in claim 16 wherein processing means comprises a mobile switching center.

25. A method for use in a cellular telephone system for assigning traffic channels, comprising the steps of:

making signal strength measurements on frequencies allocated to a base station, wherein each frequency includes a plurality of time slot traffic channels, the measurement made on those frequencies having idle time slot traffic channels to obtain uplink interference measurements;

making a report by a given base station of measurements made on selected ones of the plurality of frequencies allocated to that given base station which include

idle traffic channels, the measured signal strengths indicative of uplink interference; and

processing the reported uplink interference signal strength measurements for the selected frequencies to select for assignment by the given base station an idle traffic channel on as little an interfered one of selected frequencies as possible while simultaneously using as few of the frequencies allocated to that given base station as possible.

26. The method as in claim 25 wherein the step of making signal strength measurements comprises the step of making signal strength measurements for each idle time slot.

27. The method as in claim 25 wherein the step of processing comprises the steps of:

applying an interference penalty against the received uplink interference measurements if the measured frequency includes more than a threshold number of idle time slot traffic channels;

sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties from a least uplink interfered frequency to a most uplink interfered frequency; and

selecting for assignment by the base station at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency.

28. The method as in claim 27 wherein the step of sorting comprises the step of sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties into plural lists, each list ordered from a least uplink interfered frequency to a most uplink interfered frequency.

29. The method as in claim 28 wherein the step of selecting comprises the step of selecting from a certain one or ones of the plural lists for assignment at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency contained on that certain list.

30. The method as in claim 27 wherein step of applying comprises the step of applying an increasing interference penalty against the received uplink interference measurements corresponding to when an increasing number of idle time slot traffic channels are included within the frequency.

31. The method as in claim 27 wherein the step of selecting comprises the step of randomly selecting an idle time slot traffic channel included within the least uplink interfered frequency.

32. The method as in claim 27 wherein the step of selecting comprises the step of selecting an idle time slot traffic channel having a lowest interference included within the least uplink interfered frequency.

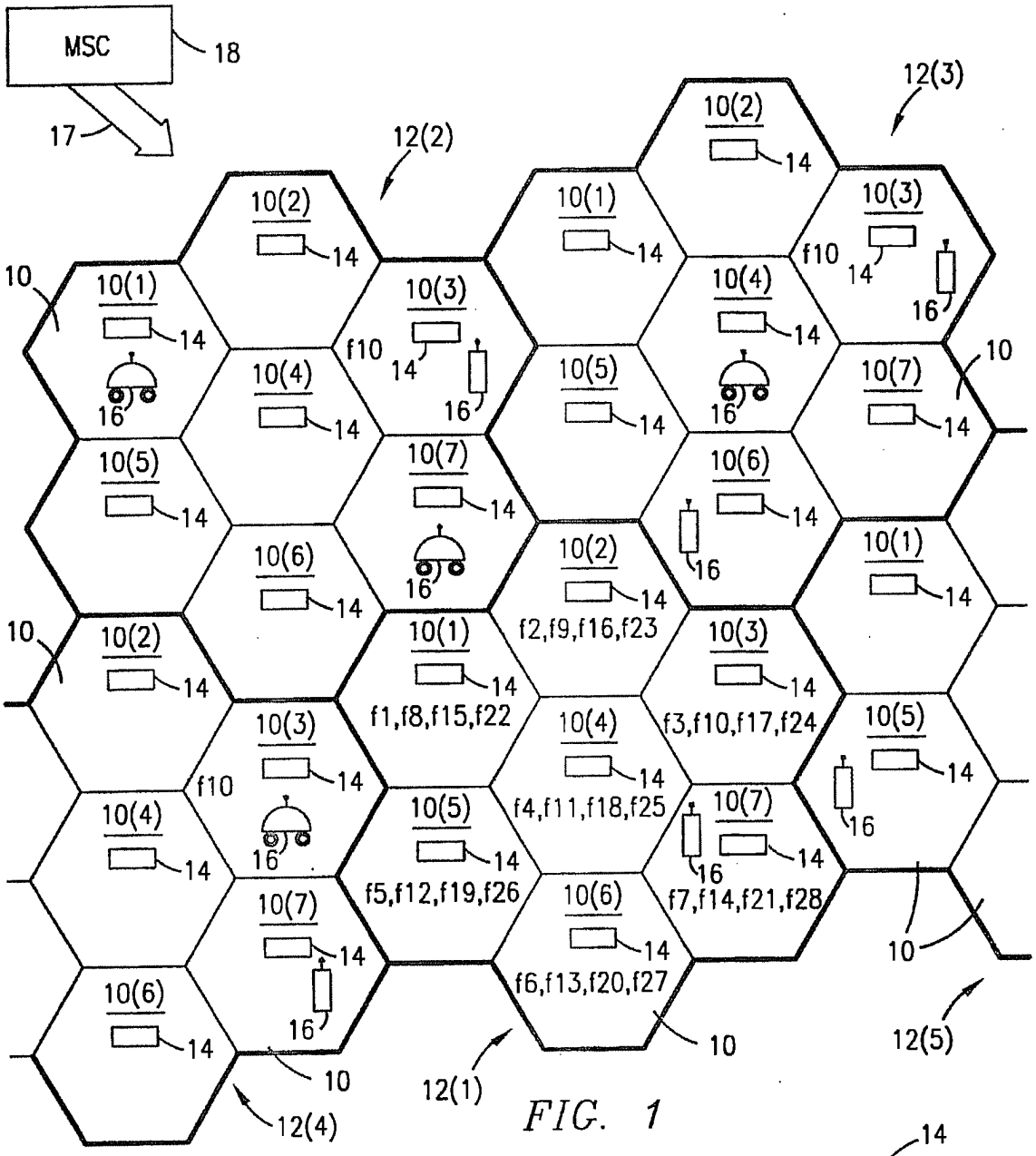

MSC
18
17
12(2)
12(3)
10
10(1)
10(2)
10(3)
10(4)
10(5)
10(6)
10(7)
14
16
f10
f2,f9,f16,f23
f1,f8,f15,f22
f3,f10,f17,f24
f4,f11,f18,f25
f5,f12,f19,f26
f7,f14,f21,f28
f6,f13,f20,f27
12(1)
12(4)
12(5)

FIG. 1

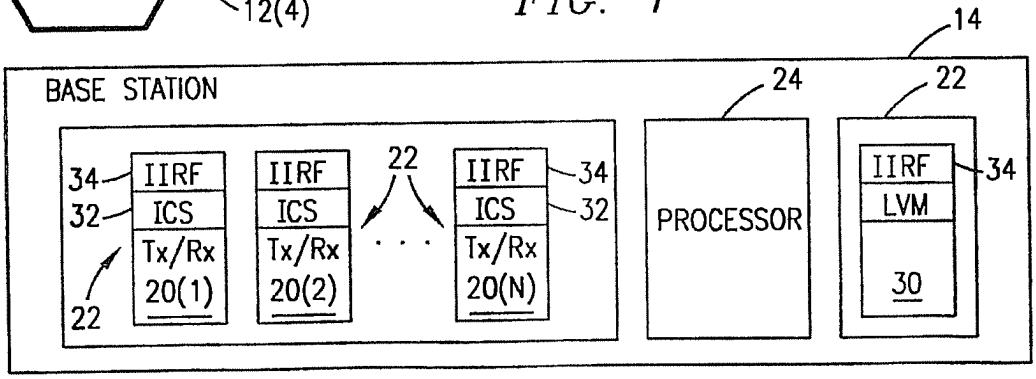

14
BASE STATION
24
22
34
32
IIRF
ICS
Tx/Rx
20(1)
20(2)
20(N)
PROCESSOR
LVM
30

FIG. 2

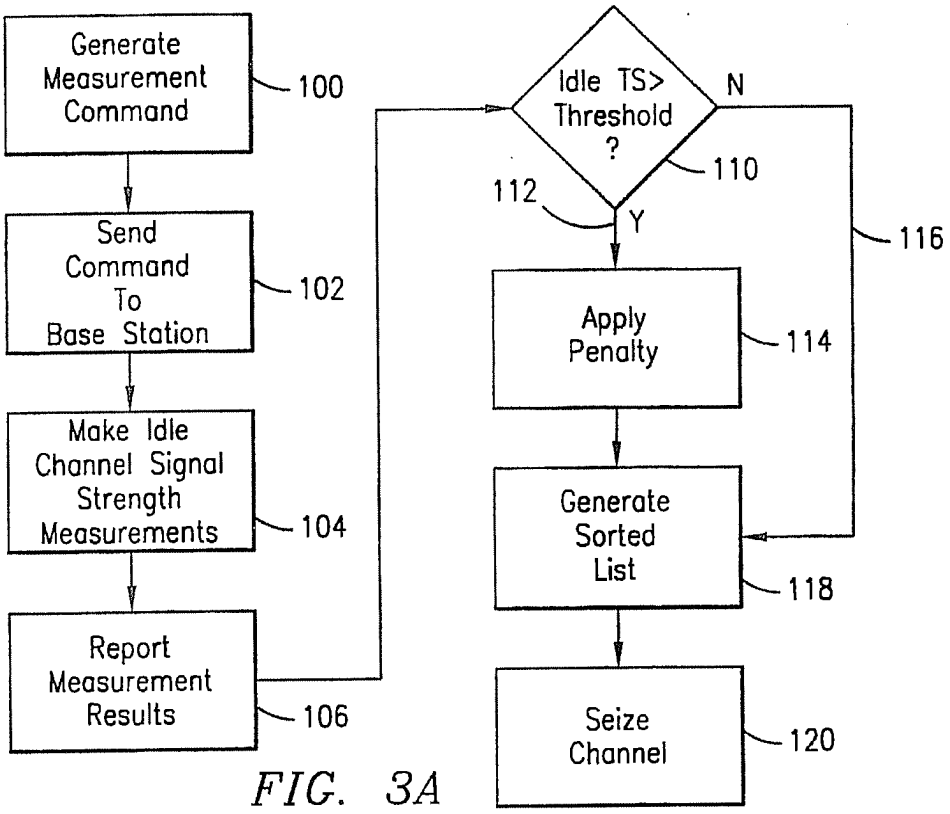

Generate Measurement Command
100
Send Command To Base Station
102
Make Idle Channel Signal Strength Measurements
104
Report Measurement Results
106
Idle TS> Threshold ?
110
N
Y
112
116
Apply Penalty
114
Generate Sorted List
118
Seize Channel
120

FIG. 3A

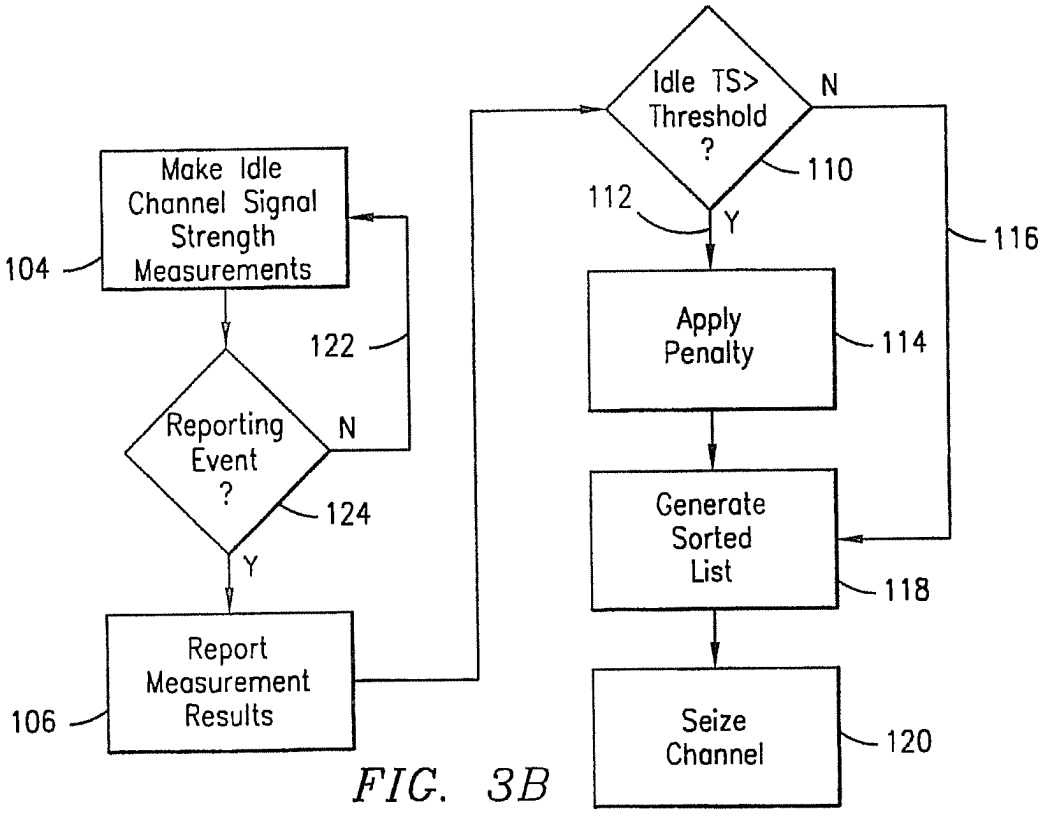

Make Idle Channel Signal Strength Measurements
104
122
Reporting Event ?
124
N
Y
Report Measurement Results
106
Idle TS> Threshold ?
110
N
Y
112
116
Apply Penalty
114
Generate Sorted List
118
Seize Channel
120

FIG. 3B

INTERNATIONAL SEARCH REPORT

Int ational Application No
PCT/SE 98/02109

A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 422 932 A (BHATIA HANS ET AL) 6 June 1995 see column 3, line 22-40 see column 6, line 51 - column 7, line 53 ---	1,9,16, 25
A	EP 0 779 755 A (NIPPON TELEGRAPH & TELEPHONE) 18 June 1997 see page 4, line 17 - page 5, line 1 ---	1,9,16, 25
P,A	EP 0 817 521 A (LUCENT TECHNOLOGIES INC) 7 January 1998 see page 4, line 10 - page 6, line 51 ------	1,9,16, 25

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 February 1999	17/02/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Weinmiller, J

2

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int ational Application No
PCT/SE 98/02109

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		JP 10079977 A	24-03-1998

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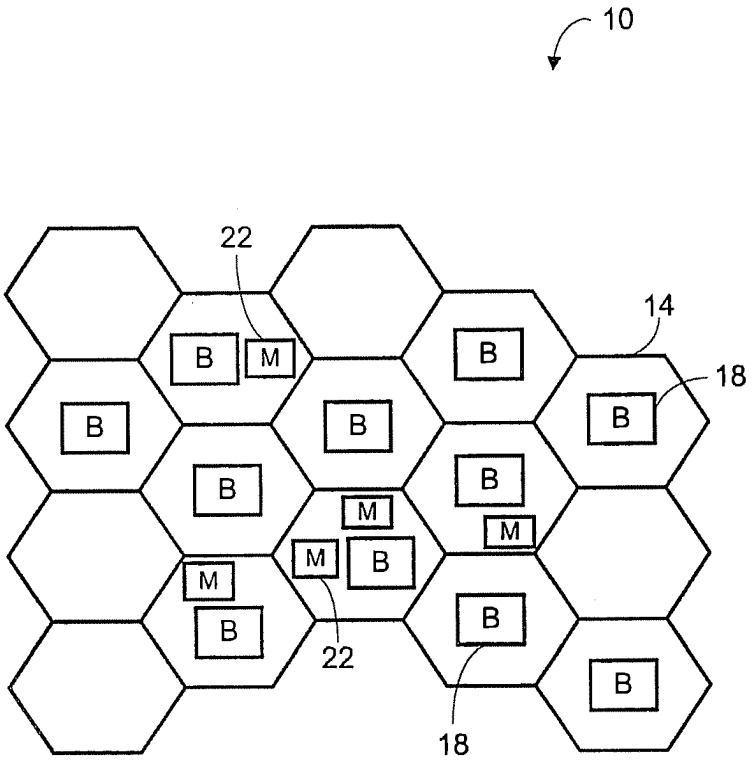
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[Continued on next page]

(54) Title: SYSTEM AND METHOD FOR FREQUENCY PLANNING IN WIRELESS COMMUNICATION NETWORKS



(57) Abstract: A system and method for frequency planning in a wireless communication network area using an impact matrix which relates signal interference impacts between sectors in a network service area for co-channel and adjacent channel interference. The impact matrix uses weighted propagation analysis and empirical measurement data to determine signal levels within each pixel of a network service area. The system merges the propagation analysis and empirical measurement data according to user assigned confidences.

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SYSTEM AND METHOD FOR FREQUENCY PLANNING IN WIRELESS COMMUNICATION NETWORKS

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BACKGROUND OF THE INVENTION

This invention relates generally to the field of frequency planning in wireless communication networks and, in particular, to a system and method for improved consideration of the impact of various factors in frequency planning.

In wireless communication systems, such as a cellular mobile radio communication system, the geographic area served by the system is divided into geographically defined cells. In the system, there is a finite number of carrier frequency channels, typically radio-frequency (RF) channels, that are available for use during communications in and between network areas cells. Typically, a frequency group, consisting of a subset of all of the available frequencies, is assigned to each cell for that cell's use during communications.

However, because the number of frequency groups is limited, it is necessary to reuse them within the area served by the system. To provide for a greater coverage by the system, and to provide for greater capacity through higher reuse of frequency groups, the network service area cells may be further divided up into sectors. Because the use of a particular frequency by two different sectors can result in interference during a call or even result in the call being completely cut-off or "dropped", an effort must be made to assign frequency groups to sectors in a manner that minimizes the amount of interference.

In wireless communication networks, there are two primary types of interference: co-channel interference and neighbor or adjacent channel interference. Co-channel interference is the interference from communication sources tuned to the same frequency as the operating channel. Adjacent-channel interference comes from

communication sources using channels near the operating channel in the frequency domain. To achieve the desired voice or data transmission quality, the ratio of the received signal over the combined co-channel and neighbor-channel interference must be above a specified threshold. Such channel interference can be up-link or down-link interference or a combination of these interferences. Down-link interference is channel interference received at regions serviced by a first base station caused from signals transmitted by other base stations. Up-link interference is interference at the base stations caused from signals transmitted by mobile units in regions of the coverage area that are not serviced by that base station.

Furthermore, other factors such as antenna patterns, power levels, scattering, and wave diffraction variations combined with buildings, various other structures, hills, mountains, foliage, and other physical objects contribute to the interference experienced during wireless communications.

In frequency planning for a wireless communication network, the primary task is to try to predict and attempt to reduce the amount of channel interference experienced by strategically assigning certain channels to certain sectors. Typically, this can be achieved by assigning frequencies so that the distance between co-channel and adjacent channel sectors is maximized. In this context, "distance" does not necessarily refer to geographic distance but connotes a distance in the RF sense. That is, although sectors far apart from each other geographically are less likely to "see" each other, they can still interfere with each other. For example, a high sector can interfere with a sector as far as hundreds of miles away. Maximizing this distance decreases the chances of the sectors conflicting with one another in the airwaves. However, a severe consequence of maximizing this distance is that it effectively reduces the amount of channel combinations possible in the network service area, thereby limiting the amount of coverage available for wireless communication. Typically, frequency planning is ordinarily accomplished by three primary techniques including channel sets, reuse patterns and pixel based interference analysis.

Channel sets are non-overlapping subsets of the available channels organized according to a periodic frequency spacing in terms of number of channels between members of a given set. The principal disadvantage of using channel sets is

that the number of channels required from sector to sector usually varies, and optimal frequency planning will require that just that number, rather than the number in an arbitrary set, be assigned to each sector.

In the reuse pattern scheme, the sectors in a network are arranged in a two-dimensional pattern, or "grid". Channels or, more commonly, channel sets, are then assigned so that co-channel or adjacent channel assignments appear periodically in different sectors. The primary disadvantage of frequency planning based upon a reuse grid is that, within a given network, varying terrain and man-made "clutter", such as buildings and other structures, will affect the characteristics of radio propagation and attenuation. Therefore, adhering to a fixed and rigid co-channel or adjacent channel spacing on a grid will likely provide inadequate isolation in some cases, resulting in excessive interference, and more than the required isolation in others, thereby reducing reuse efficiency. Furthermore, in addition to less than optimal interference levels, the fixed reuse approach results in much reduced capacity in many parts of the network where frequencies can be added freely due to an RF shield, such as a mountain ridge, but the grid prohibits such an assignment.

In pixel based interference analysis, the entire network service area is divided into a large number of very small "pixels" or "bins". In one example, each pixel would be a 100 meter square, so that a network service area of 100 kilometers by 100 kilometers would contain 1 million pixels. For each pixel, a system engineer will ascertain the strongest incident signal level from the sectors nearby and then the incident signal levels from each of the other sectors in the network to determine potential interferences. From this information, the system engineer can determine the predicted levels of co-channel or adjacent channel interference that would be present in that pixel if certain sectors were assigned, respectively, the same radio channels as the serving sector or channels adjacent to those in the serving sector.

However, pixel-by-pixel interference analysis also has many significant limitations. While pixel by pixel analysis can predict interference problems that are likely to result from a proposed frequency plan, it does not provide any such plan in the first place, nor does it inherently suggest modifications to a frequency plan that would reduce interference. Furthermore, there is an inherent limitation on the amount of data

that can be presented in pixel by pixel interference analysis. At the same time, pixel by pixel analysis produces an amount of data which is not easily susceptible to human interpretation. Finally, because conventional pixel by pixel interference analysis relies solely on predicted levels, it carries over the inaccuracies in such data as described above and results in erroneous frequency assignments.

Thus, while these existing techniques can provide for some measure of protection and relief from channel interference in the network service area, they still fail to account for the many variables and factors which can affect wireless communications on a day to day basis. Accordingly, it would be desirable to have a system and method for frequency planning within a wireless communication network which accounts for the many variables and factors affecting the quality of wireless communications, reduces the interference experienced during wireless communication, and does not limit the coverage area of network cells.

SUMMARY OF THE INVENTION

The present invention provides a system and method for creating an impact matrix for use in allocating frequency channels in a wireless communication network service area which is divided into a plurality of sectors and further divided into a plurality of pixels. The impact matrix provides impact scores which characterize the impact of making certain co-channel or adjacent channel assignment in pairs of sector by sector within a network service area.

The impact scores are developed by a series of steps, the first of which involves selectively merging signal propagation analysis data and empirical measurement data to determine an anticipated signal level for each one of the plurality of pixels in the network area. Once the signal levels within each pixel are obtained, a determination is made as to which sector within the network service area is serving that particular pixel. The system then assigns a weighted channel interference impact score for the pixel based on the interference between the pixel's signal serving sector and signals from each of the other non-serving sectors in the network area. Overall sector by sector impact scores based on the weighted channel interference impact scores are determined for all of the pixels for which a sector is the serving sector.

In one embodiment of the present invention, the signal level data from the signal propagation analysis, empirical measurement, and switch logs analysis is merged according to user assigned confidences for the data. The step of determining a weighted channel interference impact score between the pixel's signal serving sector and signals from each of the other sectors in the network area includes calculating a ratio between a signal level from the serving sector and signal levels from each of the other sectors in the network area, assigning interference impact scores for each of the other sectors in the network area, and adjusting the interference impact scores according to user assigned factors such as network area sensitivity to call quality and amount of call volume for that network area.

Once the impact matrix is developed, the scores in the matrix may be modified to further accurately characterize the signal impacts of interferences within a network service area. The impact matrix scores may be adjusted according to data which may have been previously input to the system or may be contemporaneously input. Such data includes channel pairing relationships among sectors which are known to provide low levels of excessive interference, channel pairing relationships among sectors which are known to provide high levels of excessive interference, and detailed call history information. Detailed call history information can include data on dropped calls and associated sector and channel combination where call drops occur.

The impact matrix may then be used for frequency planning in the network service area. The impact matrix will provide a user, typically a network engineer, with a way to predict the signal quality impact of certain channel assignments within the network service area.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a wireless communications network service area which is divided into cells.

FIG. 2A illustrates a network service area cell of FIG. 1 divided into sectors.

FIG. 2B is a detailed illustration of portion A in FIG. 2A showing a sector divided into pixels.

FIG 3 illustrates an exemplary impact matrix developed in accordance with the teachings of the present invention.

FIG. 4 is a flow chart illustrating a process for determining interference impact scores for use in developing the impact matrix.

FIG. 5 is a flow chart illustrating a process for determining a signal level within a pixel in the service area.

FIG. 6 is a flow chart illustrating a process for determining the potential interference impact of incident signals in a pixel from each of the other sectors in the network.

FIG. 7 illustrates how overall impact scores are determined for the impact matrix.

FIG. 8 is a flow chart illustrating a process for modifying the impact matrix.

FIG. 9 illustrates a computer system using an impact matrix of the present invention for frequency channel planning in a network service area.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown a schematic layout of a wireless communications network service area 10 divided into cells 14. It should be understood that the hexagonal shape of cells 14 depicted in FIG. 1 merely represents a drawing convention. Such a hexagonal cell representation has been chosen because it approaches a circular shape that is the ideal power coverage area for a wireless communications network service cell. Use of such circular shapes would involve overlapped areas and make a drawing of the served area unclear. With the hexagonal shaped cell convention, on the other hand, the plurality of cells representing a service area can be depicted with no gap and no overlap between cells. Generally, a typical wireless network would have far more than the illustrated number of cells but the numbers shown are sufficient for illustrative purposes.

As shown in FIG. 1, each cell 14 contains base stations 18 which are located toward the center of each cell 14. Typically the base stations employ omni-directional antennas, while base stations located toward a cell boundary typically employ directional antennas. Operating within a communications service area are

typically a large number of mobile telephone stations, or mobiles 22. At any given point in time, a subset of these mobiles will be engaged in calls.

As shown in FIG. 2A, each cell 14 in the wireless communication network service area may be divided further into sectors 30 to improve the coverage or maximize the reuse factor without increasing the interference level of the available frequency channels. Additionally, as shown in FIG. 2B, the network service area may be further divided into pixels 40 to assist in analyzing communication signal quality and interference on a more detailed basis. Typically, during wireless communications, the communicating mobile 22 will be assigned a particular frequency channel in the sector within which the mobile 22 is currently operating. If the mobile 22 moves from one sector which is currently servicing the communication, the "serving sector", to another sector which takes over the servicing of the communication, the "target sector", a "handoff' occurs in which the mobile 22 is assigned a new frequency channel from those available in the target sector.

In the present invention, the frequency channels correspond to the frequencies in approximately the 800 MHz band to the 1900 MHz band. The invention is intended for use in a system such as a Netplan system for the purpose of facilitating frequency planning for digital and/or analog channels, the invention will work in a dual mode system where analog and digital frequencies share the spectrum in each cell. The present invention is applicable to, but not limited to, "Advanced Mobile Phone System" ("AWS"), "Total Access Communications System" ("TACS"), "Nordic Mobile Telephone" ("NMT"), "Time Division Multiple Access" as defined by the Telecommunications Industry Association (TIA) interim standard IS-136 ("TDMA"), and "Global System for Mobile" ("GSM") protocols.

Referring to FIG. 3, the system and method of the present invention develops and generates an impact matrix 50 for use in frequency planning for a wireless communication network service area. Generally, the impact matrix 50 is a representation of the potential signal quality impact of making certain co-channel or adjacent channel assignments between two sectors within a wireless network, such as a cellular telephone network. It is contemplated that the impact matrix may also be organized by pixel by pixel and/or a cell by cell rather than sector by sector. In a

preferred embodiment of the present invention, two main matrices are developed, one which addresses the impact of co-channel interference and the other which addresses the impact of adjacent channel interference. The methods and processes shown and described herein will be applicable to either co-channel or adjacent channel interference determinations and measurements. In addition, the impact matrix is independent of the frequencies used in the wireless system, as long as the system works within a given interval such as, in one embodiment, a 100 MHz interval. Two impact matrices would be developed for use in a dual band network.

In the impact matrix, the columns 54 represent specific serving sectors in the network service area and the rows 58 represent interfering sectors in the network service area. A sector is considered to be a serving sector if, at a given point, the sector is currently providing the communications link to the mobile unit. The interfering sectors or "non-serving" sectors may be any sector within the network service area which may cause interference in the serving sector by virtue of a co-channel or adjacent channel assignment in that non-serving sector. For example, if a serving sector, denoted for exemplary purposes as sector S_1 is assigned a channel X, and one other sector S_2, within the network service area is also assigned channel X, then sector S_2 will be considered a potentially interfering sector.

In a preferred embodiment, the impact matrix will typically be of the dimension Q by Q, where Q is equal to the number of sectors in the network. In other embodiments, Q may include some sectors in neighboring networks which might interfere with, or be subjected to, interference from sectors that lie near the edge of the actual network service area under consideration. In such a case, the impact matrix should still be kept as a square by using null data in fields representing neighboring networks as serving sectors.

Generally, the impact matrix is developed by performing various signal quality measurements on a set of frequency channels in a network service area cell and adjusting the signal quality measurements based on a variety of factors or signal impacts, as discussed in more detail herein. In an exemplary embodiment, signal quality measurements are made not only for those frequency channels in use or available for use, but also for those frequency channels that are not currently being

used or available for use, though they may become available at a later time. These various signal quality measurements are processed, filtered, and evaluated, as described in greater detail below, and used as a basis for changing assignments of frequency channels.

The impact matrix 50 contains impact scores 72 which relate, on a sector by sector basis, the overall quality impact of making certain channel assignments in certain sectors pairings. Take, for example, the specific pairing of serving sector S_2 (column S_2) and interfering sector S_3 (row S_3). An impact score of "66" is given to the pairing of serving sector S_2 and interfering sector S_3 in the impact matrix of FIG. 3. The "66" represents the overall quality impact in areas served by sector S_2 when a co-channel or adjacent channel assignment is made in sector S_3. The scores 72 as shown in FIG. 3 are merely represented on a scale from one to ninety-nine for exemplary purposes only. It is contemplated that any numeric scale may be used in developing the impact matrix, such as a one to ten scale or any other similar scale which can provide for a relative rating in the matrix. In developing the impact scores, the system and method of present invention allow multiple data "layers" to be applied and merged so as to more accurately represent the potential signal interference impacts between sectors.

As shown in FIG. 3, in creating the impact matrix of the present invention, a number of data files or "layers" are used to provide data for development of the impact matrix. In some embodiments, such data includes output files from computer RF propagation analyses 60, output files from empirical measurements 62, files containing or implying lists of co-channel and/or adjacent channel pairing relationships among various sectors 64, and files which provide details of call records for the network for some period of time 66. Other types of data or output files may be used in accordance with the teachings of the present invention, where the data may affect the signal quality within the network service area. The system and method of the present invention are scalable so that any number of data layers are able to be incorporated into the overall impact matrix. In the present system, each of these data types or files constitutes a "layer" for eventual incorporation into an overall unified impact matrix.

As shown in FIG. 4, in one embodiment of the present invention, the development of the impact matrix generally begins with a determination of signal levels within the network service area, step 100. Once signal level information is obtained and calculated, it is determined which sector within the network service area is the serving sector for a particular pixel, step 104. Once the serving sector is identified, the potential interference of other sectors on this serving sector is quantified by way of an interference impact score assigned to that specific pairing of serving sector and interfering sector, step 108. Finally, the interference impact scores are adjusted according to some user inputtable variables and factors, step 112. The steps of the process shown in FIG. 4 will be now discussed in more detail below.

Referring now to FIG. 5, in constructing the impact matrix, the system of the present invention endeavors to determine the signal level within each pixel of the network service area. The process begins with a basic RF propagation analysis for the network service area, step 120. By way of background, the RF propagation analysis is typically based on signal predictions which take into account area topology, antenna heights, transmit power levels and even extant man-made clutter, such as building, bridges, etc. Such propagation predictions are most often performed by computer simulation programs running specially designed RF propagation analysis software, such as MSI's Plantet, Motorola's Netplan, or LCC's CellCard. After RF propagation analysis is performed, empirical measurement data is collected to provide additional information about signal levels within each pixel in the network service area, step 124. Collecting empirical signal level measurements typically are made by a receiver provided either in a mobile unit, such as car or in a hand held scanner, which scans discrete channels being transmitted by the various sectors. The measurement receiver is moved about in the network to collect signal level data in a large number of pixels, often in the form of so-called "drive tests".

Once the propagation analysis and empirical measurements are completed, confidences may be assigned to the signal level data, step 128. For example, if it is known that for a certain area the RF propagation analysis data will be incorrect or skewed, a user may assign more confidence to the empirical measurement data for that certain area. Conversely, if it is known that for another service area, the

empirical measurement information is somehow inaccurate because, for example, of possible physical/environmental clutter which may affect the empirical readings, then the user may assign more confidence to the RF propagation analysis information in that instance.

In one embodiment, a two-dimensional representation of the network service area in map format is provided to a user, on which the user can "draw" such areas as polygons or other arbitrary shapes using a "mouse" or other pointing device to designate areas to which to assign confidences to either the propagation or empirical measurements. The user may also simply assign confidence ratings to either the propagation analysis or empirical measurement information. Such ratings may be simply a one to ten rating or any scale which can rate the data on a relative basis. In such an example, the signal level data which the user has the most confidence in will be assigned a "10" and the data which the user has the least confidence in will be assigned a "1."

Once confidences are assigned, the system merges propagation analysis and empirical measurement information, step 132, in accordance with confidences assigned by the user. In an exemplary embodiment, the basic logic for the merging of the propagation analysis data and the empirical measurement data is accomplished according to the following pseudo-code:

```
for current _point = {points in drive-test} {
        for freq. = { frequencies measured in current frequency {
                for each antenna transmitting at the current frequency {
                        using some basic RF prediction model, calculate the
                        predicted signal strength in the drive test point
                        region (~500m radius), apply a geometric correlation
                        test to the sampled and predicted measurements. Store
                        the correlation index.

                        iterate to next antenna
                }
                if none of the antennas satisfied some minimal correlation threshold
                        go to frequency loop
```

take the antenna with the best correlation index and declare it
as the transmitter of the current frequency at the current point.

iterate to next frequency
}
iterate to next point
}

The merging of propagation analysis and empirical measurement information is done as a preliminary step in determining which sector in the network service area is serving a current pixel. This is accomplished by first determining which antenna in the network service area is transmitting the current signal being measured at the current pixel (current_point). The process for determining signal levels within a network service area is basically accomplished by the nested series of loops, as shown above, whereby readings are taken at a certain point (pixel) within the network service area, then at each point a certain frequency is measured, then for that certain frequency, the different antennas transmitting at that frequency are examined.

Essentially, a point by point (current_point) frequency signal analysis is conducted for all the points in the empirical test (points in drive_test). At each point, frequencies are measured (frequencies measured in current_point) to determine viable frequencies at that point. Then, for each antenna transmitting at the current frequency, the predicted signal strength is determined using basic RF prediction model data. A geometric correlation test is applied to the currently empirically sampled signal measurement and the predicted signal strength measurement to determine a correlation index. This correlation index is then stored. This process of determining and storing a correlation index is repeated for each antenna transmitting at the current frequency. If none of the antennas satisfy a minimal correlation threshold, the next frequency at the current point is examined. This process is then repeated for the next point or pixel in the empirical measurement analysis.

Once at least two correlation indices are determined for the frequency at the current point, the at least two indices are compared and the antenna with the "best" correlation index is determined to be the transmitter of the current frequency at the current point. The "best" correlation index is obtained for the antenna with the best match between the prediction and sample and whose complete set of frequencies is measured in a coordinated way. After this determination is made for the current

frequency, the system iterates to the next frequency and repeats the above process of determining the transmitter of the frequency.

Having merged the RF propagation analysis and empirical measurement data for every pixel in the network service area, the system now has a signal strength per pixel file in which, for each pixel in the network, the anticipated incident signal levels from each sector are retained. Those skilled in the art will appreciate that typically, in each pixel, the anticipated signal level from the vast majority of the sectors in the network will be below a thermal noise floor, and may thus be disregarded. Typically, the thermal noise floor will be approximately at or below 130 dB.

Referring back to FIG. 4, the present system and method identifies, in each pixel, the associated serving sector for that pixel, step 104. The probability of a mobile being served by a given antenna at a given point depends in part on the RF propagation layer, e.g., the signal strength of each antenna at each point, and also in the logical organization of the network which takes into account factors such as the handoff regulation algorithm and parameters. The following pseudo-code demonstrates the basic logic employed in an exemplary embodiment for determining which will be the serving sector for a given pixel or point in the network service area:

```
for current_point = {points in sample} {
        calc the best server in current_point.
        calc the best server signal strength at current_point.
}
for current_sector = {sectors in the network} {
        for neighbor = {neighbors to current_sector) {
                flow = number of times user handoff between current_sector and
                        neighbor.
                Simulate user movements and the handoff process (using
                the specific system handoff algorithm) and update the service
                probabilities in non-best server areas (known as handoff zone).
        }
}
```

In an exemplary embodiment, the system determines for the current pixel (current_point) out of all the pixels in the network service area (points in sample), the best server for the current_point and the best server signal strength at the current_point, as described above. Then for the current sector (current_sector) out of all the sectors in the network, each neighboring sector (neighbors to current_sector) is

examined based on the flow, user movements and the handoff process to determine service probabilities for each of the sectors. The system predicts, taking into account the system specific handoff algorithm which may vary between communication systems, which sector will serve a given pixel based on the handoff performance between the current_sector and neighboring sectors (neighbors to current_sector.) Thus, a sector will likely be a serving sector for a given pixel, if the sector both provides a strong signal to a given pixel and also actively coordinates handoffs in that given pixel's area.

Referring back now to FIG. 4, once the system determines which is the serving sector for each pixel, the system begins with an analysis of the potential interference impacts between signals from each of the other non-serving sectors in the network with that pixel's serving sector, step 108. As shown in FIG. 6, the process for determining the potential interference impact of signals begins with determining the carrier-to-interference (C/I) ratios for each potentially interfering sector, step 140. Typically, these C/I values are calculated in decibels ("dB"). A large C/I ratio indicates a signal that is substantially isolated from channel interference while a small C/I ratio indicates a signal having substantial channel interference. Thus, large C/I ratio values between conventional cellular base stations that are, for example, greater than approximately 18 dB, indicate that such base stations can use the same channel while small C/I ratio values between base stations, such as, for example, less than approximately 12 dB, indicate that substantial interference will probably occur between those two base stations when using the same or adjacent frequency channels. The specific C/I values are determined typically by the type of air interference technology used (GSM Vs TDMA, for example) and the service parameters the operator may want to use.

The system of the present invention maintains a user modifiable table which develops a quality impact "score" with respect to the determined C/I. For example, in an exemplary embodiment as shown below in Table 1, the quality impact score will range from zero to ninety-nine, with zero representing no perceptible quality impact and ninety-nine representing severe interference virtually certain to result in a dropped call. In a more specific example, a score of 0 is assigned for a potential

interferer in pixels where C/I is determined to be above 17 dB and a score of 99 for a potential interferer in pixels where C/I is determined to be below 9 dB.

Table 1

Impact Score	C/I (dB)
0	18
50	13
99	8

As shown in FIG. 6, using the C/I scoring table shown and described above, the system will then assign an interference impact score for each potential interfering sector in each pixel in the network, step 142. Referring again to FIG. 6, these interference impact scores are then adjusted according to various weighting factors, step 144.

In one preferred embodiment, the system uses weighting factors which are specified by the user. In particular, the system allows identification of areas within the network service area in which sensitivity to call quality is particularly high and other areas where such sensitivity is relatively low. For example, areas frequented by top government officials may be designated as "high" sensitivity and low traffic pedestrian areas may be designated as "low" sensitivity. In this embodiment, the system also allows identification of specific areas within the network service area in which peak time call volume, preferably on a per-pixel basis, is anticipated to be significantly higher than average, and other specific areas where such anticipated call volume is relatively low. For example, sections of major highways where vehicular traffic routinely backs up during "rush hour" might generate much higher than average peak time call volumes, so the user might designate such areas as "high" call volume per pixel. "Low" call volume per pixel designated areas may be locations such as side roads located in rural townships where activity is minimal. The user may use a number of different sources of information to provide such weighting factors, such as traffic reports, call logs from past activities in certain areas, and consumer feedback reports which may indicate areas where communication services may be currently deficient. Once these weighting factors are provided by the user, the system adjusts the interference impact scores accordingly, in line with the weighting factors.

The following pseudo-code demonstrates the basic logic for determining a single impact score between sectors:

```
define the local interferer index function using the tables matching the current network
technology, the tables assigning a local impact for each co-channel C/I and a
potentially different local impact to each adjacent channel C/I

For current_server = {sectors in the network} {
        for current_interferer = {sectors in the network ! = current_server} {
                for current_point = {points in which the traffic uses
                                        current server in non zero probability} {
                        compute the C/ I of the current_server and
                        current_interferer at the current_point using the RF
                        propagation information.
                        compute the cochannel and adjacent channel local
                        interference indices.
                        }

                use an integration policy to collect all the local interference
                indices to a single impact between current_server and
                current_interferer.
        }
}
```

In the above pseudo-code, a pixel by pixel analysis is undertaken for each serving sector (current_server) and each interfering sector (current_interferer) in the current pixel being examined. For each pixel (current_point), the C/I is computed for that specific pixel's serving sector and each of the other interfering sectors in the network service area (sectors in the network !=current_server). In one embodiment, the C/I will be computed using the RF propagation information which may be simple predicted RF propagation information or alternatively, sampled RF information and/or the RF information merged with empirical data. Once the C/I of the current_server and current_interferer is computed, the co-channel and adjacent channel local interference indices are computed from the computed C/I at the current_point. In the present embodiment, the local interference index is a measure of the user dissatisfaction from experiencing a given C/ I in a given technology. Once the local interference indices are calculated, the system uses an integration policy to collect or combine all the local interference indices to generate an impact score between the current_server and

current_interferer for that given pixel. This combination of local interference indices can be done using traffic normalized summation, maximization, prioritized weighted summation, or other variants.

The system has now created a weighted pixel-by-pixel characterization of potential interference impacts in the network service area. From this impact information, the system generates an impact matrix 146, as shown in FIG. 7. In the impact matrix 146, each of the columns represents a specific sector in the network acting as the serving sector. Each of the rows represents a specific sector in the network acting as an interfering sector. Thus, an entry in the impact matrix will represent the overall signal quality impact in areas served by a specific sector which would be caused by making co-channel or adjacent channel assignments in another sector. Typically, the higher the score in the impact matrix, the more of an impact a co-channel or adjacent channel assignment will have for that specific sector pair.

To generate an overall impact score for the impact matrix, the system considers all of the weighted interference impact scores as determined above for each pixel. In one embodiment, the system performs a weighted sum integration to generate the impact matrix from the scores. Referring to FIG. 7, for each sector S_1 S_2, S_3, and S_4. in a network service area, the system considers all of the pixels for which a specific sector, say S_1 is the serving sector. For example, if sector S_1 is the serving sector for pixels P_1, P_2, P_3 and P_4, then the weighted interference impact scores for pixels P_1, P_2, P_3 and P_4 are considered in generating an overall impact score for that sector S_1 and its potentially interfering sectors, such as S_2, S_3, and S_4. For example, for each pixel, weighted interference impact scores have been determined between each pixel serving sector and each of the other non-serving sectors S_2, S_3, and S_4 (S_1 v.S_2; S_1 v. S_3; S_1 v.S_4). Based on the weighted interference impact scores, the system determines an overall impact score for sector S_1 with respect to sectors S_2, S_3, and S_4. For example, considering sector S_1 to be the exemplary serving sector and sector S_2 to be the interfering sector, the system will examine the weighted interference impact scores for pixels P_1, P_2, P_3 and P_4 with respect to sector S_2, namely P_1 (S_1 v.S_2), P_2 (S_1 v.S_2), P_3 (S_1 v.S_2) and P_4 (S_1 v.S_2). These weighted interference impact scores for pixels P_1, P_2, P_3 and P_4 with respect to sector S_2 are then combined and weighted to generate an

overall impact score for sector S_1 as the serving sector and sector S_2 as the interfering sector. This overall impact score will then be placed into the impact matrix under the column sector S_1 and in the row sector S_2. The remaining spaces in the impact matrix are populated as described above. Typically, the spaces in the impact matrix where the serving sector and the interfering sector are the same sector remain blank, since the same sector will not be able to interfere with itself in practice.

The following pseudo-code demonstrates one set of logic behind consolidating various layers of information and data into a single overall impact matrix:

```
input :
layers[the_layer] [sector1][sector2] - the impact between sector1 and sector2 in layer
the_layer.

weight_from[the_sect] [layer] : the weight associated to impacts from sector the-sect
with regard to the layer.

weight_to[the_sect] [layer] : the weight associated to impacts to sector the_sect with
regard to the layer.

Output : the unified im - im[sector] [sector]
for sl = {set of sectors} {

for s2 = {set of sectors} {
        im[sl, s2] =
                merging_func(s1, s2, {layers[0][s1][s2], layers[1][s1][s2],..})
        }
}
merging_func(s1,s2, {entry1, entry2,....}) =

                summ(i, weight_from[s1] [i] * weight_from[s2] [i] * entry [i])
```

In consolidating all the signal and interference data into a single impact matrix, the system accepts input, such as the interference impact scores for specific areas (sector1, sector2) of the network service area, as was determined above. These impact scores thereby form a "layer" (the_layer) of data for consolidation into the single impact matrix. Such data may also be weighted, for example, by specifying which areas within the network service area are sensitive or are "high" call volume

areas. The interference impact scores and associated weightings are then processed by the system (merging_func) and outputted into a unified impact matrix.

One skilled in the art will recognize that the overall impact matrix may be generated in many different ways and still achieve the objectives of the present invention. For example, in a more general example of an integration technique, arbitrary logical expression is defined that takes a set of layer values *1M_sect1_sect2_layer_i* and an output is generated by applying the logical expression to the inputs. Having, for example, two input layers *drive_test* and *heuristic*, the system generates the impact matrix using the following expression:

```
If (heuristic >0)
        return heuristic
else
        return drive_test
```

Further embodiments involving combinations of logical expressions and weighted sums are available, as will be understood by those skilled in the art after reviewing this description.

Referring now to FIG. 8, once the impact matrix is generated, step 150, the impact scores may be adjusted to further accurately represent potential impacts of channel assignments. The scores may be adjusted according to the data which defines sector pairs for which it is known that channel assignment, either co-channel or adjacent channel, will not result in excessive interference, step 152. If the impact scores in the impact matrix suggest interference impacts higher than the known levels, step 154, the scores in the matrix are reduced accordingly, step 156.

The impact scores may also be modified in accordance to data which defines sector pairs for which it is known that channel assignment, either co-channel or adjacent channel, will result in excessive interference, step 158. If the impact scores in the impact matrix suggest interference impacts lower than the known levels, the scores in the matrix are increased accordingly.

Additionally, the system may adjust the scores in the impact matrix based on data input which contains call detail information, such as information which correlates incidences of dropped calls operating on a given radio channel in a given sector with simultaneous use of the same (or adjacent) radio channel in another sector,

step 164. When a high correlation of these factors is found, it is assumed that there is a causal relationship in that the dropped calls in one sector are likely caused by interference from the other sector. In this case, the system examines the corresponding impact score in the impact matrix, step 166. If this score is not already appropriately high, it is then increased to a high value, step 168.

Typically, the system will accept the following inputs prior to the creation of the impact matrix: files containing or implying lists of co-channel and/or adjacent channel pairing relationships among various sectors which are known to provide low levels of excessive interference; files containing or implying lists of co-channel and/or adjacent channel pairing relationships among various sectors which are known to provide high levels of excessive interference; files which provide details of call records for the network for some period of time including: for each incidence of a dropped call: the precise time of the call drop; the RF channel in use by the call when the drop occurred; and the serving sector of the call when the drop occurred; for each call handled during the period covered by the data: the time the call began; the initial RF channel assigned; the initial serving sector; the time, target sector, and new RF channel assignment for each handoff; and the time the call ended.

In a typical cellular communication network, call detail information as discussed above may be extracted from switches within the network communications system which maintain log files that track various attributes, such as dropped calls, severe C/I events, uplink noise, failed handoffs and other related events. Call detail information may also be extracted from performance monitoring systems such as WantMark's Flex-PM, ADC's Metrica, and MSI's MAXXER.

Once modifications to the impact matrix, as described above, are complete, the impact matrix is used to assist the system engineer in designing and optimizing a frequency plan for the network, wherein the object is to assign channels to each cell or sector in the numbers required while keeping the total quality impact associated with these assignments to the lowest possible value.

As shown in FIG. 9, the methods and systems of the present invention may be incorporated in software stored on a computer usable medium such as a hard or floppy disk, CD-ROM, or other electrical, magnetic, or optical memory device adapted

for use on a computer system 200. Additionally, the methods or systems may also be incorporated in hardware elements such as specially designed integrated circuits, as is known in the art. The computer system 200 may provide for the calculation, processing and generation of an impact matrix 210 in accordance with the teachings of the present invention. The impact matrix 210 may be used for frequency planning within a network service area 220 made up of cells or sectors 230. The impact matrix 210 would provide guidance on how to make specific channel assignment 240 and/or channel set assignments 250 within each cell or sector 230. For example, if a user desired to change an existing channel assignment within the network service area 220, the user would consult the impact matrix 210 to determine the impact of changing the channel assignment.

In other embodiments, the system would "score" a given frequency plan, or a given modification thereto, by applying the impact matrix's scores to the individual channel assignments in the plan or modification. For example, if a system engineer needs to add an RF channel to a particular sector to accommodate growth in peak call volume, he or she can consider a particular channel assignment. The impact matrix will provide the incremental quality degradation that such an assignment will cause within that sector's service area and in the service areas of each co-channel or adjacent channel sector.

While the invention has been described and illustrated in connection with preferred embodiments, many variations and modifications as will be evident to those skilled in this art may be made without departing from the spirit and scope of the invention, and the invention as set forth in the appended claims is thus not to be limited to the precise details of methodology or construction set forth above as such variations and modification are intended to be included within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method of generating an impact matrix for use in allocating frequency channels in a wireless communication network service area, the network area divided into a plurality of sectors which are further divided into a plurality of pixels, the impact matrix providing impact scores which characterizes sector by sector channel interference in the network service area, the method comprising:

merging signal propagation analysis data and empirical measurement data to determine an anticipated signal level for each one of the plurality of pixels in the network service area;

determining which one of the sectors in the network service area is a serving sector for the pixel;

determining channel interference impact scores for the pixel based on the interference between the pixel's serving sector and each of the other sectors in the network service area; and

providing sector by sector impact scores.

2. The method of claim 1, wherein merging propagation analysis is performed according to user ascribed confidences.

3. The method of claim 1, wherein determining channel interference impact scores between the pixel's serving sector and signals from each of the other sectors in the network service area comprises:

calculating ratios between a signal from the serving sector and signal levels from each of the other sectors in the network service area;

assigning unweighted interference impact scores based in part on the calculated ratios; and

adjusting unweighted interference impact scores according to user assigned variables.

4. The method of claim 3, wherein the user assigned variables comprise network area sensitivity to call quality and amount of call volume for that network service area.

5. The method of claim 1, further comprising modifying the overall impact scores in the impact matrix according to channel pairing relationships among sectors which are known to provide high levels and low levels of interference.

6. The method of claim 5, further comprising modifying the overall impact scores in the impact matrix according to detailed call history information.

7. The method of claim 6, wherein the detailed call history information includes dropped call information.

8. A system for developing an impact matrix for use in frequency channel planning in a wireless communication network service area, the communication network service area divided into sectors and pixels, the system comprising:

means for determining a signal strength level for each pixel in the network service area;

means for determining which is a serving sector for each pixel in the network service area;

means for determining an interference impact score between each pixel's serving sector and each of the other non-serving sectors in the network service area; and

means for determining overall sector by sector impact scores for inclusion in the impact matrix, the overall sector by sector impact scores based on the interference impact scores for the pixels within which a sector is the serving sector.

9. The system of claim 8, wherein the means for determining a signal strength for each pixel in the network service area comprises means for conducting a propagation analysis and means for performing empirical measurements.

10. The system of claim 8, wherein the means for determining an interference impact score between each pixel's serving sector and each of the other non-serving sectors in the network service area comprises:

means for calculating for each of the other non-serving sectors in the network service area, the ratio between the signal strength level from the serving sector and a signal strength level from each of the other non-serving sectors;

means for assigning interference impact scores for each of the non-serving sectors; and

means for weighting the interference impact scores.

11. The system of claim 10, wherein the means for weighting the interference impact score comprises means for allowing the user to specify sensitive areas within the communication network service area.

12. The system of claim 11, wherein the means for weighting the interference impact score comprises means for allowing the user to specify areas having high or low call volume within the communication network service area.

13. The system of claim 8, further comprising means for modifying the impact matrix based on data which specifies co-channel assignments which will not result in excessive interference.

14. The system of claim 13, further comprising means for modifying the impact matrix based on data which specifies co-channel assignments which will result in excessive interference.

15. The system of claim 14, further comprising means for modifying the impact matrix based on data which specifies adjacent channel assignments which will not result in excessive interference.

16. The system of claim 15, further comprising means for modifying the impact matrix based on data which specifies adjacent channel assignments which will result in excessive interference.

17. The system of claim 16, further comprising means for modifying the impact matrix based on call detail information.

18. The system of claim 17, wherein the call detail information includes at least one or more of the following: time of call drops, channel in use by dropped calls, serving sectors of dropped calls, time dropped calls began, initial channel assigned to dropped calls, initial serving sector of dropped calls, call handoff information and time calls ended.

19. The system of claim 8, wherein the impact matrix allows a user to make and evaluate individual channel assignments in the communication network.

20. A computer implemented process for creating an impact matrix for use in allocating channels in a wireless network which is divided into sectors, the impact matrix constructed based on a pixel by pixel analysis of signal interference within the network, the process comprising:

determining a serving sector for at least one pixel in the network;

determining weighted interference impact scores for the at least one pixel, the weighted interference impact scores based upon each of the non-serving sectors' interference impact upon the pixel's serving sector; and

determining overall impact scores based upon the weighted interference impact scores for the at least one pixel.

21. The process of claim 20, wherein determining a serving sector for at least one pixel in the network comprises merging propagation analysis and empirical data according to user ascribed confidences assigned to the data.

22. The process of claim 20, wherein determining overall impact scores comprises, for all of the pixels in the network for which a specific sector is the serving sector, processing all of the weighted interference impact scores for those pixel based upon the interference impact between the pixels' serving sector and each of the other non-serving sectors in the network.

23. A method of using an impact matrix for frequency channel planning in a wireless communication network divided into sectors, the impact matrix providing sector by sector signal quality interference ratings, the method comprising:

determining an incremental quality degradation for a potential channel assignment in the network using the impact matrix; and

assigning frequency channels to sectors according to the incremental quality degradation provided by the impact matrix.

24. The method of claim 23, wherein the impact matrix provides co-channel interference ratings.

25. The method of claim 23, wherein the impact matrix provides adjacent channel interference ratings.

26. A computer readable medium containing a program which when executed on a computer causes the computer to perform a method for creating an

impact matrix for use in frequency channel planning in a network service area which is divided into a plurality of pixels, the method comprising:

determining a serving sector for each of the plurality of pixels in the network;

determining weighted interference impact scores for the selected pixel, the weighted interference impact scores based upon each of the non-serving sectors' interference impact upon the pixel's serving sector; and

determining overall impact scores based upon the weighted interference impact scores, wherein the impact matrix characterizes the interference relationship between sectors in the network service area.

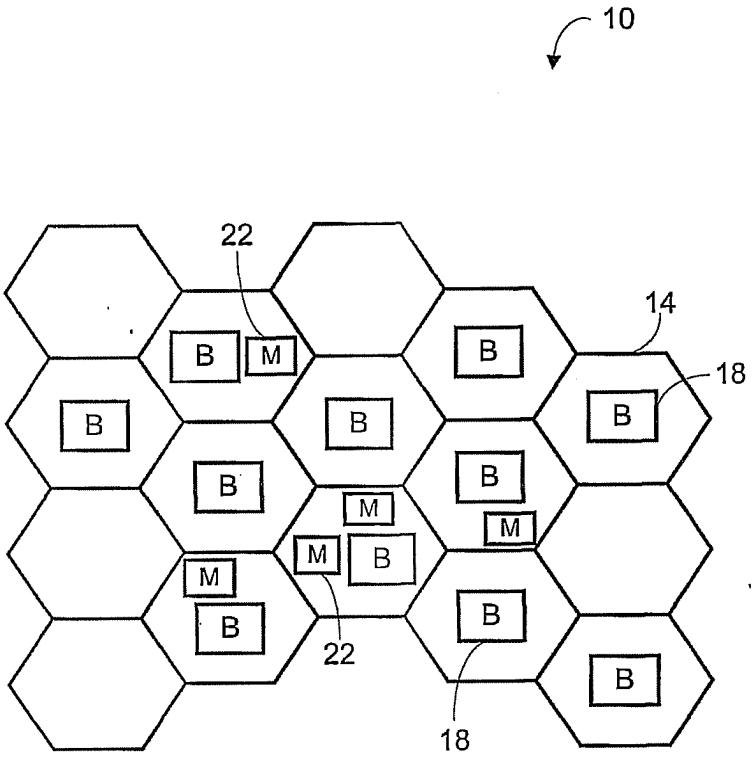


FIG. 1

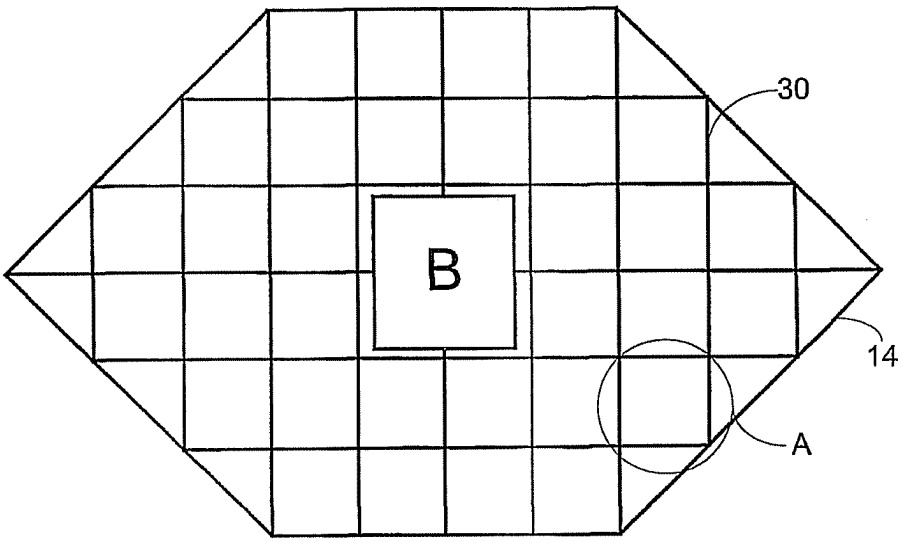


FIG. 2A

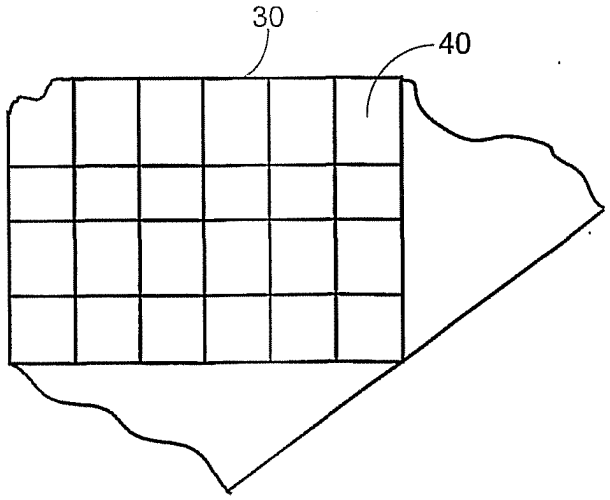


FIG. 2B

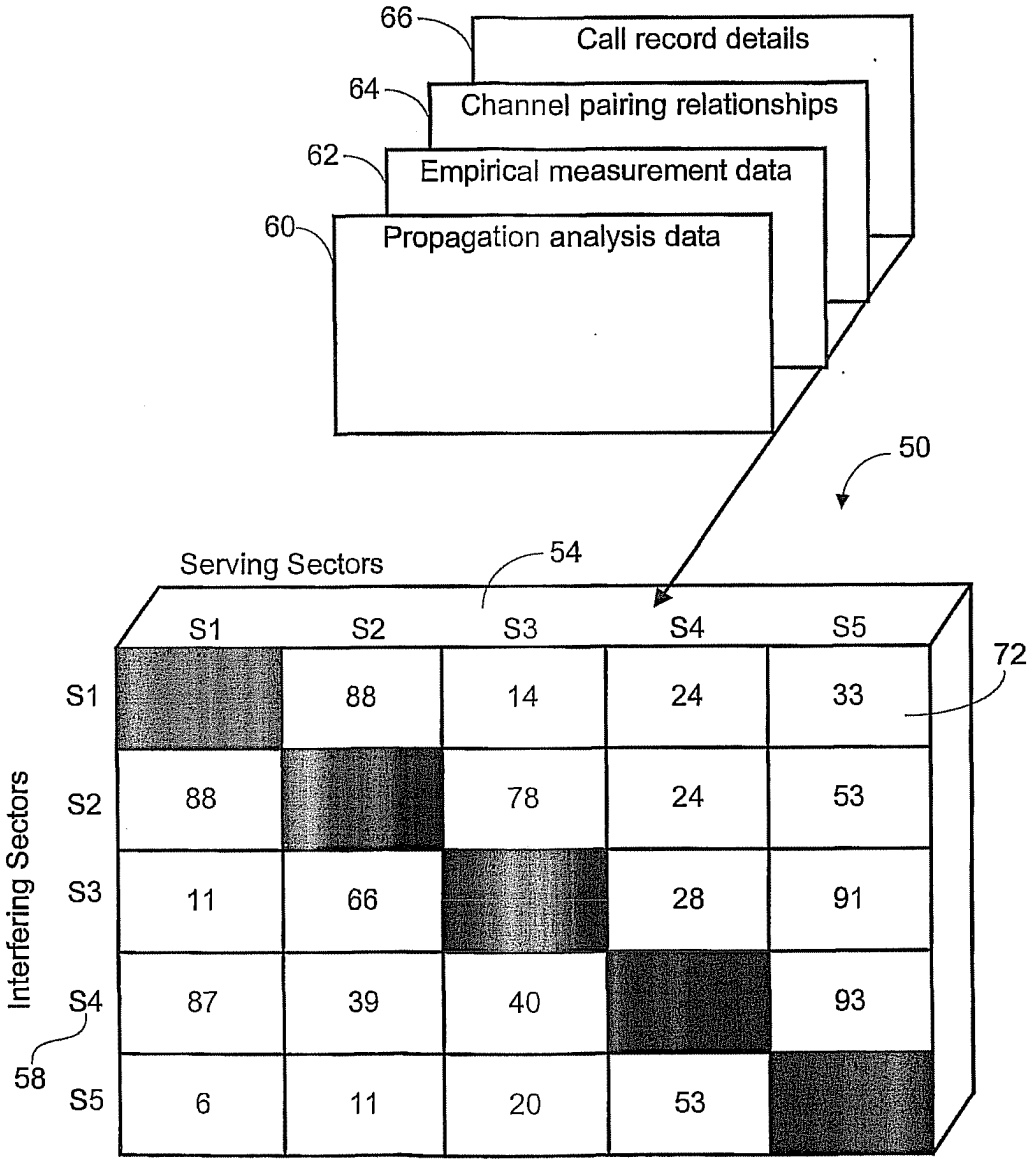

66
Call record details
64
Channel pairing relationships
62
Empirical measurement data
60
Propagation analysis data
50
Serving Sectors
54
S1
S2
S3
S4
S5
72
Interfering Sectors
58
S1 88 14 24 33
S2 88 78 24 53
S3 11 66 28 91
S4 87 39 40 93
S5 6 11 20 53

FIG. 3

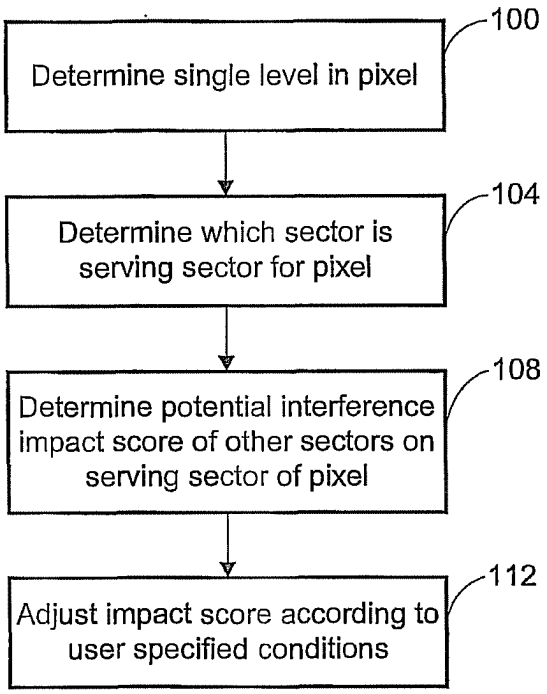

Determine single level in pixel
100
Determine which sector is serving sector for pixel
104
Determine potential interference impact score of other sectors on serving sector of pixel
108
Adjust impact score according to user specified conditions
112

FIG. 4

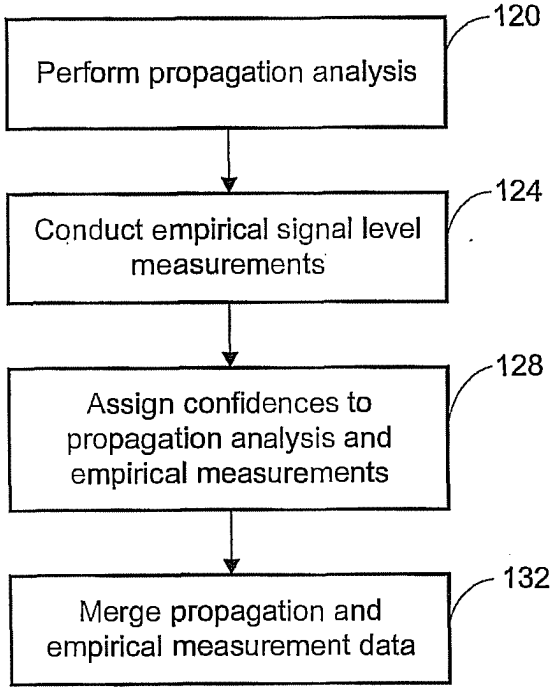

Perform propagation analysis
120
Conduct empirical signal level measurements
124
Assign confidences to propagation analysis and empirical measurements
128
Merge propagation and empirical measurement data
132

FIG. 5

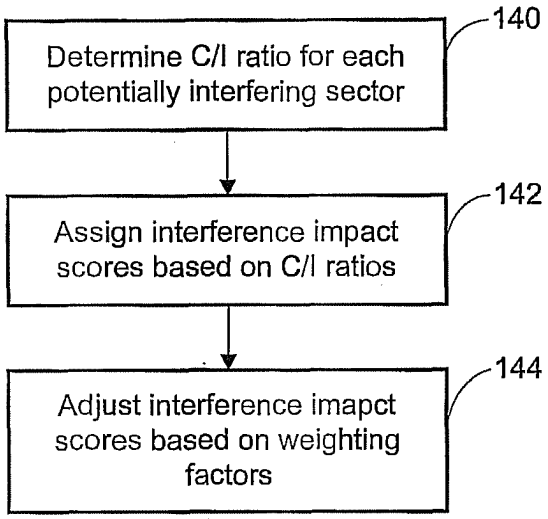

Determine C/I ratio for each potentially interfering sector
140
Assign interference impact scores based on C/I ratios
142
Adjust interference imapct scores based on weighting factors
144

FIG. 6

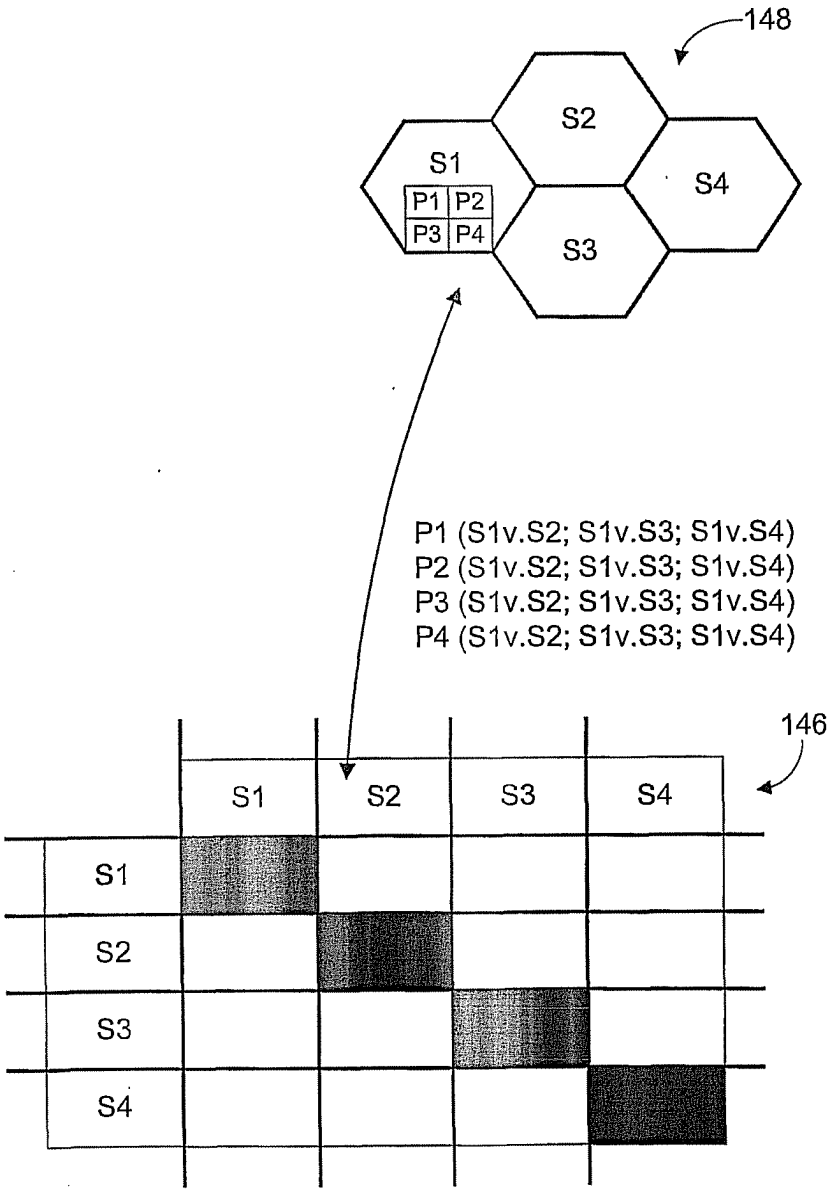

148
S1
S2
S3
S4
P1
P2
P3
P4
P1 (S1v.S2; S1v.S3; S1v.S4)
P2 (S1v.S2; S1v.S3; S1v.S4)
P3 (S1v.S2; S1v.S3; S1v.S4)
P4 (S1v.S2; S1v.S3; S1v.S4)
146
S1
S2
S3
S4
S1
S2
S3
S4

FIG. 7

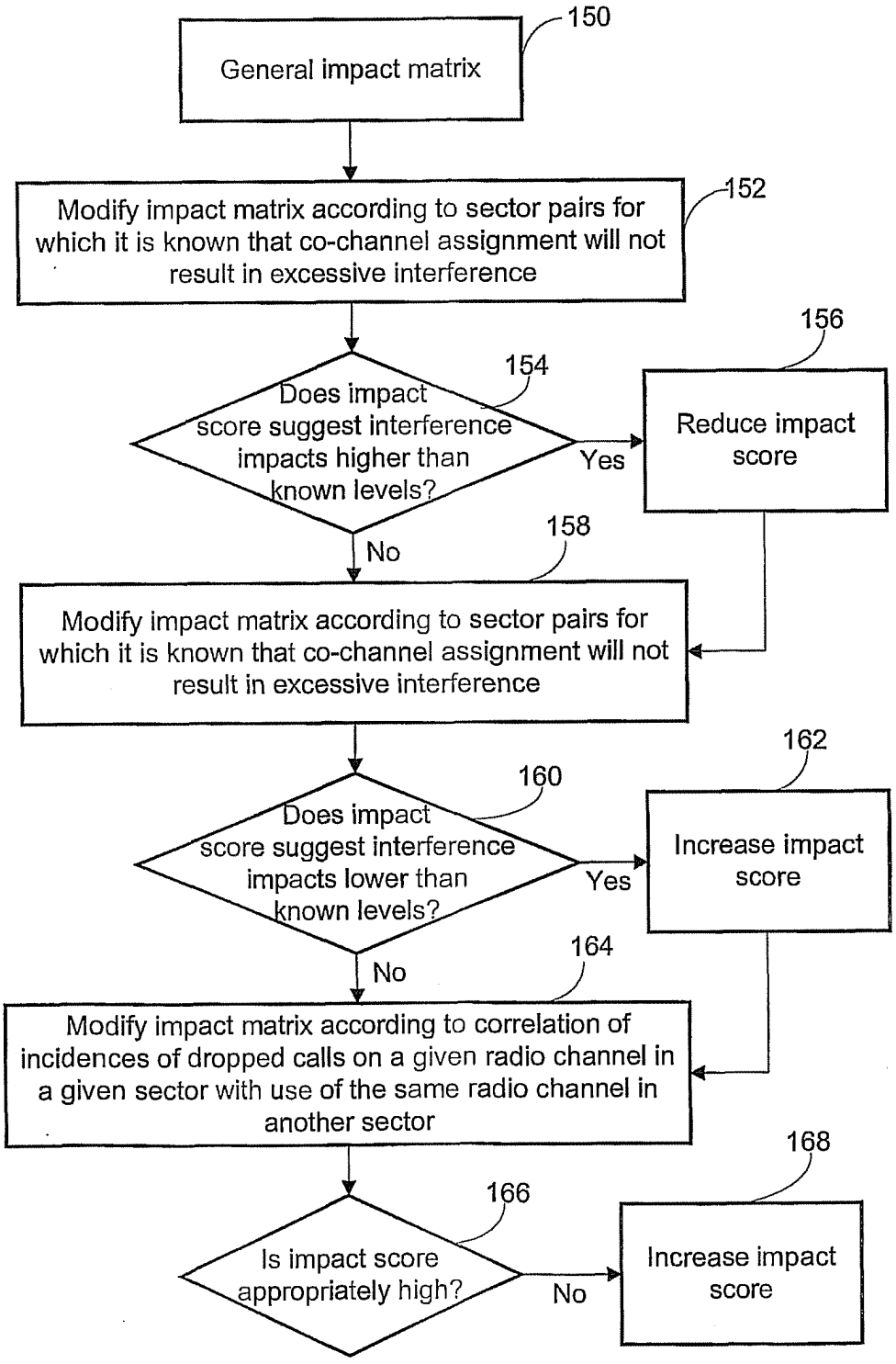

General impact matrix
150
Modify impact matrix according to sector pairs for which it is known that co-channel assignment will not result in excessive interference
152
Does impact score suggest interference impacts higher than known levels?
154
Yes
Reduce impact score
156
No
Modify impact matrix according to sector pairs for which it is known that co-channel assignment will not result in excessive interference
158
Does impact score suggest interference impacts lower than known levels?
160
Yes
Increase impact score
162
No
Modify impact matrix according to correlation of incidences of dropped calls on a given radio channel in a given sector with use of the same radio channel in another sector
164
Is impact score appropriately high?
166
No
Increase impact score
168

FIG. 8

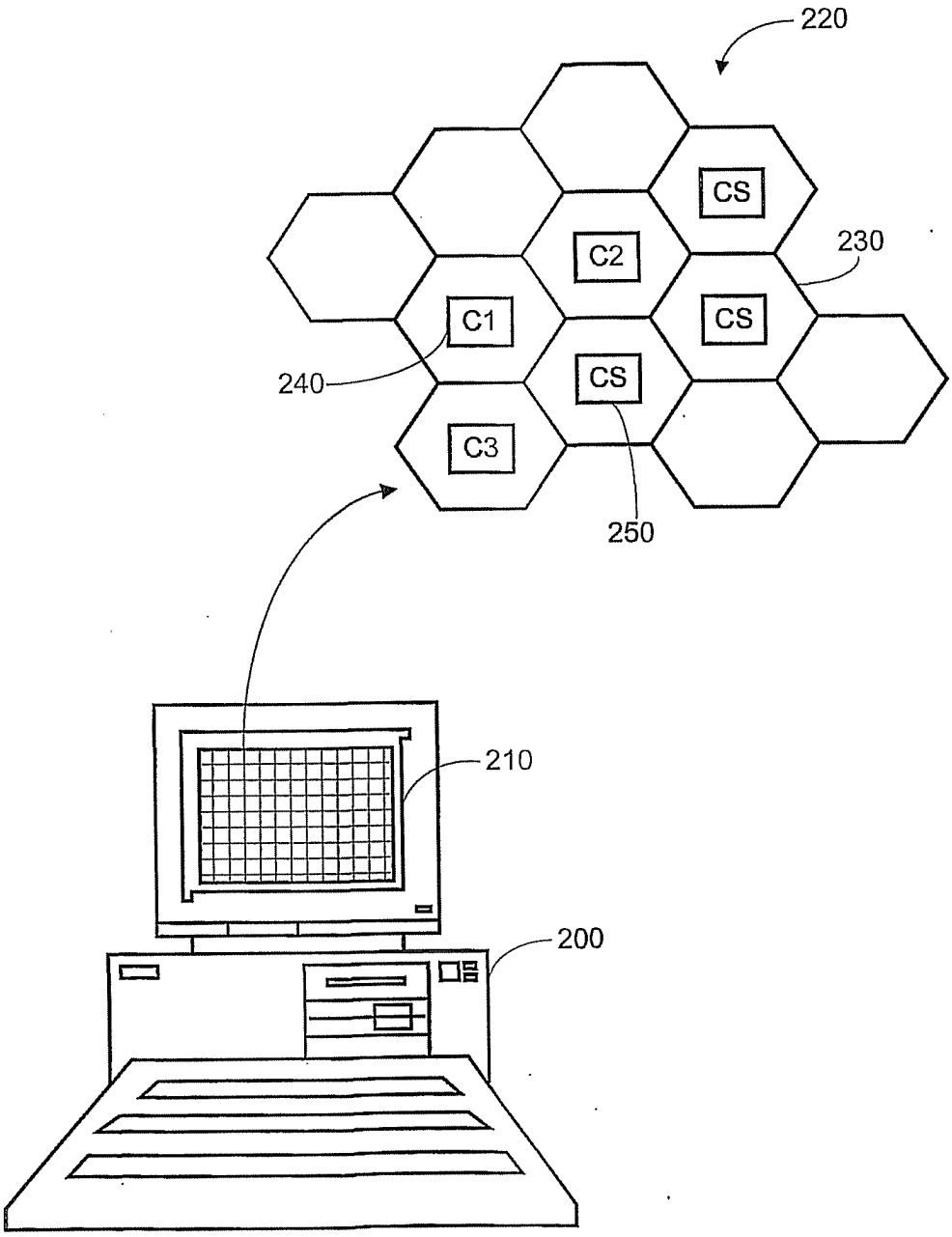


FIG. 9

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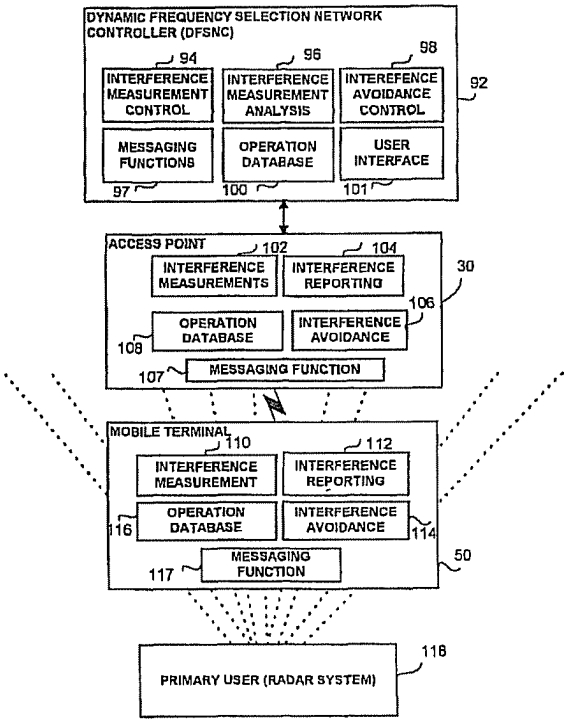
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(54) Title: METHOD AND SYSTEM FOR DETECTION OF AND DYNAMIC ADAPTATION TO RADIO INTERFERENCE IN A SHARED WIRELESS COMMUNICATIONS ENVIRONMENT



(57) Abstract: A method and system for interference detection and for dynamic adaptation and self-adjustment of a wireless communications system in response to the presence of an interfering signal in a communications channel. A controller device communicatively coupled to a network periodically instructs a device implemented in the wireless network to perform interference detection on one or more specified communications channels. The device performs the measurements, and returns the results to the controller. The controller analyzes the results, and determines the state of the measured channels in respect of the presence or the absence of a signal interference. Optionally interference avoidance measures are taken, such as switching the routine data transmission to a vacant communication channel, or utilizing the same channel co-operatively with the interfering signal. The avoidance measures could be implemented on a multi-network level, a single network level, a wireless transmitter level, or a directional sector level.

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METHOD AND SYSTEM FOR DETECTION OF AND DYNAMIC ADAPTATION TO RADIO INTERFERENCE IN A SHARED WIRELESS COMMUNICATIONS ENVIRONMENT

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to wireless communication systems in general, and to the dynamic detection and self-adjustment of the transmission parameters of a wireless local area network in response to prior controlled detection of radio frequency interference produced by diverse users, such as terrestrial radar, sky-borne radar, satellite transmitters, amateur radio service, or the like, sharing the same frequency band, in particular. The present invention further relates to a coexistence mechanism, which enables diverse radio frequency signal transceiving users to operate in parallel on the same frequency band.

DISCUSSION OF THE RELATED ART

The present invention offers a method and system for identifying signal interference phenomena produced by and applied reciprocally to wireless systems operating in a shared signal environment. The method and system is further operative in the prevention of the effects of the mutual interference to the wireless systems.

The regulating bodies dealing with the utilization of the radio frequency spectrum allocated certain frequency bands such that various wireless systems, such as wireless local area networks (WLANs), radar systems, satellite feeder systems, amateur radio services, and the like, may utilize simultaneously a shared range of frequencies. This commonality poses a strong potential for radio frequency interference in the shared communications environment. Interference occurs when a wireless device associated with a wireless data communications network, such as a WLAN, and a device associated with a another system, such as a radar, a satellite feeder, or a amateur radio transmitter, deployed in geographical

proximity or in effective broadcast range attempt to transmit substantially at the same point in time on the same frequency. In order to provide compatibility and ensure harmonic co-existence among the WLANs and the other systems operating in the same frequency band the regulating bodies attempted to mediate potential frequency conflicts by providing different priorities to different systems in the common band. Some systems, such as terrestrial radar, sky-borne radar, satellite feeders, amateur radio services, and the like, were designated as the "primary users" of the common band while other systems, such as WLANs, cellular phone networks, wireless personal area networks (WPANs), and the like, were designated as the "secondary users" of the same frequency band. The primary users were granted priority over the secondary users. It was further determined that the secondary users must not cause unacceptable interference to the primary users, and that the secondary users must accept all interference from the primary users. Thus, it is the responsibility of the secondary user, such as a WLAN, to avoid collision with a primary user, such as a radar system, a satellite transmitter, an amateur radio service, or the like. Consequently, the secondary user, such as a WLAN, must implement appropriate actions, such as detecting of the presence of an active primary user transmitting on a specific frequency within effective broadcast range, and avoiding transmission on the same frequency in order not to interfere with the primary user.

In an ideal world, timely information regarding radar system parameters, such as transmission frequencies, transmitting periods, and the like, would be routinely supplied to the operators of the functional WLANs to enable proper frequency planning of the wireless network. Such planning would provide the WLAN operators the capability of avoiding the use of frequencies associated with radar emissions, satellite broadcasts, amateur radio transmissions, and the like, in order to comply with regulations. In accordance with up-to-date information received about the activities and operational parameters of primary users deployed within effective range of one or more mobile terminals of a secondary user, such as a WLAN, the secondary user could be manually

pre-configured and periodically re-configured in order to refrain from transmitting on the frequencies utilized by the primary user.

In a realistic environment the situation is more complicated. In some countries for reasons of national security the parameters of certain primary users, such as military radar installations are not publicly available. The re-deployment of mobile radar installation for the duration of military exercises, or for periods of national emergency raises further difficulties. Occasionally transmitting, newly installed, or periodically re-configered primary user transmitters pose additional problems. Furthermore, primary users, such as radar systems, may occupy the bandwidth in a pseudo-random manner in respect to the portion of the bandwidth utilized, and to the bandwidth usage pattern. Thus, secondary users, such as WLANs, have to provide their own autonomous interference detection and avoidance means in order to avoid interference with such sensitive "partners" to the shared frequency band.

Currently, secondary users, such as WLANs, employ the "polling" technique for primary user interference detection. For example, at certain pre-defined points in time, such as at the WLAN system start-up, measurements are taken for the purpose of detecting active radar transmitters. The polling method may present difficulties when for various reasons the radar system is temporarily de-activated. For example, the radar transmitter can be shut down for the duration of maintenance activities or can be made periodically inoperative as a routine part of its standard operating procedure. When the points of time allocated by the WLAN for the performance of interference measurements coincide with or are included within the periods of the radar transmitter's inactivity the detection of the interfering transmission is not a viable option. Failure to detect activity could also be caused by the radar system operating in specific operational modes, such as in "sectorized" mode, where the radar scan is performed across a restricted azimuth range, or as in the "sweep" mode, where the radar scan is performed across the complete 360 degrees azimuth range. If the WLAN measurements period coincide with or contained in that segment rotational

periods during which the radar antenna radiation pattern is directed "away" from the measuring device then the transmission will not be detected.

Detection of a primary user transmission by a secondary user is also problematic due to physical issues, such as "interference asymmetry". Typically, primary users, such as radar systems, do not interfere "significantly enough" with secondary users, such as a WLAN, compared with the interference effected to a primary user, such as a radar system, by the transmission of signals from WLAN devices and reception of the signals by the receiver of a radar system. Due to the longer distances covered by the radar signals (the radar signals may travel a path from the radar transmitter to a reflecting target, and back to a WLAN receiver) in respect to the distance covered by the WLAN signals (typically, half the distance of the radar signals as the WLAN signal path includes single route segment between a WLAN transmitter to a radar receiver), and the resulting asymmetry in the respective propagation losses, the primary user is more interfered with by the WLAN than the WLAN is interfered by the primary user. Furthermore the radar system is more sensitive to interference due to differences in the system-specific modulation techniques. Similar interference asymmetry-related problems may also exist in regard to an interference involving a WLAN and other types of primary users, such as satellite transmitters, amateur radio service, or the like, as well.

WLAN devices are capable of detecting the presence of interfering transmitters and taking suitable actions for the avoidance of mutual signal interference by moving to an unused communication channel. The channel switch is accomplished through the utilization of a set of functions typically referred to as the Dynamic Frequency Selection (DFS) or as the Dynamic Channel Selection (DCS). In the text of this document the DFS acronym will be used.

DFS is a vendor-specific mechanism, without established and published standards but the general principles are known. Currently, the DFS function is mainly based on received signal strength (idle channel RSS) measurement taken during WLAN-idle channel conditions. Access Point (AP)

devices utilized as bridges between a wired and a wireless local area network make the measurements themselves or can require the Mobile Terminals (MT) linked thereto to take the measurements. The measurements can be taken on a channel in use or on another frequency. Interfering signals can be detected by measuring the received signal strength at intervals within a specified time slot and comparing the result to a predefined threshold value. If the idle channel RSS is higher than a maximum allowed value then it can be concluded that a strong interference source, such as a radar transmitter operates in the vicinity.

Co-existence is defined as the ability of a system to perform a task in a shared environment where other systems may or may not be using the same set of rules. Multiple wireless devices are said to co-exist if they can be collocated without significantly impacting the performance of these devices. Providing a co-existence mechanism among secondary users, such as WLANs, and primary users, such as radar systems, is important for the better utilization of the radio frequency spectrum, which is a scarce, costly, and therefore a heavily regulated resource. When signals emitted from a periodic radar transmitter associated with a pulse or sweep radar system are detected by the WLAN in respect to a specific communication channel with an allocated specific frequency, the WLAN takes suitable interference countermeasures such as moving to a vacant channel within its own allocated frequency band. The technique has a drawback such that it is substantially wasteful in terms of the useable bandwidth and in terms of WLAN-performance efficiency. It would be preferable for the WLAN to keep using the channel interfered with and co-exist with the interfering signal.

It would be readily perceived that there is an urgent need for a method and system for the detection of diverse primary users, such as non-pre-configured radar systems by secondary users, such as WLAN's, in a signal environment shared by both systems. There is also a clear and present need for a method and system to provide an improved utilization of the bandwidth available to a wireless communications system by providing a mechanism that enables co-existence of a primary user, such as a radar system, satellite system, amateur radio service, and

the like, and a secondary user, such as a WLAN, where both systems operate on a shared frequency band.

SUMMARY OF THE PRESENT INVENTION

One aspect of the present invention regards a wireless communications environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on an allocated frequency band, at least one primary user transmitting and receiving a radio frequency signal on a substantially alike allocated frequency band, and a method for the detecting and avoiding reciprocal signal interference produced by the radiation of the radio frequency signals emitted by the at least one primary user and by the at least one secondary user. The method includes establishing and dynamically maintaining interference detection and avoidance control and operation information in the at least one secondary user, dynamically and controllably measuring at least one communication channel providing a communication path between at least two wireless devices of the at least one secondary user, analyzing the results of measurements performed on the at least one communications channel in order to determine the interference status of the measured at least one communications channel of the at least one secondary user, dynamically maintaining interference detection and avoidance information in the at least one secondary user, and selectively and controllably performing interference avoidance procedures by the at least one secondary user to prevent reciprocal signal interference in the at least one secondary user and in the at least one primary user.

A second aspect of the present invention regards a communication environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on an allocated frequency band via a wireless or wired link, at least one primary user transmitting and receiving a radio frequency signal on a substantially same allocated frequency band via an unbounded medium, and a system for the dynamic detection of reciprocal signal

interference produced substantially simultaneously by the at least one secondary user and at least one primary user. The system contains at least one primary user interference detection and avoidance controller device, and at least one primary user interference detection and avoidance wireless device.

A third aspect of the present invention regards a wireless communications environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on a allocated frequency band via an air interface, at least one primary user transmitting and receiving a radio frequency signal on a substantially alike allocated frequency band via an air interface, and a method of detecting and avoiding signal interference effected to the at least one primary user by the transmission of the signal emitted by the at least one secondary user. The method includes the steps of dynamically and controllably measuring at least one communications channel utilized the at least one primary user, analyzing the results of the channel measurements performed on the at least one communications channel utilized by the at least one primary user in order to determine the interference status of the measured channel, communicating the results of the analysis to the at least one secondary user interference detection and avoidance controller device, dynamically maintaining interference detection and avoidance information concerning the identity, attributes, locations, directionality, and activity of at least one wireless device associated with at least one secondary user interfering with the at least one measured communications channel associated with the at least one primary user, and selectively and controllably performing interference avoidance measures by the at least one secondary user interference detection and avoidance controller device to prevent signal interference in the at least one communications channel associated with the at least one primary user.

A fourth aspect of the present invention regards a communication environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on allocated frequency band via a wireless or wired link, at least one primary user transmitting and receiving a radio frequency

signal on a substantially same allocated frequency band via an unbounded medium, and a system for the dynamic detection of reciprocal signal interference produced substantially simultaneously by the at least one secondary user and at least one primary user. The system consists of at least one primary user interference detection and avoidance controller device to communicate with and control at least one secondary user activity detection wireless device, and at least one secondary user activity detection wireless device to perform measurements on at least one communication channel utilized by the primary user in order to detect interference produced by the activity of at least one secondary user.

All the above aspects of the present invention provide for the dynamic and controlled detection of a radio frequency signal interference in a secondary user operating in a wireless signal environment.

All the above aspects of the present invention provide for the dynamic and controlled detection of a radio frequency signal interference in a primary user operating in a wireless signal environment.

All the above aspects of the present invention provide for the dynamically and adaptively adjust the transmission parameters of a secondary user operating in a shared signal environment.

All the above aspects of the present invention provide for preventing reciprocal signal interference in a secondary user and in a primary user by utilizing alternative interference avoidance schemes.

All the above aspects of the present invention enable co-existence of an active secondary user and an active primary user on a substantially same communications channel.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

Fig. 1 is a schematic block diagram of a wireless communications environment as known in the art; and

Fig. 2 is a block diagram of an HiperLAN/2 protocol architecture as implemented in a mobile terminal associated with a wireless communications network as known in the art; and

Fig. 3 illustrates the basic Medium Access Control (MAC) frame structure associated with the HiperLAN/2 protocol architecture as known in the art; and

Fig. 4 is a schematic block diagram illustrating an exemplary configuration of the proposed system, in accordance with the preferred embodiment of the present invention; and

Fig. 4A is a schematic block diagram illustrating an exemplary alternative configuration of the proposed system, in accordance with the preferred embodiment of the present invention; and

Fig. 5 is block diagram illustrates an exemplary configuration including a detailed view of the operative components associated with the proposed system, in accordance with the preferred embodiment of the present invention; and

Fig. 6 is a schematic block diagram showing the various tables constituting an exemplary operation database, in accordance with a preferred embodiment of the present invention; and

Fig. 7 is a flow chart depicting an exemplary set of operational steps involved in the performance of interference detection in the DFSNC control mode, in accordance with the first preferred embodiment of the present invention; and

Fig. 8 is a flow chart showing an exemplary set of operations involved in the performance of the interference detection in the wireless device control mode, in accordance with a second preferred embodiment of the present invention; and

Fig. 9 is a flow chart depicting an exemplary set of operational steps involved in the performance of he interference detection in the pattern recognition based interference detection mode, in accordance with a third preferred embodiment of the present invention; and

Fig. 10 is a flow chart depicting an exemplary set of operational steps involved in the performance of the interference detection in the co-existence mode, in accordance with a fourth preferred embodiment of the present invention; and

Fig. 11 is a graphical representation of an exemplary signals collision in a specific WLAN channel and an exemplary frequency re-assignment based solution to the conflict, in accordance to the first, second, and third embodiment of the present invention; and

Fig. 12 is a graphical representation of an exemplary signal collision in a specific WLAN channel and of the exemplary co-existence option based solution to the conflict, in accordance with the fourth embodiment of the present invention; and

Fig. 13 is an block diagram illustrating the operation of an exemplary sectorized detector Access Point device, in accordance with the fifth preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A method and system for remote interference detection and for dynamic adaptation of the operation of a wireless communications network in response to the state of the communications channels thereof affected by the presence of interfering signals in the channels is disclosed. A wireless communications network operating in a shared frequency band dynamically detects interference caused by a primary user, such as a radar system, by controllably taking measurements of one or more communication channels.

The method and system of the present invention are disclosed through the detailed description of several preferred embodiments. The embodiments can be implemented separately or in any functional combination appropriate to the implementation of the proposed system. In the first preferred embodiment of the present invention, the system operates in a specific operational mode, referred to as the DFSNC control mode. A controller device communicatively coupled to the wireless network and having an operation database established therein, periodically submits requests associated with a set of functional parameters held in the operation database to an access point and/or a mobile terminal communicatively linked to the same wireless network in order to perform communications channel measurements. The purpose of the measurements is the detection of the activity of a primary user operating in the same signal environment. The access point and/or the mobile terminal collects the requested channel measurement results produced according to the set of the functional parameters transmitted by the controller device and returns the measurement values obtained to the controller device. The controller device analyses the results of the channel measurement values received from the access point and/or mobile terminal, and in accordance with the products of the analysis and of a predetermined set of rules and data, determines the presence and optionally the power level of an interfering signal generated by the activity of a primary user on the measured communication channel. If a primary user-related interfering signal is detected then, in accordance with the current signal measurement results, the

prior signal measurement results, and a predefined set of data in rules in the operation database, the controller device could instruct the access point and/or mobile terminal to take suitable interference avoidance measures, such as moving to a vacant communication channel within the allocated frequency range, lowering the transmission power, or activating a specific co-existence mechanism. Additionally the controller device updates the operation database with essential information concerning the values of the channel measurements and the products of the analysis process. Subsequently the controller device alerts the network controller and/or the network operators. The controller device may further utilize the results of the analysis as a trigger to issue a set of instructions to other wireless networks, which are known to operate in the environment and are known to utilize the channel being interfered with.

The second preferred embodiment of the present invention the system operates in a specific operational mode referred to as the wireless device control mode. The controller device according to instructions of a network operator downloads a set of parameters functional to the performance of the primary user-related interference detection scheme to an access point and/or a mobile terminal. The downloaded parameters are stored within an operation database established in the access point and/or the mobile terminal. The periodic execution of the interference detection process is performed by the access point and/or the mobile terminal independently of the controller device, and according to the parameter values received from the controller device. The analysis of the channel measurement values, the determination regarding the presence and optionally the power level of an interfering signal generated by a primary user on the measured communications channel, and the necessary actions to be taken, such as channel re-assignments, transmission power adjustments, or co-existence handling, are executed by the access point and/or the mobile terminal and/or the controller device. The access point and/or the mobile terminal update the operation database established therein and optionally upload the essential update information to the controller device.

The third preferred embodiment of the present invention the system operates in a specific operational mode referred to as the pattern-recognition-based interference detection mode. A predefined interference pattern table and a channel parameter table is established on the access point and/or the mobile terminal deployed within the wireless network. In the course of the routine data exchange operations the access point and/or the mobile terminal collects changes sequentially occurring in the standard channel parameters, such as bit error rates, frame error rates, or the like. Additional changes to be collected can be physical layer parameters, such as symbol error rate, mean distance of correlation, mean error of the frequency/phase/amplitude modulation, and the like. The changes in the channel parameters are obtained continuously during any routine data exchanges, such as between the access point and the mobile terminal, or as between different mobile terminals. The changes are recorded in the channel parameter changes table. Then the changes are selectively analyzed in order to detect certain meaningful patterns. When the certain meaningful patterns are detected the access point and/or the mobile terminal and/or the controller device could initiate appropriate interference avoidance techniques, such as moving to a vacant channel within the allocated frequency range, adjusting the transmission power, or activating the co-existence mechanism. Additionally the access point and/or the mobile terminal update the local operation database, optionally upload essential information to the remote network controller concerning the results of the pattern-recognition-based interference detection scheme, and suitably notify the controller device regarding the consequent actions taken. In the third preferred embodiment of the present invention, interference detection is performed by the access point and/or the mobile terminal as an integral part of the normal operation of the wireless device.

In the fourth preferred embodiment of the present invention the system operates in a specific operational mode, referred to as the Detector Device mode. A detector device is a wireless platform co-located with a known primary user, such as a radar system, at the known primary user site, such as a radar

installation. The detector device is coupled to the controller of a wireless communications network via a wireless or a wired link. The detector device is used to detect wireless activity that could interfere with the operation of the primary user. The detector device could further be programmed to collect and store the vital transmission parameters of the primary user, such as the transmission channel, the transmission periods, transmission/reception coverage areas, and the like. This information could be also provided to the detector device by the network operator via a suitable user interface. The detector device is operative in scanning the transmission channel that is known to be used by the primary user for the purpose of detecting wireless communications network transmissions on the same channel such that the transmission could have a significant impact on the performance of the primary user. Subsequent to the detection of such activity the detector device alerts the controller device of the transmitting wireless network. The alert may further include significant control information, such as the network identification, access point identification, transmitting device identification, the periods of the transmission, and the like. The information may also include the transmission parameters of the primary user. In accordance with the received alert and the attached information the wireless network controller identifies the transmitting individual device and may instruct the device to take appropriate interference avoidance measures, such as switching channels, cease transmitting, or suitably adjusting the power level of the transmission.

The detector device could be sectorized. When sectorized the detector device could collect, collate and communicate information having a directional dimension. The information communicated could be based on a RF topology mapping of the signal environment including the location and the permanent or temporary directionality of a primary user and the location of the sectorized or non-sectorized WLAN devices with their existing sectors and sectors' directions. The map could be created manually by a network operator and/or by appropriate interference detection-driven modules implemented on the detector device. The

additional directional information could enable the detector device to control the interference avoidance measures taken by the WLAN devices on a sector level. Thus, a sectorized WLAN device could be instructed to take suitable interference avoidance measures, such as "going silent" on one or more of its sectors, lowering power levels on one or more of its sectors while keep transmitting normally on the rest of its sectors.

Subsequent to the detection of a primary user-related interference alternative interference avoidance schemes can be performed. The interference avoidance measures include but are not limited to channel re-assignment, transmission power adjustment, and the activation of a co-existence mechanism. Alternative interference detection modes can be used in various combinations with the proposed interference avoidance measures. Channel switching and the adjustment of the signal power levels are known techniques. The co-existence mechanism involves the establishment of an interfering signal periodicity table, and a time window table on the access point and/or the mobile terminal and/or the controller device deployed within the wireless network. The tables could be built and maintained by a network operator according to known information concerning the activities of a known primary user in the environment. The tables could also be created and maintained automatically by the access point and/or the mobile terminal and/or the controller device through the utilization of an interference detection scheme. The tables are examined by the access point and/or the mobile terminal and/or the controller in respect to the temporal regularity of the interfering signal in order to determine the interfering signal transmission periods. If periodicity of the interfering signal is established then the co-existence mechanism may be activated. A time window control table is set up on the access point and/or the mobile terminal and/or the controller device. The time window control table is operative in providing time slots specific to the transmission periods of the interfering signal. In these established primary user-specific time slots the entire wireless network i.e., the access points and the mobile terminals thereof, is instructed not to transmit or to lower the transmission power level in

order not to interfere with the primary user's signal. Consequently, the access point and/or the mobile terminal may keep operating on the same channel. By providing the channel periodic silent periods or reduced level of transmission the wireless network avoids interference with the established primary user's signal and thereby achieves co-existence with the primary user.

In the preferred embodiments of the present invention the secondary user is a wireless communication network, and more specifically a wireless local area network (WLAN). The primary user of the shared communications band is a radar system. It would be clear to one with ordinary skills in the art that in other preferred embodiments of the present invention diverse other wireless communications network could be used such as cellular telephone systems, wireless personal area networks, and the like. The primary user of the shared frequency band could be any other transmitting source designated as the system having priority in the utilization of the allocated frequency band, such as Industrial, Scientific, and Medical (ISM) devices, amateur radio services, terrestrial or sky-borne radar systems, satellite feeders, or the like. In the preferred embodiment of the present invention the mobile terminal referred to is a laptop computer, such as a ThinkPad 360 of IBM, a 4000 CT of HP, or the like. The mobile terminal could also be a stand-alone wireless station such as a modem card, or the like. In other preferred embodiments of the invention diverse other devices could be used such as cellular phones, Personal Digital Assistants (PDAs), and the like. The following description is provided to enable a ready understanding of the operations and the functional structure of the system proposed by the present invention and not meant to be limiting such as to exclude diverse other uses that could be contemplated, developed, and based on the underlying concept of the present invention. The scope of the invention is to be limited only by the attached claims.

According to the practices of persons skilled in the art of computer programming, the present invention is described below with reference to actions and symbolic representations of operations that are performed by the processing

computer system. It will be readily understood by one skilled in the art that the actions and the symbolically represented operations include the manipulation of electric signals by a central processing unit (CPU). The electrical signals represent data bits which effect a resulting transformation or reduction of the electrical signal representation, and the maintenance of data bits at memory locations in the memory system to thereby reconfigure or otherwise alter he CPU's operation, as well as other processing of signals. The memory locations are physical locations that have particular electrical, magnetic, or optical, properties corresponding to the data bits. The interference detection and avoidance method includes sets of computer programs implemented on different computing and communicating platforms and consisting of computer software instructions specifically developed for the practice of the present invention. The software installed in the network controller, in the access points, and the mobile terminals causes the controller, the access points, and the mobile terminals respectively to perform the various functions described herein. In the preferred embodiments of the present invention dedicated electronic hardware is made and used to perform all functionality described herein. The interference detection and avoidance method is implemented as firmware by the embedding of the predetermined program instructions and/or appropriate control information and associated data within suitable electronic hardware devices containing application-specific integrated circuits (ASIC).

Referring now to Fig. 1 that illustrates a communications environment in which the preferred embodiments of the present invention can operate. Fig. 1 is illustrative only and it is not the only communications environment in which the various preferred embodiments of the present invention can operate. The environment contains a wired network 10, a wireless network 20, a wireless network 21, a wireless network 23, and a primary user, such as a radar system 62. Wired network 10 is coupled to wireless network 20 via standard communication lines 22, 24, 26, and via link 27. Specific activities of the wireless network 21 and

the wireless network 23 can be controlled by the communication of information from wireless network 20. Therefore, the network 21 and the network 23 are communicatively linked to the wireless network 20 via a link 25', and a link 25'' respectively. Although in the drawing only two wireless networks are shown it would be easily understood that in a realistically configured environment several wireless networks could be coupled to the network 20. Wired network 10 is a Local Area Computer Network (LAN) that includes various computing and communicating devices such as a network manager 14, a network printer 16, and a network terminal 18 linked by fixed communication lines such as one or more coaxial cables, twisted pair, fiber optics, and any other media to support wired communications. In another preferred embodiments a wireless communication network can replace the wired network 10. In yet other embodiments wired network 10 can be a Wide Area Network (WAN). Although in the drawing only three wired network devices are shown it would be easily understood that in a realistically configured wired network a plurality of devices could operate. Network manager 14 includes a computing platform such as a Personal Computer (PC), a Sun workstation, a MacIntosh computer, or a specialized network management device. The network manager 14 includes a memory for storing information and a process for accessing and processing the information. Wired network 10 is linked to Access Points (AP) 28, 30, 32 via respective communication lines 22, 24, 26. AP devices 28, 30, 32 include a computing and communication platform. The function of the Access Points is to bridge traffic from the wired network infrastructure 10 to the mobile terminals. Lines 22, 24, 26 include one or more coaxial cables, twisted pair, fiber optics or any other media to support wired communication. Each AP includes a transceiver (not shown) to support wireless communication and a Dynamic Frequency Selection component (DFS) 34, 36, and 38 to support interference detection and avoidance. The network 10 is communicatively connected to a wireless access point (AP) 31 via a link 27. The AP 31 includes a transceiver (not shown) to support wireless communication and a DFS 33 to support interference detection and avoidance.

The AP 28, 30, 31, 32 are communicatively linked to one or more mobile terminals (MT) 40, 42, 44, 46, 50 via links. Each MT includes a transceiver (not shown) supporting wireless communication and a DFS to support interference detection and avoidance. The AP 28, 30, 31, 32 are controlled by a network manager device 14 and communicate with the MT 40, 42, 44, 46, 50 through radio frequency signals transmitted by their respective transceivers. The primary user of the designated frequency band, such as the radar system 62, functions in the communications environment through the transmission of a continuous or a periodic radio frequency signal typically in the microwave band of the spectrum. It is undesirable that the signals emitted by the radar system 62 received by the wireless networks 20, 21, and 23, as the radar signal will interfere with the WLAN signals. Nevertheless if one or more wireless devices deployed within the wireless networks 20, 21, 23 are in the operational range of the radar system's 62 transmitter the wireless devices may receive the radar signal. The unintended reception of the radar signal will effect interference with the radio frequency signals communicated between the AP devices 28, 30, 31, 32 and the MT devices 40, 42, 44, 46, 50. Similarly the radio frequency signals communicated by the transmitting devices of the WLAN 20, 21, 23 could interfere with the reflected radar signal received by the radar system 62. Such interference could degrade the quality of the communication within the WLAN 20, 21, 23 and could jam the signals transmitted by the radar system 62 and thus cause it to malfunction. Note should be taken that networks 20, 21, and 23 could be deployed in different distances and different directions from the radar system 62. Thus, the strength and the directionality of the signals effecting mutual interference between each of the networks 20, 21, 23 and the radar system 62 could be varied. Note should be also taken that the function of the DFS components 34, 36, 38, 33, 52, 54, 56, 58, 60 is to attempt to minimize the effects of interference between the various inter-network devices, and between devices of different wireless network devices, such as Bluetooth devices, cellular devices, and the like.

In the preferred embodiments of the present invention, the WLAN 20 of Fig. 1 is a HiperLAN/2-type wireless network. HiperLAN/2 is a broadband radio transmission technology operating in the 5 GHz frequency band. Currently frequencies are allocated for HiperLAN networks within in the 5.15-5.825 GHz band depending on geographical area in which the network is implemented. In other embodiments of the present invention alternative technologies could be used such as 802.11a, 802.11h, HiperLAN, OpenAir, HomeRF, HiSWAN (Japan), or the like. The features of the HiperLAN/2 standard are known. In order to enable ready understanding of the method and system suggested by the present invention, a brief and simplified description will be provided concerning the protocol architecture of the HiperLAN/2 radio interface as implemented for a mobile terminal associated with the WLAN 20 of Fig. 1, and the Medium Access Control (MAC) frame structure. The description will deal with those parts of the protocol and the MAC frame that are relevant to the method and system proposed by the present invention.

Referring now to Fig. 2 illustrating the implementation of the HiperLAN/2 protocol stack in a mobile terminal (MT) 81. Using OSI 7 layers model as the reference model, the MT device 81 operates within a WLAN and is communicatively linked to a wired LAN via one or more Access Points (AP) that bridge the WLAN with a wired LAN. The MT 81 includes a Physical Layer (PHY) 90, and a Data Link Control Layer (DLC) 82. The MT 81 could also include transport channels 89, and Convergence Layer (CL) 83. The sub-layer functions as detailed below are of the HiperLAN/2 protocol. In other protocols certain functions may or may not exist, other functions could be added or removed, and the division of the sub-functionality may differ. The PHY 90 supports the electrical or mechanical interface to the physical medium. For example, this layer determines how to put a stream of bits from the DLC layer 82 on to a radio carrier. The physical layer is usually a combination of software and hardware programming and may include electromechanical devices. The functions

of the CL 83 is adapting service requests from the higher protocol layers to the service offered by the DLC 82, and to convert the higher level data packets into a fixed size that is used within the DLC 82. The DLC 82 constitutes the logical link between an Access Point (AP) and the mobile terminal (MT) 81. The DLC 82 assures that an initial connection has been set up, divides output data into data frames, and handles the acknowledgements from a receiver that the data arrived successfully. It also ensures that incoming data has been received successfully by analyzing bit patterns at special places in the frames. The DLC 82 includes functions for medium access and transmission as well as terminal and connection handling. Thus the DLC 82 layer consists of a set of sub-layers: a Medium Access Control (MAC) protocol 88, an Error Control (EC) protocol 86, and a Radio Link Control (RLC) protocol 84. The MAC protocol 88 is used for access to the radio link with the resulting transmission of data onto that medium. EC protocol 86 is used to increase reliability over the radio link by detecting bit errors and re-transmitting the data if such errors are detected. EC 86 also ensures that the data units are delivered in-sequence to the CL 83. RLC 84 gives a transport service to the signaling entities such as Association Control Function (ACF) 95, Radio Resource Control function (RRC) 92, and the Connection Control Function (CCF) 96. RLC 84, ACF 95, RRC 94 and CCF 96 provide for the exchange of signaling messages between an Access Point (AP) and the MT 81. RRC 92 is a group of control functions on the top of the RLC 84 that is responsible for the handling of the radio resources. RRC 92 includes a Dynamic Frequency Selection (DFS) function 94 to provide for the performance of measurements on radio signals received from neighboring mobile terminals as well as to instruct the MT 81 to perform measurements when needed. Subsequently the DFS 94 automatically allocates vacant frequencies to each AP for communication, allows several operators to share the available frequency spectrum, and can be used to avoid the use of interfered frequencies. Note should be taken that the DFS 94 sub-function need not necessarily be part of the RRC 94. RRC 94 could be an independent function or could be embedded within a different sub-functionality.

The air interface in HiperLAN/2 is based on time-division duplex (TTD) and dynamic time-division multiple access (TDMA) methods. The time-slotted structure of the medium allows for simultaneous communications in both downlink and uplink within the same time frame called MAC frame. Time slots for downlink and uplink communication are allocated dynamically depending on the need for transmission resources. The basic MAC frame on the air interface has a fixed duration of 2 ms and comprises transport channels for broadcast control, frame control, access control, downlink (DL) and uplink (UL) data transmission and random access. The MAC frame and the transport channels form the interface between DLC 82 and the PHY 90.

Referring now to Fig. 3 illustrating the basic MAC frame structure. MAC frames 200, 201, 202 each comprise broadcast channel (BCH) 203, frame control channel (FCH) 204, access feedback channel (ACH) 205, DL phase 205, and a UL phase 206, and random access channel 207. The BCH 203 contains control information sent in every MAC frame and reaches all the MTs, such as transmission power levels, AP identifiers, network identifiers, and the like. The FCH 204 contains a description of the resources allocated within the current MAC frame. The ACH 205 conveys information on previous access attempts made in the RCH. Downlink and uplink traffic (DL 206 and UL 207) consist of Protocol Data Unit (PDU) trains to and from the MTs. The RCH 208 is used by the MTs to request transmission resources for the DL phase 206 and the UL phase 207 in the upcoming MAC frames and convey the RLC 84 signaling messages.

Fig. 4 illustrates the components constituting the proposed system and functional to the operation of the proposed method of the present invention. The illustrated configuration is exemplary only and in order to accomplish the objectives of the proposed method and system various other configurations could be used. The method involves the exchange of a plurality of downloaded and uploaded messages between the mobile terminals of the WLAN and a remote

interference detection controller. In addition to the standard data exchange packets the messages include but are not limited to instructions with associated parameters, notifications, requests, replies, reports, measurement parameters such as threshold values, measurement results, range of blocked channels, range of channels to operate with, neighboring channels allocated, operation instructions, and the like. The operation instructions include but are not limited to ceasing transmission in one or more specific sectors, to provide re-adjusting the transmission power of other specific sectors, to increase permanently or temporarily the time allocation to specific sectors, and the like. The WLAN 20 is communicatively coupled to a wireless network 21 and a wireless network 23 via the links 25 and 27 respectively. The WLAN 20 is operative in communicating interference detection information to networks 21, and 23 in order to enable networks 21, 23 to take appropriate interference avoidance measures. Networks 21, and 23 could also communicate relevant information to network 20. The WLAN 20 includes a remote Dynamic Frequency Selection Network Controller (DFSNC) 92, an AP 30 and a MT 44. The DFSNC 92 could be co-located with the AP 30, or with an another AP (not shown) deployed within the network and thus is remote to the set of APs deployed within the network The DFSNC 92 could be also a stand-alone device. The DFSNC 92 includes a computing and communication platform such as a PC and is connected to the AP 30 via a link 24. The DFSNC 92 could include a transceiver (not shown) to support wireless communication. The function of the DFSNC 92 is to control remotely interference detection and avoidance by communicating with the AP 30 and the MT 44. The AP 30 is coupled to the MT 44 via a link 101. Although only one DFSNC, one AP and one MT are shown on the drawing discussed it is understood that a realistically configured network could contain more than one DFSNC and more than one AP devices coupled communicatively to one more MT devices. The AP 30 includes a transceiver (not shown) to support wireless communication and a set of DFS functions 36 to support interference detection and avoidance. The MT 44 includes a transceiver (not shown) to support wireless communication and a

set of DFS functions 56 to support interference detection and avoidance. Periodically, according to pre-defined operational parameters introduced by a WLAN operator, the DFSNC 92 sends suitable instructions via the link 24 to AP 30 and to MT 44 to initiate interference detection. The instruction includes parameters operative in defining the type of detection to be performed, the measurements to be collected, the channel to be measured, the sub-set of potentially usable channels, and the like. Consequently the AP 30 and/or the MT 44 perform the required measurements by utilizing the set of DFS functions 36 and the set of DFS functions 56 respectively. The AP 30 could perform the measurements itself or could instruct the MT 44 to via the link 101 to perform the same. The results of the detection process are returned by the MT 44 and/or by the AP 30 to the DFSNC 92 for analysis. The DFSNC 92 performs the analysis on the results received. The products of the analysis provide information concerning the presence, the absence, and the power level of an interfering signal on a specifically measured channel. When a primary user-generated interference is identified by the DFSNC 92 an instruction is sent from the DFSNC 92 via the link 24 to the AP 30 and/or to the MT 44 regarding the activation of the set of the DFS functions 36 and the set of DFS functions 56 respectively in order to take appropriate interference avoidance measures, such as moving to another channel within the allocated frequency band of the WLAN 20.

Fig. 4A illustrates alternative configuration of the proposed system that is functional to the operation of the proposed method of the present invention. The illustrated configuration is exemplary only and in order to accomplish the objectives of the proposed method and system various other configurations could be used. The WLAN 20 is communicatively coupled to the wireless networks 21 and 23 via links 25, and 27 respectively. The WLAN 20 is operative in communicating interference detection alerts and associated information to networks 21, 23. Similarly, networks 21 and 23 communicate relevant information, such as topology data, identified primary users, and the like, back to

WLAN 20. The WLAN 20 includes a remote Dynamic Frequency Selection Network Controller (DFSNC) 92, and a MT 44. The DFSNC 92 includes a computing and communication platform such as a PC and is connected to the MT 44 via a link 24. The DFSNC 92 may include a transceiver (not shown) to support wireless communication. The function of the DFSNC 92 is to control remotely interference detection and avoidance by communicating with the MT 44. Although only one DFSNC and one MT are shown on the drawing discussed it is understood that a realistically configured network could contain more than one DFSNC coupled communicatively to one or more MT devices. The MT 44 includes a transceiver (not shown) to support wireless communication and a set of DFS functions 56 to support interference detection and avoidance. Periodically, according to pre-defined operational parameters introduced by a WLAN operator, the DFSNC 92 sends suitable instructions via the link 24 to MT 44 to initiate interference detection. The instruction includes parameters operative in defining the type of detection to be performed, the measurements to be collected, the channel to be measured, the sub-set of a potentially usable channels, and the like. Consequently the MT 44 perform the required measurements by utilizing the set of DFS functions 56. The results of the detection process are returned by the MT 44 to the DFSNC 92 for analysis. The DFSNC 92 performs the analysis on the results received. The products of the analysis provide information concerning the presence, the absence, and the power level of an interfering signal on a specifically measured channel. When such an interference is identified by the DFSNC 92 an instruction is downloaded from the DFSNC 92 via the link 24 to the MT 44 regarding the activation of the set of DFS functions 56 in order to take appropriate interference avoidance measures, such as moving to another channel within the allocated frequency band of the WLAN 20. Note should be taken in the above-described configuration no AP device is implemented. Therefore all the functionalities of the AP are implemented in the MT 44 as access point functionality 55.

Fig. 5 provides a detailed view of the operative components associated with the proposed method and system. The illustrated configuration is exemplary only and in order to accomplish the objectives of the proposed method and system various other configurations could be used. The exemplary system configuration presented consists of a remote DFSNC 92, an AP 30, and a MT 50. A primary user device 118 is an interfering source, which is operating near to the WLAN and transmitting radio frequency signals. In the preferred embodiment of the present invention the primary user device 118 is a radar transmitter. The DFSNC 92 is programmable device. The DFSNC is pre-configured and can be periodically re-configured by the network operator utilizing the user interface 101. The re-configuration is effected by the manipulation of the relevant data stored in the operation database 100. Although only one DFSNC is shown on the drawing under discussion more than one such devices could be deployed across the wireless network space when each separate device could be programmed and configured in a different manner according to the network topography, known local interference sources, and the like. The DFSNC 92 is dynamically configured according to the results of the interference detection process performed by the AP 30 and/or the MT 50. The DFSNC 92 is capable of controlling a distinct sub-set of mobile terminals in the network or the entire set of mobile terminals deployed across the WLAN space. The DFSNC 92 includes but not limited to a user interface 101, an interference measurement control 94, an interference measurement analysis 96, an interference avoidance control 98, a messaging function 97, and an operation database 100. The operation database 100 is pre-configured by the wireless network operator and periodically re-configured in accordance with the results of the measurements transmitted by the AP 30, and the MT 50. The operation database 100 stores information concerning the known frequencies used by the operating interfering device 118, measurement parameters to be transmitted to the AP 30 and to the MT 50 to be used as controlling values for the performance of the measurement process. The parameters include but are

not limited to the type of measurement to be made, signal thresholds to be detected, frequencies to check, sub-sets of potentially usable channels, sub-sets of preferred channels, sub-sets of channels used by specific WLANs, geo-locations of specific WLANs with associated RF network topology including sector information, and the like. The operation database 100 is periodically updated by the AP device 30, and/or the MT 50 device with information associated with the detected interference, such as frequencies, interfering signal level, interference periods, error rates, and the like. Interference measurement control 94 is a process designed to manage the interference detection and avoidance functions of the AP device 30 and the MT device 50. The control 94 operates in the application layer level of the HiperLAN/2 protocol. The control 94 is responsible for the overall operation of the DFSNC 92 by coordinating the various functions included therein with the interference detection and avoidance functions implemented in a set of mobile terminal devices. The control 94 operates according to the operating parameters stored within the operation database 100. The control 94 obtains the sub-sets of potentially usable channels from the operation database 100 and communicates the information to the APs. The information may be periodically updated according to channel measurement results and/or the operator's input. The control 94 obtains the measurement parameters from operation database 100 and sends the parameters in association with suitable instruction measurement initiating instructions to the AP device 30 and/or the MT device 50. The interference measurement analysis function 96 is operative in receiving the uploaded result values of the measurements from the AP device 30 and/or the MT device 50, in analyzing the result values, in identifying the presence or absence of an interfering signal on the measured channel and in returning the results produced to the interference measurement control 94. The interference measurement control 94 activates the messaging function 98. The messaging function 98 is responsible for the downloading of the appropriate instructions to the AP device 30 and/or the MT device 50 concerning the initiation of the appropriate interference avoidance actions, such as moving to another channel.

The interference avoidance function 98 sends frequency selection parameters attached to the channel changing instruction, power levels required to the adjustment of transmitted signal levels, and the like. The parameters could also include a range of unusable frequencies, a range of preferred frequencies, RF topology information such as AP locations, AP sectors and the directionality thereof, and the like. In accordance with the geographical location of the AP 30 and the associated mobile terminals thereof different measurement-related or frequency change-related parameters can be downloaded to different mobile terminals. For example, if a known radar transmitter is operating in a defined locality of certain WLANs then APs and/or the mobile terminals within the range of the radar transmitter are instructed not to move to the frequencies known to be used by the radar system. Thus, an on-going dynamic interference detection process is taking place through which the interference-related information in the operation database 100 of the DFSNC is dynamically maintained. The operation database 100 includes but is not limited to a channel parameters changes table, a predefined channel information table, an RF topology information table including APs locations, APs sectors with associated directionality data, a time window control table, and a channel periodicity table. The functionality of the additional tables will be described hereunder in association with the following drawings. Note should be taken that in other embodiments of the present invention other alternative processes, functions, and components could be used, the functionality of the processes can be different, and the operation database and the tables stored therein could be implemented and structured in a number of alternative ways. For example, the user interface unit 101 can be enhanced such as to be utilized in addition to the interactive control of the parameters, for the submission of queries, for producing statistical listings, and the like.

Still referring to Fig. 5 AP 30 includes but not limited to an interference measurement function 102, an interference reporting function 104, an interference avoidance function 106, a messaging function 107, and an operation database 108. The operation database 108 stores diverse measurement

information, channel information, interference information, operating parameters, channel periodicity data, time slot control data, and the like. The operation database 108 enables the AP device 30 to operate independently of the DFSNC 92 under specific circumstances such as in the case of a communication failure between the AP 30 and the DFSNC 92. The table 108 also enables the AP 30 to operate autonomously as defined by the in the different operation modes of the method and system offered by the invention. Thus, following the performance of the required measurements the AP device 30 updates the operation database 108 with the results of the measurement before/after/while sending in the link the information to the DFSNC 92. The interference avoidance function 106 is implemented for activating appropriate interference avoidance options according to the relevant parameters received from the DFSNC 92. The interference measurements function 102 is implemented in the application layer of the protocol stack and is responsible for the activation of the interference detection functions in accordance with the instructions received from the DFSNC 92. The interference reporting function 104 is operative in the sending in the link the results of the measurements to the DFSNC 92. The AP 30 can also instruct the MT 50 to perform the requested interference detection and avoidance operation by sending the necessary parameters to the MT 50. Note should be taken that in other embodiments of the present invention other alternative processes, functions, and components could be used, the functionality of the processes can be different, and the operation database could be implemented in a number of alternative ways.

Still referring to Fig. 5 the MT device 50 consists of but not limited to an interference measurement function 110, an interference reporting function 112, an interference avoidance function 114, a messaging function 117, and an operation database 116. The operation database 116 stores diverse measurement information, channel information, interference information, operating parameters, channel periodicity data, time window control data, and the like. The operation database 112 enables the MT 50 to operate independently of the AP 30, and the DFSNC 92 under specific circumstances such as in the case of a communication

failure along the uplink communication path. The database 116 also enables MT 50 to operate autonomously as defined by the different operation modes of the method and system offered by the invention. Thus, following the performance of the required measurements the MT 50 updates the operation database 116 with the results of the measurements before sending the information to the AP 30. The interference measurements function 110 is implemented in the application layer of the protocol stack and is responsible for the activation of the interference detection functions in accordance with the instructions received from the AP 30. The interference reporting function 112 operative in the sending of the results of the measurements to the AP 30. Note should be taken that in other embodiments of the present invention other alternative processes, functions, and components could be used, the functionality of the processes can be different, and the operation database could be implemented in a number of alternative ways. The substantially modular configuration of the proposed system allows for several varied implementation schemes. Thus, in other embodiments of the invention some or all of the functions implemented in the AP and/or the MT could be implemented in the DFSNC only. Accordingly, a method of interoperability between the mobile terminals of any manufacturer and the DFSNC can be provided. This option enables operators of the WLANs to use third party wireless interference detection solutions from companies that specialize in that area, rather than develop similar solutions in-house.

Still referring to Fig. 5 the AP 30 allocates the channels for operation to the MT 50 according to the instructions received from the DFSNC 92. The AP 30 selects a specific channel for operation by utilizing a list of channels sent by the DFSNC 92. The list contains a sub-set of potentially usable channels and a sub-set of unusable channels. The list could further provide preference information associated with the entries constituting the usable channels sub-set. The AP 30 examines the list, ignores the channels in the unusable channel sub-set and selects a channel from the usable channel sub-set. If preference data is

provided with the usable channel sub-set then the selection could be made in accordance with the preference data.

Fig. 6 illustrates the structure of the operation database implemented on the DFSNC devices, the AP devices, and the MT devices. In different operation modes the structure of the operation database implemented on the different platforms could substantially differ. The operation database 400 includes but not limited to an operating parameters table 402, a measurement parameters table 404, an interference data table 406, a channel data table 408, a channel parameter changes data table 410, a time window data table 412, a network topology table 413, and a channel priority data table 414. The operating parameters table 402 is used for defining the overall interference detection scheme for the interference detection function. The table 402 includes but not limited to lists of installed DFSNCs, APs, MTs, detection process time tables, and the like. The measurement parameters table 404 is utilized by the interference detection mechanism to identify a radar signal. The table 404 includes but is not limited to radar signal characteristics as determined by known radar transmitters, such as frequency, scan rate, pulse width, pulse rise/fall time, power, minimum detectable signal, pulse repetition frequency, pulse recurrence time, pulse duration, and the like. The interference data table 406 includes detected interference values, such as received signal strength, and the like. The data in table 406 is utilized as input to the interference measurement analysis and to channel sub-set allocations. The channel data table 408 includes a list or range of blocked frequencies, a list or range of available frequencies, and the like. The entries in the list or range of frequencies could include preference order and operating conditions, such as date or time of the day. The information stored in the channel data table 406 is used as parameters associated with the interference avoidance instructions sent to the relevant devices. The channel parameter changes table 410 stores lists of changes detected in the channel parameters during the pattern-based detection mode. The time slot data table 412 stores

interfering signal periodicity data. The network topology table 413 includes but not limited to specific network information and device information, such as network identification, device identification, and the like. Table 413 could also include data about the geographical location of the various devices, such as APs, implemented in the network, sector information associated with sectorized devices, such as number of sectors, sector direction, and the like. Table 413 could further include topology information concerning other WLANs in the environment as well as information concerning known, estimated, or identified primary users operating in the vicinity. The primary user information could include known or estimated geographical location, user type, and the like. Table 413 is operative in the creation and maintenance of a transmission/reception coverage map of one or more WLANs. Note should be taken than in other embodiments of the present invention additional tables could be used, such as a historical data table, statistical data table, operators profile table, and the like.

Referring now to FIG. 7 showing an exemplary sequence of functional steps operative in the performance of the interference detection and avoidance process according to the first preferred embodiment of the present invention. The first embodiment implements the DFSNC control mode. At step 119 the operation database implemented on the DFSNC device is updated by the operator of the DFDSNC. The operator is provided with the option of manipulating the parameters of the system in order to enable activation of the interference detection process at certain points in time for the entire set or a limited sub-set of one or more DFSNC devices. The operator of the DFSNC is provided with the capability of inserting, updating and deleting data stored in the operation databases. The data includes but not limited to the set of MT/AP devices to be controlled by one or more DFSNC devices, the set of MT/AP devices required to perform interference detection, a range of frequencies to examine for the presence of interference, a range of frequencies to be used for the re-assignment of the channels being interfered with, or conditionally reassigned, and a range of frequencies blocked or

conditionally blocked for re-assignment or for use. The conditional reassignment or the blocking of the channels can be done in accordance with specific parameter values, such as the date, the time of day, and the like. The operator can further manipulate and modify specific measurement values, such as the examined interference signal threshold levels, and the like. The operator is provided with the option of disabling the interference detection process, of querying the status of the system, of producing varied statistical listings, to change the topology map of the WLAN and/or other neighboring WLANs and/or known/estimated primary users, and the like. Additionally the operator can select the appropriate operation mode of the system, such as the DFSNC control mode, the wireless device control mode, the standard interference measurement (i.e., RSS-based) mode, the pattern-recognition-based interference measurement mode, interference avoidance by the frequency re-assignment option, interference avoidance by transmission power level adjustment, by the activation of the co-existence scheme, and the like. The various operational modes of the proposed method will be described hereunder in association with the respective preferred embodiments of present invention and the accompanying drawings. At step 120 the DFSNC retrieves the necessary parameters from the operation database and at step 122 the DFSNC instructs the specified devices to perform interference detection. The appropriate parameters are sent to the specified devices in association with the instructions. At step 124 a wireless device, such as an AP device and/or an MT device receives the instruction with the accompanying parameter values and at step 126 the AP device and/or the MT device perform interference measurement of a desired specific channel in the specifically defined operation mode in accordance with the measurement parameters received from the DFSNC. The wireless device collects the measurement results, updates the local operation database with the results and at step 128 sends the results to the DFSNC. At step 130 the DFSNC receives the measurement results, analyses the results, updates the operation database, and determines the interference-related status of the examined channel. If the channel measured is recognized such as to include an interfering signal at step 132 the

DFSNC instructs the wireless devices in regard to necessary interference avoidance actions, such as moving to a different channel in the allocated frequency band in order avoid collision between the WLAN channel traffic and the interfering signal therein, to properly adjust transmission power levels in order not to interfere with the transmission/reception of the primary user, or activating the co-existence scheme. At step 134 the wireless device takes the requested avoidance measure updates the local operation database, and notifies the DFSNC by uploading the updates performed.

The proposed method and system provide several operational modes. The different operational modes could be implemented in alternative combinations, and in varied ways, such as being predetermined and pre-set at system generation, or could be dynamically modified by the DFSNC operator at certain points in time according to the circumstances, such as the changing of network topology, the addition, the removal, or the replacement of specific devices, the installation or upgrading of interference detection and avoidance-related functions, new information received concerning a wireless communications system, such as a WLAN, or a primary user, such as a radar system, operating in the vicinity, and the like. A specific operation mode can be uniformly applied across the entire WLAN or several different operation modes could be variably applied to one or more DFSNC devices and associated APs/MTs according to the type of installed devices, the type of functions implemented therein, and the like.

The remote interference detection and avoidance method and system offered by the present invention makes available to the operators of the DFSNCs with the option of dynamic geographical frequency planning. The system and method allows for allocating differential frequency ranges to one or more sets of one or more wireless devices. The allocation can be done dynamically by the network controller according to measurements and feedback received from the devices. The feedback and the measurements results could be used for the building of frequency usage maps, for studies of interference, and for the

diagnostics processes utilized to improve spectrum usage. The method and system advantageously allows the WLAN operators to outsource the interference detection and prevention functions to third party developers having suitable expertise in the specific field and having the capability to centrally implement required modifications, changing basic DFS data, such as information concerning new radar installations, satellite feeder transmitters, recent DFS algorithms, and the like. Outsourcing the process to expert third parties can benefit the entire industry and the regulating bodies by enabling the regulators to inspect and control a substantially limited number of interference detection and avoidance packages rather than obliging each individual WLAN manufacturer to go through extensive testing procedures in order to receive authorization for the utilization of their own interference detection and avoidance systems.

Referring now to Fig. 8 showing an exemplary sequence of functional steps operative in the performance of the interference detection and avoidance process, in accordance with a second preferred embodiment of the present invention. The second preferred embodiment of the present invention implements the wireless device control mode. A set of one or more relevant wireless devices includes a modified version of the DFSNC control functions. A higher-level operation database and a set of specific higher-level operation database-related supporting functions are implemented in the DFSNC. At step 500 the higher-level operation database implemented on the DFSNC is updated by the operator of the DFSNC. The operator is provided with the capability of modifying the parameters of the system to enable activation of the interference detection process at certain points in time for the entire set or a sub-set of one or more wireless devices. The operator can also insert into the operation database parameters, such as a set of one or more of MTs/APs desired to perform interference detection, a range of frequencies to examine, a range of frequencies to be used for the re-assignment of the channels being interfered with, and a range of frequencies blocked for re-assignment or for use. The operator can further manipulate and modify specific

measurement values, such as the examined interference signal threshold level, and the like. The operator is provided with the option of disabling the interference detection process, of querying the status of the system, of producing varied statistical listings, to change the topology map of the WLAN, of the primary users, and the like. At step 502 the parameters from the higher-level operation database of the DFSNC are downloaded to the wireless devices according the instructions of the DFSNC operator. In the wireless device control mode the control of the interference detection and avoidance process is made autonomously by the wireless devices. The process loop describing the operation of the wireless device is described across step 504 through step 516. At step 504 the local interference detection control function implemented in the wireless device retrieves the necessary parameters from the local operation database and at step 506 the local control function initiates the performance of the interference detection process. The appropriate parameters are obtained from the local operation database. At step 508 the wireless device, such as an AP and/or a MT perform interference measurement of the specific channel in the specific operation mode in accordance with the measurement parameters received from the local operation database. The wireless device collects the measurement results, updates the local operation database with the results, at step 510 analyses the results, and determines the interference-related status of the examined channel. If the channel measured is recognized such as to include an interfering signal the wireless field performs the consequent interference avoidance actions, such as clearing the measured channel and moving to a different channel in order avoid collision between the WLAN channel traffic and the interfering signal therein. At step 512 the wireless device performs interference avoidance measures. At step 514 the local operation database of the wireless device are updated and at step 516 the device sends the results of the interference detection and interference avoidance process to the DFSNC in order to update the operation database established therein. Process control then proceeds to step 504 to resume the interference detection loop.

The method according to the second preferred embodiment allows the operators of wireless networks the option of controlling the network adaptively. The operators receive dynamic up-to-date information from the devices concerning primary user-related interference, which was detected by the devices. According to the received information the operators can adaptively control the network, such as manually introduce information concerning known primary users and sending the updated information to the devices.

In the pattern-recognition-based interference detection mode interfering sources in the range of a WLAN transmitting radio signals on the same frequency used by a WLAN channel can be detected without the need to be aware of the identity, and characteristics of the transmitter in order to detect the signals interfering with the signals of the WLAN. The method proposed in the pattern-recognition-based mode is based on the identification of one or more specific patterns discernible in a set of changes occurring on the time axis in the parameters of a measured WLAN channel. The measurement is performed as part of the normal operation of the wireless device, such as an AP device and/or MT device. In the pattern-recognition based mode the wireless device performs interference detection and avoidance simultaneously with the standard data exchange operations taking place between the various devices of the network. Thus, no specific time slots need to be allocated for the performance of the interference detection process.

In yet another operation mode, the wireless device still performs the ongoing measurements, but the pattern recognition is performed at the DFSNC. The wireless device reports the collected channel-specific measured anomalies, such as identified errors. The wireless device sends the data along with associated parameters, such as timestamps, periods, and the like to the DFSNC device. Subsequently, the DFSNC device itself performs the pattern recognition process.

The patterns that can be identified as part of the normal operation of the wireless device are related to the basic channel parameters, such as the error

rate changes including bit error rates, frame error rates, packet error rates, signal-to-noise (SNR) changes, phase shift differentials, and the like. Patterns in the continuously changing channel parameters can be recognized on the data carriers, on the pilot carriers, and optionally on the control carriers. In the pattern-recognition-based mode the wireless device will record changes in the channel parameters and will attempt to detect a pattern in the changes. The pattern recognition method may utilize thresholding functions, statistical analysis functions to account for small fluctuations in the range of the changes and/or in the range of the period in which the changes occur, or Artificial Intelligence (AI) implementations such as used by commercially available neuron networks. Threshold values can be used for defining the time slots during which the changes are to be repeated to form a meaningful pattern and/or for defining the longest time slot without changes. The interference detection can be performed upon any specific combination of the channel parameter changes.

Referring now to Fig. 9 showing an exemplary sequence of functional steps operative in the performance of the interference detection and avoidance process according to the third preferred embodiment of the present invention. In the third preferred embodiment the system implements the pattern-recognition-based interference detection mode. At step 600 a signal is received by the wireless device. At step 602 the signal is sampled and converted to digital format by an analog-digital converter. At step 604 the pattern analysis parameters are read from the operation database. At 606 the pattern analysis is performed by obtaining the suitable channel parameters, such as error rates, SNR changes, and the like, building channel parameters changes lists and processing the lists by appropriate analysis functions, such as the Histerhasys function, the neuron network, or the like. At step 608 an interference pattern is recognized on the examined channel, and appropriate interference avoidance actions are performed, such as moving to a vacant channel within the allocated frequency

band. At step 610 the operation database are updated with the relevant data, and at step 612 the updates are optionally uploaded to an AP and/or the DFSNC.

Note should be taken that in another operational mode the steps 606 through 610 could be performed in the DFSNC device and step 612 could be replaced by a reporting step to the wireless device.

The pattern-recognition-based interference detection mode proposed by the method and system of the present invention is performed on an on-going basis rather than in "interrupted" periods, which may or may not include the interfering signals. The performance of interference detection in this mode requires neither information in respect to the radar systems operating within the range of the WLAN nor decisions by the higher layers of the communications protocol or the remote network controller. Yet the method could be combined with and be assisted by radar system-related information and/or by certain decisions made in the higher layers of the communication protocol. For example, if certain radar systems are known to have a fixed 10 seconds "sweep" rotation period then the wireless devices channel measurements functions could be calibrated such as to perform the channel measurements having the same 10 seconds periodicity. The operational decisions concerning the presence and/or the power level of interference and can be made locally by the low layers of the wireless device based on the locally accumulated and locally analyzed channel parameter information. In addition the information is collected without interrupting the on-going standard data exchange operations of the network.

Note should be taken that in other operational mode the decisions could be made in the DFSNC. Thus, the WLAN operators will be provided with the option to outsource the interference detection and prevention process to a third party.

The co-existence mode relates to the adaptive modification of a WLANs transmission parameters in response to the detection of a periodic interference detected by one of the interference detection schemes described

above, or known in advance. Many of the radar systems transmit periodically. Therefore WLAN devices operating in the vicinity of a periodic radar systems will be periodically effected by the interference caused by the signals emitted from a radar system transmitting on the frequency utilized by a WLAN device, and similarly periodically effect the same radar by the WLAN signals. In current wireless system when a periodic interference detected the channel used by a wireless device is re-assigned to a different channel. The detection of a periodic interference will cause activation of a process in the WLAN that will provide the capability for both systems operating in the same geographical area within broadcast range to keep functioning effectively on the same channel. Thus, a substantially improved utilization of the allocated bandwidth is achieved, which is specifically important in the about 5 GHz spectrum including periodic transmitters, such as pulse/sweep radar systems. Co-existence on the same channel allows better utilization of the allocated spectrum while not compromising the operation of the primary user, such as a radar system. The resulting negative impact on the performance of the wireless communications system, such as a WLAN, is non-existent or negligible.

Fig. 10 illustrates an exemplary sequence of functional steps operative in the performance of the interference detection and avoidance process that implements the co-existence scheme. At step 700 a signal is received by the wireless device of the WLAN. At step 702 the signal is sampled and converted to digital format by an analog-digital converter. At step 704 interference periodicity measurements are performed by the wireless device of the WLAN. At step 706 the interference periodicity measurement results are collected into suitable lists and at step 706 the lists are processed and analyzed in an attempt to recognize systematic periodicity of the interference. At step 708 the systematic periodicity of the interference is established and an appropriate time slot table is set up. In the time slot table the wireless device of the WLAN allocates vacant time slots to its WLAN devices such that the interfering primary user will continue to operate

uninterrupted and the interfered WLAN will keep functioning without interrupting the interfering primary user. Within the allocated time slot stored in the time slot table the entire wireless network associated with the WLAN will be instructed not to transmit or alternatively to adjust its transmission power such as not to interfere with the periodically transmitting primary user, such as a pulse radar. As a result within the allocated time slots the WLAN will not interfere with the signals transmitted by the primary user either by not transmitting or by lowering the power levels of the signals transmitted. At step 710 the time slot table and related information from the operation database uploaded to a network controller for appropriate processing. At step 712 the network controller analyzes the uploaded time information and performs a suitable co-existence related process. The process is designed to allow both the wireless network and the primary user to continue operating on the same channel on a specific frequency by instructing the wireless network not to transmit during the time slots allocated to the signal of the primary user.

Note should be taken that the periodicity measurements, the analysis of the results, and the building of the time window table could be performed in diverse other manners. For example, the appropriate periodicity data could be received from the operators of a known primary user operator and could be inserted into the suitable table by the wireless network operator or the DFSNC operator. Similarly the process of analysis, and the time window table maintenance could be initiated by the wireless network operator or the DFSNC operator. The relevant tables could be then stored on the controller device and could be controllably downloaded when necessary to the wireless device.

Fig. 11 illustrates graphically a signal collision and an exemplary solution thereof in a WLAN channel. Signal 801 is a WLAN signal comprising MAC frames 800, 802, 804, 806, 808 transmitted via a link set up between two or more WLAN devices such as an AP and a MT on an assigned WLAN channel having a specific frequency allocated thereto. Signal 803 is a continuous radar

signal transmitted via air interface by a radar transmitter. Signal 801 and signal 803 are transmitted on the same frequency. The receiving WLAN wireless device, such as a MT device, is deployed such that the device is in the operative range of the radar transmitter emitting signal 803. As a result the WLAN wireless device, such as a MT device, is receiving simultaneously both signals 801 and 803. The signal 801 is overlaid in the specific communication channel associated with the MT device by signal 803 and the resulting signal 805 is a corrupted version of signal 801. The signal 805 is referred to as interference where the interference is created by the unintended reception of signal 802. Similarly, the reception of the WLAN signal 801 by the primary user effects interference to the same primary user. In the preferred embodiment of the present invention the signal 805 is detected by the interference detection method and system described hereinabove. Consequent to the detection of the corrupted signal 805 specific interference avoidance functions are activated and a number of alternative interference countermeasure actions are taken. One such action includes interference avoidance, such as changing the communication path of the signal 801. After a suitable time interval 801 required for the performance of the channel switching operation, the path is changed by switching from channel 807 to a new channel 809 transmitted on an unused frequency 809. The WLAN signal 801 comprising the MAC frames 800, 802, 804, 806, and 806 will be transmitted undisturbed on the newly allocated channel 809 while the radar signal will keep transmitting on the original channel 805.

Fig. 12 illustrates graphically a signal collision and an alternative solution thereof in a WLAN channel according to the preferred embodiment of the present invention. Signal 811 is a WLAN signal comprising MAC frames 800, 802, 804, 806, 808. Signal 811 is transmitted via a link set up between two or more WLAN devices such as an AP and a MT on an assigned WLAN channel having a specific allocated frequency. Signal 814, 816, 818 are a set of periodic radar signal transmitted via air interface by a radar transmitter for radio-location

and ranging purposes. Signal 811 and signals 814, 816, 818 are transmitted on the same frequency. The receiving WLAN wireless device, such as a MT, is deployed such that the device is in the operative range of the radar transmitter emitting periodic signals 814, 816, 818. As a result, the WLAN wireless device, such as a MT device, is receiving simultaneously both signals 811 and periodic signals 814, 816, 818. The signal 811 is overlaid in the specific communication channel associated with the MT device by the periodic signals 814, 816, 818 and the resulting signal 813 is a corrupted version of signal 811. The signal 813 includes periods of interference 812', 812'', and 812'''. that correspond to the reception of the interfering periodic signals 814, 816, 818. Signal 815 represent the WLAN signal train as transmitted in the channel subsequent to the activation and completion of the co-existence option if no channel switch was performed by the WLAN after the detection of the primary user as stated in the other embodiments. Signal 815 comprises intermittent WLAN traffic consisting of MAC frames 822, 826, 830, time guard intervals 823, 823', 823'', 823''', 823'''', and periodic "WLAN silence" time slots 824, 828, and 832. The periodic WLAN silence slots correspond to the duration of the periodic radar signals 814, 816, 818 that were detected, analyzed and collated by the appropriate interference detection functions. In order to enable co-existence with the radar, and to allow undisturbed transmission of the periodic radar signals, for the duration of time slots 824, 826, 828 the transmission of signals between the entire set of WLAN devices is suspended or powered down. The WLAN silence slots 824, 826, 828 are suitably separated by configurable time guard intervals 823, 823', 823'', 823''', and 823''''.

Implementing the co-existence mode provides the operators of a WLAN with the option of spreading out the network across a wide frequency range. Thereby the overall useable bandwidth capacity of the network is increased and a significant improvement is achieved in the utilization of the unlicensed 5 GHz spectrum. The present invention provides operators of a WLAN and the spectrum regulators a mechanism to ensure compliance with the regulations and

with the changing deployments of primary users, such as radar systems, satellites, amateur radio service, and the like. The remote mechanism as offered by the preferred embodiments of the present invention provides the capability to co-exist even on frequencies certain primary users are known to operate thereon.

In wireless network containing on or more sectorized wireless devices basic sector-related information can be provided to the controller device (DFSNC) by multiple network operators. The sector information, such as the list of sectorized devices, the number of sectors included within each device, the directionality of the specific sector, and the like, will be stored within the operation database established on the controller device (DFSNC). The interference detection data communicated by a sectorized wireless device will include information concerning the specific sectors on which the interfering signals were detected. As a result, the controller device will have substantially precise information in respect to the location of the interfering primary user device and/or neighboring WLANs. The location of the devices could be communicated to other wireless networks operating in the same environment but located at a distance further from the interfering source and therefore less likely to detect it. Thus, the controller device can be used as an assessor for the other wireless networks based on the information collected by other wireless networks.

Additionally the interference avoidance measures taken by the wireless devices could be sector specific. For example, when on sector X an interfering source is detected the controller could instruct the reporting wireless device to cease periodically or permanently transmitting only on sector X, or adjust the signal power levels only on sector X while continue normal operations on the other sectors.

Referring now to Fig. 13 illustrating the operation the method and system in accordance with the fourth preferred embodiment of the present invention. The operation described involves a detector AP implemented in association with one or more WLANs having a sectorized or an omnidirectional

mode of operation. The detector AP can operate either in an omnidirectional mode or in a sectorized mode. A sectorized detector AP is used to provide additional information in regard to the directionality of the detected signals. A sectorized detector AP 812 is co-located with a primary user, such as a radar system 802. A sectorized AP 804, a sectorized AP 816, and an omnidirectional AP 808 operate in the environment within various transmission/reception coverage areas and transmission/reception ranges from the radar system 802. The sectorized AP 804 includes a transmission/reception coverage sector 830, a sector 832, a sector 834, a sector 836, a sector 838, and a sector 840. For purposes of readability the sectors included in the sectorized AP 822 are not shown. Each AP 804, 806, 808 has the capability of controlling several MTs. The drawing illustrates that the AP 804 controls a MT 818, a MT 820, the AP 806 controls a MT 814, a MT 822, and the AP 808 controls a MT 824. Although only a limited number of APs and MTs are shown it will be readily understood that in a realistic environment several APs could be implemented controlling several MTs. Note should be taken that the different APs could be associated with different WLANs.

The transmission/reception coverage area of each of the six sectors included in AP 804 is covering an azimuth of about 60 degrees. Lines 854, 856 indicate the limits of the transmission/reception coverage area of the sector 832. When the WLAN AP 804 transmits through the sector 832 the signals may interfere with the radar system 802. When the AP 804 transmits through the other sectors 830, 834, 836, 838, 840 no interference is effected with the radar 802 due to the differential directionality of the transmission. In contrast when the radar 802 is transmitting, the radar signals may interfere with the section 832, and with the section 838, which is within the transmission/reception directional reception line of the radar 802.

The detector AP 812 receives the transmission of the APs 804, 806, 808 via link 850, 846, 852 respectively. Link 850, 846, 852 could be a wireless link or a wired link. In accordance with the diverse transmission/reception ranges between the detector AP 812 and the APs 804, 806, 808 the respective power

levels of the signals received by the detector AP 812 could be different in respect to each of the APs. Under certain circumstances, for example when the APs are deployed such that the detector AP 812 is out of their effective broadcast range, the detector AP 812 may not detect the signals transmitted by specific APs.

A DFSNC 810 is coupled to the WLAN APs 808, 806, 804 via links 840, 842, and 844 respectively, for purposes of communication and control. The DFSNC 810 could be co-located within one the WLAN APs or could be deployed on an independent platform within one of the WLANs. The detector AP 812 is normally instructed to be functionally receptive to signals transmitted on the channel used by the radar system 802. Thus, the detector AP 812 also has the capability of detecting the radar system's transmission periods directed towards each transmission/reception coverage sector associated with the WLAN devices. The detector AP 812 is utilized to detect the "sweep" of the radar or the temporal and directional position of the radar's radiation pattern during the full rotational period of the radar's antenna. The detector AP 812 is also responsible for detecting the transmission of different WLANs operating in the vicinity of the radar system 802 by identifying the radiating sources. Those sources can be APs and the associated MTs thereof implemented across different WLANs operating in the vicinity of the radar system 802. If the detector AP 812 is non-sectorized then the information acquired will have no directional dimension. In contrast, if the detector AP 812 is sectorized then the reception information will have directional dimension. Thus, at a certain point in time the sectorized AP 812 will receive on one of the sectors thereof the radar signal as a part of the radar "sweep" while on the rest of the sectors thereof various WLAN signals will be received. The detector AP 812 is further provided with the capability of detecting various MTs operating in the WLANs that are deployed near the radar system 802. Thus the detector AP 812 acquires further indication of the fact that a WLAN operates on the radar system's 802 channel. Subsequently the detector AP 812 notifies the DFSNC 810 through the link 846 concerning the collected results of the signal detection process performed in the environment.

In a similar manner, the APs 804, 806, 808 sends the results of the interference detection measurements performed thereby to the DFSNC 810 via the links 844, 842, 840. If the APs are sectorized then the uploaded information includes directional dimension. The information received from detector AP 812, AP 804, AP 806, and AP 808 is analyzed by the DFSNC 810 and in combination with the data the DFSNC 810 already has in respect to the location of the various APs, and the directionality of their respective sectors, the channels utilized, the location and parameters of the radar, and other relevant data. The result of the analysis enables the DFSNC 810 to build up a RF topology mapping of the signal environment. In accordance with the "signal environment map" the DFSNC 810 performs specific predefined measures in order to co-ordinate the signaling activities of the diverse wireless devices. For example, in order to accomplish signal harmony in the environment the DFSNC 810 could notify the AP 804, and the AP 806 to cease transmission for specific periods of time following the detector AP 812 notification in regard to the radar system 802 "sweeping" movement in time and space. Utilizing the directional information the DFSNC 810 has concerning the AP 804, and the AP 806, the DFSNC 810 could further specify that only specific sectors need to be "silent", such as sector 832 and sector 836 in AP 804, while the rest of the sectors, such as sector 834, 836, 830 may continue normal or powered down operations. Additionally, due to the dynamic time allocation process within the MAC frame, some APs, such as AP 804 could utilize the time allocated originally for the sector 832 and sector 836 such as to be used by the other sectors, such as sector 843, 836, and 830. As a result the AP over-all time-related capacity is preserved.

The extensive signal environment map data established by DFSNC 810 enables DFSNC 810 to control WLAN devices that are unable to detect interference independently due to their distance from the interfering transmission source. For example, the currently discussed drawing shows AP 808 deployed such that it is more remote from the radar system 812 than the AP 804, and the AP 806. Thus, AP 808 may not be able to detect interfering radar signals emitted

by radar system since the signals received will be having a power level lower than the signal detection threshold provided to the interference measurement mechanism of AP 808. Yet at the same time the transmission of AP 808 may interfere with the radar system 802 due, for example to the higher sensitivity of the radar's receiver. Utilizing the signal environment map the DFSNC 810 can notify the AP 808 to take specific interference avoidance measures, such as to cease transmitting, or to lower the transmission power thereof.

The detector AP 812 co-located with the primary user, such as the radar system 802 can be utilized for detecting the signals transmitted by other WLANs as received at the site of the primary user. Subsequently the detector AP 812 notifies the DFSNC 810 AP-specific information, such as AP identification, network identification, received signal strength (RSS) and the like. If the transmitting AP operates in a sectorized mode then the detector AP 812 sends to the DFSNC 810 the appropriate directional information. The directional information enables the DFSNC 810 to instruct the suitable device, such as the AP, to take predefined interference avoidance measures, such as ceasing transmission, or lowering transmission power on one or more of its existing sectors.

The detector AP 812 co-located with the primary user, such as the radar system 802 is also operative in tracing the primary user, such as radar system 802 "sweeping" movement. Subsequently the detector AP 812 can notify the DFSNC 810 in regard to the temporality and directionality of the "sweep" process. The communicated and analyzed information provides the DFSNC 810 with the capability to instruct the WLANs deployed on the path of the radar antenna's sweep to take predefined interference avoidance measures, such as interrupting transmission or lowering transmission level on one or more existing sectors.

It will be easily perceived by one with ordinary skill in the art that the steps and components mentioned in the foregoing description were provided as examples and were not intended to be limiting. Diverse other components and

methods could be used to accomplish the underlying objectives of the present invention and several enhancements and improvements to the described embodiment could be contemplated within the framework of the general issues inherent in the proposed system.

The above description of the construction and use of systems incorporating a plurality of mobile terminals, access points, network controllers, transceivers, and the like makes particular reference to use in a land-based wireless local area network (WLAN). However, it will be understood that the use of the technique is in no way limited to land-based wireless local area networks and that it is equally applicable to wireless wide area networks, and other fixed and/or mobile wireless communication systems incorporating satellite links.

Persons skilled in the art will appreciate that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims, which follow.

I CLAIM:

1. In a wireless communications environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on an allocated frequency band via an air interface, at least one primary user transmitting and receiving a radio frequency signal on a substantially alike allocated frequency band via an air interface, a method for the detecting and avoiding reciprocal signal interference produced by the radio frequency signals emitted by the at least one primary user and by the at least one secondary user, the method comprising the steps of:

establishing dynamic interference detection and avoidance control and operation information in the at least one secondary user; and

dynamically and controllably measuring at least one communication channel providing a communication path between at least two wireless devices of the at least one secondary user; and

analyzing the results of measurements performed on the at least one communications channel in order to determine the interference status of the measured at least one communications channel of the at least one secondary user; and

dynamically maintaining interference detection and avoidance information in the at least one secondary user; and

selectively performing controllable interference avoidance procedures by the at least one secondary user to prevent reciprocal signal interference in the at least one secondary user and in the at least one primary user.

2. The method of claim 1 further comprising selectably performing a signal co-existence procedure to enable co-existence of the at least one secondary user with the at least one primary user on the substantially alike pre-allocated frequency band in the communications environment.

3. The method of claim 1, further comprising the at least one secondary user communicating interference detection and avoidance information and instructions to at least one other secondary user.

4. The method of claim 1 wherein the step of establishing comprises the steps of:

maintaining communications environment status information in the at least one secondary user; and

creating detected signals information in the at least one secondary user; and

building interference measurement information in the at least secondary user; and

originating interference avoidance information in the at least one secondary user.

5. The method of claim 1, wherein the step of measuring comprises the steps of:

sending interference measurement control information to at least one interference detection and avoidance wireless device by the interference detection and avoidance controller device of the at least one secondary user; and

instructing the at least one interference detection and avoidance wireless device to perform interference measurements with respect to at least one communications channel by the interference detection and avoidance controller device of the at least one secondary user; and

performing interference measurements by the at least one interference detection and avoidance wireless device on the at least one communications channel; and

communicating the results of the interference measurements by the at least one interference detection and avoidance wireless device to the interference detection and avoidance controller of the at least one secondary user.

6. The method of claim 1, wherein the step of measuring comprises the steps of:

examining the parameters of the signal received on the at least one measured communications channel by the at least one interference detection and avoidance wireless device; and

comparing the received signal parameters with the suitable interference detection information communicated by the interference detection and avoidance controller.

7. The method of claim 1, wherein the step of performing comprises the steps of:

modifying the suitable interference avoidance procedure by the interference detection and avoidance controller; and

selecting the suitable interference avoidance procedure by the interference detection and avoidance controller; and

communicating the suitable interference avoidance procedure and attached interference avoidance information to the at least one interference detection and avoidance wireless device by the interference detection and avoidance controller; and

executing the communicated interference avoidance procedure by the at least one interference detection and avoidance wireless device.

8. The method of claim 5, wherein the step of interference measurements performance is executed by the at least one interference detection and avoidance controller device.

9. The method of claim 5, wherein the step of interference avoidance performing is executed by the at least one interference detection and avoidance controller device.

10. The method of claim 1, wherein the step of maintaining interference detection and avoidance control and operation information further comprises:

manually maintaining the interference detection and avoidance information stored in the operation database by an operator of the secondary user in accordance with information received from external sources; and

dynamically maintaining the interference detection and avoidance information stored in operation database by interference detection and avoidance device; and

dynamically maintaining the interference detection and avoidance information stored in operation database by interference detection and avoidance service.

11. In a communication environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on a pre-allocated

frequency band via a link, at least one primary user transmitting and receiving a radio frequency signal on a substantially same pre-allocated frequency band via an unbounded medium, a system for the dynamic detection and avoidance of reciprocal signal interference produced substantially simultaneously by the at least one secondary user and at least one primary user, the system comprising the elements of:

at least one primary user interference detection and avoidance controller device; and

at least one primary user interference detection and avoidance wireless device.

12. The system of claim 11, wherein the at least one controller device comprises the elements of:

an interference measurement control function to instruct at least one interference detection and avoidance wireless device to perform interference detection; and

an interference measurement analysis function to identify the type, the quality, and the source of the measured interference; and

an interference avoidance control function to instruct at least one interference detection and avoidance wireless device to perform interference avoidance procedures; and

a messaging function to communicate the instructions to the at least one interference detection and avoidance wireless device; and

a user interface function to enable an operator to create and maintain the operation database; and

an operation database to hold interference detection parameters, interference avoidance parameters, network information, wireless device information, available channel information, channel periodicity data, primary user information, measurement results, and general operating parameters.

13. The system of claim 12, wherein the operation database comprises the elements of:

an operating parameters table utilized to control interference detection modes, interference avoidance methods, secondary user information, primary user information; and

a measurements parameter table to determine the operative parameters of the interference detection process ; and

an interference information table to provide information in regard of the interference detected on the at least one communication table; and

a channel data table to provide usable and non-usable communication channel information; and

a channel parameter changes table to hold the collection of the channel anomalies; and

a time window data table to indicate operational periods of a periodically operative primary user; and

a channel periodicity table to hold a set of consecutive time slot values functional in enabling the at least one secondary user and the at least one primary user to use co-operatively the same communication channel; and

a network topology data table to provide information concerning the at least one secondary user, the at least one secondary user devices, and the at least one primary user.

14. The system of claim 11, wherein the at least one interference detection and avoidance wireless device comprises the elements of:

an interference measurement function to selectively measure at least one communication channel operative in the linking of at least two wireless devices of the at least one secondary user; and

an interference avoidance function to perform interference avoidance measures; and

an interference reporting function to assemble and structure messages concerning the results of the interference measurement functions; and

an operation database to hold interference detection parameters, interference avoidance parameters, network information, wireless device information,

available channel information, channel periodicity data, primary user information, measurement results, and general operating parameters.

15. The system of claim 11, wherein the at least one interference detection and avoidance device wireless device further comprising a messaging function to communicate the results of the interference measurements performed by the wireless device to the interference detection and avoidance controller device.

16. The system of claim 14, wherein the interference avoidance function comprises the elements of:

a channel re-assignment function to avoid mutual interference between the at least one secondary user and the at least one primary user by providing the at least one communicating wireless devices of the secondary user with an alternative communication channel ; and

a transmission power adjustment function to prevent interference to the at least one primary user dynamically lowering the transmission, power level of the signal radiated by the at least one secondary user; and

a co-existence function suitably dividing the communication channel into mutually exclusive time slots providing the at least one secondary user and the at least one primary user to utilize the channel co-operatively and alternately.

17. The system of claim 14, wherein the interference measurement function comprises the elements of:

a received signal strength measurement function; and

a received signal period measurement function to examine the power level of the signal received on the at least one communications channel; and

a channel anomalies measuring function to collect and collate channel anomalies during the routine data exchange operations on the at least one communications channel; and

a received signal periodicity identifier function to describe the transmission periods at least one periodically transmitting primary source.

18. The system of claim 11, wherein the at least one primary user interference detection and avoidance controller device is collocated with the at least one primary user interference detection and avoidance wireless device.

19. The system of claim 14, wherein the at least one secondary user is a wireless local area network (WLAN).

20. The system of claim 19, wherein the WLAN is a HiperLAN/2-type network.

21. The system of claim 19, wherein the WLAN is an IEEE 802.11a-type network.

22. The system of claim 19, wherein the WLAN comprises at least one transmitting and receiving wireless devices.

23. The system of claim 19, wherein the WLAN comprises at least one sectorized wireless devices operative in transmitting and receiving via at least one operative sectors having different radiation directionality.

24. The system of claim 19, wherein the WLAN is coupled to a wired communications network.

25. The system of claim 24, wherein the wired communications network is a local area network (LAN).

26. The system of claim 24, wherein the wired communication network is wide area network (WAN).

27. The system of claim 19, wherein the WLAN is operative in communicating interference related information and instruction to other secondary users.

28. The system of claim 11, wherein the at least one primary user is a radar system.

29. The system of claim 28, wherein the radar system is a continuous wave (CW) radar system.

30. The system of claim 28, wherein the radar system is a pulse/sweep radar system.

31. The system of claim 11, wherein the at least one primary user is a satellite feeder system.

32. The system of claim 11, wherein the at least one primary user is an amateur radio service.

33. In a wireless communications environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on a pre-allocated frequency band via an air interface, at least one primary user transmitting and receiving a radio frequency signal on a substantially alike pre-allocated frequency band via an air interface, a method of detecting and avoiding signal interference effected to the at least one primary user by the transmission of the signal emitted by the at least one secondary user, the method comprising the steps of:

dynamically and controllably measuring at least one communications channel utilized the at least one primary user; and

analyzing the results of the channel measurements performed on the at least one communications channel utilized by the at least one primary user in order to determine the interference status of the measured channel; and

communicating the results of the analysis to the at least one secondary user interference detection and avoidance controller device; and

dynamically maintaining interference detection and avoidance information concerning the identity, attributes, locations, directionality, and activity of at least one wireless device associated with at least one secondary user interfering with the at least one measured communications channel associated with the at least one primary user;

selectively and controllably performing interference avoidance measures by the at least one secondary user interference detection and avoidance controller device to prevent signal interference in the at least one communications channel associated with the at least one primary user.

34. The method of claim 33 further comprising building and maintaining a functional RF topology mapping of the communication environment.

35. The method of claim 33 further comprising selectably and controllably performing a signal co-existence option to enable shared utilization of the at least one communications channel by the at least one primary user and the at least one secondary user.

36. The method of claim 35, wherein the co-existence of the at least one secondary user with the at least one primary user on the substantially alike at least one communications channel is accomplished by selectively adjusting the transmission power level of the signals radiated by the at least one secondary user.

37. The method of claim 35, wherein the co-existence of the at least one secondary user with the at least one primary user on the substantially alike at least one communications channel is accomplished by selectively ceasing transmission of the signals by the at least one secondary user for the duration of the signals transmitted by the at least one primary user.

38. The method of claim 35, wherein the adjustment of the transmission power level performed specifically for at least one directional sector associated with at least one wireless device associated with the at least one secondary user.

39. The method of claim 35, wherein the interruption of the transmission of the signals by the at least one secondary user performed specifically on at least one directional sector associated with at least one wireless device associated with the at least one secondary user.

40. In a communication environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on a allocated frequency band via a link, at least one primary user transmitting and receiving a radio frequency signal on a substantially same allocated frequency band via an unbounded medium, a system for the dynamic detection of reciprocal signal interference produced substantially simultaneously by the at least one secondary user and at least one primary user, the system comprising the elements of:

at least one primary user interference detection and avoidance controller device to communicate with and control at least one secondary user activity detection wireless device; and

at least one secondary user activity detection wireless device to perform measurements on at least one communication channel utilized by the primary user in order to detect interference produced by the activity of at least one secondary user.

41. The system of claim 40, wherein the at least one primary user interference detection and avoidance device is collocated with the at least one primary user.

42. The system of claim 40, wherein the at least one secondary user is a wireless local area network (WLAN).

43. The system of claim 40, wherein the at least one secondary user is a cellular telephone network.

44. The system of claim 40, wherein the at least one secondary user is a Wireless Personal Area Network (WPAN).

45. The system of claim 42, wherein the WLAN comprises at least one transmitting and receiving wireless device.

46. The system of claim 42, wherein at WLAN comprises at least one sectorized wireless device operative in transmitting and receiving in via the at least one sector having specific radiation directionality.

47. The system of claim 40, wherein the at least one primary user is a radar system.

48. The system of claim 43, wherein the radar system comprises a sweep/pulse radar.

49. The method of claim 1, wherein the wireless communications environment accommodates at least two secondary users.

50. The method of claim 1, wherein the method of detecting and avoiding interference is operative in the detection and avoidance of reciprocal signal

interference produced by the radiation of radio frequency signals emitted by the at least two secondary users.

51. The system of claim 11, wherein the communications environment accommodates at least two secondary systems.

52. The system of claim 11, wherein the system for the detection and avoidance of the signal interference is operative in detecting and avoiding signal interference between at least two secondary systems.

53. The method of claim 33, wherein the wireless communications environment accommodates at lest two secondary users.

54. The system of claim 40, wherein the communication environment accommodates at least two secondary users.

55. The system of claim 12, wherein the operation database is implemented on the primary user detection and avoidance wireless device.

56. The system of claim 13, wherein the network topology data table provides information concerning at least two secondary users and at least two secondary users devices.

57. The system of claim 16, wherein the channel re-assignment function is operative in avoiding mutual interference between at least two secondary users.

58. The system of claim 16, wherein the co-existence function is implemented on the interference detection and avoidance controller device.

59. The system of claim 19, wherein the at least one secondary user is a cellular phone network.

60. The system of claim 19, wherein the at least one secondary user is a Wireless Personal Area Network (WPAN).

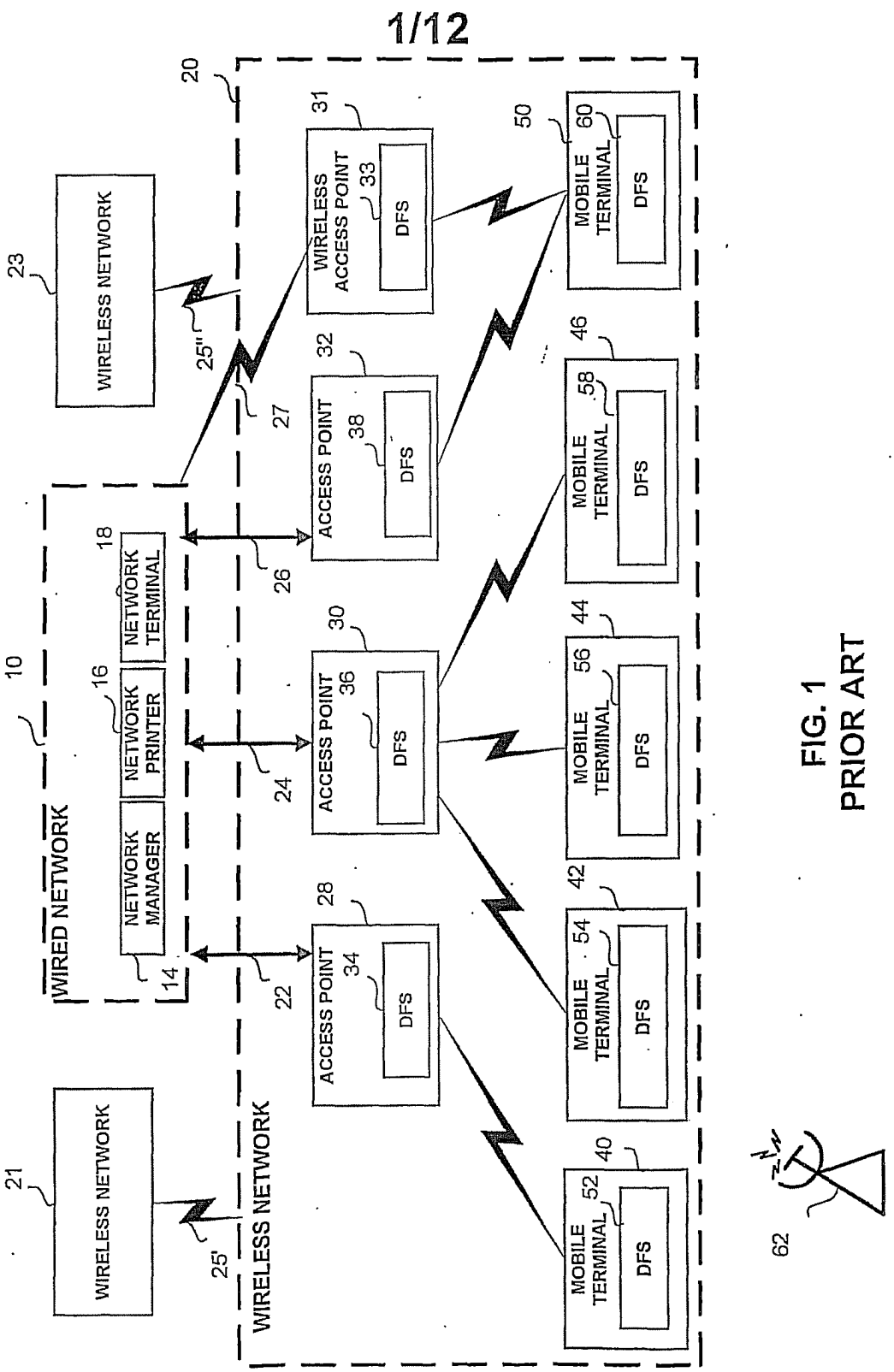


FIG. 1
PRIOR ART

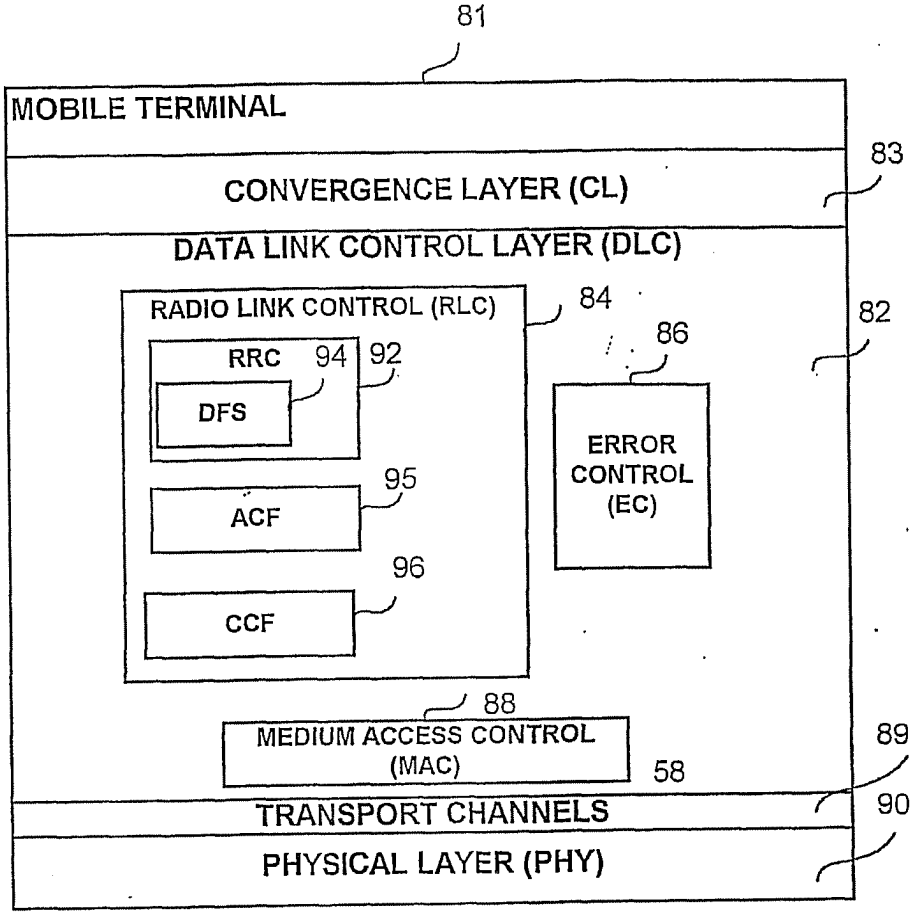


FIG. 2
PRIOR ART

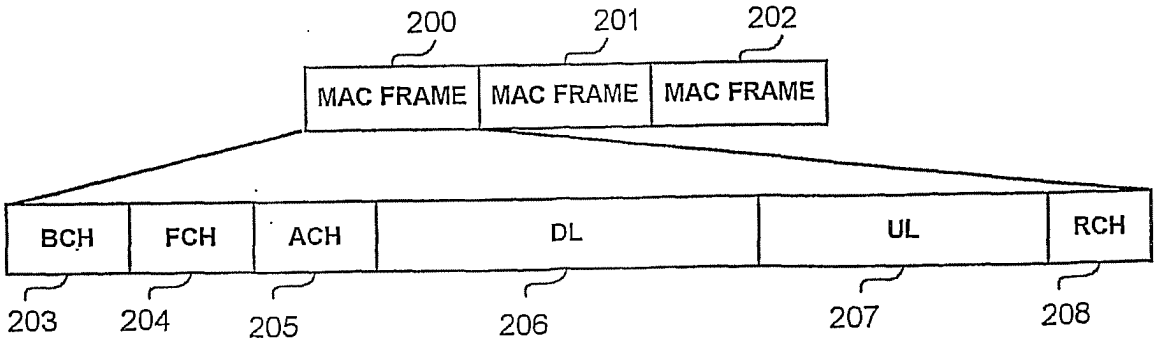


FIG. 3
PRIOR ART

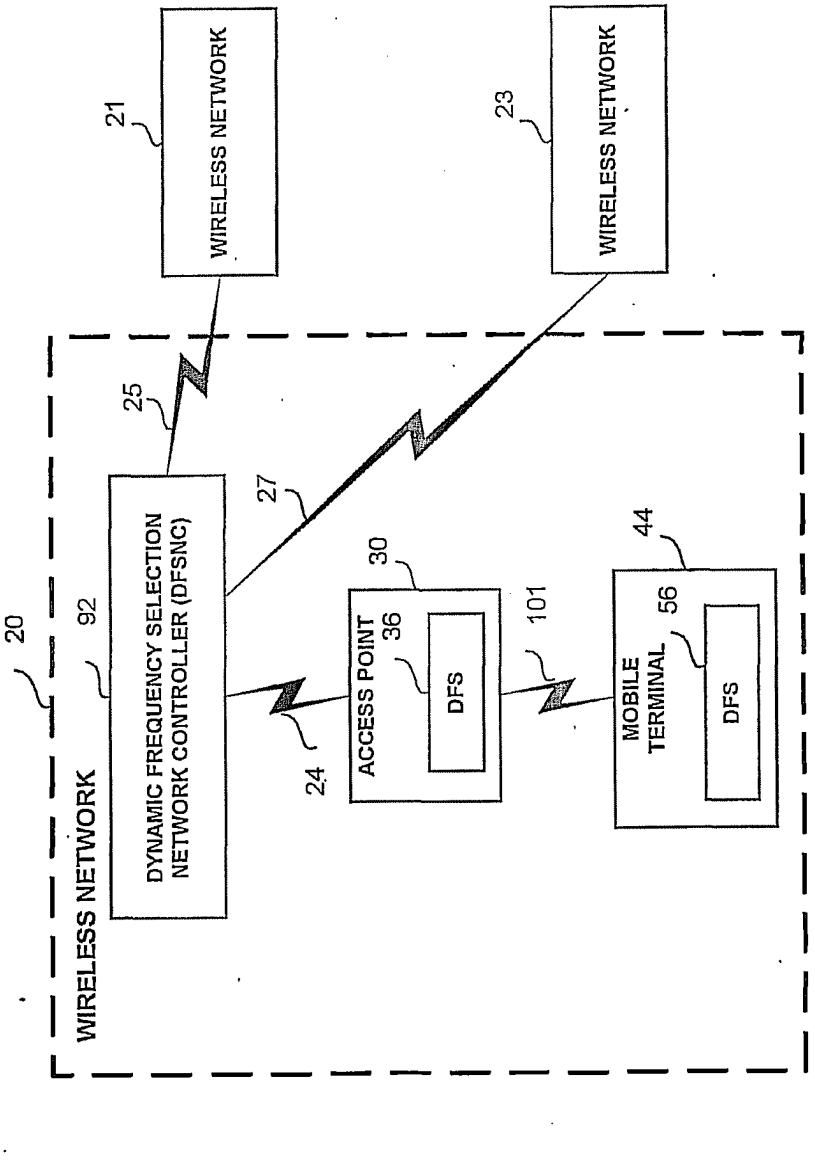

WIRELESS NETWORK
21
WIRELESS NETWORK
23
25
27
20
WIRELESS NETWORK
92
DYNAMIC FREQUENCY SELECTION NETWORK CONTROLLER (DFSNC)
24
30
ACCESS POINT
36
DFS
101
44
MOBILE TERMINAL
56
DFS
78

FIG. 4

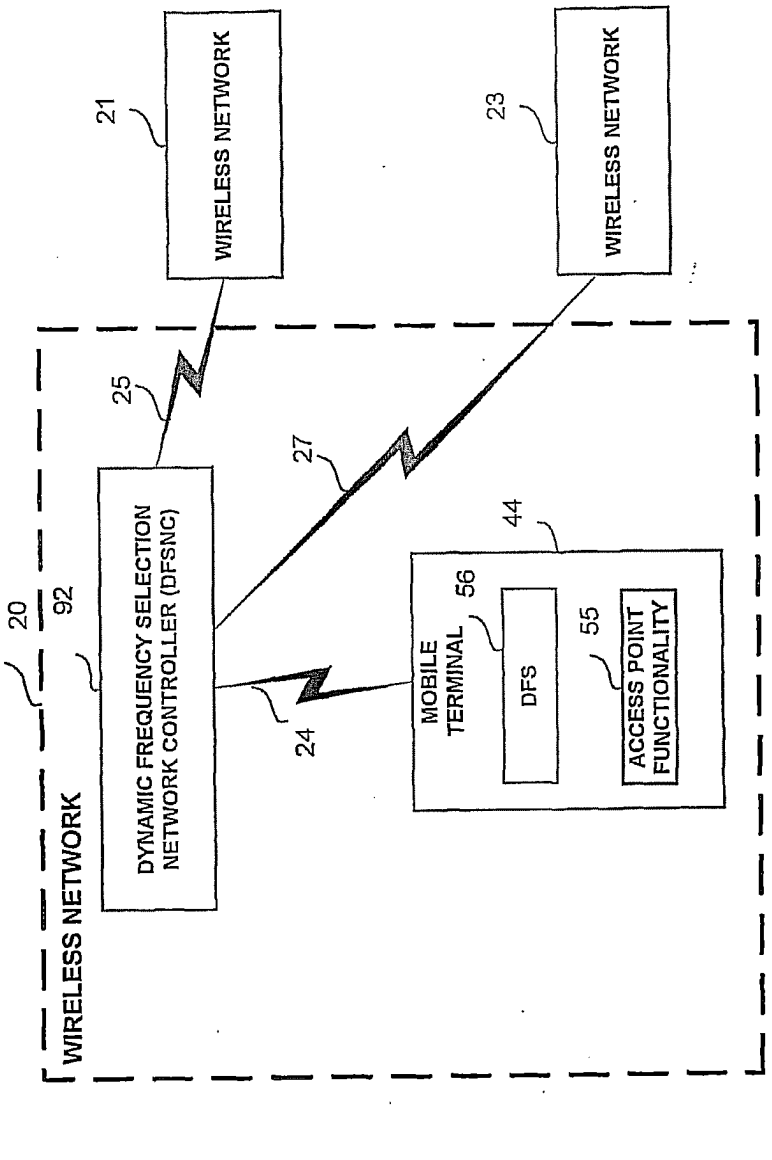

WIRELESS NETWORK
21
WIRELESS NETWORK
23
25
27
20
92
DYNAMIC FREQUENCY SELECTION NETWORK CONTROLLER (DFSNC)
24
44
MOBILE TERMINAL
56
DFS
55
ACCESS POINT FUNCTIONALITY
78

FIG. 4A

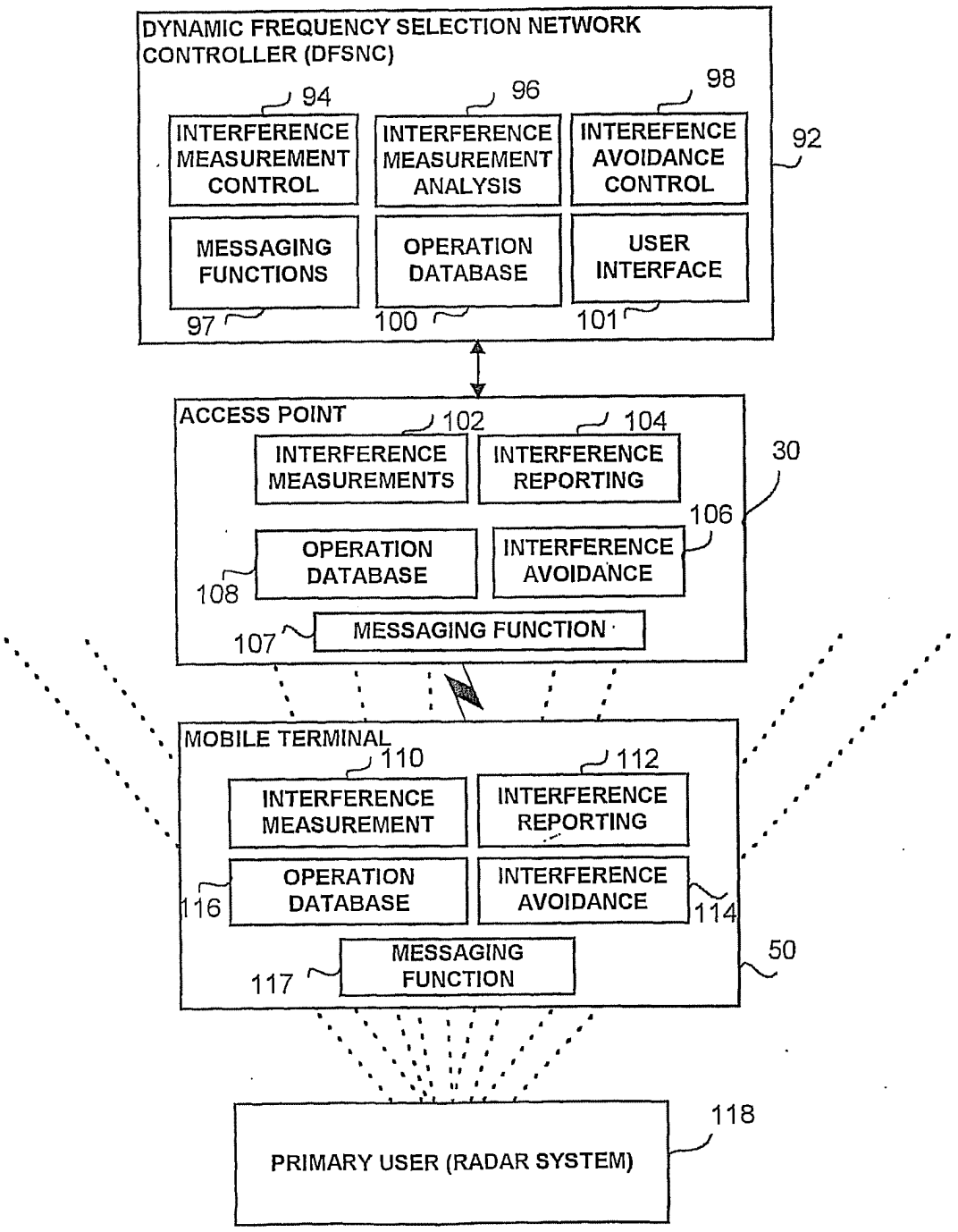

DYNAMIC FREQUENCY SELECTION NETWORK CONTROLLER (DFSNC)
94
96
98
INTERFERENCE MEASUREMENT CONTROL
INTERFERENCE MEASUREMENT ANALYSIS
INTEREFENCE AVOIDANCE CONTROL
92
MESSAGING FUNCTIONS
OPERATION DATABASE
USER INTERFACE
97
100
101
ACCESS POINT
102
104
INTERFERENCE MEASUREMENTS
INTERFERENCE REPORTING
30
106
OPERATION DATABASE
INTERFERENCE AVOIDANCE
108
MESSAGING FUNCTION
107
MOBILE TERMINAL
110
112
INTERFERENCE MEASUREMENT
INTERFERENCE REPORTING
OPERATION DATABASE
INTERFERENCE AVOIDANCE
116
114
MESSAGING FUNCTION
117
50
PRIMARY USER (RADAR SYSTEM)
118

FIG. 5

6/12

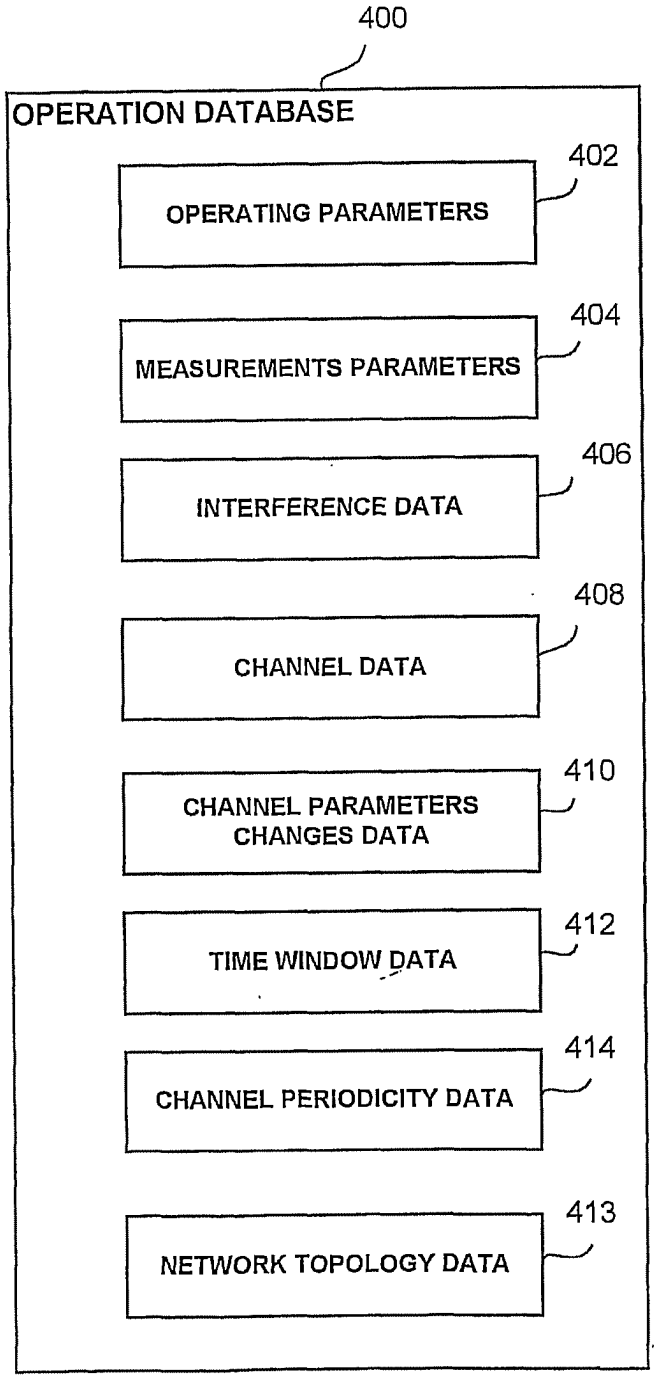

400
OPERATION DATABASE
402
OPERATING PARAMETERS
404
MEASUREMENTS PARAMETERS
406
INTERFERENCE DATA
408
CHANNEL DATA
410
CHANNEL PARAMETERS CHANGES DATA
412
TIME WINDOW DATA
414
CHANNEL PERIODICITY DATA
413
NETWORK TOPOLOGY DATA

FIG. 6

7/12

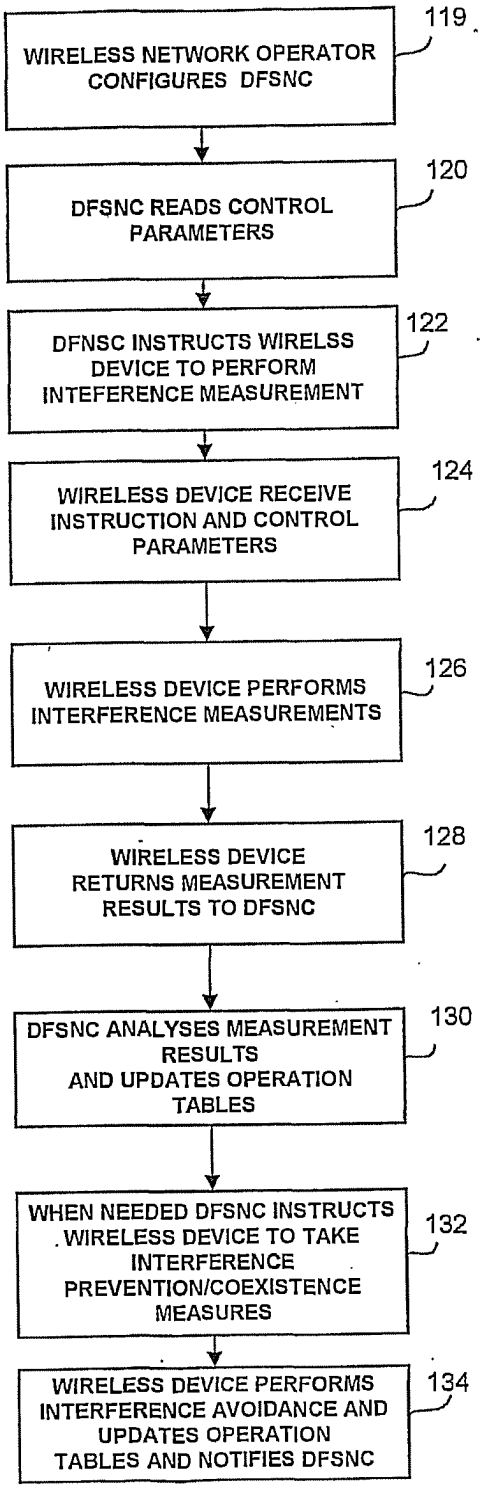

WIRELESS NETWORK OPERATOR CONFIGURES DFSNC
119
DFSNC READS CONTROL PARAMETERS
120
DFNSC INSTRUCTS WIRELSS DEVICE TO PERFORM INTEFERENCE MEASUREMENT
122
WIRELESS DEVICE RECEIVE INSTRUCTION AND CONTROL PARAMETERS
124
WIRELESS DEVICE PERFORMS INTERFERENCE MEASUREMENTS
126
WIRELESS DEVICE RETURNS MEASUREMENT RESULTS TO DFSNC
128
DFSNC ANALYSES MEASUREMENT RESULTS AND UPDATES OPERATION TABLES
130
WHEN NEEDED DFSNC INSTRUCTS WIRELESS DEVICE TO TAKE INTERFERENCE PREVENTION/COEXISTENCE MEASURES
132
WIRELESS DEVICE PERFORMS INTERFERENCE AVOIDANCE AND UPDATES OPERATION TABLES AND NOTIFIES DFSNC
134

FIG. 7

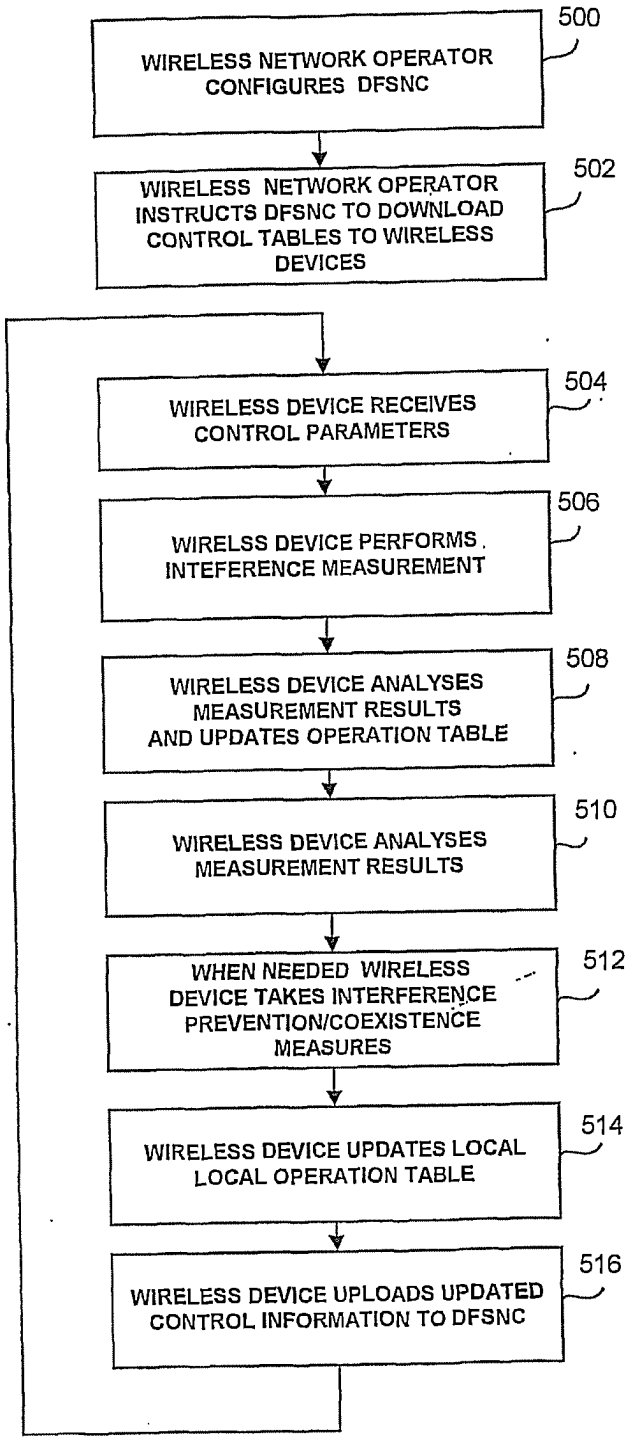

WIRELESS NETWORK OPERATOR CONFIGURES DFSNC
500
WIRELESS NETWORK OPERATOR INSTRUCTS DFSNC TO DOWNLOAD CONTROL TABLES TO WIRELESS DEVICES
502
WIRELESS DEVICE RECEIVES CONTROL PARAMETERS
504
WIRELSS DEVICE PERFORMS INTEFERENCE MEASUREMENT
506
WIRELESS DEVICE ANALYSES MEASUREMENT RESULTS AND UPDATES OPERATION TABLE
508
WIRELESS DEVICE ANALYSES MEASUREMENT RESULTS
510
WHEN NEEDED WIRELESS DEVICE TAKES INTERFERENCE PREVENTION/COEXISTENCE MEASURES
512
WIRELESS DEVICE UPDATES LOCAL LOCAL OPERATION TABLE
514
WIRELESS DEVICE UPLOADS UPDATED CONTROL INFORMATION TO DFSNC
516

FIG. 8

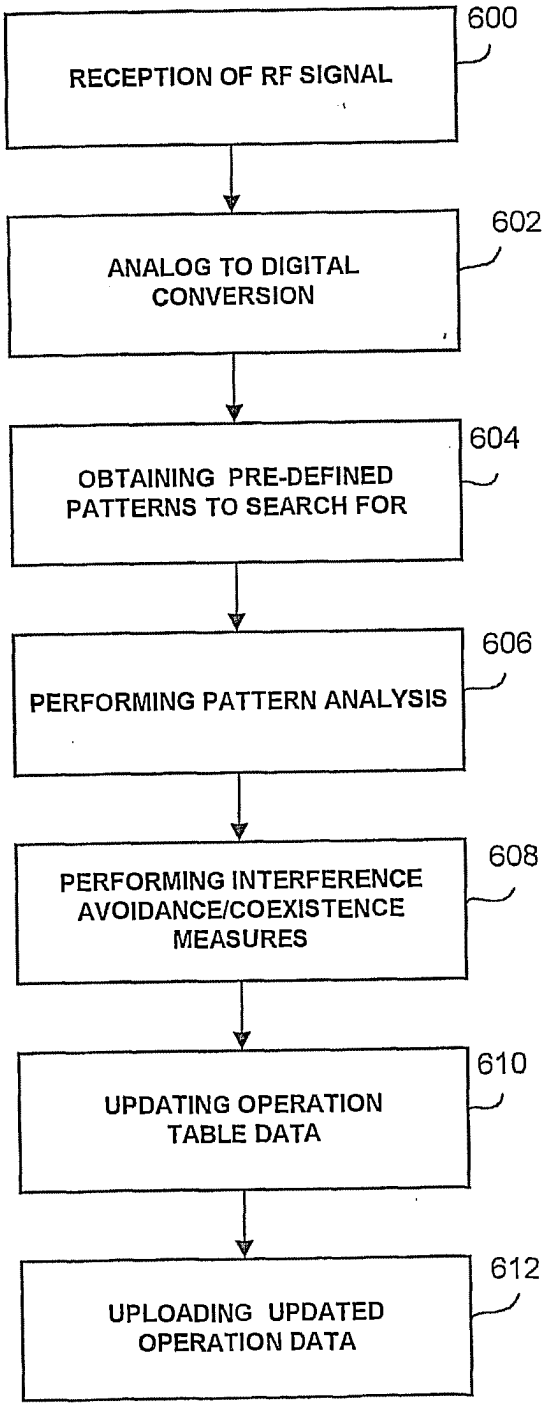

RECEPTION OF RF SIGNAL
600
ANALOG TO DIGITAL CONVERSION
602
OBTAINING PRE-DEFINED PATTERNS TO SEARCH FOR
604
PERFORMING PATTERN ANALYSIS
606
PERFORMING INTERFERENCE AVOIDANCE/COEXISTENCE MEASURES
608
UPDATING OPERATION TABLE DATA
610
UPLOADING UPDATED OPERATION DATA
612

FIG. 9

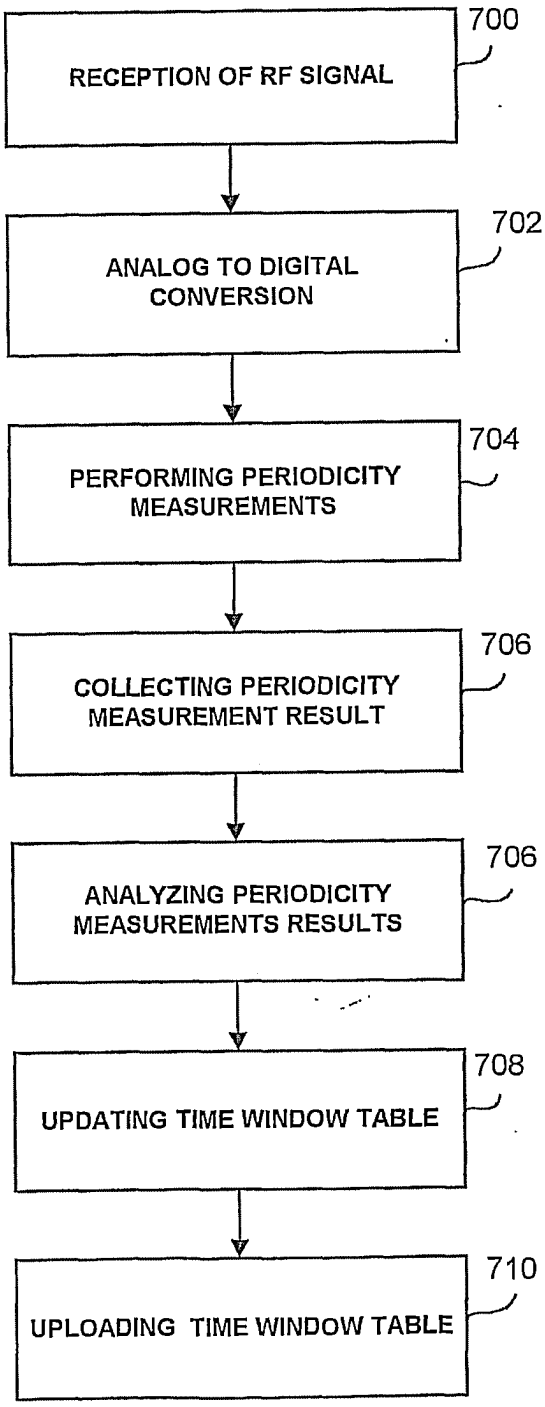

RECEPTION OF RF SIGNAL
700
ANALOG TO DIGITAL CONVERSION
702
PERFORMING PERIODICITY MEASUREMENTS
704
COLLECTING PERIODICITY MEASUREMENT RESULT
706
ANALYZING PERIODICITY MEASUREMENTS RESULTS
706
UPDATING TIME WINDOW TABLE
708
UPLOADING TIME WINDOW TABLE
710

FIG. 10

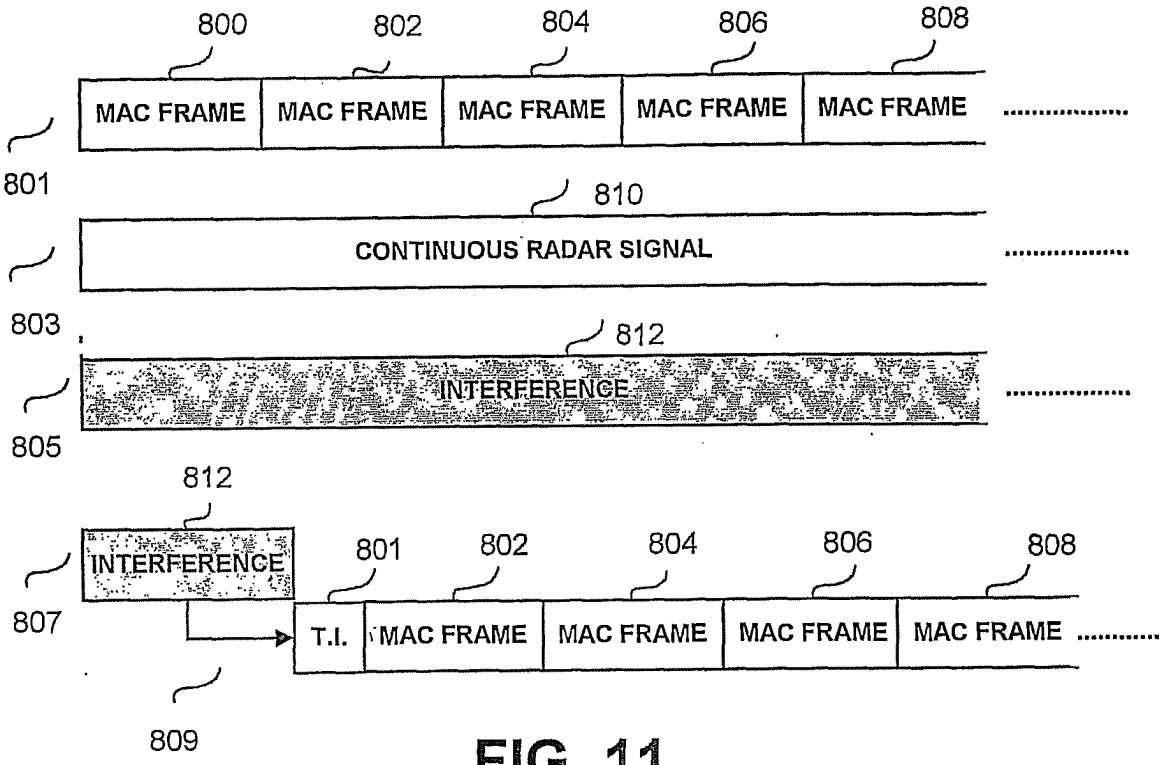

800
802
804
806
808
MAC FRAME
MAC FRAME
MAC FRAME
MAC FRAME
MAC FRAME
801
810
CONTINUOUS RADAR SIGNAL
803
812
INTERFERENCE
805
812
INTERFERENCE
801
802
804
806
808
807
T.I.
MAC FRAME
MAC FRAME
MAC FRAME
MAC FRAME
809

FIG. 11

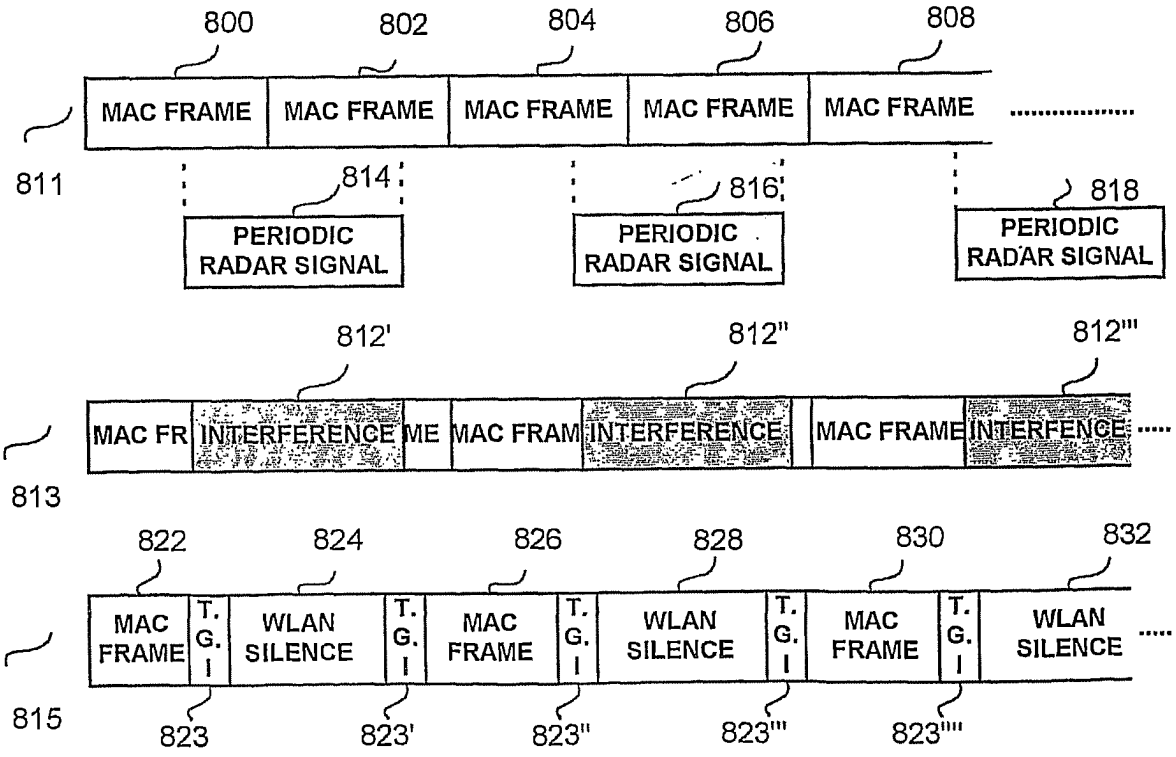

800
802
804
806
808
MAC FRAME
MAC FRAME
MAC FRAME
MAC FRAME
MAC FRAME
811
814
816
818
PERIODIC RADAR SIGNAL
PERIODIC RADAR SIGNAL
PERIODIC RADAR SIGNAL
812'
812"
812'"
MAC FR
INTERFERENCE
ME
MAC FRAM
INTERFERENCE
MAC FRAME
INTERFENCE
813
822
824
826
828
830
832
MAC FRAME
T. G. I
WLAN SILENCE
T. G. I
MAC FRAME
T. G. I
WLAN SILENCE
T. G. I
MAC FRAME
T. G. I
WLAN SILENCE
815
823
823'
823"
823'"
823""

FIG. 12

12/12

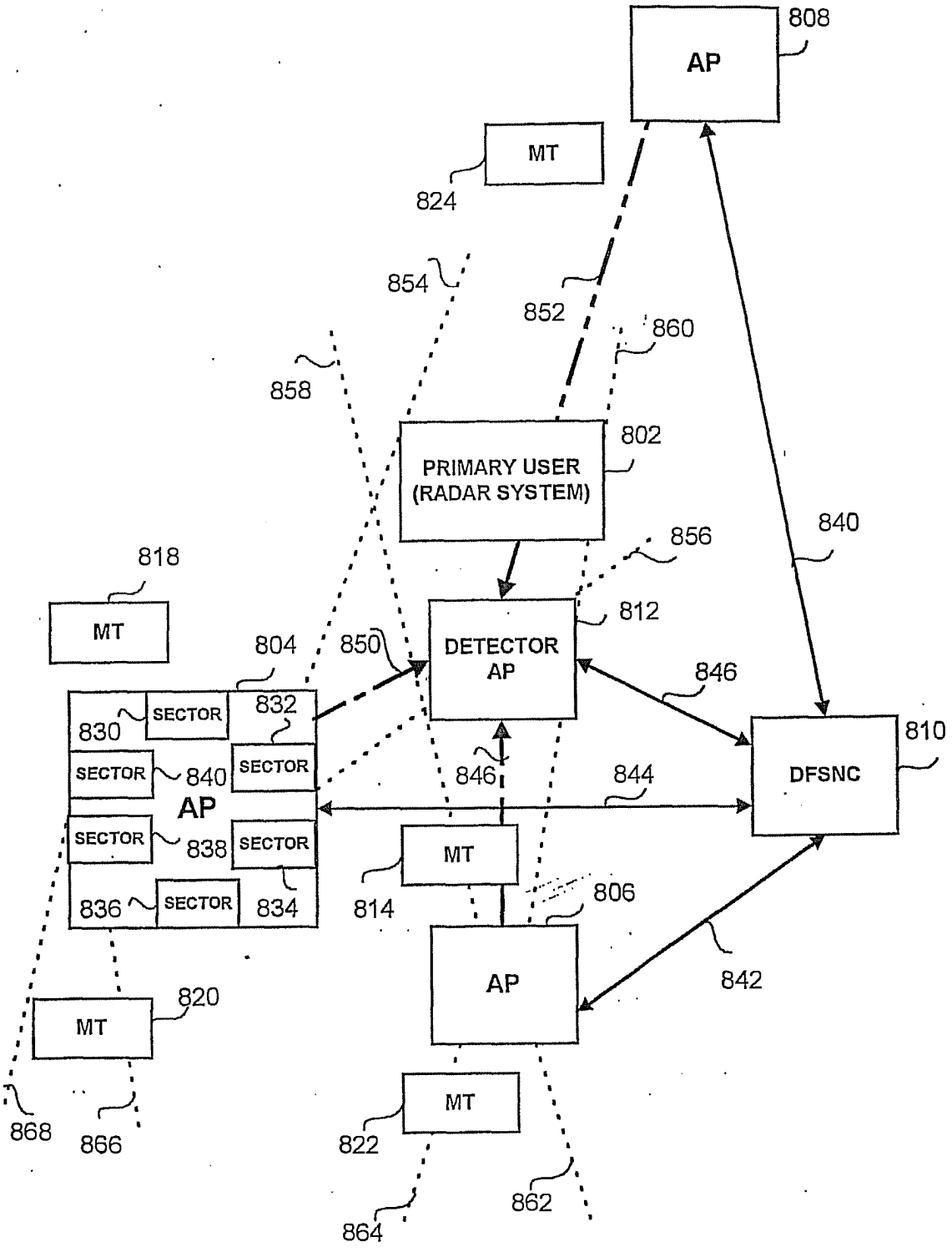

AP
808
MT
824
854
852
860
858
PRIMARY USER
(RADAR SYSTEM)
802
840
856
818
MT
812
804
850
DETECTOR
AP
846
SECTOR
832
830
SECTOR
SECTOR
840
846
844
AP
SECTOR
838
SECTOR
DFSNC
810
MT
814
836
SECTOR
834
806
AP
842
820
MT
868
866
MT
822
862
864

FIG. 13

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/IL 01/00577

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L12/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01 37463 A (NOKIA CORP ;SALOKANNEL JUHA (FI); LAPPETELAEINEN ANTTI (FI); SMOLA) 25 May 2001 (2001-05-25) page 5, line 4 -page 8, line 6 page 10, line 5 - line 25	1-9,11, 14-60
Y	page 14, line 6 -page 16, line 2	10,12,13
X	WO 00 70812 A (NOKIA CORP ;LAPPETELAEINEN ANTTI (FI); SMOLANDER VISA TAPIO (FI)) 23 November 2000 (2000-11-23) page 14, line 7 -page 15, line 20 figure 2	11,40
Y	WO 01 24455 A (MOBILIAN CORP) 5 April 2001 (2001-04-05) abstract	10,12,13

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 February 2002	01/03/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Schneider, G

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	"Broadband Radio Access Networks (BRAN);HIPERLAN Type 2; System Overview" , ETSI TR 101 683 V1.1.1, XX, XX, PAGE(S) 1-20 XP002176358	

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/IL 01/00577

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0137463 A	25-05-2001	FI 992473 A	19-05-2001
		AU 1527401 A	30-05-2001
		WO 0137463 A1	25-05-2001
WO 0070812 A	23-11-2000	FI 991102 A	13-11-2000
		FI 991240 A	13-11-2000
		AU 4570800 A	05-12-2000
		EP 1177652 A1	06-02-2002
		WO 0070812 A1	23-11-2000
WO 0124455 A	05-04-2001	AU 7622200 A	30-04-2001
		AU 7734300 A	30-04-2001
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		AU 7734500 A	30-04-2001
		AU 7736800 A	30-04-2001
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		WO 0124458 A1	05-04-2001
		AU 7736600 A	06-06-2001
		WO 0135578 A1	17-05-2001

Electronic Acknowledgement Receipt

EFS ID:	2836510
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and apparatus for determining path loss by active signal detection
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	39290
Filer:	Mark Charles Comtois/Jacquetta McBee
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND07 061 US
Receipt Date:	08-FEB-2008
Filing Date:	
Time Stamp:	17:43:48
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement Letter	AND01_061_IDS.pdf	559985 cd92012f163c465e9b9774c84463dda0051782c1	no	5

Warnings:	
Information:	

2	Foreign Reference	References.pdf	16783956 14c6e194d36d5d16b170494ffed299dbb4be674f	no	169

Warnings:	
Information:	
Total Files Size (in bytes):	17343941

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of John ARPEE, et al.

Serial No.: 11/920,075 Art Unit: Unassigned

Filed: 08 November 2007 Examiner: Unassigned

Title: **METHOD AND APPARATUS FOR DETERMINING COUPLED PATH LOSS**

TRANSMITTAL

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith is an Information Disclosure Statement pursuant to 37 CFR §1.56 in connection with the above-identified application .

[X] No fee required:

[ ] Filed within three months of filing application, or

[ ] Certification made.

[X] Filed prior to first Office Action.

No fees are believed to be due with this submission. However, should any fees be required, the Commissioner is hereby authorized to charge such required fees to **Deposit Account No. 04-1679.**

Respectfully submitted,

/mcc/
Mark C. Comtois Reg. No. 46,285

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Washington, D.C. 20006
Telephone: (202) 776-7800
Facsimile: (202) 776-7801
Dated: February 8, 2008

PTO/SB/08a (05-07)
Approved for use through 09/30/2007. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11920075
	Filing Date	2007-11-08
	First Named Inventor	Arpee, et al.
	Art Unit	Unassigned
	Examiner Name	Unassigned
	Attorney Docket Number	AND01 062

U.S.PATENTS						
Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6236365	B1	2001-05-22	LeBlanc, et al.	
	2	6556832	B1	2003-04-29	Soliman	
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	Attorney Docket Number	AND01 062

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
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☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

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Name/Print	Mark C. Comtois	Registration Number	46,285

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(54) **Path loss data normalization for growth management of a cellular system**

(57) The RF propagation of a wireless system is normalized to remove the directionality, orientation and gain characteristics of the antennae deployed in the system to allow for enhanced growth management of a wireless system. RF propagation data for a wireless system is gathered by any collection method. For example, drive test of the cellular system can be performed to receive and measure the signal strength throughout the system to determine the receive power of signals from cell sites in the system. Other methods such as uplink collection, E911 data can be used. After measurements of the system are collected, the data is post-processed to remove the effective gain achieved by each antenna associated with each of the signals to normalize the signals to a conceptual antenna having an isotropic radiation pattern. A database of the antenna gain and deployment patterns of the actual antennae in the system is used to normalize the data. The expected receive power of the conceptual antennae signals at the locations throughout the cellular system are determined using a propagation model. The modeled conceptual signals correspond to the measured signals and the characteristics of the conceptual antennae substituted to model the conceptual signals. The Propagation modeling can be revised through analysis of the correlation with the measured data. Once the system has been normalized and the propagation model is acceptably accurate, the system designer can model data corresponding to a variety of antenna gain, directionality and orientation choices to effectively enhance growth management through effective redeployment and specification of antennae without the need to physically experiment with antenna of varying characteristics and perform numerous data collections after antennae substitutions or reconfigurations. A final data collection such as a final drive test can be performed after implementation of a new antenna deployment.

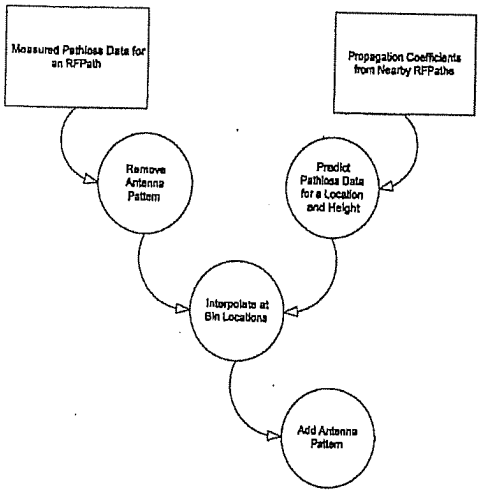


Figure 1

EP 1 191 804 A2

Description

REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of provisional patent application 60/235,435, filed September 26, 2000.

FIELD OF THE INVENTION

[0002] This invention relates to the management of channel interference in a cellular telephone systems and, more particularly, to a the improved analysis of the RF propagation in a cellular system for improved deployment of antenna designs, configurations and orientations.

BACKGROUND OF THE INVENTION

[0003] Present day commercial mobile communication systems typically have a plurality of fixed-location base stations arranged in patterns in which each base station has a plurality of antennae divided among a number of sectors, to transmit and receive on a number of frequencies. The distribution of antennae, sectors and assignment of frequencies as well as the selection of antennae is intended to be optimize coverage. The channels used by a base station are separated from one another in frequency sufficiently that signals on any channel do not interfere with signals on another channel from that base station.

[0004] However, in order to allow mobile units to transmit and receive telephone communications over a wide area, each cell is normally positioned with its area of coverage adjacent and overlapping the areas of coverage of a number of other cells. When a mobile unit moves from an area covered by one base station to that covered by another, the communication is transferred from the former station to the latter in an area where the coverage from the different cells overlaps. Because of this overlapping coverage, the channels allotted to the cells are carefully selected so that adjoining cells do not transmit or receive on the same frequencies. The channels used by adjoining base stations are also supposedly separated from one another in frequency sufficiently that signals from any base station do not interfere with signals from another nearby base station. This is typically accomplished by assigning channels to some central cell, which are widely separated in frequency in the manner described above, and then assigning channels to the cells surrounding that central cell using a pattern to optimize coverage and minimize interference. The pattern of channel assignments continues similarly in the other cells adjoining the central cell. It will be noted that the technique of separating each channel assigned to any cell from the next channel assigned to that cell allows a number of cells having entirely different frequencies to be positioned in a system before any frequency must be repeated. The pattern is often called a frequency reuse pattern and may vary in many ways.

[0005] In some systems, especially those with cells in urban areas carrying heavy traffic, each cell is further divided into three sectors each of which includes assignment of channels. The antennas of each sector are typically arranged to provide 120 degrees of coverage within the cell. With slightly over four hundred channels available, a repeating pattern may be achieved in a hexagonal arrangement, using seven cells that each have three sectors.

[0006] In theory, this form of cell arrangement and the channel assignment scheme allow the frequency reuse pattern to be repeated at distances sufficiently separated to minimize interference between mobile units.

[0007] Unfortunately, interference does occur for a number of reasons. Antenna patterns, power levels, scattering, and wave diffraction differ from cell to cell. Buildings, hills, mountains, foliage, and other physical objects cause the transmitted signal strength to vary over the region covered by a cell. Consequently, the boundaries at which the signal strength of a channel falls below a level sufficient to support communications with a mobile unit vary widely from cell to cell. For this reason, cells adjacent to one another do not, in fact, typically form the precise geometric boundaries suggested above and coverage gaps can occur. Since cell boundaries must overlap to provide complete coverage of an area and the boundaries of cells are imprecisely defined, overlapping coverage often occurs between channels. As a result, channels having an overlapping coverage area may interfere with each other.

[0008] The odd-shaped boundaries of the cells and the necessity that the cells have overlapping coverage areas increases the likelihood that multiple signals on the same channel will interfere with each other, even though they are generated by non-adjacent or widely separated cells. This is especially true when a sectored cell pattern is used because the cells are much closer to each other than in a simple cell pattern. A signal originating from a remote cell (sometimes referred to as an interferor I) may interfere with a second stronger signal carrying a mobile transmission (sometimes referred to as the carrier signal S), on the same channel, when the difference in signal strength between the two signals is less than some threshold level (typically measured in decibels as the S/I ratio). Moreover, signals on adjacent channels are carried by abutting cells in accordance with the above-described frequency reuse pattern. Typically, frequency filtering is insufficient to eliminate the reception of adjacent frequencies entirely. Consequently,

there may be adjacent channel interference. A signal on an adjacent frequency may interfere with a communication link when the difference in signal strength between the two signals is less than some second, usually lower, threshold level. Normally an adjacent channel may have a signal strength closer to that of the communication link without causing significant interference because the frequency filtering of the receivers eliminates a substantial portion of the adjacent channel's signal strength.

[0009] In order to optimize coverage and to overcome interference when designing or reconfiguring the coverage of a mobile cellular system, a cellular system operator uses predictive software to determine what signal strength may be expected at locations throughout the cellular system from each of a particular set of cells. This software can utilize data describing the physical characteristics of the terrain surrounding each cellular site and the physical characteristics of the cellular station to plot predicted signal strengths around the cellular site. These signal strength predictions are then overlaid on a graphical plot to determine where antennas should be placed to provide optimum coverage, with appropriate overlapping areas for hand-offs. Once the antenna sites have been determined, the operator assigns channel groups to the cells in accordance with the technique described above.

SUMMARY OF THE INVENTION

[0010] It is common that coverage cannot be optimized and the expected interference among signals cannot be eliminated using predictive software alone. To discover the differences between the predicted system and realized system characteristics, it may be necessary to perform data collection to measure the signal strength of each sector at multiple points within the region of interest and compare these measurements with the predicted characteristics. Data collection can be accomplished by a number of methods which measure the signal strength of channels.

[0011] During the data collection to determine RF signal strengths, indication of RF signal strength at a plurality of locations throughout the system is collected. In one form of collection, referred to as a drive test, a mobile unit with a scanning receiver drives over the roads of the test region. The scanning receiver scans, receives, identifies and measures the strength of signals transmitted by the cells and/or sectors as the mobile unit moves throughout the system. For each measurement point, this provides a strength measurement of the signal generated by each cell. These strength signals are recorded for the cells and sectors from which they emanate. The collected data indicates RF coverage for the system. Also, by comparing the relative signal strengths of signals originating from different sectors and measured at a common point, it is possible to determine which sectors may potentially interfere with each other in the event they use a common or adjacent channel frequency. Thus, the effective coverage pattern may be used to optimize coverage and the actual interference points may be used to determine whether sufficient interference exists to change the channel group assigned to the particular area. The collected data can also be used for a number of other analysis or implementation applications. The present invention does not rely on any particular data collection nor is the present invention limited to particular analysis application. The present invention is a post-processing technique which can be widely applied to enhance network growth management.

[0012] If the geographic region of interference is sufficiently great, the channel assignment pattern for the system may be changed. That is, a frequency or a frequency group assigned to an antenna, a sector or a cell (or cells) is typically changed in its entirety to another non-interfering frequency group. Sometimes, interference may be eliminated by changing the cell characteristics (such as antenna tilt or power used in particular cells) without changing the channel assignment.

[0013] The present invention processes collected data after collection and prior to additional analysis. The present invention overcomes the problems of the prior art when designing or reconfiguring antenna gain patterns, directionality, orientation and selection, by using both measured and predicted signal level data for a system to characterize interference between cellular channels. The invention characterizes the expected interference based upon dynamic information corresponding to in-use performance. The method of the present invention also analyses and normalizes reception data to remove the effect of antenna directionality from the measured and modeled propagation profile of a cellular system. Moreover, the invention may be used to adaptively reassign radio frequency (RF) channels and power settings based upon the measured system performance and prospective parametric variations, to maximize capacity while minimizing overall interference within the system. The analysis method herein also allows for system expansion planning and for determination of optimum antenna gain pattern selection.

[0014] When collecting data for analysis and optimization of a wireless system, measured path loss data may be used as the foundation for analyzing cellular systems. Path loss is defined as the attenuation between a source antenna (sector) and a point on the terrain of the wireless system. The path loss is measured by subtracting the Received Signal Strength Indicator (RSSI) of a signal, at a location on the terrain, from a known transmitted signal level for the received signal.

[0015] The path loss equation may be expressed as:

$$\text{Path Loss [dB]} = P_{tx}\text{ [dBm]} - \text{RSSI [dBm]}$$

where,

P_{tx} is the transmitted power

[0016] RSSI values can be obtained at various locations of a cellular system by any desired method or means.

[0017] Once data has been collected, it is post processed. The post processing involves associating each measurement with a sector transmission so that the path loss may be calculated. The association includes matching a measured RF channel with an RF channel used in a sector. The path loss calculation requires knowledge of at least one reference RF channel used in a sector and its transmit power.

[0018] To completely analyze a cellular system, it is necessary to have path loss information, at each measurement location, for sectors that may serve and sectors that may interfere at the particular location. For example, if a system requires a Signal to Interference ratio (S/I) of 20 dB for interference-free communication, the collection must obtain measurements of sector signals that are discernable at the location and have RSSI power levels within 20 dB of the serving signal level. With this information, it is possible to automate optimization tasks, such as determining frequency and power assignments that provide a desired quality of service.

[0019] In reality, it is not always possible to acquire measured path loss information at every potential measurement point. Therefore, the present invention can augment the acquirable measured path loss information with predicted path loss information obtained using a propagation model. A linear regression analysis can also be applied to the preliminary results provided by the propagation model to better match the propagation model to the realized cellular system. Other techniques such as geostatistical analysis can also be used, as can interactive interpolation of weighted measured and propagation data. Once the propagation model is refined, the expected path loss information produced by the model is integrated with the measured information. Thereafter, the combined information may be used to improve or model the performance of the cellular system.

[0020] As described above, the path loss is measured by subtracting the Received Signal Strength Indicator (RSSI) of a signal, at a location on the terrain, from a known transmitted signal level for the received signal and may be expressed by the equation:

$$\text{Path Loss [dB]} = P_{tx}\text{ [dBm]} - \text{RSSI [dBm]},$$

where P_{tx} is the transmitted power

[0021] Since P_{tx} is the transmitted power radiated by the transmission antenna, the path loss equation expressed above does not provide the propagation path loss. Instead, the equation provides the combined path loss for the RF link comprising the transmission antenna and the propagation medium, assuming the loss of the receiver system has been factored into the value for RSSI. The propagation path loss may be obtained from the above-described equation by factoring out the gain provided by the transmission antenna. Once the antenna gain is removed from the path loss calculation for the RF link, the resulting propagation path loss value may be used to model the propagation characteristics of a signal communicated between the transmit and receive points without regard to the gain or beam pattern of the transmission antenna.

[0022] An embodiment of the invention is a process for optimizing the performance of a wireless communication system, employing a number of techniques for determining improved antenna distribution and orientation, including: identifying a drive test region; measuring a signal from each of a plurality of sectors of a plurality of cell sites for the drive test region, to determine the receive power of the measured signals; removing the effective antenna gain associated with each of the measured signals to normalize each of the measured signals to a conceptual antenna having an isotropic radiation pattern; correlating each of the measured signals with the corresponding modeled conceptual signal; revising the propagation model, based on the correlation between each measured signal with the corresponding modeled conceptual signal, to create a revised propagation model that better predicts an expected path loss of the conceptual signal; applying the revised propagation model to the conceptual signal from each sector of the plurality of sectors to determine the predicted path loss to a number of additional non-overlapping spatial bins; planning antenna variations, changes and substitutions based on the conceptual model to enhance coverage through increased effective use of directional antennas, antenna gain patterns and antenna orientation; applying the revised propagation model to a planned signal from each sector of a planned plurality of sectors to determine the expected path loss of the planned signal to each of the plurality of bins; and/or repeating the steps a number of times to improve a co-channel signal-to-noise ratio for the planned signal in each of the bins.

[0023] The present invention can utilize a database containing antenna specification data corresponding to the antennae deployed throughout the system to remove antenna effects to normalize data. The data base can contain additional information about other antennae so that the system can implement a plurality of propagation analysis

through substitution of antennae with known properties into cell site locations to determine enhanced system coverage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Figures 1 through 3 are logical flow diagrams illustrating the overall flow of the process of the present invention.
[0025] Figure 4 illustrates a representative three-dimensional gain pattern;
[0026] Figure 5 illustrates a receiver point located of the horizontal and vertical planes of the gain pattern shown in Figure 4;
[0027] Figure 6 illustrates a plane orthogonal to the boresight containing the ellipse formed by horizontal and vertical plane intersection points for the receiver;
[0028] Figure 7 illustrates a graphical means for determining the angle in the horizontal plane between the antenna boresight and the receiver point;
[0029] Figure 8A and 8B illustrate a graphical means for determining the angle in the vertical plane between the antenna's effective boresight and the receiver point;
[0030] Figure 9 illustrates a graphical means for determining the angle of intersection between the ellipse of Figure 5 and a radial drawn from the boresight to the receiver point;
[0031] Figure 10 illustrates typical antenna specification data.
[0032] Figure 11 illustrates the parameters used to calculate pathloss values for new pathloss points along a ray using the designated radials method;
[0033] Figure 12 illustrates the created pathloss points uniformly distributed along numerous radials of an inscribed arc using the designated radials method;
[0034] Figure 13 illustrates an example of calculating the effective antenna height using the height above average terrain (HAAT) method;
[0035] Figure 14 illustrates the static method for computing average terrain elevation;
[0036] Figure 15 illustrates a representative Picquenard model;
[0037] Figure 16 illustrates the measured pathloss points assigned to numerous radial regions;
[0038] Figure 17 illustrates the radial regions of Figure 16 divided into sections having a uniform step size; and
[0039] Figure 18 graphically illustrates a method for calculating diffraction in each section of Figure 17.
[0040] Figure 19 illustrates the measurement of radiation center offsets of modeled antennae in a system.

DETAILED DESCRIPTION OF THE INVENTION

[0041] This section defines the nomenclature used in this specification. The following properties of a cellular system refer to a set of attributes that describe some physical characteristic of the system.
[0042] Location - the set of attributes describing a cell site's position on the earth.
[0043] RFMount - the set of attributes describing the position of an antenna above some point on the earth.
[0044] RFPath - the set of attributes describing the directional mounting of an antenna at an RFMount. More specifically, the physical information needed to determine how the cell site antenna focuses energy over a geographical area.
[0045] Pathloss Point - the set of attributes describing the pathloss value and associated geographic information for a particular point in space.
[0046] When one of these properties is referenced in the specification, the set of attributes defining this property is being referenced, also. The set of attributes associated with each property are summarized in Table 1.

Table 1

Attributes	Location	RFMount	RFPath	Pathloss Point
Longitude	X	X	X	X
Latitude	X	X	X	X
Elevation	X	X	X	X
Radiation Center		X	X	
Orientation			X	
Electrical Tilt			X	
Mechanical Tilt			X	
Antenna			X	

Table 1 (continued)

Attributes	Location	RFMount	RFPath	Pathloss Point
Path Loss				X
Variance				X

[0047] The attributes listed in Table 1 have the following meanings in this specification, however, the physical characteristics of a cellular system may vary greatly from the exemplary system described herein without departing form the scope of the invention.

[0048] Longitude: Earth coordinate position in centiseconds. Positive for the Eastern hemisphere.

[0049] Latitude: Earth coordinate position in centiseconds. Positive for the northern hemisphere.

[0050] Elevation: Height from mean sea level to ground level in meters.

[0051] Radiation Center: Height from the ground to the center of an antenna in meters. Sometimes abbreviated as radctr.

[0052] Orientation: Physical direction of an antenna in the horizontal plane of the earth. Units are degrees with respect to true north. Orientation increases clockwise from north.

[0053] Mechanical Tilt: Physical direction of an antenna in the vertical plane of the earth. Units are degrees with respect to the horizon. Tilt has a positive value for an angle below the horizon and a negative value for an angle above the horizon. This parameter is sometimes abbreviated as mtilt.

[0054] Electrical Tilt: Shift in the main lobe of the antenna pattern in the vertical plane of the earth. Units for electrical tilt are in degrees and follow the same representation as mechanical tilt. This parameter is sometimes abbreviated as etilt.

[0055] Antenna: This is a reference to a set of attributes describing the characteristics of an antenna.

[0056] Pathloss: The difference in signal level, in dB, between transmit power and receive power.

[0057] Variance: The range in ± dB about the recorded pathloss value, an actual measured value may vary for a given confidence level.

[0058] The invention generates predicted pathloss values from normalized measured pathloss values, producing a set of data for an analysis of differing antenna gain configurations. The process for creating predicted pathloss values and generating interference patterns for a variety of antenna specifications allows for enhanced cellular system coverage.

[0059] The overall process of the system of the present invention is illustrated in Figure 1. A cellular system analysis program, capable of executing the inventive method described herein, is executed by a computer to evaluate the qualitative and quantitative aspects of a cellular system. When the analysis program requests data for an RFPath, both measured and predicted values are merged by an interpolation process to produce binned pathloss values. The interpolation process uses pathloss values containing no antenna effects. The antenna effects are absent either because they have been removed from the measured pathloss values or because they were not initially added to the predicted pathloss values. When the gain characteristics of the RFPath's antenna are needed in the system analysis, they are additively incorporated into the binned pathloss values.

[0060] An RFMount concept is introduced by this invention and is used to describe the attributes of all RFPaths originating at the same location and height, with their respective antenna effects omitted. Measured RFPath data is converted to RFMount data by removing the gain provided by the antenna pattern. Predicted data is generated for an RFMount using the gain characteristic of an isotropic radiation source in the propagation model. After both types of RFMount information are developed, they are combined by an interpolation process to produce binned RFMount data.

[0061] The process of removing the antenna gain from measured data converts RFPath pathloss data to RFMount pathloss data by making an adjustment to the calculated pathloss value. The overall flow of this process is illustrated in Figure 2. This permits the grouping of data by an RFMount, which is more easily combined with predicted data, and more easily adjusted when small changes to RFPath configurations occur. The process used to negate the effect of an antenna gain from a measured RFPath pathloss value is also used to quantify the environmental propagation characteristics of the RFPath and modify the variance attribute of the pathloss value in accordance with the propagation characteristics.

[0062] Predicted pathloss data is generated for an RFMount using a propagation model. The resulting values are easily merged with measured RFMount data by considering the relative variance value of the sources. Predicted values are generated using factors derived from measured values of nearby RFPaths. Each value either measured or predicted has an associated variance value which reflects the confidence in the value. Measured values are generally assigned greater confidence than predicted values. The confidence of a measured value can vary depending on the distance between the measured location and the antennae cell and dependant on the orientation of the antennae as well as other factors.

[0063] It is difficult to determine the relative numbers of measured and predicted pathloss values that may be required to accurately characterize a particular region of a cellular system. For this reason, variance attributes are attached to each pathloss value. The interplay of confidence of predicted and measured data is illustrated in Figure 3. A relatively high variance value is assigned to predicted pathloss values and a relatively low variance is assigned to measured pathloss values because of the greater confidence in measured data over predicted data. Since the interpolation can ignore high-variance predicted values when enough measured data is available in an area, it can be preferred to include the predicted values and let the interpolation process decide whether to use them. Therefore, pathloss interpolation can accommodate both measured values and predicted values, allowing variance to guide the interpolation algorithm in choosing and weighting the significance of the source data.

[0064] The variance assigned to measured data will be influenced by the confidence in the antenna manufacturing specifications. Antenna specifications have greater accuracy in the main frontal lobes than in ancillary side or back lobes, which can be greatly affected by antenna mounting. When the antenna gain pattern is removed in the present invention post-processing of the collected data, the inaccuracy can be compounded by the antenna confidence factor especially in side or back lobes. Therefore, the variance of measured values can vary due to antenna variance factors.

[0065] To better understand the purpose and means for negating the effects of antenna gain for each binned pathloss value, this section identifies the attributes that describe an antenna. Of primary interest are the attributes describing the electrical properties. The electrical properties are supplied by the antenna manufacturer and identify the antenna's ability to focus RF energy in three dimensions. This information is defined by the maximum gain and two sets of gain offset values surrounding the antenna. The gain offset values identify the difference in maximum gain for points along the horizontal and vertical planes, forming a horizontal and vertical gain (offset) patterns.

[0066] The gain pattern is represented by an array of 360 gain offset values having units of decibels (dB). A gain offset value represents the difference in gain from the maximum gain point of the antenna to some gain pattern point associated with an angle in degrees {0° ... 359°} from the boresight of the antenna. Therefore, the gain offset value is zero for the horizontal and vertical gain patterns at the maximum gain point of the antenna and must be negative or zero for all other points of the gain pattern.

[0067] The antenna's boresight refers to the physical direction (aim) of the antenna. The boresight corresponds to the angles 0°,0° in the horizontal and vertical planes. Note that the boresight is not necessarily the point of maximum gain on the gain pattern. A gain pattern is a complex three-dimensional shape. To represent this shape, the manufacturer provides a cross section of the gain pattern in the horizontal and vertical planes. The three-dimensional gain pattern can be constructed by combining these horizontal and vertical cross sections. Figure 4 depicts a three dimensional gain pattern for a simplified antenna pattern.

[0068] The gain offset for a receiver point in space is determined by the angle between the antenna and a receiver point. When the receiver point is located on the vertical or horizontal planes, the gain offset is obtained by calculating the angle on the respective gain pattern and retrieving the gain offset value. In most cases, the receiver point is not located on these planes, so an interpolation is required to determine the gain offset. Figure 5 illustrates a receiver point located off the horizontal and vertical planes.

[0069] To interpolate the gain offset for a receiver point in space, a line is constructed from the antenna to the receiver point. Next, the intersection points of this line with the horizontal and vertical gain patterns are determined. The gain offset values form two points on an elliptical curve joining the intersection points and the plane of this elliptical curve is orthogonal to the boresight of the antenna, as illustrated in Figure 6.

[0070] The antenna gain associated with the RFPath pathloss to the binned receiver point, is determined by the following steps of:

1) calculating the horizontal angle between the binned receiver point and the antenna to determine the horizontal gain offset;
2) calculating the vertical angle between the binned receiver point and the antenna to determine the vertical gain offset;
3) calculating the angle between the binned receiver point and the antenna, on the plane orthogonal to the boresight, to interpolate the spatial gain offset; and
4) calculating the antenna gain by subtracting the spatial gain offset from the maximum antenna gain.

[0071] Referring now to Figure 7, to determine the horizontal gain offset from the horizontal antenna pattern, the angle θ between the antenna boresight and the binned receiver point must first be determined. In practice, this requires calculating the angle from true north to the binned receiver point and then subtracting from this angle the angle between true north and the boresight orientation. These calculations are performed in the following way. The angle between the binned receiver point and true north is given by atan(dX/dY), where $dX = X_p - X_s$, $dY = Y_p - Y_s$, X_p and Y_s are the planar coordinates of the binned receiver point, and X_s and Y_s, are the planar coordinates of the source antenna. Angle θ may be determined from the equation:

$$\theta = \text{atan}(dX/dY) - \text{RFPath.orientation},$$

where RFPath.orientation is the angle between the antenna boresight and true north. With θ known, the antenna's horizontal gain offset, $G_{ant,hor}[\theta]$, may be obtained by examination of the antenna's horizontal gain pattern.

[0072] Referring now to Figures 8A and 8B, to determine the vertical gain offset from the vertical antenna pattern, the angle σ between the antenna's effective boresight and the binned receiver point must first be determined. In practice, this requires calculating the angle between the RFPath horizon and the path loss data point, and subtracting from this value the RFPath mechanical and electrical tilt angles (i.e., the effective boresight angle). These calculations are performed in accordance with the following equations:

$$dZ = Z_p - (Z_s + \text{RFPath.radctr})$$

$$dX = X_p - X_s$$

$$dY = Y_p - Y_s$$

$$dist = (dX^2 + dY^2)^{1/2}$$

$$\sigma = \text{atan}(-dZ/dist) - (\text{RFPath.etilt} + \text{RFPath.mtilt})$$

where,

X_p, Y_p, and Z_p are the coordinates of the binned receiver point;
X_s, Y_s, and Z_s are the coordinates of the source antenna;
RFPath.etilt is the angle of electrical tilt forming the angle between the effective boresight and the actual boresight; and
RFPath.mtilt is the angle between the horizon and the actual boresight.

[0073] With σ known, the antenna's vertical gain offset, $G_{ant,ver}[\sigma]$, may be obtained by examination of the antenna's vertical gain pattern. The horizontal and vertical gains pattern is stored in a database which has information on each of the antennae deployed in the system. The database can also have information on a number of alternative antennae for use later in the process for proposed antennae substitutions. Figure 10 is an illustrative example of a typical antenna pattern data. Although the determination of $G_{ant,ver}[\sigma]$ must consider whether the binned receiver point is in front of or behind the antenna, this consideration has been omitted for clarity of discussion. One of ordinary skill in the art would understand how to incorporate the consideration of whether the binned receiver point is in front of or behind the antenna.

[0074] After ascertaining the horizontal and vertical gain offset values, an elliptical approximation is used to interpolate the gain offset. To perform this interpolation, it is necessary to calculate the angle, φ, from the antenna boresight to the path loss data point. Figure 9 illustrates this angle in the plane lying orthogonal to the boresight and containing the ellipse.

[0075] The equations to calculate the angle φ are as follows:

$$dZ = \sin(\sigma);$$

$$dR = \sin(\theta);$$

and

$$\varphi = \text{atan}(dZ/dR).$$

Calculating the gain offset requires solving for the radius of the ellipse at the angle φ. The equation for an ellipse is:

$$((i/a)^2 + (j/b)^2)^{½} = 1$$

Substituting:

$$i = r * \sin(\varphi)$$

$$j = r * \cos(\varphi)$$

provides the equation:

$$((r * \cos(\varphi)/a)^2 + (r)* \sin(\varphi)/b)^2)^{½} = 1$$

Solving for r:

$$r = ((\cos(\varphi)/a)^2 + (\sin(\varphi)/b)^2)^{-½}$$

and substituting:

$$a = G_{ant,hor}[\theta]$$

$$b = G_{ant,ver}[\sigma]$$

provides the equation:

$$G_{offset}[\varphi] = ((\cos(\varphi)/G_{ant,hor}[\theta])^2 + (\sin(\varphi)/G_{ant,ver}[\sigma])^2)^{-½}$$

Finally, the antenna gain is calculated as:

$$G_{ant}[\varphi] = G_{ant,max} - G_{offset}[\varphi]$$

[0076] When including the effects of an antenna in the pathloss value, we subtract the antenna gain from the path loss data point;

$$PL_{new} = PL_{original} - G_{ant}$$

[0077] When removing the effects of an antenna in the pathloss value, we add the antenna gain to the path loss data point, as described in the equation:

$$PL_{new} = PL_{original} + G_{ant}$$

In both cases, the pathloss has a positive value.

[0078] Variance is additive since the antenna pattern variance is independent of the path loss data point variance. Therefore, the variance of the antenna pattern is added to the variance of the path loss data point. The process for calculating the antenna variance uses the same procedure as calculating the gain offset. In particular, the process has the steps:

1) Calculate $VAR_{ant,hor}[\theta]$;
2) Calculate $VAR_{ant,ver}[\sigma]$;
3) Calculate $VAR_{ant}[\varphi]$; and
4) $VAR_{new} = VAR_{original} + VAR_{ant}[\varphi]$.

[0079] Path Loss Data Normalization (PLDN) provides the ability to add or remove the effects of an antenna from a set of path loss data. This process involves offsetting the path loss value, for each path loss data point, with the antenna gain relative to each path loss data point location. In addition, the variance associated with each path loss data point may be adjusted by the variance associated with the corresponding point on the antenna pattern.

[0080] At a typical cellular tower, there are three sectors that are each served by a different transmit antenna. Each antenna forms a unique RFPath. Measured pathloss data is recorded separately for each RFPath. In order to combine the data from all three RFPaths into a single data set, it is necessary to normalize the data by removing the antenna effects from each pathloss point measurement.

[0081] RFPath data is translated to RFMount data for several reasons:

1) to combine measured data from multiple RFPaths into a single RFPath.
2) to combine measured data with modeled data; and
3) to model new RFPaths for an existing RFMount.

[0082] PLDN is initialized by submitting a desired RFPath. PLDN works with a single pathloss point at a time. Each pathloss point is submitted individually for processing by the computer. Using the procedures described above, the horizontal and vertical offset angles, $\{\theta, \sigma\}$, to the pathloss point are calculated. Next, the horizontal and vertical offset gain values are retrieved from an antenna database. The antenna database contains the same offset gain information as the horizontal and vertical gain pattern graphs, but in the database the antenna values will be loaded numerically in one-degree increments. The horizontal and vertical gain offsets are used to interpolate the gain, $G_{ant}[\varphi]$, of the antenna at some angle φ in three dimensional space, where $\varphi = \text{atan}(\sin(\sigma)/\sin(\theta))$. Once the offset gain is calculated, the RFMount pathloss value may be calculated.

[0083] For example, suppose the RFPath pathloss for a pathloss point is derived from a measurement at the point and found to have a value of 102 dB. Further suppose that the RFPath antenna gain, $G_{ant}[\varphi]$, for the relevant value of angle φ has a value of 5.2 dB. The RFMount pathloss is calculated as the sum of the RFPath pathloss and the RFPath antenna gain and has a value of 107.2 dB. Although the gain of the antenna does not, in fact, affect the pathloss of a propagation link in any way, summing the RFPath pathloss with the antenna gain provides a convenient way to characterize the propagation loss of an RF link. This propagation loss is characterized as though the RF transmission originated from an isotropic radiator and is commonly referred to as the free space loss. The RFPath pathloss contains the propagation effects of both the free space loss and the antenna gain. Translating RFMount data to RFPath data simply reverses the process described above.

[0084] The gain patterns provided by a manufacturer represent the theoretical gain performance of an antenna model. These gain patterns are normally measured in a lab environment under controlled conditions.

[0085] When an antenna is deployed at a cell site, the actual gain pattern is affected by mounting conditions, near field objects, and frequency. These effects cause the actual gain pattern to differ from the theoretical gain pattern reported by the manufacturer. In particular, the gain pattern outside the main beam of the antenna (side lobes) is most likely to be different in the real environment. Within the main beam of the antenna, the gain pattern typically remains consistent with the theoretical gain pattern.

[0086] The variance pattern identifies the confidence associated with the gain pattern. This variance can be included when adding or removing the gain pattern from a set of pathloss data points, thus incorporating the confidence of the gain pattern in the data. The variance pattern is represented by an array of 360 decimal values in dB corresponding with the horizontal and vertical gain patterns.

[0087] Variance is additive, since the antenna pattern variance is independent of the pathloss point variance, and is calculated from the equation:

$$VAR_{new} = VAR_{original} + VAR_{ant}[\theta,\sigma]$$

where,

$VAR_{ant}[\theta,\sigma]$ = variance value in the direction of the pathloss point using elliptical approximation not separate variance for horizontal and vertical antennae patterns

[0088] Since variance increases with each PLDN translation, it will be important to use the minimum number of translations to model a particular RFPath or RFMount. For example, if ten different RFPaths are modeled for the same

RFMount, then the original measured data should be used as the input for all ten models rather than using the output of each model as the input to the succeeding model.

[0089] The propagation model calculates pathloss between an RFMount and a pathloss point. A number of different propagation models have been developed to capture different propagation effects. Since all the factors that influence pathloss can not be modeled, a calculated value can only estimate the pathloss within a statistical variance. One generic propagation model has the form:

$$PL_{RFMount} = w_0 (c_0 - c_1 \log_{10} (h)) + w_1 (c_2 - c_3 \log_{10} (h) \log_{10} (r)) + w_2 (\text{diffraction}) + w_3$$

(local effects)

where,

h is the effective height of the RFMount in meters;
r is the distance between the RFMount and the pathloss point in meters;
c_0, c_1, c_2, and c_3 are constants;
diffraction is the diffraction component;
local effects is a correction factor to adjust for local terrain type; and
w_0, w_1, w_2, and w_3 are weighting factors, having a default value of one.

In the free space pathloss model:

$$c_0 = 32.4 + 20 \log_{10} (\text{frequency}) - 60;$$

$$c_1 = 0;$$

$$c_2 = 20;$$

$$c_3 = 0;$$

and

$$\text{pathloss} = 32.4 + 20 \log_{10} (\text{frequency}) + 20 \log_{10} (r) - 60$$

In the Okamura-Hata pathloss model:

$$c_0 = 69.55 + 26.16 \log_{10} (\text{frequency});$$

$$c_1 = 13.82;$$

$$c_2 = 44.9;$$

$$c_3 = 6.55;$$

and

$$\text{pathloss} = 69.55 + 26.16 \log_{10} (\text{frequency}) - 13.82 \log_{10} (h) + (44.9 - 6.55 \log_{10}$$

$(h))\log_{10}(r)$

The generic equation can be expanded as follows:

$$PL_{RFMount} = w_0 c_0 + w_1 c_2 - w_0 c_1 \log_{10}(h) + w_1 c_3 \log_{10}(h) \log_{10}(r) + w_2 (\text{diffraction}) + w_3 (\text{local effects})$$

Combining common terms provides the equation:

$$PL_{RFMount} = b_0 + b_1 \log_{10}(h) + b_2 \log_{10}(h) \log_{10}(r) + b_3 (\text{diffraction}) + b_4 (\text{local effects})$$

where;

$b_0 = w_0 c_0 + w_1 c_2$;
$b_1 = - w_0 c_1$;
$b_2 = -w_1 c_3$;
$b_3 = w_2$; and
$b_4 = w_3$.

In this final form of the generic equation, b_0 through b_4 are the pathloss coefficients.

[0090] Pathloss data generation can be performed for a single pathloss point or a series of pathloss points, if the locations of the pathloss points are already known. One application of the generation process is used for pathloss coefficient generation, when modeled pathloss values must be calculated for each measured pathloss point used in the coefficients regression.

[0091] To perform pathloss data generation, information concerning the following features is required for each pathloss point:

RFMount;
Receiver Height (meters);
Signal Frequency (MHZ);
Propagation Coefficents (b_0 - b_4); and
pathloss Variance (dB).

[0092] The propagation coefficients and pathloss variance are calculated during the generation of pathloss coefficients. During initial modeling, all coefficient values are set to one. Diffraction values are calculated for segmented areas, as described later.

[0093] Pathloss data generation can be used to calculate pathloss for new pathloss points that are uniformly distributed along a ray, or for multiple rays uniformly distributed within an azimuthal angle. To perform the pathloss data generation using the designated radials method, the following information is required:

RFMount;
Receiver height (float meters);
Signal frequency (float MHZ);
Propagation coefficients (float b_0 - b_4);
pathloss variance (float dB);
Number of radials (int);
Radial length (int meters);
Step size along radial (int meters);
Starting azimuth (int degrees); and
Inscribed arc angle (int degrees).

[0094] Figure 11 provides a graphical display of the input parameters. An initial radial is constructed using the radial length and azimuth values. Pathloss point locations along the radial are determined using the step size value. Each pathloss point location along the radial is translated into a latitude and longitude. Elevation is extracted from the terrain

database. Propagation and diffraction losses are sequentially calculated for each pathloss point.

[0095] The orientation of the second and succeeding radials are calculated by dividing the inscribed arc angle by the number of radials, and adding this value to the previous radial's orientation.

[0096] Figure 12 shows the resulting output. Pathloss points are uniformly distributed along each radial and the radials are uniformly distributed within the inscribed arc.

[0097] Note that there are three variables that describe a radial: total length, step size, and number of steps. There are three variables that describe the inscribed arc: total arc span, angular spacing, and number of radials. As shown in the following table, these values may be expressed in nine different ways to describe the same distribution of pathloss points.

	Radial Description		Inscribed Arc Description	
1	total length	step size	total arc span	no. of radial
2	total length	step size	total arc span	angular spacing
3	total length	step size	no. of radial	angular spacing
4	total length	no. of steps	total arc span	no. of radial
5	total length	no. of steps	total arc span	angular spacing
6	total length	no. of steps	no. of radial	angular spacing
7	step size	no. of steps	total arc span	no. of radial
8	step size	no. of steps	total arc span	angular spacing
9	step size	no. of steps	no. of radial	angular spacing

[0098] A preferred embodiment of the invention uses the first set of inputs to describe the distribution of pathloss points. Other input sets can be implemented, as well.

[0099] In propagation modeling, the height of the transmit and receive antennas has a direct effect on the total path loss for a given link. Increasing antenna height generally reduces pathloss. In a flat earth model, antenna height is an easily determined attribute. In a real world scenario with variable terrain, there are different techniques for dealing with antenna height, as illustrated in Figure 13. Most treatments of antenna height neglect the mobile antenna height. The mobile antenna height is typically in the range of 1.5-2.0 meters. The base station antenna height has considerably more variation.

[0100] In the pathloss data generation, effective antenna height is used in the generic propagation model. The diffraction algorithm uses an actual antenna height rather than an effective antenna height. However, the diffraction algorithm directly calculates the terrain effects on propagation and is a more precise measure.

[0101] For the generic propagation model, the effective antenna height is calculated as height above average terrain (HAAT). Average terrain elevation is extracted from the terrain database. Figure 13 shows an example of calculating effective antenna height using HAAT.

[0102] The FCC has defined a standard method for computing average terrain to be used by public mobile services in all application filings. With this method, eight uniformly distributed radials are drawn from the RFMount starting with true north (0°). A minimum of fifty evenly spaced elevation points are collected between 3 km and 16 km (2 to 10 miles) along each radial. An average elevation is computed for each radial. Then, the radial elevations are averaged to produce a final average terrain elevation. Figure 14 shows the static method for computing average terrain elevation.

[0103] As illustrated in Figure 15, the diffraction algorithm of the propagation model calculates how obstructions interfere with the signal path between the RFMount and pathloss point. The diffraction algorithm employs the Picquenard model. In this model, the effective height of a first obstacle is measured from the baseline formed by a segment connecting the transmitter and the receiver. The effective height of each succeeding obstacle is measured from a baseline segment drawn from the top of the previous obstacle to the receiver.

[0104] Diffraction values are calculated for measured pathloss points during coefficient generation. A particular RFMount may be associated with 40,000 or more measured pathloss points. Calculating a separate elevation profile for each pathloss point is computationally inefficient.

[0105] As illustrated in Figure 16, an alternative approach divides the region around the RFMount into segmented areas. A single diffraction value is calculated for each area and assigned to all pathloss points within the area. To implement the segmented area approach, the diffraction algorithm requires the following inputs:

RFMount;

Receiver height (float meters);
Signal frequency (float MHZ);
Number of radials (int); and
Step size along radial (int meters).

[0106] Using the number of radials, the area around the RFMount is divided into radial regions with uniform angular spacing. Each pathloss point is assigned to a particular radial region based on its location. The length of each radial region is set equal to the distance to the furthest pathloss point in that region (each radial region can have a different length). Figure 16 shows the measured pathloss points assigned to radial regions.

[0107] Next, each radial region is divided into concentric sections using the uniform step size as shown in Figure 17. Finally, a diffraction value is calculated in the center of each section of each region. The calculated diffraction value is assigned to all pathloss points in the section of each region. Figure 18 shows the final configuration.

[0108] Generic propagation models are based on best-fit calculations of measured field data. When applying a generic model to a different location, the accuracy of the results will depend on how closely the characteristics of the new location match those of the location where the model was derived. In accordance with the present invention, measured data for each location is compared to the path loss values calculated by the pathloss data algorithm. Based on this comparison, new coefficient values are calculated to minimize the variance between the measured and modeled values. The comparison can be accomplished in any of a number of manners, including simple substitution, iterative convergence or regression analysis. Once the propagation model has been optimized, new pathloss points may be modeled.

[0109] Coefficient generation is used to determine the set of weighting factors that minimizes the variance between the propagation model and the measured value. The equation for the generic propagation model:

$$PL_{RFMount} = w_0 c_0 + w_1 c_2 - w_0 c_1 \log_{10}(h) + w_1 c_3 \log_{10}(h) \log_{10}(r) + w_2 (\text{diffraction}) + w_3 (\text{local effects})$$

Combining common terms provides the equation:

$$PL_{RFMount} = b_0 + b_1 \log_{10}(h) + b_2 \log_{10}(h) \log_{10}(r) + b_3 (\text{diffraction}) + b_4 (\text{local effects})$$

where,

$b_0 = w_0 c_0 + w_1 c_2$;
$b_1 = - w_0 c_1$;
$b_2 = -w_1 c_3$;
$b_3 = w_2$; and
$b_4 = w_3$;
h = the effective height of the RFMount in meters;
r = the distance between the RFMount and the pathloss point in meters;
diffraction = diffraction component; and
local effects = a correction factor to adjust for local terrain type.

[0110] In this final form of the generic equation, b_0 through b_4 are the pathloss coefficients.

[0111] The pathloss equation fits the regression model, where:

$x_1 = \log_{10}(h)$
$x_2 = \log_{10}(h)\log_{10}(r)$
x_3 = diffraction
x_4 = local_effects

[0112] An analysis with measured data is required to confirm that the pathloss varies linearly with the diffraction and local effects values. To perform pathloss coefficients generation for an existing RFMount, the following inputs are required:

RFMount;
Receiver Height (meters); and
Signal frequency (MHZ).

[0113] For each point in the pathloss point list, the pathloss coefficients generator algorithm calculates values for x_1 through x_4. Each set of x's and the measured pathloss (y_i) form a row in the observations matrix. When all of the pathloss points are processed, the least-squares matrix is formed. The pathloss coefficients are calculated through the solution of the least-squares matrix.

[0114] To be useful, the coefficient generator must indicate how closely the modeled propagation values match the measured values. The resulting pathloss values must also include a variance value describing the expected bounds for pathloss at a given pathloss point. Regression analysis provides a number of methods for interpreting the results that are calculated along with the estimated coefficients. The coefficient generator will provide the following values for analysis of variance:

Variance: The variance of the modeled pathloss value; and
Variance and Standard deviation apply to the resulting pathloss value.

[0115] The same variance calculated in the coefficients generator algorithm applies to all pathloss points modeled with the same coefficients. Since the variance of measured values changes as a function of the measurement environment, it is possible that on a point-by-point analysis, the modeled variance will be less than the measured variance. Variance must be analyzed based on complete sets of data in order to be valid.

[0116] The coefficient generator algorithm is also used to calculate propagation components for a new (or simulated) RFMount, such as illustrated in Figure 19, having no measured data. In this case a new regression model is needed that determines the effects of antenna height, elevation, effective antenna height, and the distance between an existing RFMount and the modeled RFMount.

[0117] There are several methods that can be used to estimate values, and each has merits under different evaluation conditions. Kriging is an estimation method associated with spatial data that has several beneficial properties and can be used to calculate coefficient values for the modeled RFMount.

[0118] Although the present invention has been described in terms of a preferred embodiment, it will be appreciated that various modifications and alterations might be made by those skilled in the art without departing from the spirit and scope of the invention. The invention should therefore be measured in terms of the claims which follow.

Claims

1. A method for collecting and processing received signal level data from the individual sectors of a cell site, comprising the steps of:

   gathering signal level data at a known location within a wireless system;
   differentiating individual signals within said signal level data;
   determining the sector of origin of individual signals;
   determining the path loss of individual signals;
   retrieving a set of antenna parameters for antenna corresponding to said sector determinations; and
   normalizing the path loss value for each signal based upon said retrieved antenna parameters.

2. A method according to claim 1, wherein said antenna parameters include:

   directionality of the antenna design for the sector corresponding to the signal; and
   said normalization is a correction based upon the relative position of the known location with respect to the cellular site to compensate for error introduced into the gathered data.

3. A method of refining the determination of the quality of signal coverage in a wireless system, comprising the steps of:

   measuring actual path loss data at a plurality of locations within said wireless system;
   obtain predicted path loss data from a propagation model applied to said wireless system;
   combining said measured data and said predicted data to augment said measured path loss data with predicted path loss data to determine data for locations without measured data.

4. The method of claim 3, wherein:

   said combination is a weighted combination wherein said measured data and said predicated are assigned confidence indicators to determine the optimal weighting of each of said data.

5. The method of claim 3, further comprising:

assigning a confidence factor to each value within each set of data wherein said confidence factor is greater for measured data and is based upon the relationship between the data for a particular location and the data for proximate locations.

6. A method of managing the growth of a wireless system, comprising the steps of:

sub-dividing a drive test region into a plurality of spatial bins;
within each of said plurality of bins, measuring a signal from each of a plurality of sectors, which are within a region of examination that is at least partially co-extensive with or within propagation distance of said drive test region, to determine the receive power of said measured signal;
removing the effective gain achieved by an antenna associated with each of said measured signals to normalize each of said measured signals to a conceptual antenna having an isotropic radiation pattern;
applying a propagation model to a conceptual signal from each sector of said plurality of sectors to determine the predicted receive power of the conceptual signal within each of said plurality of bins, wherein each of said modeled conceptual signals corresponds to a different one of said measured signals and the characteristics of said conceptual antenna are used to model said conceptual signals; and
correlating each of said measured signals with said corresponding modeled conceptual signal.

7. The method of claim 6, further comprising the step of:

revising said propagation model, based on said correlation between each measured signal with said corresponding modeled conceptual signal, to create a revised propagation model that better predicts an expected path loss of said conceptual signal.

8. The method of claim 7, further comprising the step of:

applying said revised propagation model to said conceptual signal from each sector of said plurality of sectors to determine the expected path loss to a number of additional spatial bins.

9. The method of claim 7, further comprising the step of:

applying said revised propagation model to a planned signal from each sector of a planned plurality of sectors to determine the expected path loss of said planned signal to each of said plurality of bins.

10. The method of claim 9, further comprising the step of:

varying a propagation parameter value of said planned signal;
applying said revised propagation model to said planned signal and each of said plurality of bins; and
identifying an improved overall co-channel signal-to-noise ratio for said system based upon a revised propagation corresponding to a set of varied propagation parameters.

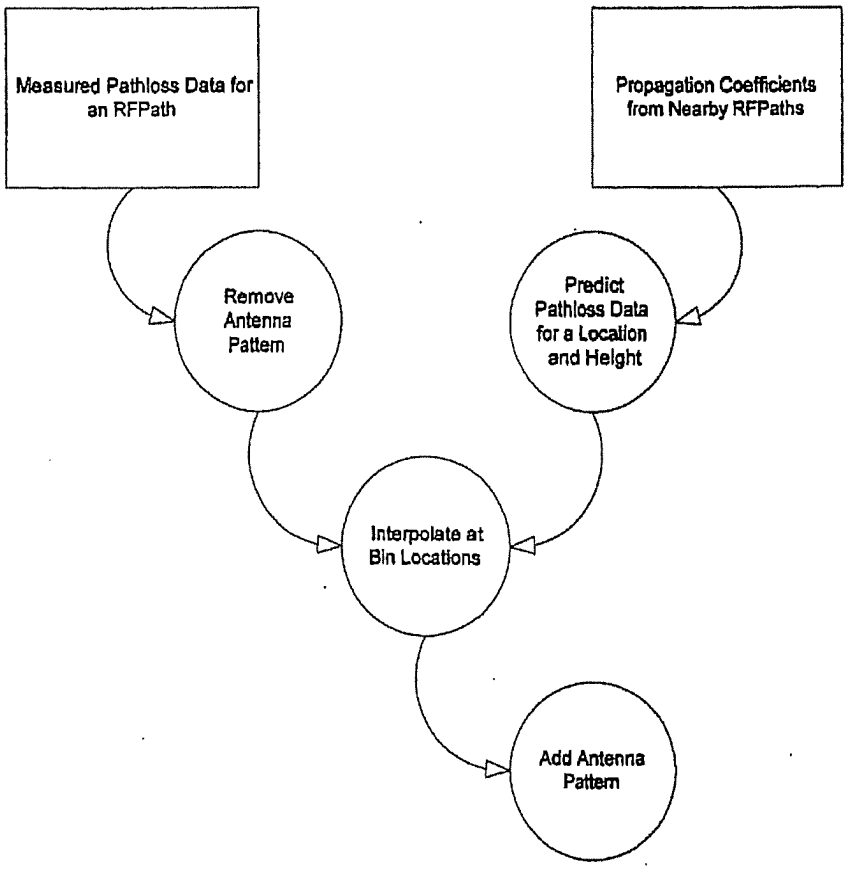

Measured Pathloss Data for an RFPath
Propagation Coefficients from Nearby RFPaths
Remove Antenna Pattern
Predict Pathloss Data for a Location and Height
Interpolate at Bin Locations
Add Antenna Pattern

Figure 1

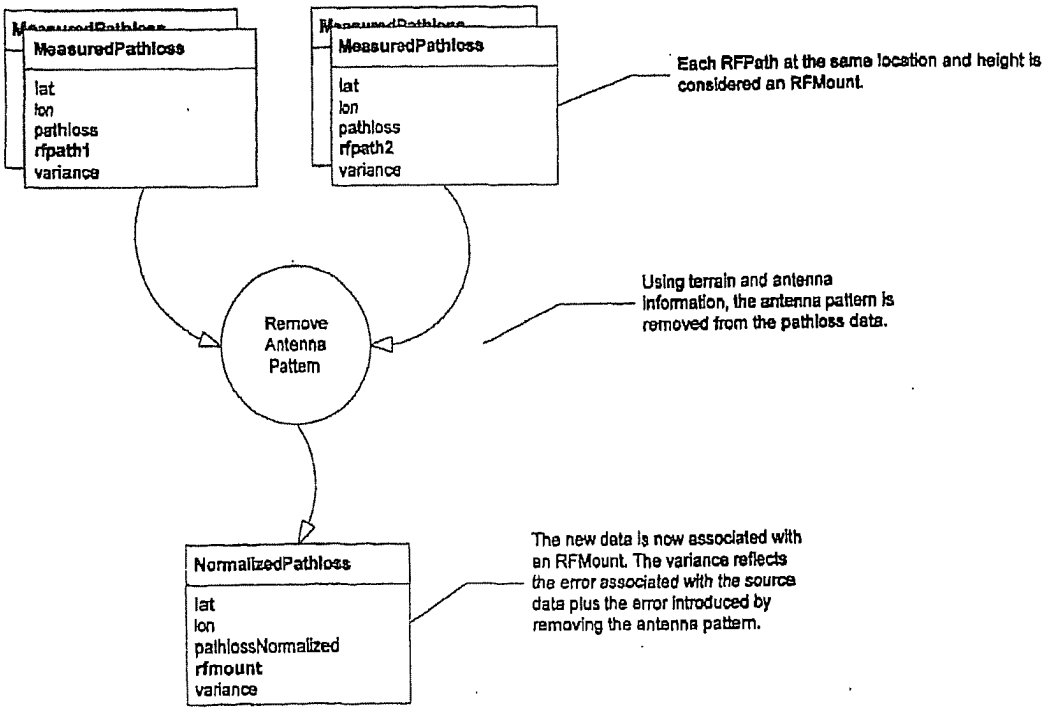

MeasuredPathloss
lat
lon
pathloss
rfpath1
variance
MeasuredPathloss
lat
lon
pathloss
rfpath2
variance
Each RFPath at the same location and height is considered an RFMount.
Remove Antenna Pattern
Using terrain and antenna information, the antenna pattern is removed from the pathloss data.
NormalizedPathloss
lat
lon
pathlossNormalized
rfmount
variance
The new data is now associated with an RFMount. The variance reflects the error associated with the source data plus the error introduced by removing the antenna pattern.

Figure 2

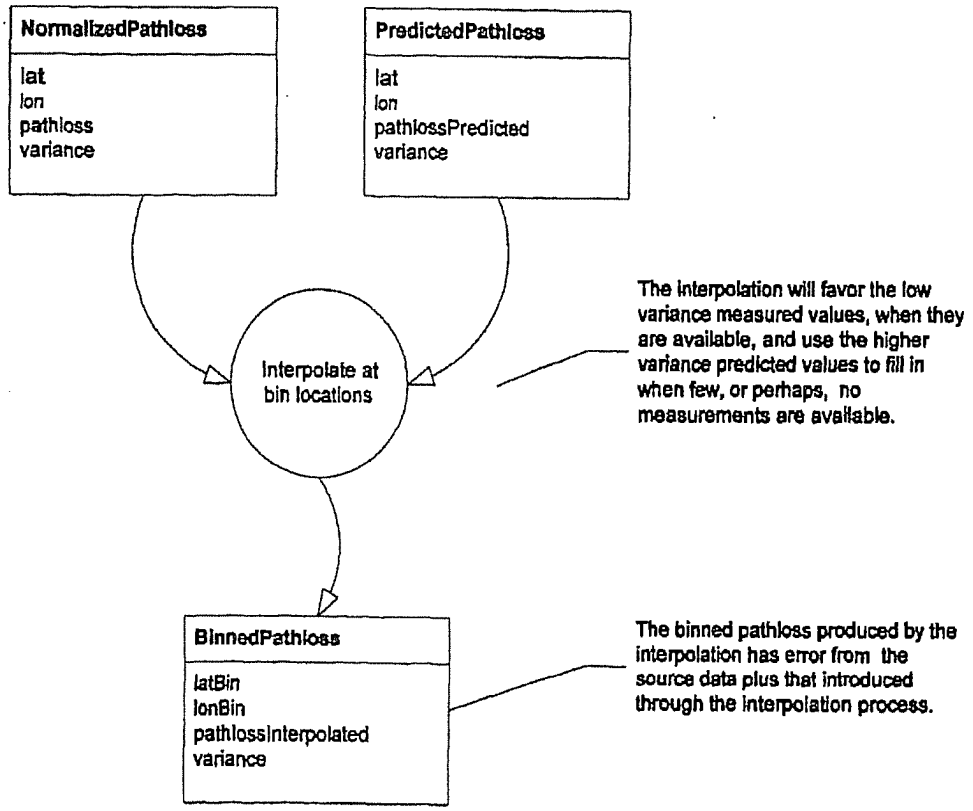

NormalizedPathloss
lat
lon
pathloss
variance
PredictedPathloss
lat
lon
pathlossPredicted
variance
Interpolate at bin locations
The interpolation will favor the low variance measured values, when they are available, and use the higher variance predicted values to fill in when few, or perhaps, no measurements are available.
BinnedPathloss
latBin
lonBin
pathlossInterpolated
variance
The binned pathloss produced by the interpolation has error from the source data plus that introduced through the interpolation process.

Figure 3

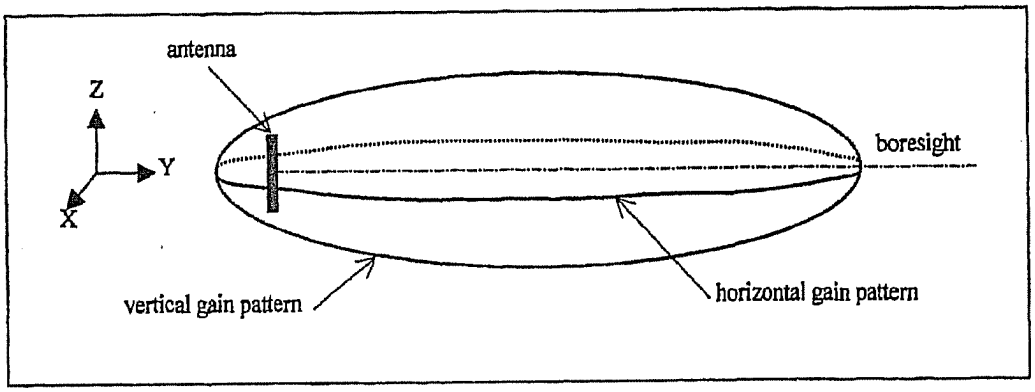


Figure 4

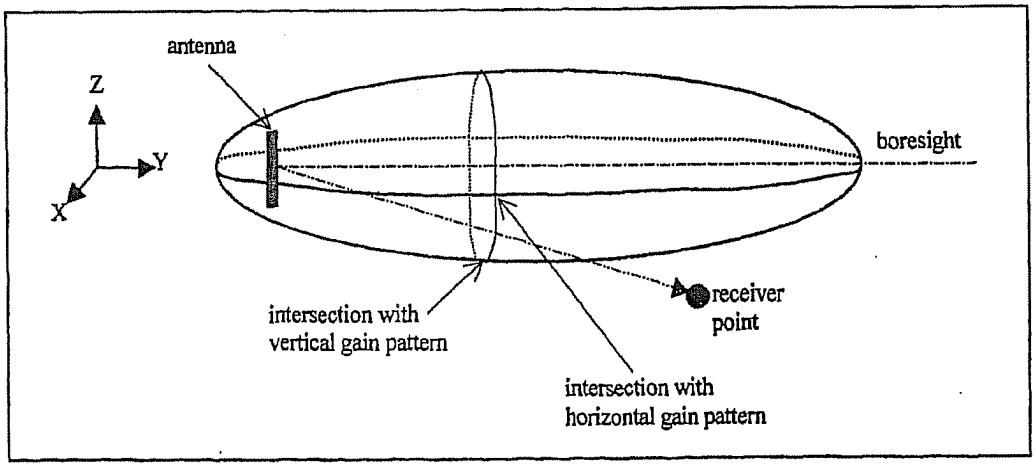


Figure 5

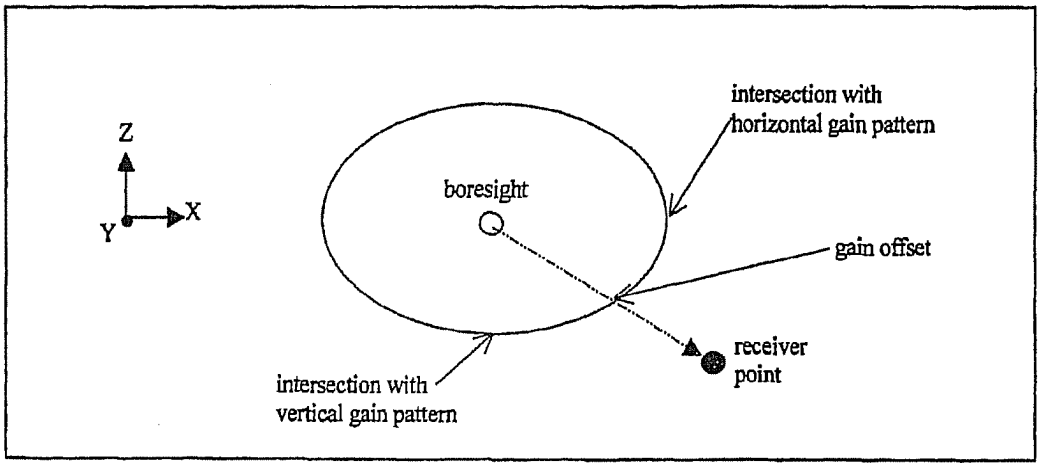


Figure 6

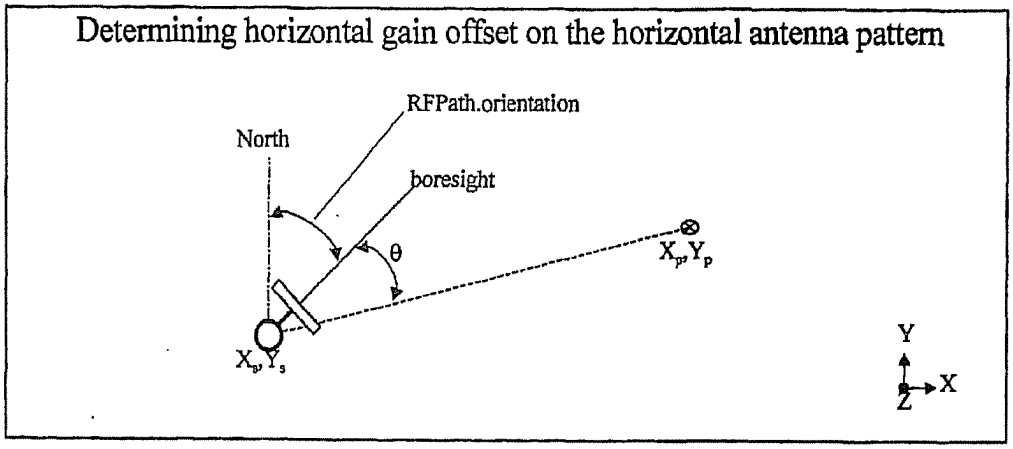


Figure 7

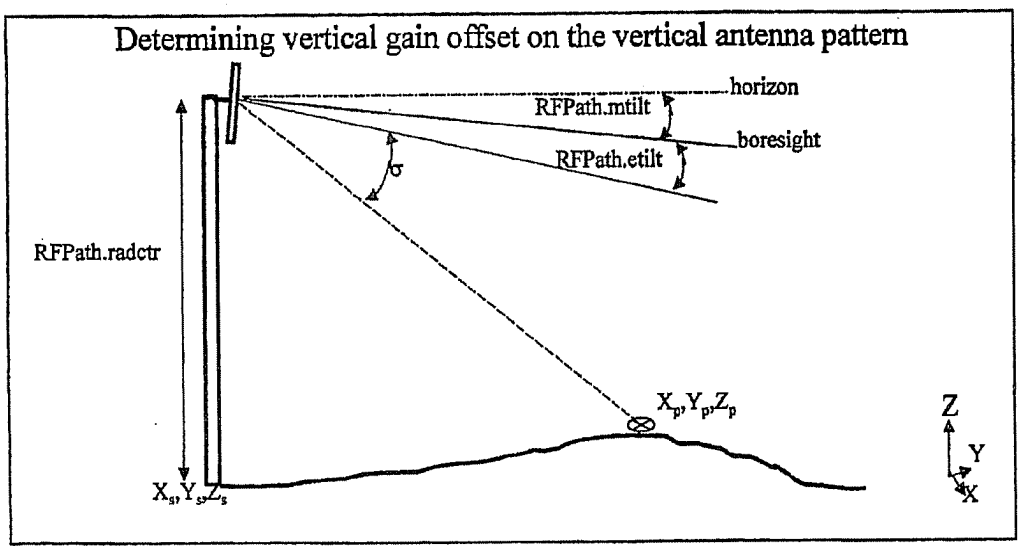


Figure 8A

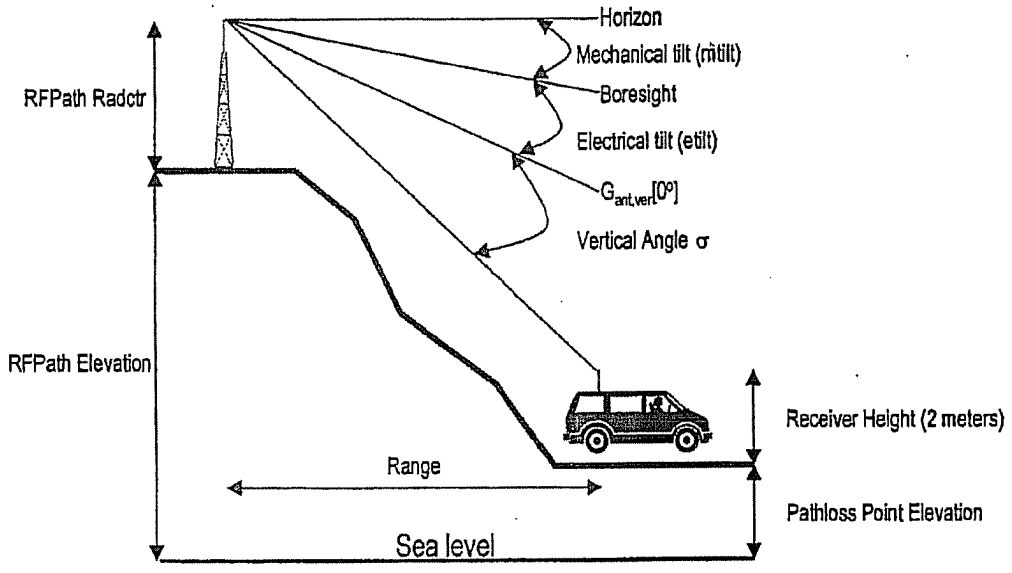


Figure 8B

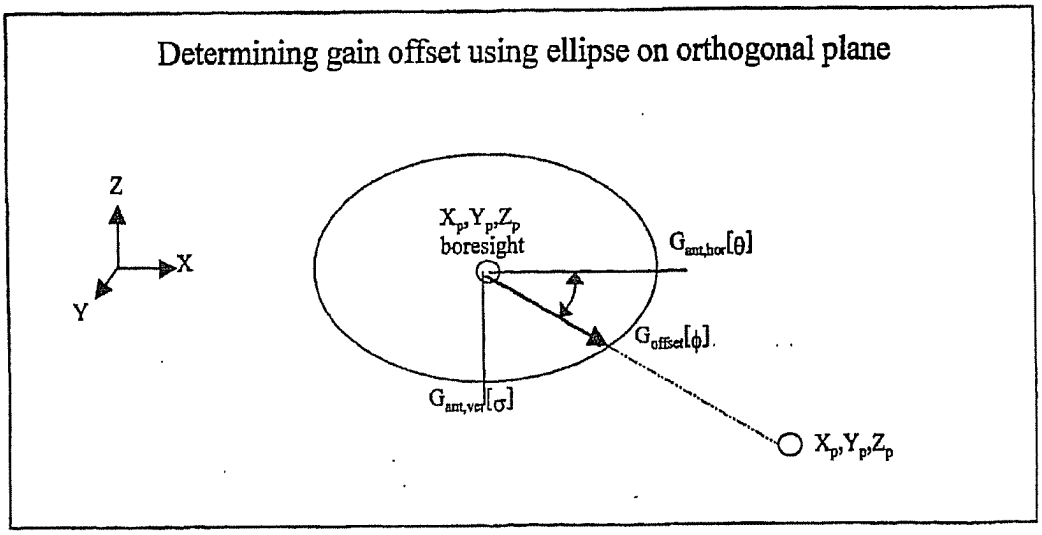


Figure 9

Manufacturer: TASC, Industries
Model: Glla2000
Date: October 2, 2000
Min Frequency: 880 MHz
Max Frequency: 960 MHz
Front-to-Back: 14 dB
Max Gain: 7.2 dB
Horizontal Beamwidth: 80 degrees
Vertical Beamwidth: 60 degrees
Electrical Tilt: 0 degrees

$G_{ant}[h,v] = G_{ant,max} + G_{ant,hor}[55] + G_{ant,ver}[40]$
$= 7.2 + (-2) + 0$
$= 5.2$ dB (Total Gain)

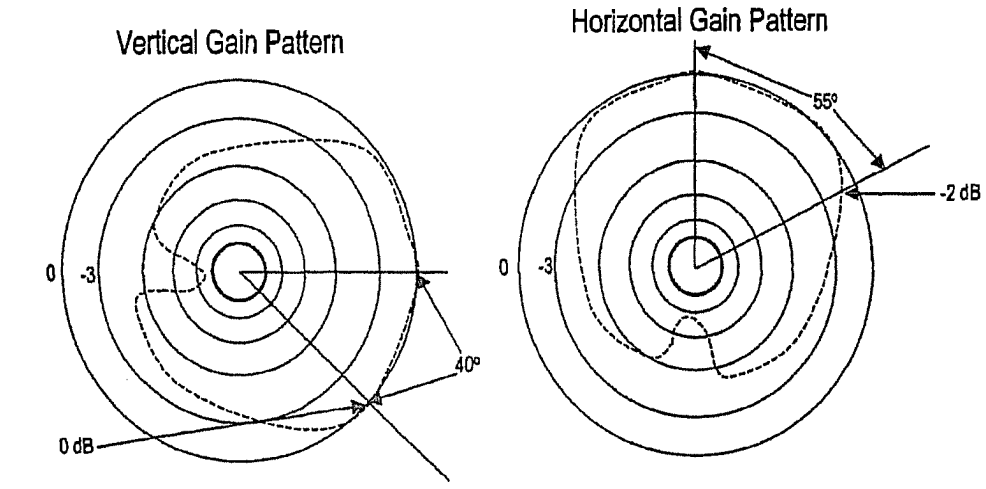


Figure 10

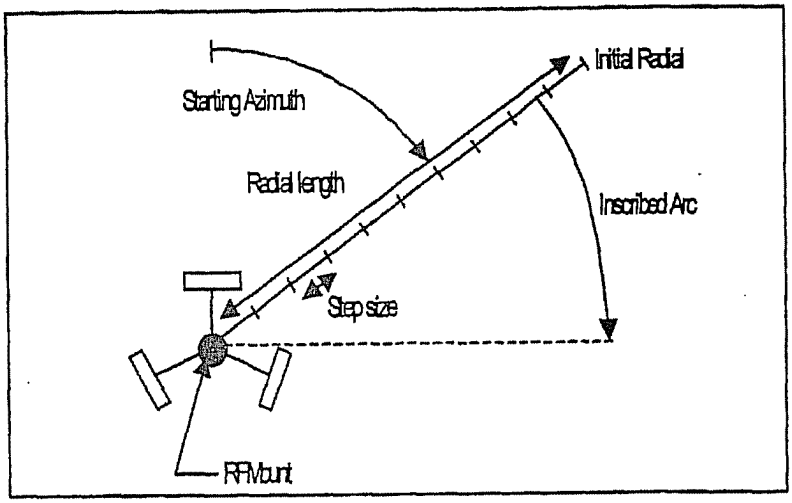


Figure 11

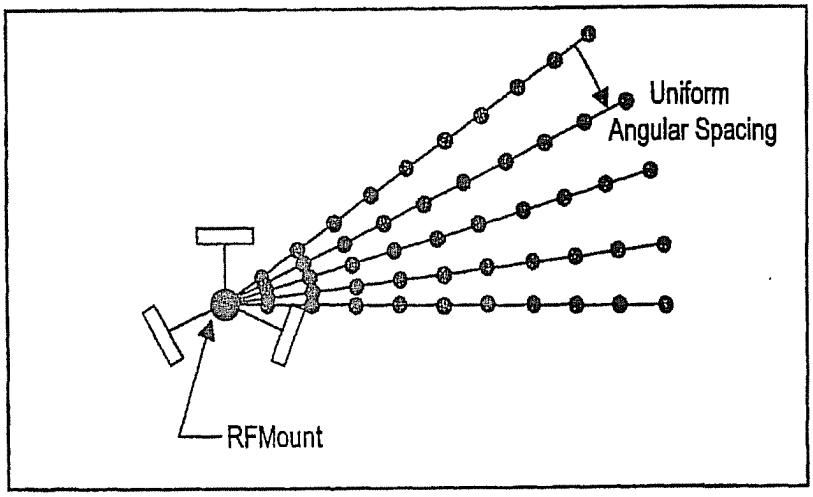


Figure 12

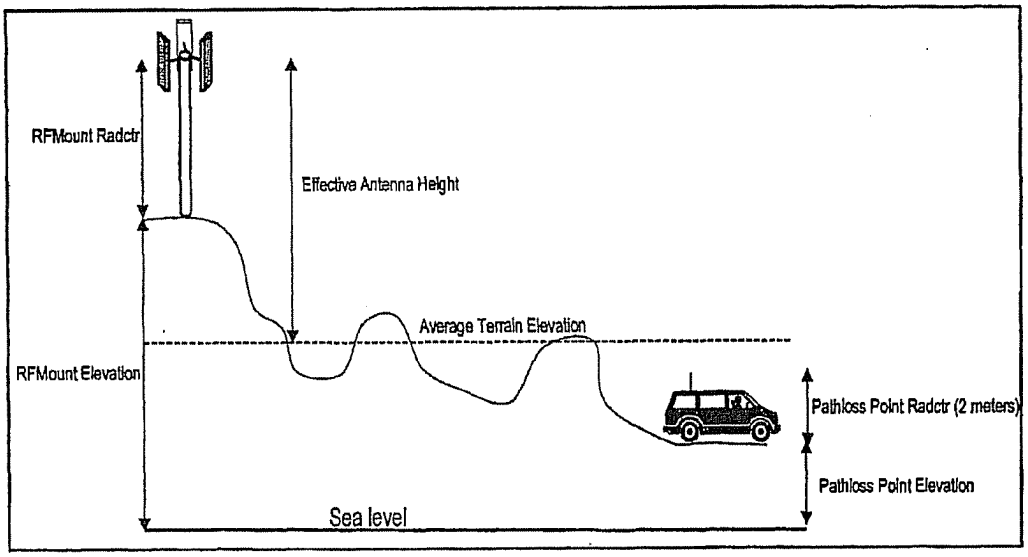


Figure 13

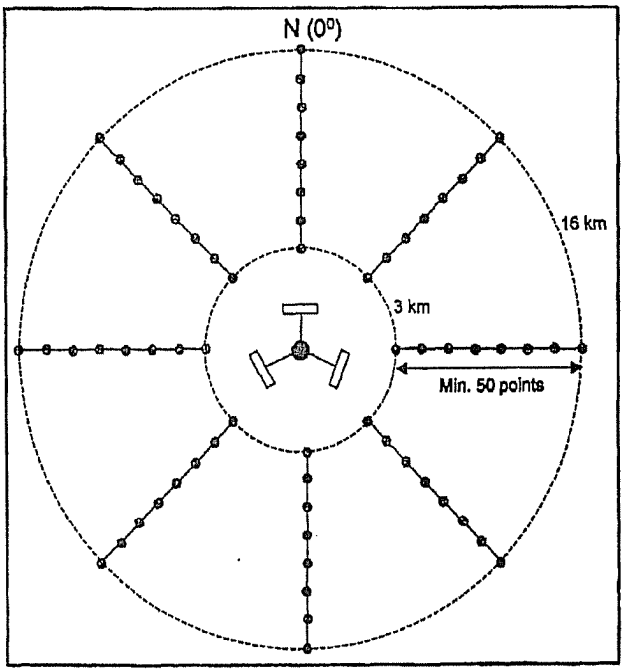


Figure 14

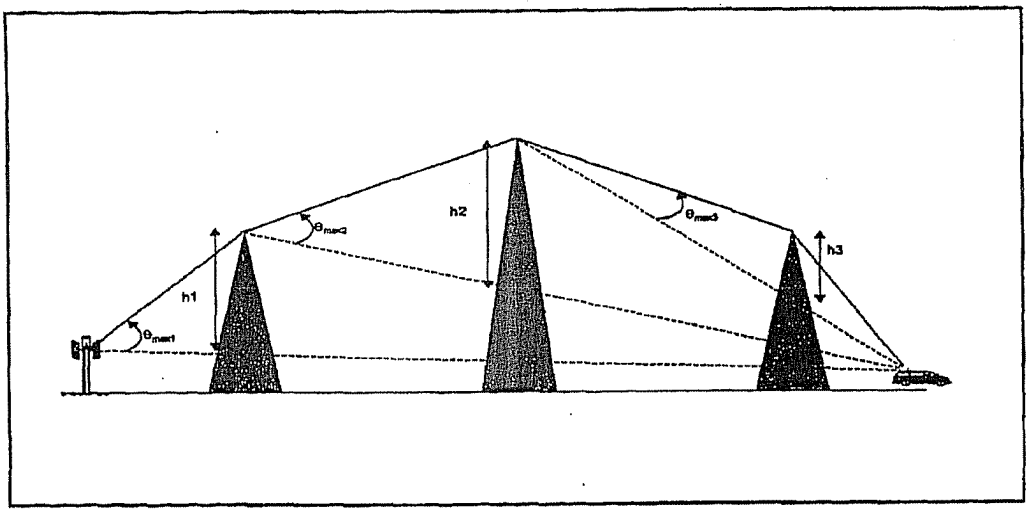


Figure 15

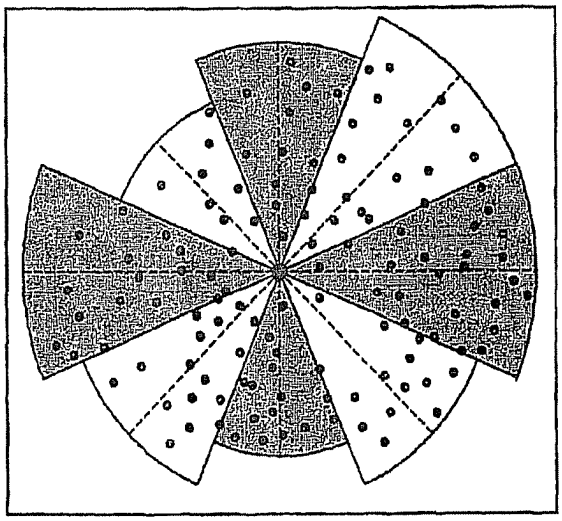


Figure 16

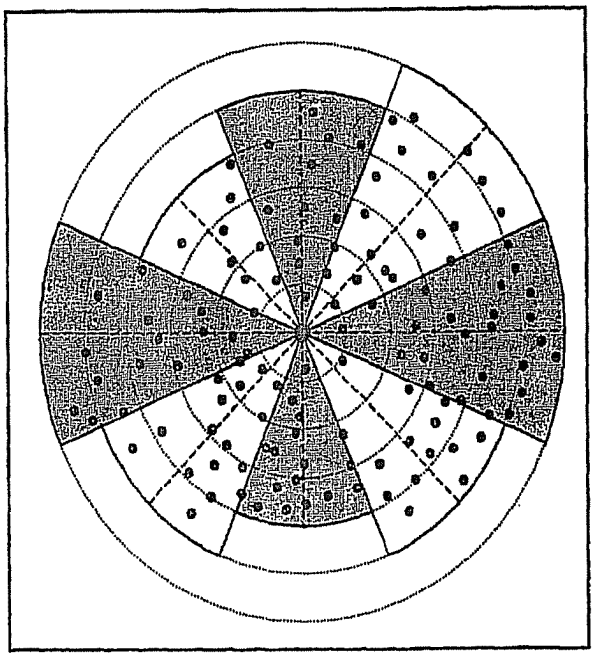


Figure 17

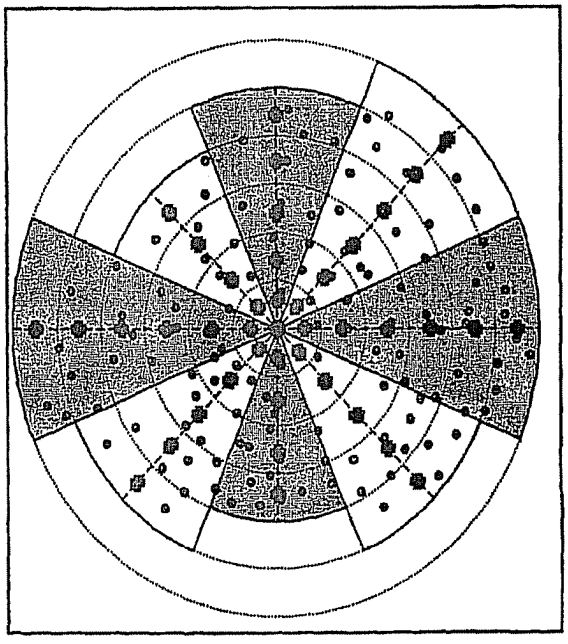


Figure 18

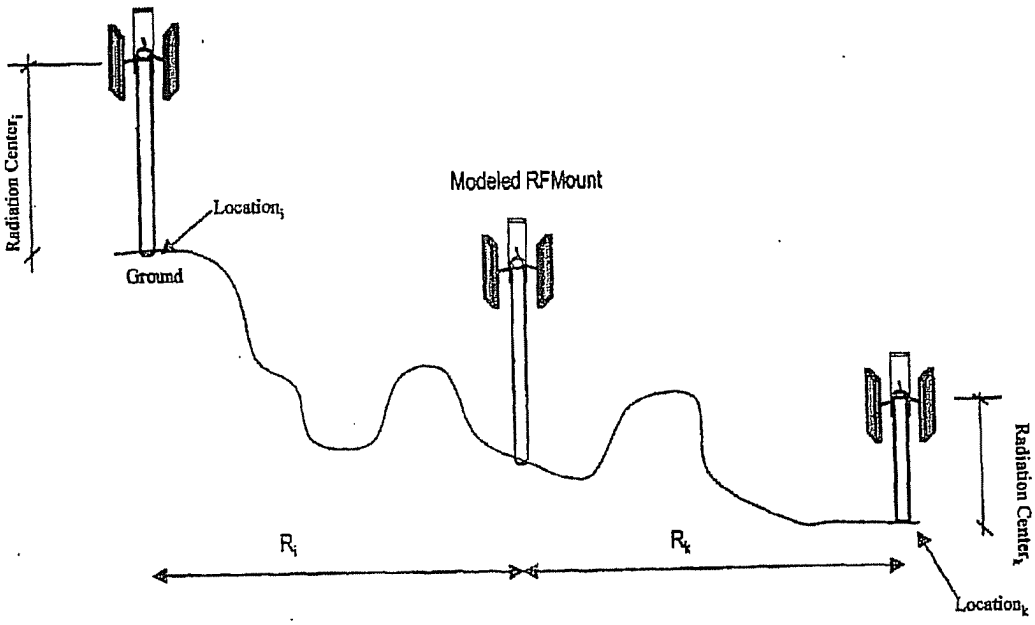

Radiation Center$_i$
Location$_i$
Ground
Modeled RFMount
Radiation Center$_k$
R_i
R_k
Location$_k$

Figure 19

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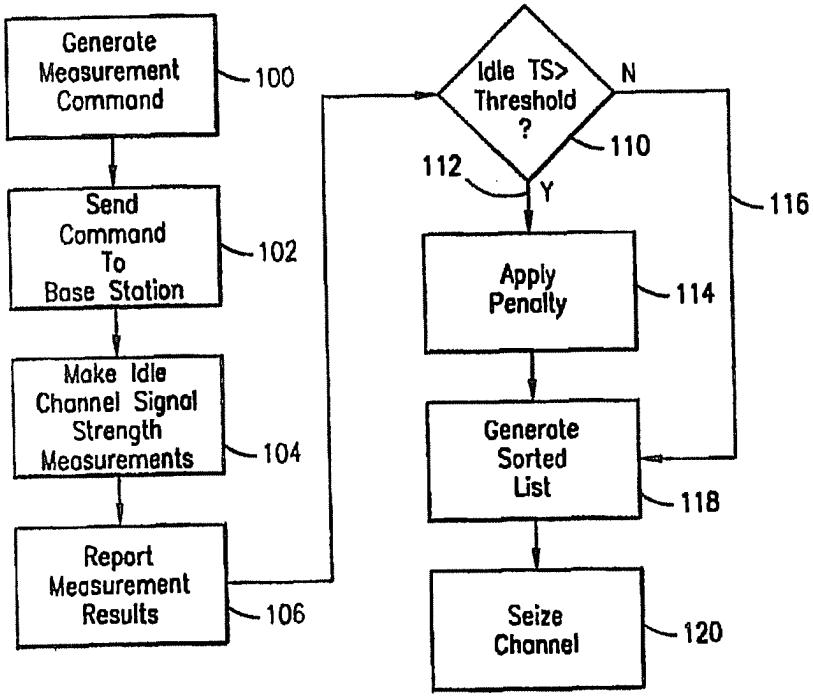
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(54) Title: TRAFFIC CHANNEL ASSIGNMENT IN A CELLULAR TELEPHONE SYSTEM USING AN UPLINK INTERFERENCE DRIVEN FREQUENCY PACKING METHOD

(57) Abstract

Each base station (14) in a cellular telephone system includes a signal strength measurement device (30, 32) operable to tune to and make signal strength measurements on not only the frequencies allocated to other cells, but also on its own allocated frequencies. Measurements (104) are made by the device on those of its own frequencies having idle traffic channels to obtain an indication of injected uplink interference. An interference penalty is then assessed (114) against the measured uplink interference for those frequencies having more than a threshold number (110) of idle traffic channels. The adjusted measurements for the frequencies allocated to the cell are then sorted (118) in relative order of idle traffic channel (adjusted) measured uplink interference from a least (adjusted) interfered frequency to a most (adjusted) interfered frequency. An idle traffic channel is then selected for assignment (120) at either call set–up or hand–off from the least (adjusted) interfered frequency.



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TRAFFIC CHANNEL ASSIGNMENT IN A CELLULAR TELEPHONE SYSTEM USING AN UPLINK INTERFERENCE DRIVEN FREQUENCY PACKING METHOD

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to cellular telephone systems and, in particular, to a method and apparatus for selection and assignment of a traffic channel during call set-up and hand-off by evaluating uplink signal strength measurements combined with frequency packing analysis.

Description of Related Art

Cellular telephone systems divide a large service area into a number of smaller discrete geographical areas called "cells" each typically ranging in size from about one-half to about twenty kilometers in diameter. Each cell is contiguous with multiple adjacent cells to provide continuous coverage throughout the service area. A base station including a plurality of transceivers capable of operating independently on different radio frequencies is provided for each of the cells. Via the transceivers, the base stations engage in simultaneous communications with plural mobile stations operating within the area of the associated cell. The base stations further communicate via data links (and voice trunks) with a central control station, commonly referred to as a mobile switching center, which functions to selectively connect telephone calls to and from the mobile stations through the base stations and, in general, control operation of the system.

Each cell is allocated the use of a predetermined set of frequencies, wherein each frequency comprises a physical channel supporting a plurality of logical channels (i.e., time slots) therein. The availability of multiple frequencies per cell, with multiple logical channels per frequency, permits base stations to simultaneously handle many telephone conversations with many mobile stations. The frequencies allocated to a cell are preferably spaced apart across the frequency spectrum of the cellular band. This serves to minimize the instances of adjacent channel interference.

Because only a limited number of frequencies are available in the cellular band, allocation of the same frequencies is repeated (i.e., reused) in other cells in a distant part of large service areas with many cells. No adjacent cells, however, are assigned the same frequency. Furthermore, the power levels of the signal transmissions on any given frequency are limited in strength. The foregoing precautions serve to minimize the likelihood of co-channel interference caused by reuse of that same frequency in a distant cell.

In spite of the precautions taken by service providers, it is known that instances of adjacent channel and co-channel interference do occur. This interference often adversely affects system operation by, for example, degrading voice or data quality on the traffic channels or interfering with the transmission and reception of control signals on the control channels.

The mobile switching center functions to dynamically assign the traffic channels available in any one cell among the plurality of mobile stations located within the cell area that desire communications. In this regard, the traffic channels comprise time slots in digital time division multiple access (TDMA) formatted frequencies which are allocated to the cell. Commands that assign for mobile station use a certain digital traffic channel assigned to a given cell are transmitted from the mobile switching center to the base station for that cell. The commands are then relayed by the base station to the certain mobile station over one of the channels to direct mobile station selection of the assigned traffic channel for handling the call.

Assignment by the mobile switching center of a particular digital traffic channel in a cell to a particular mobile station for carrying a cellular communication (i.e., a call) primarily occurs in two instances. The first instance is at call set-up when the subscriber activates the mobile station to initiate a call and the system selects for assignment the traffic channel to carry that new call. The second instance is at call hand-off when the subscriber, while engaged in a call, moves from one cell in the service area to another cell, and the system selects for assignment the traffic channel in the new cell that will continue the handling of the on-going call. In either case, it is important that the traffic channel selected for assignment at call set-up or hand-off be of the highest quality possible.

Conventionally, the selection and assignment by the system of a traffic channel to carry a call is performed by randomly choosing a logical channel from the available (idle) digital traffic channels allocated to the cell currently serving the mobile station. Alternatively, the system maintains a record of historic traffic channel use for each cell (normally in the form of a FIFO queue), and the traffic channel selected to carry the call is the channel allocated to that cell which has not been assigned for mobile station calling use in the longest period of time. While each of these selection methods is successful in assigning a traffic channel in a cell to a mobile station for carrying the call, the selection fails to take into consideration whether the traffic channel is the best quality (i.e., least interfered) channel available to carry the call. The prior art selection methods further fail to take into account concerns over minimizing the interference that may subsequently arise following the assignment of the traffic channel, and minimizing the number of frequencies simultaneously in use. In many instances there may be significant interference (often comprising adjacent channel or perhaps more frequently co-channel interference) on the randomly or queue selected traffic channel, or unacceptable interference may result following assignment due to inefficient simultaneous use of frequencies, and another one of the available idle traffic channels in the cell would have been a more appropriate assignment selection for use in carrying the call.

A need then exists for an improved method for assigning traffic channels to carry a call in response to either a call set-up or hand-off occurrence. This method should give consideration not only to whether the traffic channel is the best quality (i.e., least interfered) channel available to carry the call, but also whether a minimum required number of frequencies are being used as is possible to handle traffic needs.

SUMMARY OF THE INVENTION

Signal strength measurements are made by a signal strength measurement device in each cell base station on those frequencies allocated to that cell which have idle traffic channels. From these measurements, the injected uplink interference (comprising either adjacent channel, co-channel, or other type of interference) on the frequencies for each of the idle traffic channels is determined and reported to the mobile switching center. The reported uplink interference measurements are then

adjusted by a predetermined interference penalty if the frequency allocated to the cell presently includes more than a predetermined number of idle traffic channels. The adjusted measurements for all the frequencies are then sorted in relative order of idle traffic channel (adjusted) measured uplink interference from a least (adjusted) interfered frequency to most (adjusted) interfered frequency. The sorted list is then used by the system in selecting, for a base station, a traffic channel from the least (adjusted) interfered frequency for assignment at either call set-up or hand-off.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be obtained by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

FIGURE 1 is an exemplary cell diagram schematically illustrating a frequency reuse cellular telephone system wherein the present invention is implemented;

FIGURE 2 is a simplified block diagram of a base station in accordance with the present invention for use in the frequency reuse cellular telephone system of FIGURE 1; and

FIGURES 3A and 3B are flow diagrams illustrating alternative methods of operation for the channel selection process of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

There are a plurality of radio frequencies in the cellular band available to cellular telephone system providers for use in communicating with mobile stations. These radio frequencies support both traffic channels and control channels. The traffic channels are used for carrying telephone voice or data conversations. The control channels are used for carrying system operation control signals (commands). Such control signals include page signals, page response signals, location registration signals, traffic channel assignments, maintenance instructions, and cell selection or re-selection instructions.

A cellular service area can cover a large geographic area, and in many instances there will be a need for a large number of cells that often exceeds in number the number of cells provided by dividing the available radio frequencies in such a

manner as to handle expected subscriber usage. Accordingly, in order to provide sufficient call handling capacity throughout the service area, the cells are grouped into clusters of cells and the radio frequencies in the cellular band are reused in each of the clusters.

Reference is now made to FIGURE 1 for an illustration of an example of the frequency reuse concept commonly utilized in cellular systems. An arbitrary geographic area (hereinafter "the service area") is divided into a plurality of contiguous cells 10 schematically represented by hexagons. The cells 10 are then grouped into clusters 12 (outlined in bold to ease recognition), which in the present example comprise seven cells 10(1)-10(7) in each cluster. Assume for this example that there are a total of twenty-eight frequencies fn (wherein n=1 to 28) available in the cellular band. It will of course be understood that each frequency actually comprises a paired uplink and downlink frequency. The frequencies f1-f28 are divided equally amongst the cells 10(1)-10(7) to provide four frequencies per cell. Thus, each of the cells 10(1) in the service area is allocated frequencies f1, f8, f15 and f22 for carrying its traffic and control channels. Similar assignments are made for each of the remaining cells 10, with the frequencies also being reused across each of the included clusters 12. The complete allocation of the frequencies f1-f28 to the cells 10(1)-10(7) in each cluster 12 in accordance with this example of cellular frequency reuse is illustrated in detail in FIGURE 1 with respect to cluster 12(1).

It is noted in this frequency reuse scheme that in no instance have adjacent cells been allocated use of the same frequency. Reuse of an identical frequency in the service area at a minimum requires a separation of at least one cell 10 along with a regulation of broadcast power from each cell to constrain radio propagation substantially within the cell area. Furthermore, it is noted that in no instance does any one cell 10 utilize adjacent frequencies in the cellular band. Adjacent frequencies should exist no closer than one cell 10 away from each other. By arranging the cells 10 in clusters 12 as shown in the figure, regulating broadcast power of communications within the cell, and further by allocating frequencies in the fashion described above and shown in the figure, the likelihood of interference is minimized while simultaneously providing effective and efficient cellular communications services across a very large service area.

In spite of the precautions taken to avoid interference, it is known that interference does occur in cellular systems like that previously described. One aspect of this interference originates from communications occurring in the cells of other clusters 12 on the same frequency (i.e., co-channel interference). To understand this phenomena, assume the existence of concurrent voice communications using frequency f10 (and perhaps individual time slots therein) in each of the cells 10(3) in each of the clusters 12(2), 12(3) and 12(4) as shown in FIGURE 1. In spite of any imposed broadcast power limitations, a certain amount of the radio frequency energy of those voice communications propagates beyond the respective cell boundaries and is injected as interference into frequency f10 in cell 10(3) of cluster 12(1).

Another aspect of this injected interference originates from communications occurring in other cells on adjacent frequencies (i.e., adjacent channel interference). To understand this phenomena, assume the existence of concurrent voice communications on frequency f8 in cell 10(1) and frequency f9 in cell 10(2), and perhaps individual time slots therein, of cluster 12(1) as shown in FIGURE 1. In spite of any regulations on broadcast power and the presence of guard bands around each of the frequencies, improper transceiver broadcasts around one frequency (for example, f8) may be injected as interference into the adjacent frequency f9. It should be recognized that adjacent channel interference is not nearly as common an occurrence as co-channel interference in well regulated and stable communication systems.

Because this injected interference may adversely affect cellular voice communications over a given frequency, it would be unwise for the system to act during certain times of high interference by assigning that given frequency (or channel therein) to a mobile station at either call set-up or hand-off to carry a cellular voice communication. Unfortunately, the prior art random or queued channel selection methods fail to obtain knowledge of and consider such injected interference and its adverse effects in selecting and assigning a voice channel (comprising a time slot within the frequency) during either call set-up or hand-off. There would be a great advantage to system operation if voice channel quality measurements could be made and evaluated prior to system voice channel selection and assignment.

The concerns over co-channel interference extend down to the time slot level within each frequency. It is recognized that at times of light or moderate loading, not every frequency (or every time slot therein) is needed for assignment to handle voice communications. Situations arise then where not every one of the plural time slots associated with a single frequency are used. Some injected co-channel interference arises from this use. At the same time, none of the plural time slots in another frequency may be used. No injected co-channel interference arises from this use. When a traffic channel assignment is then subsequently made, the prior art random or queued channel selection methods fail to obtain knowledge of and consider time slot usage between the allocated frequencies in a cell before selecting and assigning a voice channel (comprising a time slot within the frequency) during either call set-up or hand-off. There would be a great advantage to system operation if efforts were made to minimize the number of frequencies actively being used to carry communications prior in connection with system voice channel selection and assignment.

Each of the cells 10 in a cellular system such as that illustrated in FIGURE 1 includes at least one base station (BS) 14 configured to facilitate radio frequency communications with mobile stations 16 roaming throughout the service area. The base stations 14 are illustrated as being located at or near the center of each of the cells 10. However, depending on geography and other known factors, the base stations 14 may instead be located at or near the periphery of, or otherwise away from the centers of, each of the cells 10. In such instances, the base stations 14 may broadcast and communicate with mobile stations 16 located within the cells 10 using directional rather than omni-directional antennas. The base stations 14 are connected by communications links (illustrated schematically by arrow 17) to at least one mobile switching center (MSC) 18 operating to control the operation of the system for providing cellular communications with the mobile stations 14.

Reference is now additionally made to FIGURE 2 wherein there is shown is a simplified block diagram of a base station 14 used in the system of FIGURE 1 in accordance with the present invention. The base station 14 includes a plurality of transceivers (Tx/Rx) 20(1) through 20(N), wherein N is the number of frequencies allocated to the cell 10 served by the base station. In the exemplary system shown in FIGURE 1, N=4 wherein seven cells 10 are included in each cluster 12 and a total of

twenty-eight available radio frequencies in the cellular band. The transceivers 20 have a configuration known in the art that includes a transmitter and a receiver tuned to operate on one of the frequencies allocated to the base station 14 for its traffic and/or control channels. Each allocated frequency provides a plurality of digital TDMA channels for mobile station use.

The base station 14 also includes a signal strength measurement device 22 that is used in one mode known in the art during hand-off to measure the signal strength of communications on the voice frequencies assigned to and used by other cells. In accordance with the present invention, the operation of the signal strength measurement device 22 of each base station 14 is controlled in an additional operating mode by received mobile switching center commands and/or the base station programming to measure the signal strength of communications on each of the frequencies supporting idle traffic channels allocated to the base station. These measurements are made at selected times or are made periodically in accordance with system specifications. The results of the measurements provide an indication of the amount of injected uplink interference caused by same or adjacent channel communications occurring simultaneously within the system, or caused by any other interference source. The idle traffic channel signal strength measurements comprising the measured uplink interference (on either a frequency or time slot basis) are reported by the signal strength measurement device 22 of the base station 14 to the mobile switching center 18 (perhaps along with the hand-off traffic channel signal strength measurements made on the frequencies/channels allocated to other cells) and considered in connection with the process for selecting and assigning a voice channel at either call set-up or hand-off. Alternatively, a processor 24 within the base station 14 may receive the measured uplink interference (on either a frequency or time slot basis) for processing to select and assign a voice channel at either call set-up or hand-off.

In one embodiment of the present invention, the signal strength measurement device 22 comprises a locating verification module (LVM) 30 including a receiver and frequency synthesizer for selectively tuning to any one of the frequencies available in the cellular band. As each of the frequencies allocated to a cell 12 is subdivided into a plurality of time slots comprising the traffic channels, the locating verification

module 30 further includes a circuit (not explicitly shown) for synchronizing operation of the module to the TDMA communications protocol being implemented by the system so that the signal strength measurements on a selected frequency may be made during each of the plurality of included time slots therein. This would include not only the frequencies/time slots allocated to and used by other cells, but also the frequencies/time slots allocated to and used by the cell served by the base station 14. The signal strength measurements made by the locating verification module 30 are then filtered by an infinite impulse response filter (IIRF) 34 before being subsequently processed in accordance with the present invention. The filtering removes fast changes in the measured interference levels to provide a stable estimate for output and subsequent processing. With respect to the implementation of the present invention, the locating verification module 30 makes and reports measurements made on the frequencies/time slots associated with idle traffic channels in order to supply uplink interference measurement data.

In another embodiment of the present invention, the signal strength measurement device 22 comprises an idle channel supervision (ICS) functionality 32 associated with each transceiver 20. The idle channel supervision functionality 32 advantageously uses the receiver portion of the transceiver 20 to make the uplink signal strength measurements. This idle channel supervision functionality 32 may include a circuit (not explicitly shown) for synchronizing measurement operation to the TDMA communications protocol being implemented by the system so that the signal strength measurements on a selected frequency may be made during each of the plurality of included time slots therein. The selected frequencies upon which measurements are made comprise the frequencies/time slots allocated to and used by the cell served by the base station 14. With respect to the implementation of the present invention, the locating verification module 30 makes and reports measurements made on the frequencies/time slots associated with idle traffic channels in order to supply uplink interference measurement data. The signal strength measurements made by the idle channel supervision functionality 32 are then filtered by an infinite impulse response filter (IIRF) 34 before being subsequently processed in accordance with the present invention. The filtering removes fast changes in the

measured interference levels to provide a stable estimate for output and subsequent processing.

In one embodiment of the present invention, the base stations report signal strength measurements on a per idle time slot basis to either the processor 24 or the mobile switching center for processing. For this embodiment, the processing means comprising either the processor 24 or the mobile switching center may make intelligent time slot specific channel assignments with respect to minimizing interference concerns (for example, by choosing a least interfered time slot within a selected frequency). In another embodiment, the base stations process the signal strength measurements made on a per idle time slot basis to obtain an interference measure for the frequency (i.e., the carrier). It is this carrier based interference measurement that is reported to the processing means comprising either the processor 24 or the mobile switching center. For this embodiment, the processor 24 or mobile switching center does not possess per time slot interference information from which to make an intelligent assignment selection. Instead, the processor 24 or mobile switching center makes the decision as to which time slot channel to assign based on a random selection among the idle time slots in the least interfered carrier. More information on the processes implemented in accordance with the present invention is provided herein.

Reference is now made to FIGURE 3A wherein there is shown a flow diagram illustrating one manner of operation of the channel selection process of the present invention. In step 100, at a designated point in time the mobile switching center of the cellular telephone system generates a message commanding certain ones of the base stations to make idle traffic channel signal strength measurements. This command message is sent to the designated base stations in step 102. At each of the receiving base stations, the command message is implemented in step 104 by configuring the signal strength measurement device of the base station to tune to the base station's own allocated frequencies and make signal strength measurements (i.e., uplink interference measurements) on the frequencies with idle traffic channels that have been allocated to the cell served by the particular measuring base station. If possible, these measurements are made on a per idle time slot basis. It should be understood that this is an operating mode in addition to the conventional operating mode of making

measurements on neighboring cell voice channels in response to a hand-off request and the determination of a target cell.

The results of the uplink interference (signal strength) measurements on the frequencies with idle traffic channels are reported by the signal strength measurement device back to the mobile switching center in step 106. Again, alternatively, the measurements are reported to the processor 24 of the base station. This report also may be made upon receipt of a request from the mobile switching center. The report comprises either the measurements on a per idle time slot basis, or the accumulated measurement for a frequency (carrier). If the report is time slot specific, appropriate accumulation processing is performed at the processing means comprising either the processor of the base station or the mobile switching center to make a per frequency interference calculation. A determination is then made in step 110 as to the relative loading on each frequency having an uplink interference measurement reported in step 106. This loading determination evaluates, in general, the number of idle time slots within each measured frequency. If the number of idle time slots exceeds a predetermined threshold number (see, path 112), an interference penalty is assessed against the measured uplink interference for that frequency/carrier (step 114). If the threshold number is not exceeded (see, path 116), no penalty is applied. Although not specifically illustrated, it is understood that the process of steps 110 and 114 is performed, as needed, with respect to each of the frequencies having a step 106 reported uplink interference measurement. Following the adjustment (if any) applied in step 114 to the reported uplink interference measurements, the (adjusted) measurements in step 118 are processed to generate a sorted list of measured frequencies having idle traffic channels that are candidates for selection and assignment at either call set-up or hand-off. The generated list is sorted from the reported measurements in relative order of idle traffic channel measured (adjusted) uplink interference (e.g., from the least interfered (adjusted) frequency to the most interfered (adjusted) frequency). At an instance of traffic channel seizure (step 120), an idle one of the traffic channels within the least interfered (adjusted) frequency on the re-sorted list is randomly selected and assigned for either call set-up or hand-off. Alternatively, if individual time slot interference information is available, the least interfered time slot within that least interfered (adjusted) frequency is selected.

Referring now to FIGURE 3B, there is shown a flow diagram illustrating an alternative method of operation in accordance with the present invention wherein loop 122 and step 104 concern the programming of the base station to periodically measure signal strength on frequencies having idle voice channels that have been assigned to the cell served by the particular measuring base station. If possible, these measurements are made on a per idle time slot basis. At step 124 in loop 122, the base station programming tests for the occurrence of a reporting event. By this it is meant some cellular system event in response to which the measurements are to be reported to the mobile switching center or the base station processor. One such event comprises receipt of a command from the mobile switching center specifying the transmittal of the latest measurements. Another such event comprises receipt of a command from the mobile switching center directing the signal strength measuring device to make measurement on the traffic channels of other neighboring cells in preparation for hand-off and the selection of a target cell. In that case, the measurements relating to the own traffic channels are appended to the message reporting on the measurements made of the traffic channels for the neighboring cells. Yet another such event comprises a time out occurrence, thus effectuating periodic reporting of the traffic channel signal strength measurement information. Still further, the reporting event comprises a change in measured interference greater than a certain hysteresis value.

Once the reporting event occurs, the measurements are reported in step 106 to the mobile switching center. Again, alternatively, this measurement report may be made to the processor 24 of the base station. The report comprises either the measurements on a per idle time slot basis, or the accumulated measurement for a frequency (carrier). If the report is time slot specific, appropriate accumulation processing is performed at the processor of the base station or mobile switching center to make a per frequency interference calculation. Preferably, no report 106 is made if the most recent previous report was sent within a predetermined time threshold. A determination is then made in step 110 as to the relative loading on each frequency having an uplink interference measurement reported in step 106. This loading determination evaluates, in general, the number of idle time slots within each frequency. If the number of idle time slots exceeds a predetermined threshold number

(see, path 112), an interference penalty is assessed against the measured uplink interference for that frequency (step 114). If the threshold number is not exceeded (see, path 116), no penalty is applied. Although not specifically illustrated, it is understood that the process of steps 110 and 114 is performed, as needed, with respect to each of the frequencies having a step 106 reported uplink interference measurement. Following the adjustment (if any) applied in step 114 to the reported uplink interference measurements, the (adjusted) measurements in step 118 are processed to generate a sorted list of frequencies having idle traffic channels that are candidates for selection and assignment at either call set-up or hand-off. The generated list is sorted from the reported measurements in relative order of idle traffic channel measured (adjusted) uplink interference (e.g., from the least interfered (adjusted) frequency to the most interfered (adjusted) frequency). At an instance of traffic channel seizure (step 120), an idle one of the traffic channels within the least interfered (adjusted) frequency on the re-sorted list is randomly selected and assigned for either call set-up or hand-off. Alternatively, if individual time slot interference information is available, the least interfered time slot within that least interfered (adjusted) frequency is selected.

The particular penalty applied in step 114 against the previously made and sorted uplink interference measurements when the number of idle traffic channels exceeds the threshold may differ depending on the precise number of idle traffic channels that are present. For example, in a commonly implemented TDMA communications system, each frequency includes three time slots. The predetermined threshold in such a situation may require that two or more idle time slots be found with respect to a given frequency before applying the penalty. Then, if two idle time slots are found, the penalty that is applied to the uplink interference measurement is X dB. If, on the other hand, three idle time slots are found, the penalty that is applied to the uplink interference measurement is X+Y dB. A similar penalty scheme is implemented with respect to the eight time slots (resulting in seven penalty levels) associated with a Global System for Mobile (GSM) communications system. In any case, the object of applying the penalty to make the associated frequency having such a large number of idle time slots less attractive when the seizure of step 120 is performed. Conversely, for the frequency having only a single idle time slot, no

penalty is applied in order to continue making its lone idle time slot an attractive candidate for seizure.

With respect to the sorted (step 118) list, all frequencies allocated to a cell having idle time slots may be included on a single, comprehensive list. Alternatively, multiple lists may be generated in step 118 to account, for example, for differences that may need to be considered when the seizure of step 120 is performed. For example, it is known that the cellular frequency band includes both a basic band and an extended band. It is possible for separate step 118 sorted lists to be generated, one list for the frequencies having idle traffic channels in the basic band, and one list for the frequencies having idle traffic channels in the extended band. In another example, one list may be provided for data calls only, one list for voice calls only, and one list for either data calls or voice calls. At the time of seizure (step 120), an appropriate one (or perhaps more than one) of the re-sorted lists is then evaluated in connection with randomly or intelligently choosing an idle traffic channel for call set-up or hand-off assignment.

Although a preferred embodiment of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A cellular telephone system, comprising:

a base station allocated use of a plurality of frequencies, each frequency including a plurality of time slot traffic channels, comprising:

a signal strength measuring device selectively tunable to make signal strength measurements on the frequencies allocated to the base station having idle time slot traffic channels and obtain uplink interference measurements on those measured frequencies; and

processing means connected to receive the uplink interference measurements, the processing means operating to:

apply an interference penalty against the received uplink interference measurements if the measured frequency includes more than a threshold number of idle time slot traffic channels;

sort the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties from a least uplink interfered frequency to a most uplink interfered frequency; and

select for assignment by the base station at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency.

2. The system as in claim 1 wherein the signal strength measuring device comprises a base station locating verification module.

3. The system as in claim 1 wherein the signal strength measuring device comprises a base station idle channel supervision functionality provided by a base station transceiver.

4. The system as in claim 1 wherein the signal strength measuring device makes signal strength measurements for each idle time slot.

5. The system as in claim 1 wherein the processing means sorting operation sorts the measured frequencies by their uplink interference measurements

adjusted by any applied interference penalties into plural lists, each list ordered from a least uplink interfered frequency to a most uplink interfered frequency.

6. The system as in claim 5 wherein the processing means selecting operation selects from a certain one or ones of the plural lists for assignment at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency contained on that certain list.

7. The system as in claim 1 wherein the processing means applying operation applies an increasing interference penalty against the received uplink interference measurements corresponding to when an increasing number of idle time slot traffic channels are included within the frequency.

8. The system as in claim 1 wherein the processing means comprises a mobile switching center connected to the base station.

9. A method for use in a cellular telephone system for assigning traffic channels, comprising the steps of:

making signal strength measurements on frequencies allocated to a base station, wherein each frequency includes a plurality of time slot traffic channels, the measurement made on those frequencies having idle time slot traffic channels to obtain uplink interference measurements;

applying an interference penalty against the made uplink interference measurements if the measured frequency includes more than a threshold number of idle time slot traffic channels;

sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties from a least uplink interfered frequency to a most uplink interfered frequency; and

selecting for assignment by the base station at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency.

10. The method as in claim 9 wherein the step of making signal strength measurements comprises the step of making signal strength measurements for each idle time slot.

11. The method as in claim 9 wherein the step of sorting comprises the step of sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties into plural lists, each list ordered from a least uplink interfered frequency to a most uplink interfered frequency.

12. The method as in claim 11 wherein the step of selecting comprises the step of selecting from a certain one or ones of the plural lists for assignment at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency contained on that certain list.

13. The method as in claim 9 wherein step of applying comprises the step of applying an increasing interference penalty against the received uplink interference measurements corresponding to when an increasing number of idle time slot traffic channels are included within the frequency.

14. The method as in claim 9 wherein the step of selecting comprises the step of randomly selecting an idle time slot traffic channel included within the least uplink interfered frequency.

15. The method as in claim 9 wherein the step of selecting comprises the step of selecting an idle time slot traffic channel having a lowest interference included within the least uplink interfered frequency.

16. A cellular telephone system having a plurality of frequencies available for carrying cellular communications, each frequency including a plurality of time slot traffic channels, comprising:

a plurality of base stations distributed across a service area, each base station being allocated to use a subset of the plurality of frequencies wherein each base station includes:

a signal strength measuring device selectively tunable for making signal strength measurements on any of the plurality of frequencies in the system; and

processing means:

connected to receive a report from a given base station of measurements made by the signal strength measuring device on selected ones of the subset of frequencies allocated to that given base station which include idle traffic channels, the measured signal strengths indicative of uplink interference; and

operating to process uplink interference signal strength measurements for the selected frequencies and select for assignment by the given base station an idle traffic channel on as little an interfered one of selected frequencies as possible while simultaneously using as few of the frequencies allocated to that given base station as possible.

17. The system of claim 16 wherein the signal strength measuring device comprises a locating verification module.

18. The system of claim 16 wherein the signal strength measuring device comprises an idle channel supervision functionality provided by a base station transceiver.

19. The system as in claim 16 wherein the signal strength measuring device makes signal strength measurements for each idle time slot.

20. The system as in claim 16 wherein the processing means operates to process and select by:

applying an interference penalty against the received uplink interference measurements if the measured frequency includes more than a threshold number of idle time slot traffic channels;

sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties from a least uplink interfered frequency to a most uplink interfered frequency; and

selecting for assignment by the base station at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency.

21. The system as in claim 20 wherein the processing means performs the sorting operation to sort the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties into plural lists, each list ordered from a least uplink interfered frequency to a most uplink interfered frequency.

22. The system as in claim 21 wherein processing means performs the selecting operation to select from a certain one or ones of the plural lists for assignment at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency contained on that certain list.

23. The system as in claim 20 wherein the processing means performs the applying operation to apply an increasing interference penalty against the received uplink interference measurements corresponding to when an increasing number of idle time slot traffic channels are included within the frequency.

24. The system as in claim 16 wherein processing means comprises a mobile switching center.

25. A method for use in a cellular telephone system for assigning traffic channels, comprising the steps of:

making signal strength measurements on frequencies allocated to a base station, wherein each frequency includes a plurality of time slot traffic channels, the measurement made on those frequencies having idle time slot traffic channels to obtain uplink interference measurements;

making a report by a given base station of measurements made on selected ones of the plurality of frequencies allocated to that given base station which include

idle traffic channels, the measured signal strengths indicative of uplink interference; and

processing the reported uplink interference signal strength measurements for the selected frequencies to select for assignment by the given base station an idle traffic channel on as little an interfered one of selected frequencies as possible while simultaneously using as few of the frequencies allocated to that given base station as possible.

26. The method as in claim 25 wherein the step of making signal strength measurements comprises the step of making signal strength measurements for each idle time slot.

27. The method as in claim 25 wherein the step of processing comprises the steps of:

applying an interference penalty against the received uplink interference measurements if the measured frequency includes more than a threshold number of idle time slot traffic channels;

sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties from a least uplink interfered frequency to a most uplink interfered frequency; and

selecting for assignment by the base station at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency.

28. The method as in claim 27 wherein the step of sorting comprises the step of sorting the measured frequencies by their uplink interference measurements adjusted by any applied interference penalties into plural lists, each list ordered from a least uplink interfered frequency to a most uplink interfered frequency.

29. The method as in claim 28 wherein the step of selecting comprises the step of selecting from a certain one or ones of the plural lists for assignment at call set-up or hand-off one of the idle time slot traffic channels included within the least uplink interfered frequency contained on that certain list.

30. The method as in claim 27 wherein step of applying comprises the step of applying an increasing interference penalty against the received uplink interference measurements corresponding to when an increasing number of idle time slot traffic channels are included within the frequency.

31. The method as in claim 27 wherein the step of selecting comprises the step of randomly selecting an idle time slot traffic channel included within the least uplink interfered frequency.

32. The method as in claim 27 wherein the step of selecting comprises the step of selecting an idle time slot traffic channel having a lowest interference included within the least uplink interfered frequency.

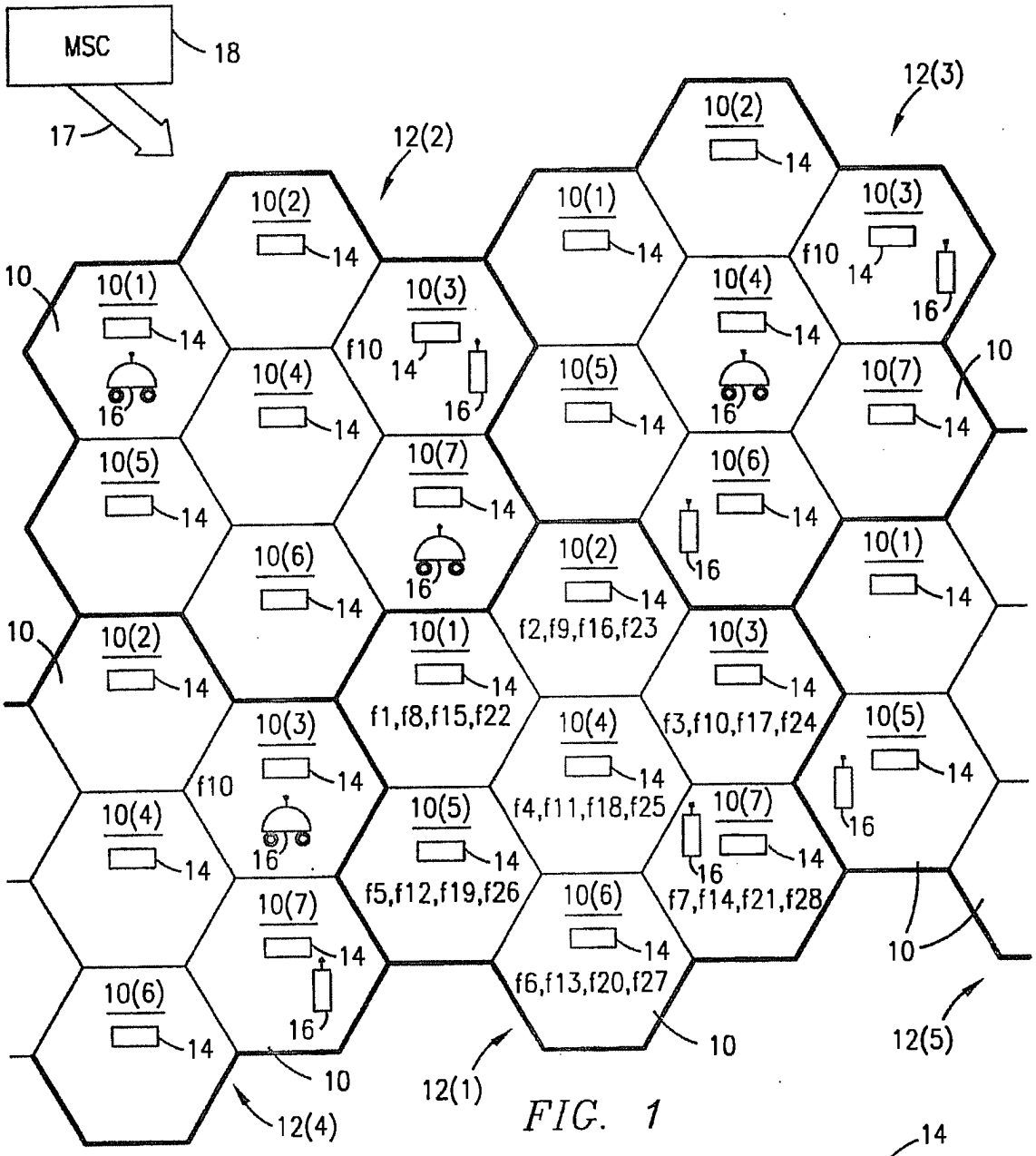

MSC
18
17
12(2)
12(3)
10
10(1)
10(2)
10(3)
10(4)
10(5)
10(6)
10(7)
14
16
f10
f2,f9,f16,f23
f1,f8,f15,f22
f3,f10,f17,f24
f4,f11,f18,f25
f5,f12,f19,f26
f7,f14,f21,f28
f6,f13,f20,f27
12(1)
12(4)
12(5)

FIG. 1

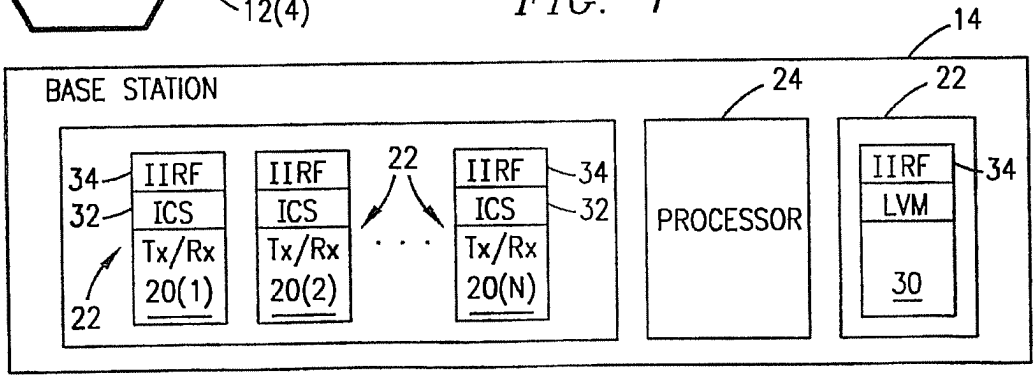

14
BASE STATION
24
22
34
32
IIRF
ICS
Tx/Rx
20(1)
20(2)
20(N)
PROCESSOR
LVM
30

FIG. 2

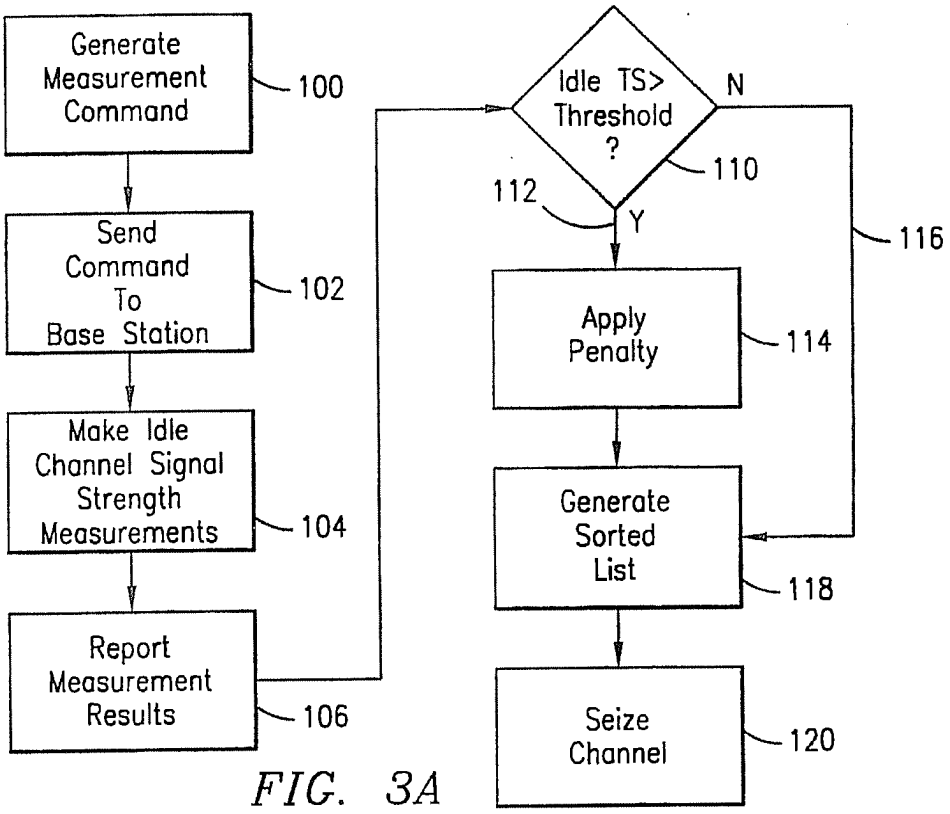

Generate Measurement Command
100
Send Command To Base Station
102
Make Idle Channel Signal Strength Measurements
104
Report Measurement Results
106
Idle TS> Threshold ?
110
N
Y
112
116
Apply Penalty
114
Generate Sorted List
118
Seize Channel
120

FIG. 3A

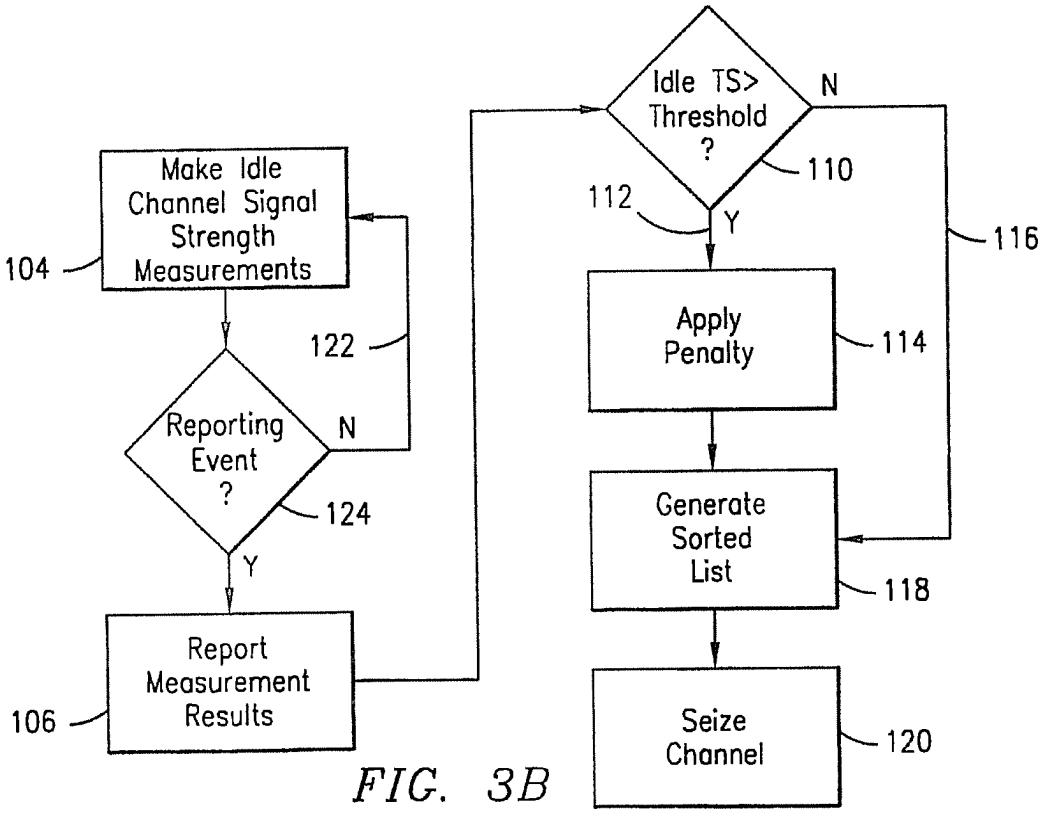

Make Idle Channel Signal Strength Measurements
104
122
Reporting Event ?
124
N
Y
Report Measurement Results
106
Idle TS> Threshold ?
110
N
Y
112
116
Apply Penalty
114
Generate Sorted List
118
Seize Channel
120

FIG. 3B

INTERNATIONAL SEARCH REPORT

Int ational Application No
PCT/SE 98/02109

A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 422 932 A (BHATIA HANS ET AL) 6 June 1995 see column 3, line 22-40 see column 6, line 51 - column 7, line 53 ---	1,9,16, 25
A	EP 0 779 755 A (NIPPON TELEGRAPH & TELEPHONE) 18 June 1997 see page 4, line 17 - page 5, line 1 ---	1,9,16, 25
P,A	EP 0 817 521 A (LUCENT TECHNOLOGIES INC) 7 January 1998 see page 4, line 10 - page 6, line 51 ------	1,9,16, 25

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 February 1999	17/02/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Weinmiller, J

2

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Int ational Application No
PCT/SE 98/02109

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		JP 10079977 A	24-03-1998

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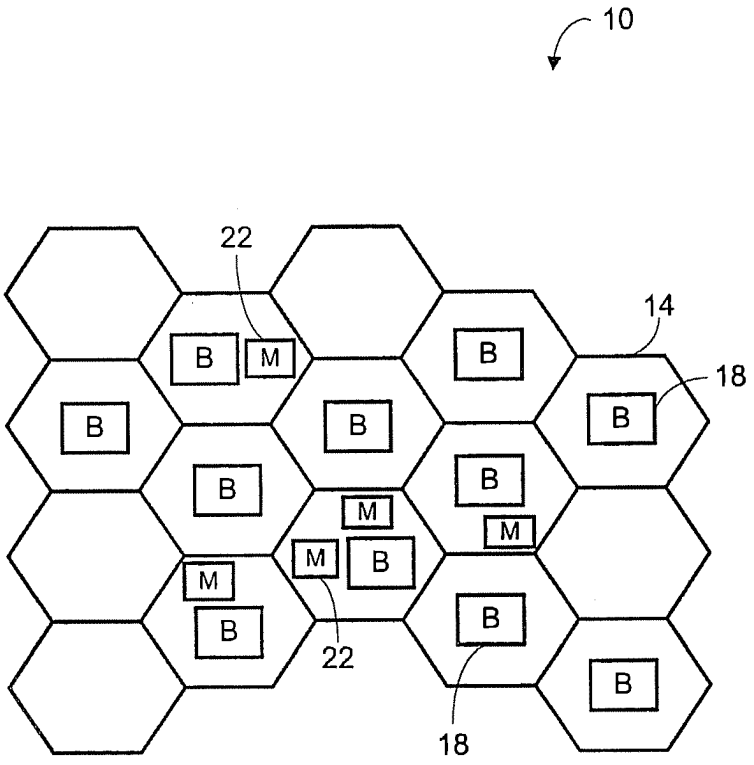
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[Continued on next page]

(54) Title: SYSTEM AND METHOD FOR FREQUENCY PLANNING IN WIRELESS COMMUNICATION NETWORKS



(57) Abstract: A system and method for frequency planning in a wireless communication network area using an impact matrix which relates signal interference impacts between sectors in a network service area for co-channel and adjacent channel interference. The impact matrix uses weighted propagation analysis and empirical measurement data to determine signal levels within each pixel of a network service area. The system merges the propagation analysis and empirical measurement data according to user assigned confidences.

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SYSTEM AND METHOD FOR FREQUENCY PLANNING IN WIRELESS COMMUNICATION NETWORKS

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BACKGROUND OF THE INVENTION

This invention relates generally to the field of frequency planning in wireless communication networks and, in particular, to a system and method for improved consideration of the impact of various factors in frequency planning.

In wireless communication systems, such as a cellular mobile radio communication system, the geographic area served by the system is divided into geographically defined cells. In the system, there is a finite number of carrier frequency channels, typically radio-frequency (RF) channels, that are available for use during communications in and between network areas cells. Typically, a frequency group, consisting of a subset of all of the available frequencies, is assigned to each cell for that cell's use during communications.

However, because the number of frequency groups is limited, it is necessary to reuse them within the area served by the system. To provide for a greater coverage by the system, and to provide for greater capacity through higher reuse of frequency groups, the network service area cells may be further divided up into sectors. Because the use of a particular frequency by two different sectors can result in interference during a call or even result in the call being completely cut-off or "dropped", an effort must be made to assign frequency groups to sectors in a manner that minimizes the amount of interference.

In wireless communication networks, there are two primary types of interference: co-channel interference and neighbor or adjacent channel interference. Co-channel interference is the interference from communication sources tuned to the same frequency as the operating channel. Adjacent-channel interference comes from

communication sources using channels near the operating channel in the frequency domain. To achieve the desired voice or data transmission quality, the ratio of the received signal over the combined co-channel and neighbor-channel interference must be above a specified threshold. Such channel interference can be up-link or down-link interference or a combination of these interferences. Down-link interference is channel interference received at regions serviced by a first base station caused from signals transmitted by other base stations. Up-link interference is interference at the base stations caused from signals transmitted by mobile units in regions of the coverage area that are not serviced by that base station.

Furthermore, other factors such as antenna patterns, power levels, scattering, and wave diffraction variations combined with buildings, various other structures, hills, mountains, foliage, and other physical objects contribute to the interference experienced during wireless communications.

In frequency planning for a wireless communication network, the primary task is to try to predict and attempt to reduce the amount of channel interference experienced by strategically assigning certain channels to certain sectors. Typically, this can be achieved by assigning frequencies so that the distance between co-channel and adjacent channel sectors is maximized. In this context, "distance" does not necessarily refer to geographic distance but connotes a distance in the RF sense. That is, although sectors far apart from each other geographically are less likely to "see" each other, they can still interfere with each other. For example, a high sector can interfere with a sector as far as hundreds of miles away. Maximizing this distance decreases the chances of the sectors conflicting with one another in the airwaves. However, a severe consequence of maximizing this distance is that it effectively reduces the amount of channel combinations possible in the network service area, thereby limiting the amount of coverage available for wireless communication. Typically, frequency planning is ordinarily accomplished by three primary techniques including channel sets, reuse patterns and pixel based interference analysis.

Channel sets are non-overlapping subsets of the available channels organized according to a periodic frequency spacing in terms of number of channels between members of a given set. The principal disadvantage of using channel sets is

that the number of channels required from sector to sector usually varies, and optimal frequency planning will require that just that number, rather than the number in an arbitrary set, be assigned to each sector.

In the reuse pattern scheme, the sectors in a network are arranged in a two-dimensional pattern, or "grid". Channels or, more commonly, channel sets, are then assigned so that co-channel or adjacent channel assignments appear periodically in different sectors. The primary disadvantage of frequency planning based upon a reuse grid is that, within a given network, varying terrain and man-made "clutter", such as buildings and other structures, will affect the characteristics of radio propagation and attenuation. Therefore, adhering to a fixed and rigid co-channel or adjacent channel spacing on a grid will likely provide inadequate isolation in some cases, resulting in excessive interference, and more than the required isolation in others, thereby reducing reuse efficiency. Furthermore, in addition to less than optimal interference levels, the fixed reuse approach results in much reduced capacity in many parts of the network where frequencies can be added freely due to an RF shield, such as a mountain ridge, but the grid prohibits such an assignment.

In pixel based interference analysis, the entire network service area is divided into a large number of very small "pixels" or "bins". In one example, each pixel would be a 100 meter square, so that a network service area of 100 kilometers by 100 kilometers would contain 1 million pixels. For each pixel, a system engineer will ascertain the strongest incident signal level from the sectors nearby and then the incident signal levels from each of the other sectors in the network to determine potential interferences. From this information, the system engineer can determine the predicted levels of co-channel or adjacent channel interference that would be present in that pixel if certain sectors were assigned, respectively, the same radio channels as the serving sector or channels adjacent to those in the serving sector.

However, pixel-by-pixel interference analysis also has many significant limitations. While pixel by pixel analysis can predict interference problems that are likely to result from a proposed frequency plan, it does not provide any such plan in the first place, nor does it inherently suggest modifications to a frequency plan that would reduce interference. Furthermore, there is an inherent limitation on the amount of data

that can be presented in pixel by pixel interference analysis. At the same time, pixel by pixel analysis produces an amount of data which is not easily susceptible to human interpretation. Finally, because conventional pixel by pixel interference analysis relies solely on predicted levels, it carries over the inaccuracies in such data as described above and results in erroneous frequency assignments.

Thus, while these existing techniques can provide for some measure of protection and relief from channel interference in the network service area, they still fail to account for the many variables and factors which can affect wireless communications on a day to day basis. Accordingly, it would be desirable to have a system and method for frequency planning within a wireless communication network which accounts for the many variables and factors affecting the quality of wireless communications, reduces the interference experienced during wireless communication, and does not limit the coverage area of network cells.

SUMMARY OF THE INVENTION

The present invention provides a system and method for creating an impact matrix for use in allocating frequency channels in a wireless communication network service area which is divided into a plurality of sectors and further divided into a plurality of pixels. The impact matrix provides impact scores which characterize the impact of making certain co-channel or adjacent channel assignment in pairs of sector by sector within a network service area.

The impact scores are developed by a series of steps, the first of which involves selectively merging signal propagation analysis data and empirical measurement data to determine an anticipated signal level for each one of the plurality of pixels in the network area. Once the signal levels within each pixel are obtained, a determination is made as to which sector within the network service area is serving that particular pixel. The system then assigns a weighted channel interference impact score for the pixel based on the interference between the pixel's signal serving sector and signals from each of the other non-serving sectors in the network area. Overall sector by sector impact scores based on the weighted channel interference impact scores are determined for all of the pixels for which a sector is the serving sector.

In one embodiment of the present invention, the signal level data from the signal propagation analysis, empirical measurement, and switch logs analysis is merged according to user assigned confidences for the data. The step of determining a weighted channel interference impact score between the pixel's signal serving sector and signals from each of the other sectors in the network area includes calculating a ratio between a signal level from the serving sector and signal levels from each of the other sectors in the network area, assigning interference impact scores for each of the other sectors in the network area, and adjusting the interference impact scores according to user assigned factors such as network area sensitivity to call quality and amount of call volume for that network area.

Once the impact matrix is developed, the scores in the matrix may be modified to further accurately characterize the signal impacts of interferences within a network service area. The impact matrix scores may be adjusted according to data which may have been previously input to the system or may be contemporaneously input. Such data includes channel pairing relationships among sectors which are known to provide low levels of excessive interference, channel pairing relationships among sectors which are known to provide high levels of excessive interference, and detailed call history information. Detailed call history information can include data on dropped calls and associated sector and channel combination where call drops occur.

The impact matrix may then be used for frequency planning in the network service area. The impact matrix will provide a user, typically a network engineer, with a way to predict the signal quality impact of certain channel assignments within the network service area.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a wireless communications network service area which is divided into cells.

FIG. 2A illustrates a network service area cell of FIG. 1 divided into sectors.

FIG. 2B is a detailed illustration of portion A in FIG. 2A showing a sector divided into pixels.

FIG 3 illustrates an exemplary impact matrix developed in accordance with the teachings of the present invention.

FIG. 4 is a flow chart illustrating a process for determining interference impact scores for use in developing the impact matrix.

FIG. 5 is a flow chart illustrating a process for determining a signal level within a pixel in the service area.

FIG. 6 is a flow chart illustrating a process for determining the potential interference impact of incident signals in a pixel from each of the other sectors in the network.

FIG. 7 illustrates how overall impact scores are determined for the impact matrix.

FIG. 8 is a flow chart illustrating a process for modifying the impact matrix.

FIG. 9 illustrates a computer system using an impact matrix of the present invention for frequency channel planning in a network service area.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown a schematic layout of a wireless communications network service area 10 divided into cells 14. It should be understood that the hexagonal shape of cells 14 depicted in FIG. 1 merely represents a drawing convention. Such a hexagonal cell representation has been chosen because it approaches a circular shape that is the ideal power coverage area for a wireless communications network service cell. Use of such circular shapes would involve overlapped areas and make a drawing of the served area unclear. With the hexagonal shaped cell convention, on the other hand, the plurality of cells representing a service area can be depicted with no gap and no overlap between cells. Generally, a typical wireless network would have far more than the illustrated number of cells but the numbers shown are sufficient for illustrative purposes.

As shown in FIG. 1, each cell 14 contains base stations 18 which are located toward the center of each cell 14. Typically the base stations employ omni-directional antennas, while base stations located toward a cell boundary typically employ directional antennas. Operating within a communications service area are

typically a large number of mobile telephone stations, or mobiles 22. At any given point in time, a subset of these mobiles will be engaged in calls.

As shown in FIG. 2A, each cell 14 in the wireless communication network service area may be divided further into sectors 30 to improve the coverage or maximize the reuse factor without increasing the interference level of the available frequency channels. Additionally, as shown in FIG. 2B, the network service area may be further divided into pixels 40 to assist in analyzing communication signal quality and interference on a more detailed basis. Typically, during wireless communications, the communicating mobile 22 will be assigned a particular frequency channel in the sector within which the mobile 22 is currently operating. If the mobile 22 moves from one sector which is currently servicing the communication, the "serving sector", to another sector which takes over the servicing of the communication, the "target sector", a "handoff' occurs in which the mobile 22 is assigned a new frequency channel from those available in the target sector.

In the present invention, the frequency channels correspond to the frequencies in approximately the 800 MHz band to the 1900 MHz band. The invention is intended for use in a system such as a Netplan system for the purpose of facilitating frequency planning for digital and/or analog channels, the invention will work in a dual mode system where analog and digital frequencies share the spectrum in each cell. The present invention is applicable to, but not limited to, "Advanced Mobile Phone System" ("AWS"), "Total Access Communications System" ("TACS"), "Nordic Mobile Telephone" ("NMT"), "Time Division Multiple Access" as defined by the Telecommunications Industry Association (TIA) interim standard IS-136 ("TDMA"), and "Global System for Mobile" ("GSM") protocols.

Referring to FIG. 3, the system and method of the present invention develops and generates an impact matrix 50 for use in frequency planning for a wireless communication network service area. Generally, the impact matrix 50 is a representation of the potential signal quality impact of making certain co-channel or adjacent channel assignments between two sectors within a wireless network, such as a cellular telephone network. It is contemplated that the impact matrix may also be organized by pixel by pixel and/or a cell by cell rather than sector by sector. In a

preferred embodiment of the present invention, two main matrices are developed, one which addresses the impact of co-channel interference and the other which addresses the impact of adjacent channel interference. The methods and processes shown and described herein will be applicable to either co-channel or adjacent channel interference determinations and measurements. In addition, the impact matrix is independent of the frequencies used in the wireless system, as long as the system works within a given interval such as, in one embodiment, a 100 MHz interval. Two impact matrices would be developed for use in a dual band network.

In the impact matrix, the columns 54 represent specific serving sectors in the network service area and the rows 58 represent interfering sectors in the network service area. A sector is considered to be a serving sector if, at a given point, the sector is currently providing the communications link to the mobile unit. The interfering sectors or "non-serving" sectors may be any sector within the network service area which may cause interference in the serving sector by virtue of a co-channel or adjacent channel assignment in that non-serving sector. For example, if a serving sector, denoted for exemplary purposes as sector S_1 is assigned a channel X, and one other sector S_2, within the network service area is also assigned channel X, then sector S_2 will be considered a potentially interfering sector.

In a preferred embodiment, the impact matrix will typically be of the dimension Q by Q, where Q is equal to the number of sectors in the network. In other embodiments, Q may include some sectors in neighboring networks which might interfere with, or be subjected to, interference from sectors that lie near the edge of the actual network service area under consideration. In such a case, the impact matrix should still be kept as a square by using null data in fields representing neighboring networks as serving sectors.

Generally, the impact matrix is developed by performing various signal quality measurements on a set of frequency channels in a network service area cell and adjusting the signal quality measurements based on a variety of factors or signal impacts, as discussed in more detail herein. In an exemplary embodiment, signal quality measurements are made not only for those frequency channels in use or available for use, but also for those frequency channels that are not currently being

used or available for use, though they may become available at a later time. These various signal quality measurements are processed, filtered, and evaluated, as described in greater detail below, and used as a basis for changing assignments of frequency channels.

The impact matrix 50 contains impact scores 72 which relate, on a sector by sector basis, the overall quality impact of making certain channel assignments in certain sectors pairings. Take, for example, the specific pairing of serving sector S_2 (column S_2) and interfering sector S_3 (row S_3). An impact score of "66" is given to the pairing of serving sector S_2 and interfering sector S_3 in the impact matrix of FIG. 3. The "66" represents the overall quality impact in areas served by sector S_2 when a co-channel or adjacent channel assignment is made in sector S_3. The scores 72 as shown in FIG. 3 are merely represented on a scale from one to ninety-nine for exemplary purposes only. It is contemplated that any numeric scale may be used in developing the impact matrix, such as a one to ten scale or any other similar scale which can provide for a relative rating in the matrix. In developing the impact scores, the system and method of present invention allow multiple data "layers" to be applied and merged so as to more accurately represent the potential signal interference impacts between sectors.

As shown in FIG. 3, in creating the impact matrix of the present invention, a number of data files or "layers" are used to provide data for development of the impact matrix. In some embodiments, such data includes output files from computer RF propagation analyses 60, output files from empirical measurements 62, files containing or implying lists of co-channel and/or adjacent channel pairing relationships among various sectors 64, and files which provide details of call records for the network for some period of time 66. Other types of data or output files may be used in accordance with the teachings of the present invention, where the data may affect the signal quality within the network service area. The system and method of the present invention are scalable so that any number of data layers are able to be incorporated into the overall impact matrix. In the present system, each of these data types or files constitutes a "layer" for eventual incorporation into an overall unified impact matrix.

As shown in FIG. 4, in one embodiment of the present invention, the development of the impact matrix generally begins with a determination of signal levels within the network service area, step 100. Once signal level information is obtained and calculated, it is determined which sector within the network service area is the serving sector for a particular pixel, step 104. Once the serving sector is identified, the potential interference of other sectors on this serving sector is quantified by way of an interference impact score assigned to that specific pairing of serving sector and interfering sector, step 108. Finally, the interference impact scores are adjusted according to some user inputtable variables and factors, step 112. The steps of the process shown in FIG. 4 will be now discussed in more detail below.

Referring now to FIG. 5, in constructing the impact matrix, the system of the present invention endeavors to determine the signal level within each pixel of the network service area. The process begins with a basic RF propagation analysis for the network service area, step 120. By way of background, the RF propagation analysis is typically based on signal predictions which take into account area topology, antenna heights, transmit power levels and even extant man-made clutter, such as building, bridges, etc. Such propagation predictions are most often performed by computer simulation programs running specially designed RF propagation analysis software, such as MSI's Plantet, Motorola's Netplan, or LCC's CellCard. After RF propagation analysis is performed, empirical measurement data is collected to provide additional information about signal levels within each pixel in the network service area, step 124. Collecting empirical signal level measurements typically are made by a receiver provided either in a mobile unit, such as car or in a hand held scanner, which scans discrete channels being transmitted by the various sectors. The measurement receiver is moved about in the network to collect signal level data in a large number of pixels, often in the form of so-called "drive tests".

Once the propagation analysis and empirical measurements are completed, confidences may be assigned to the signal level data, step 128. For example, if it is known that for a certain area the RF propagation analysis data will be incorrect or skewed, a user may assign more confidence to the empirical measurement data for that certain area. Conversely, if it is known that for another service area, the

empirical measurement information is somehow inaccurate because, for example, of possible physical/environmental clutter which may affect the empirical readings, then the user may assign more confidence to the RF propagation analysis information in that instance.

In one embodiment, a two-dimensional representation of the network service area in map format is provided to a user, on which the user can "draw" such areas as polygons or other arbitrary shapes using a "mouse" or other pointing device to designate areas to which to assign confidences to either the propagation or empirical measurements. The user may also simply assign confidence ratings to either the propagation analysis or empirical measurement information. Such ratings may be simply a one to ten rating or any scale which can rate the data on a relative basis. In such an example, the signal level data which the user has the most confidence in will be assigned a "10" and the data which the user has the least confidence in will be assigned a "1."

Once confidences are assigned, the system merges propagation analysis and empirical measurement information, step 132, in accordance with confidences assigned by the user. In an exemplary embodiment, the basic logic for the merging of the propagation analysis data and the empirical measurement data is accomplished according to the following pseudo-code:

```
for current _point = {points in drive-test} {
        for freq. = { frequencies measured in current frequency {
                for each antenna transmitting at the current frequency {
                        using some basic RF prediction model, calculate the
                        predicted signal strength in the drive test point
                        region (~500m radius), apply a geometric correlation
                        test to the sampled and predicted measurements. Store
                        the correlation index.

                        iterate to next antenna
                }
                if none of the antennas satisfied some minimal correlation threshold
                        go to frequency loop
```

take the antenna with the best correlation index and declare it
as the transmitter of the current frequency at the current point.

iterate to next frequency
}
iterate to next point
}

The merging of propagation analysis and empirical measurement information is done as a preliminary step in determining which sector in the network service area is serving a current pixel. This is accomplished by first determining which antenna in the network service area is transmitting the current signal being measured at the current pixel (current_point). The process for determining signal levels within a network service area is basically accomplished by the nested series of loops, as shown above, whereby readings are taken at a certain point (pixel) within the network service area, then at each point a certain frequency is measured, then for that certain frequency, the different antennas transmitting at that frequency are examined.

Essentially, a point by point (current_point) frequency signal analysis is conducted for all the points in the empirical test (points in drive_test). At each point, frequencies are measured (frequencies measured in current_point) to determine viable frequencies at that point. Then, for each antenna transmitting at the current frequency, the predicted signal strength is determined using basic RF prediction model data. A geometric correlation test is applied to the currently empirically sampled signal measurement and the predicted signal strength measurement to determine a correlation index. This correlation index is then stored. This process of determining and storing a correlation index is repeated for each antenna transmitting at the current frequency. If none of the antennas satisfy a minimal correlation threshold, the next frequency at the current point is examined. This process is then repeated for the next point or pixel in the empirical measurement analysis.

Once at least two correlation indices are determined for the frequency at the current point, the at least two indices are compared and the antenna with the "best" correlation index is determined to be the transmitter of the current frequency at the current point. The "best" correlation index is obtained for the antenna with the best match between the prediction and sample and whose complete set of frequencies is measured in a coordinated way. After this determination is made for the current

frequency, the system iterates to the next frequency and repeats the above process of determining the transmitter of the frequency.

Having merged the RF propagation analysis and empirical measurement data for every pixel in the network service area, the system now has a signal strength per pixel file in which, for each pixel in the network, the anticipated incident signal levels from each sector are retained. Those skilled in the art will appreciate that typically, in each pixel, the anticipated signal level from the vast majority of the sectors in the network will be below a thermal noise floor, and may thus be disregarded. Typically, the thermal noise floor will be approximately at or below 130 dB.

Referring back to FIG. 4, the present system and method identifies, in each pixel, the associated serving sector for that pixel, step 104. The probability of a mobile being served by a given antenna at a given point depends in part on the RF propagation layer, e.g., the signal strength of each antenna at each point, and also in the logical organization of the network which takes into account factors such as the handoff regulation algorithm and parameters. The following pseudo-code demonstrates the basic logic employed in an exemplary embodiment for determining which will be the serving sector for a given pixel or point in the network service area:

```
for current_point = {points in sample} {
        calc the best server in current_point.
        calc the best server signal strength at current_point.
}
for current_sector = {sectors in the network} {
        for neighbor = {neighbors to current_sector) {
                flow = number of times user handoff between current_sector and
                        neighbor.
                Simulate user movements and the handoff process (using
                the specific system handoff algorithm) and update the service
                probabilities in non-best server areas (known as handoff zone).
        }
}
```

In an exemplary embodiment, the system determines for the current pixel (current_point) out of all the pixels in the network service area (points in sample), the best server for the current_point and the best server signal strength at the current_point, as described above. Then for the current sector (current_sector) out of all the sectors in the network, each neighboring sector (neighbors to current_sector) is

examined based on the flow, user movements and the handoff process to determine service probabilities for each of the sectors. The system predicts, taking into account the system specific handoff algorithm which may vary between communication systems, which sector will serve a given pixel based on the handoff performance between the current_sector and neighboring sectors (neighbors to current_sector.) Thus, a sector will likely be a serving sector for a given pixel, if the sector both provides a strong signal to a given pixel and also actively coordinates handoffs in that given pixel's area.

Referring back now to FIG. 4, once the system determines which is the serving sector for each pixel, the system begins with an analysis of the potential interference impacts between signals from each of the other non-serving sectors in the network with that pixel's serving sector, step 108. As shown in FIG. 6, the process for determining the potential interference impact of signals begins with determining the carrier-to-interference (C/I) ratios for each potentially interfering sector, step 140. Typically, these C/I values are calculated in decibels ("dB"). A large C/I ratio indicates a signal that is substantially isolated from channel interference while a small C/I ratio indicates a signal having substantial channel interference. Thus, large C/I ratio values between conventional cellular base stations that are, for example, greater than approximately 18 dB, indicate that such base stations can use the same channel while small C/I ratio values between base stations, such as, for example, less than approximately 12 dB, indicate that substantial interference will probably occur between those two base stations when using the same or adjacent frequency channels. The specific C/I values are determined typically by the type of air interference technology used (GSM Vs TDMA, for example) and the service parameters the operator may want to use.

The system of the present invention maintains a user modifiable table which develops a quality impact "score" with respect to the determined C/I. For example, in an exemplary embodiment as shown below in Table 1, the quality impact score will range from zero to ninety-nine, with zero representing no perceptible quality impact and ninety-nine representing severe interference virtually certain to result in a dropped call. In a more specific example, a score of 0 is assigned for a potential

interferer in pixels where C/I is determined to be above 17 dB and a score of 99 for a potential interferer in pixels where C/I is determined to be below 9 dB.

Table 1

Impact Score	C/I (dB)
0	18
50	13
99	8

As shown in FIG. 6, using the C/I scoring table shown and described above, the system will then assign an interference impact score for each potential interfering sector in each pixel in the network, step 142. Referring again to FIG. 6, these interference impact scores are then adjusted according to various weighting factors, step 144.

In one preferred embodiment, the system uses weighting factors which are specified by the user. In particular, the system allows identification of areas within the network service area in which sensitivity to call quality is particularly high and other areas where such sensitivity is relatively low. For example, areas frequented by top government officials may be designated as "high" sensitivity and low traffic pedestrian areas may be designated as "low" sensitivity. In this embodiment, the system also allows identification of specific areas within the network service area in which peak time call volume, preferably on a per-pixel basis, is anticipated to be significantly higher than average, and other specific areas where such anticipated call volume is relatively low. For example, sections of major highways where vehicular traffic routinely backs up during "rush hour" might generate much higher than average peak time call volumes, so the user might designate such areas as "high" call volume per pixel. "Low" call volume per pixel designated areas may be locations such as side roads located in rural townships where activity is minimal. The user may use a number of different sources of information to provide such weighting factors, such as traffic reports, call logs from past activities in certain areas, and consumer feedback reports which may indicate areas where communication services may be currently deficient. Once these weighting factors are provided by the user, the system adjusts the interference impact scores accordingly, in line with the weighting factors.

The following pseudo-code demonstrates the basic logic for determining a single impact score between sectors:

```
define the local interferer index function using the tables matching the current network
technology, the tables assigning a local impact for each co-channel C/I and a
potentially different local impact to each adjacent channel C/I

For current_server = {sectors in the network} {
        for current_interferer = {sectors in the network ! = current_server} {
                for current_point = {points in which the traffic uses
                                        current server in non zero probability} {
                        compute the C/ I of the current_server and
                        current_interferer at the current_point using the RF
                        propagation information.
                        compute the cochannel and adjacent channel local
                        interference indices.
                        }

                use an integration policy to collect all the local interference
                indices to a single impact between current_server and
                current_interferer.
        }
}
```

In the above pseudo-code, a pixel by pixel analysis is undertaken for each serving sector (current_server) and each interfering sector (current_interferer) in the current pixel being examined. For each pixel (current_point), the C/I is computed for that specific pixel's serving sector and each of the other interfering sectors in the network service area (sectors in the network !=current_server). In one embodiment, the C/I will be computed using the RF propagation information which may be simple predicted RF propagation information or alternatively, sampled RF information and/or the RF information merged with empirical data. Once the C/I of the current_server and current_interferer is computed, the co-channel and adjacent channel local interference indices are computed from the computed C/I at the current_point. In the present embodiment, the local interference index is a measure of the user dissatisfaction from experiencing a given C/ I in a given technology. Once the local interference indices are calculated, the system uses an integration policy to collect or combine all the local interference indices to generate an impact score between the current_server and

current_interferer for that given pixel. This combination of local interference indices can be done using traffic normalized summation, maximization, prioritized weighted summation, or other variants.

The system has now created a weighted pixel-by-pixel characterization of potential interference impacts in the network service area. From this impact information, the system generates an impact matrix 146, as shown in FIG. 7. In the impact matrix 146, each of the columns represents a specific sector in the network acting as the serving sector. Each of the rows represents a specific sector in the network acting as an interfering sector. Thus, an entry in the impact matrix will represent the overall signal quality impact in areas served by a specific sector which would be caused by making co-channel or adjacent channel assignments in another sector. Typically, the higher the score in the impact matrix, the more of an impact a co-channel or adjacent channel assignment will have for that specific sector pair.

To generate an overall impact score for the impact matrix, the system considers all of the weighted interference impact scores as determined above for each pixel. In one embodiment, the system performs a weighted sum integration to generate the impact matrix from the scores. Referring to FIG. 7, for each sector S_1 S_2, S_3, and S_4. in a network service area, the system considers all of the pixels for which a specific sector, say S_1 is the serving sector. For example, if sector S_1 is the serving sector for pixels P_1, P_2, P_3 and P_4, then the weighted interference impact scores for pixels P_1, P_2, P_3 and P_4 are considered in generating an overall impact score for that sector S_1 and its potentially interfering sectors, such as S_2, S_3, and S_4. For example, for each pixel, weighted interference impact scores have been determined between each pixel serving sector and each of the other non-serving sectors S_2, S_3, and S_4 (S_1 v.S_2; S_1 v. S_3; S_1 v.S_4). Based on the weighted interference impact scores, the system determines an overall impact score for sector S_1 with respect to sectors S_2, S_3, and S_4. For example, considering sector S_1 to be the exemplary serving sector and sector S_2 to be the interfering sector, the system will examine the weighted interference impact scores for pixels P_1, P_2, P_3 and P_4 with respect to sector S_2, namely P_1 (S_1 v.S_2), P_2 (S_1 v.S_2), P_3 (S_1 v.S_2) and P_4 (S_1 v.S_2). These weighted interference impact scores for pixels P_1, P_2, P_3 and P_4 with respect to sector S_2 are then combined and weighted to generate an

overall impact score for sector S_1 as the serving sector and sector S_2 as the interfering sector. This overall impact score will then be placed into the impact matrix under the column sector S_1 and in the row sector S_2. The remaining spaces in the impact matrix are populated as described above. Typically, the spaces in the impact matrix where the serving sector and the interfering sector are the same sector remain blank, since the same sector will not be able to interfere with itself in practice.

The following pseudo-code demonstrates one set of logic behind consolidating various layers of information and data into a single overall impact matrix:

```
input :
layers[the_layer] [sector1][sector2] - the impact between sector1 and sector2 in layer
the_layer.

weight_from[the_sect] [layer] : the weight associated to impacts from sector the-sect
with regard to the layer.

weight_to[the_sect] [layer] : the weight associated to impacts to sector the_sect with
regard to the layer.

Output : the unified im - im[sector] [sector]
for sl = {set of sectors} {

for s2 = {set of sectors} {
        im[sl, s2] =
                merging_func(s1, s2, {layers[0][s1][s2], layers[1][s1][s2],..})
        }
}
merging_func(s1,s2, {entry1, entry2,....}) =

                summ(i, weight_from[s1] [i] * weight_from[s2] [i] * entry [i])
```

In consolidating all the signal and interference data into a single impact matrix, the system accepts input, such as the interference impact scores for specific areas (sector1, sector2) of the network service area, as was determined above. These impact scores thereby form a "layer" (the_layer) of data for consolidation into the single impact matrix. Such data may also be weighted, for example, by specifying which areas within the network service area are sensitive or are "high" call volume

areas. The interference impact scores and associated weightings are then processed by the system (merging_func) and outputted into a unified impact matrix.

One skilled in the art will recognize that the overall impact matrix may be generated in many different ways and still achieve the objectives of the present invention. For example, in a more general example of an integration technique, arbitrary logical expression is defined that takes a set of layer values *1M_sect1_sect2_layer_i* and an output is generated by applying the logical expression to the inputs. Having, for example, two input layers *drive_test* and *heuristic*, the system generates the impact matrix using the following expression:

```
If (heuristic >0)
        return heuristic
else
        return drive_test
```

Further embodiments involving combinations of logical expressions and weighted sums are available, as will be understood by those skilled in the art after reviewing this description.

Referring now to FIG. 8, once the impact matrix is generated, step 150, the impact scores may be adjusted to further accurately represent potential impacts of channel assignments. The scores may be adjusted according to the data which defines sector pairs for which it is known that channel assignment, either co-channel or adjacent channel, will not result in excessive interference, step 152. If the impact scores in the impact matrix suggest interference impacts higher than the known levels, step 154, the scores in the matrix are reduced accordingly, step 156.

The impact scores may also be modified in accordance to data which defines sector pairs for which it is known that channel assignment, either co-channel or adjacent channel, will result in excessive interference, step 158. If the impact scores in the impact matrix suggest interference impacts lower than the known levels, the scores in the matrix are increased accordingly.

Additionally, the system may adjust the scores in the impact matrix based on data input which contains call detail information, such as information which correlates incidences of dropped calls operating on a given radio channel in a given sector with simultaneous use of the same (or adjacent) radio channel in another sector,

step 164. When a high correlation of these factors is found, it is assumed that there is a causal relationship in that the dropped calls in one sector are likely caused by interference from the other sector. In this case, the system examines the corresponding impact score in the impact matrix, step 166. If this score is not already appropriately high, it is then increased to a high value, step 168.

Typically, the system will accept the following inputs prior to the creation of the impact matrix: files containing or implying lists of co-channel and/or adjacent channel pairing relationships among various sectors which are known to provide low levels of excessive interference; files containing or implying lists of co-channel and/or adjacent channel pairing relationships among various sectors which are known to provide high levels of excessive interference; files which provide details of call records for the network for some period of time including: for each incidence of a dropped call: the precise time of the call drop; the RF channel in use by the call when the drop occurred; and the serving sector of the call when the drop occurred; for each call handled during the period covered by the data: the time the call began; the initial RF channel assigned; the initial serving sector; the time, target sector, and new RF channel assignment for each handoff; and the time the call ended.

In a typical cellular communication network, call detail information as discussed above may be extracted from switches within the network communications system which maintain log files that track various attributes, such as dropped calls, severe C/I events, uplink noise, failed handoffs and other related events. Call detail information may also be extracted from performance monitoring systems such as WantMark's Flex-PM, ADC's Metrica, and MSI's MAXXER.

Once modifications to the impact matrix, as described above, are complete, the impact matrix is used to assist the system engineer in designing and optimizing a frequency plan for the network, wherein the object is to assign channels to each cell or sector in the numbers required while keeping the total quality impact associated with these assignments to the lowest possible value.

As shown in FIG. 9, the methods and systems of the present invention may be incorporated in software stored on a computer usable medium such as a hard or floppy disk, CD-ROM, or other electrical, magnetic, or optical memory device adapted

for use on a computer system 200. Additionally, the methods or systems may also be incorporated in hardware elements such as specially designed integrated circuits, as is known in the art. The computer system 200 may provide for the calculation, processing and generation of an impact matrix 210 in accordance with the teachings of the present invention. The impact matrix 210 may be used for frequency planning within a network service area 220 made up of cells or sectors 230. The impact matrix 210 would provide guidance on how to make specific channel assignment 240 and/or channel set assignments 250 within each cell or sector 230. For example, if a user desired to change an existing channel assignment within the network service area 220, the user would consult the impact matrix 210 to determine the impact of changing the channel assignment.

In other embodiments, the system would "score" a given frequency plan, or a given modification thereto, by applying the impact matrix's scores to the individual channel assignments in the plan or modification. For example, if a system engineer needs to add an RF channel to a particular sector to accommodate growth in peak call volume, he or she can consider a particular channel assignment. The impact matrix will provide the incremental quality degradation that such an assignment will cause within that sector's service area and in the service areas of each co-channel or adjacent channel sector.

While the invention has been described and illustrated in connection with preferred embodiments, many variations and modifications as will be evident to those skilled in this art may be made without departing from the spirit and scope of the invention, and the invention as set forth in the appended claims is thus not to be limited to the precise details of methodology or construction set forth above as such variations and modification are intended to be included within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method of generating an impact matrix for use in allocating frequency channels in a wireless communication network service area, the network area divided into a plurality of sectors which are further divided into a plurality of pixels, the impact matrix providing impact scores which characterizes sector by sector channel interference in the network service area, the method comprising:

merging signal propagation analysis data and empirical measurement data to determine an anticipated signal level for each one of the plurality of pixels in the network service area;

determining which one of the sectors in the network service area is a serving sector for the pixel;

determining channel interference impact scores for the pixel based on the interference between the pixel's serving sector and each of the other sectors in the network service area; and

providing sector by sector impact scores.

2. The method of claim 1, wherein merging propagation analysis is performed according to user ascribed confidences.

3. The method of claim 1, wherein determining channel interference impact scores between the pixel's serving sector and signals from each of the other sectors in the network service area comprises:

calculating ratios between a signal from the serving sector and signal levels from each of the other sectors in the network service area;

assigning unweighted interference impact scores based in part on the calculated ratios; and

adjusting unweighted interference impact scores according to user assigned variables.

4. The method of claim 3, wherein the user assigned variables comprise network area sensitivity to call quality and amount of call volume for that network service area.

5. The method of claim 1, further comprising modifying the overall impact scores in the impact matrix according to channel pairing relationships among sectors which are known to provide high levels and low levels of interference.

6. The method of claim 5, further comprising modifying the overall impact scores in the impact matrix according to detailed call history information.

7. The method of claim 6, wherein the detailed call history information includes dropped call information.

8. A system for developing an impact matrix for use in frequency channel planning in a wireless communication network service area, the communication network service area divided into sectors and pixels, the system comprising:

means for determining a signal strength level for each pixel in the network service area;

means for determining which is a serving sector for each pixel in the network service area;

means for determining an interference impact score between each pixel's serving sector and each of the other non-serving sectors in the network service area; and

means for determining overall sector by sector impact scores for inclusion in the impact matrix, the overall sector by sector impact scores based on the interference impact scores for the pixels within which a sector is the serving sector.

9. The system of claim 8, wherein the means for determining a signal strength for each pixel in the network service area comprises means for conducting a propagation analysis and means for performing empirical measurements.

10. The system of claim 8, wherein the means for determining an interference impact score between each pixel's serving sector and each of the other non-serving sectors in the network service area comprises:

means for calculating for each of the other non-serving sectors in the network service area, the ratio between the signal strength level from the serving sector and a signal strength level from each of the other non-serving sectors;

means for assigning interference impact scores for each of the non-serving sectors; and

means for weighting the interference impact scores.

11. The system of claim 10, wherein the means for weighting the interference impact score comprises means for allowing the user to specify sensitive areas within the communication network service area.

12. The system of claim 11, wherein the means for weighting the interference impact score comprises means for allowing the user to specify areas having high or low call volume within the communication network service area.

13. The system of claim 8, further comprising means for modifying the impact matrix based on data which specifies co-channel assignments which will not result in excessive interference.

14. The system of claim 13, further comprising means for modifying the impact matrix based on data which specifies co-channel assignments which will result in excessive interference.

15. The system of claim 14, further comprising means for modifying the impact matrix based on data which specifies adjacent channel assignments which will not result in excessive interference.

16. The system of claim 15, further comprising means for modifying the impact matrix based on data which specifies adjacent channel assignments which will result in excessive interference.

17. The system of claim 16, further comprising means for modifying the impact matrix based on call detail information.

18. The system of claim 17, wherein the call detail information includes at least one or more of the following: time of call drops, channel in use by dropped calls, serving sectors of dropped calls, time dropped calls began, initial channel assigned to dropped calls, initial serving sector of dropped calls, call handoff information and time calls ended.

19. The system of claim 8, wherein the impact matrix allows a user to make and evaluate individual channel assignments in the communication network.

20. A computer implemented process for creating an impact matrix for use in allocating channels in a wireless network which is divided into sectors, the impact matrix constructed based on a pixel by pixel analysis of signal interference within the network, the process comprising:

determining a serving sector for at least one pixel in the network;

determining weighted interference impact scores for the at least one pixel, the weighted interference impact scores based upon each of the non-serving sectors' interference impact upon the pixel's serving sector; and

determining overall impact scores based upon the weighted interference impact scores for the at least one pixel.

21. The process of claim 20, wherein determining a serving sector for at least one pixel in the network comprises merging propagation analysis and empirical data according to user ascribed confidences assigned to the data.

22. The process of claim 20, wherein determining overall impact scores comprises, for all of the pixels in the network for which a specific sector is the serving sector, processing all of the weighted interference impact scores for those pixel based upon the interference impact between the pixels' serving sector and each of the other non-serving sectors in the network.

23. A method of using an impact matrix for frequency channel planning in a wireless communication network divided into sectors, the impact matrix providing sector by sector signal quality interference ratings, the method comprising:

determining an incremental quality degradation for a potential channel assignment in the network using the impact matrix; and

assigning frequency channels to sectors according to the incremental quality degradation provided by the impact matrix.

24. The method of claim 23, wherein the impact matrix provides co-channel interference ratings.

25. The method of claim 23, wherein the impact matrix provides adjacent channel interference ratings.

26. A computer readable medium containing a program which when executed on a computer causes the computer to perform a method for creating an

impact matrix for use in frequency channel planning in a network service area which is divided into a plurality of pixels, the method comprising:

determining a serving sector for each of the plurality of pixels in the network;

determining weighted interference impact scores for the selected pixel, the weighted interference impact scores based upon each of the non-serving sectors' interference impact upon the pixel's serving sector; and

determining overall impact scores based upon the weighted interference impact scores, wherein the impact matrix characterizes the interference relationship between sectors in the network service area.

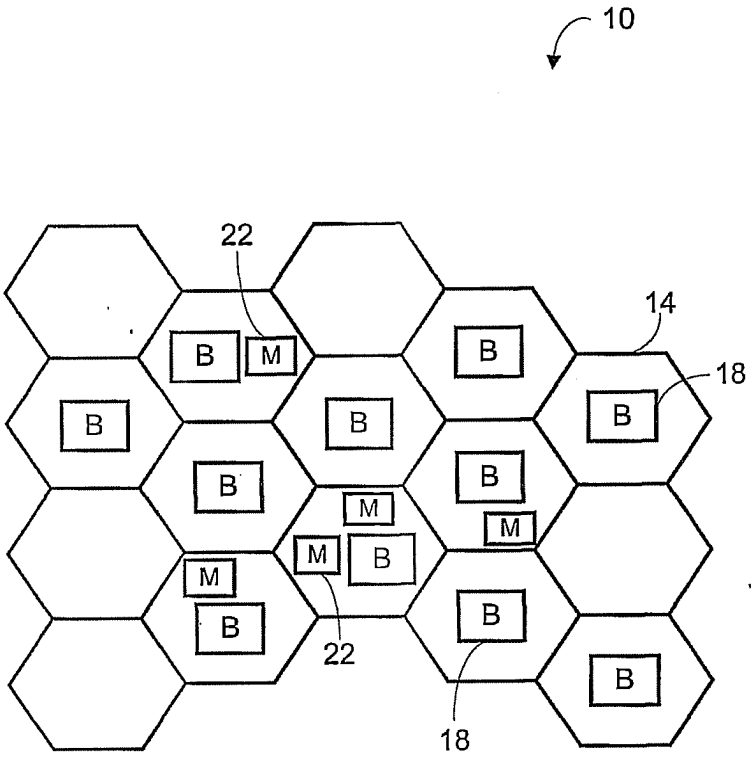


FIG. 1

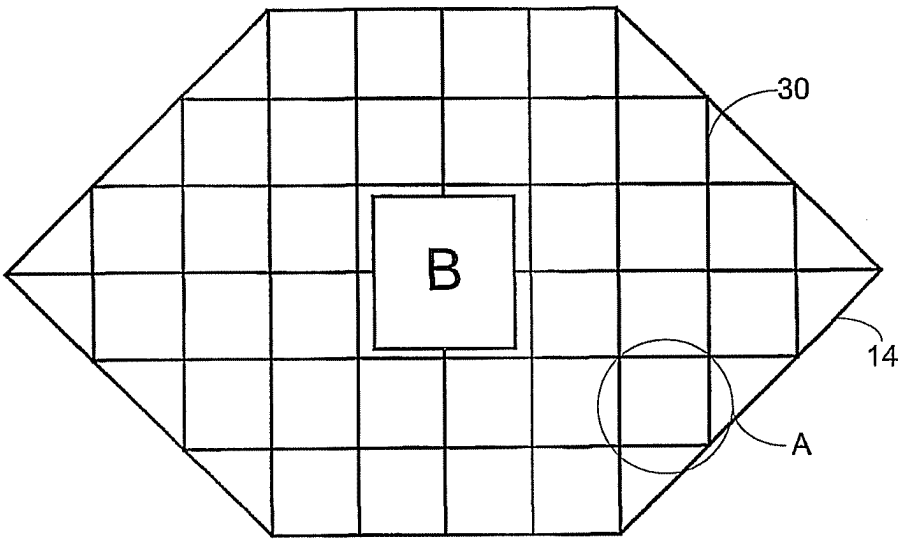


FIG. 2A

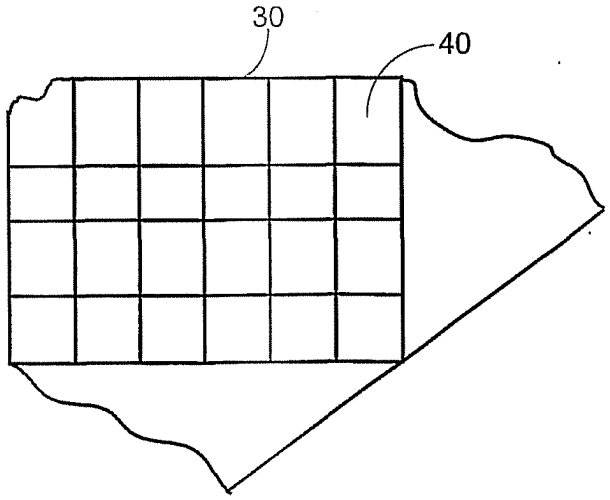


FIG. 2B

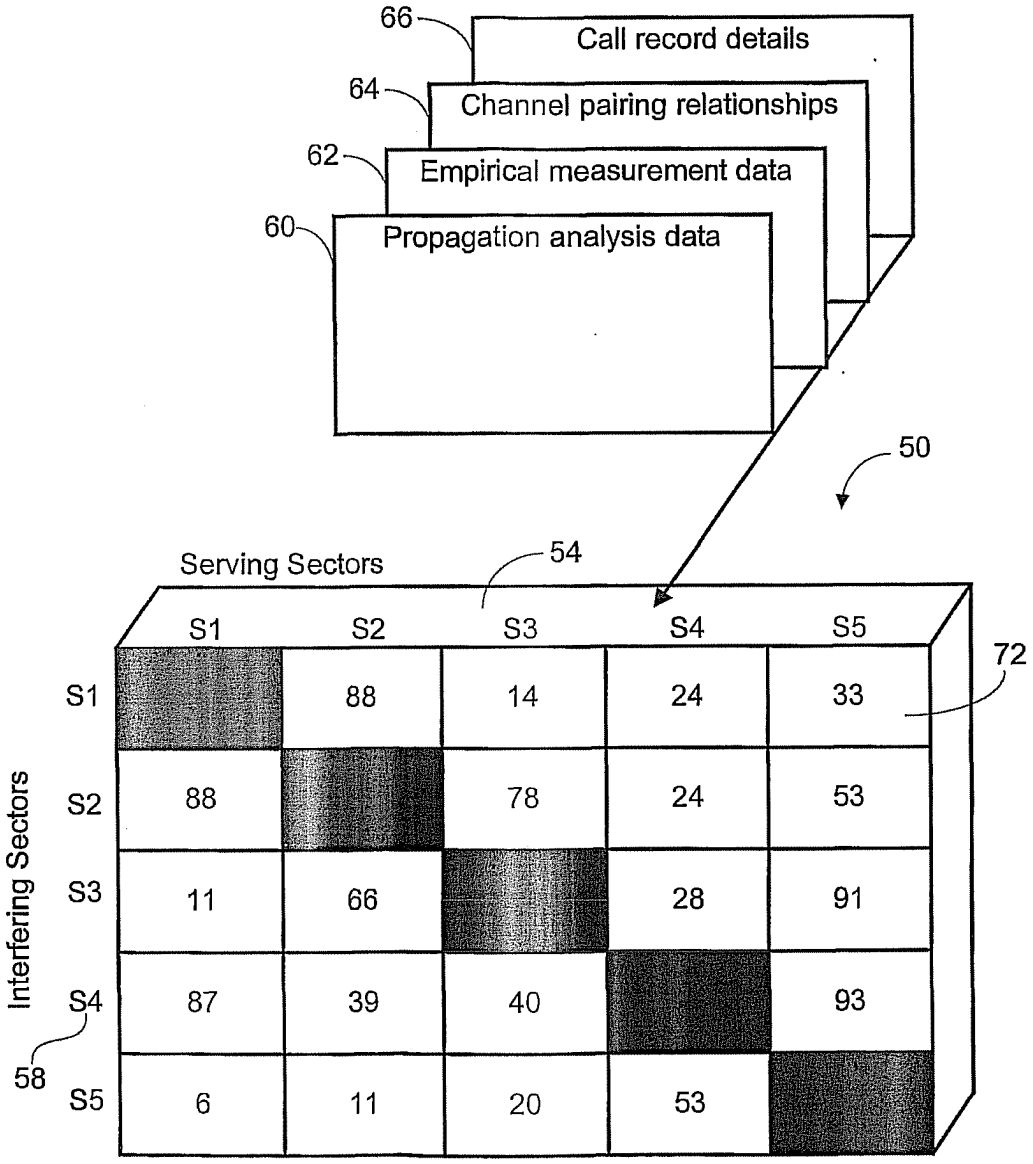

66
Call record details
64
Channel pairing relationships
62
Empirical measurement data
60
Propagation analysis data
50
Serving Sectors
54
S1
S2
S3
S4
S5
72
Interfering Sectors
58
S1 88 14 24 33
S2 88 78 24 53
S3 11 66 28 91
S4 87 39 40 93
S5 6 11 20 53

FIG. 3

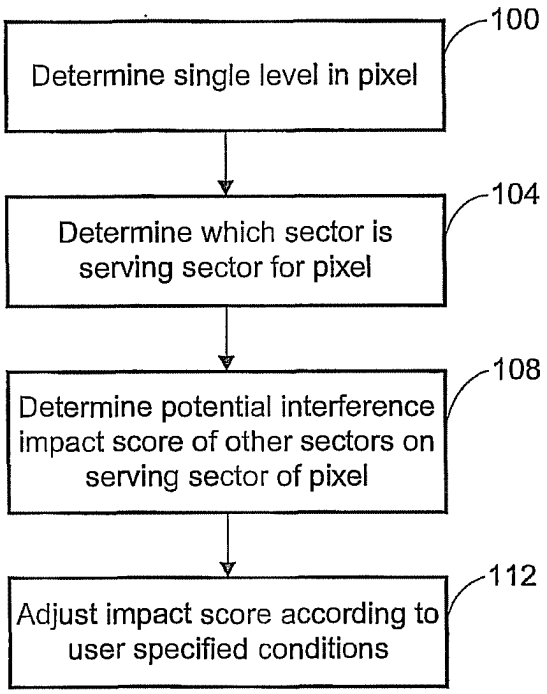

Determine single level in pixel
100
Determine which sector is serving sector for pixel
104
Determine potential interference impact score of other sectors on serving sector of pixel
108
Adjust impact score according to user specified conditions
112

FIG. 4

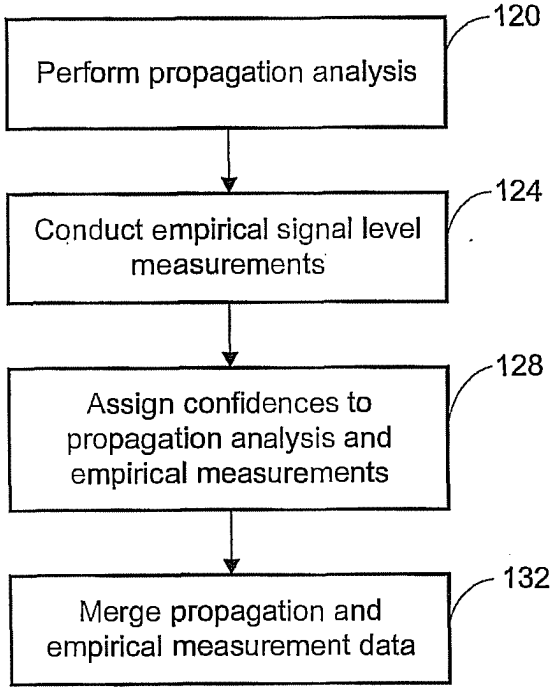

Perform propagation analysis
120
Conduct empirical signal level measurements
124
Assign confidences to propagation analysis and empirical measurements
128
Merge propagation and empirical measurement data
132

FIG. 5

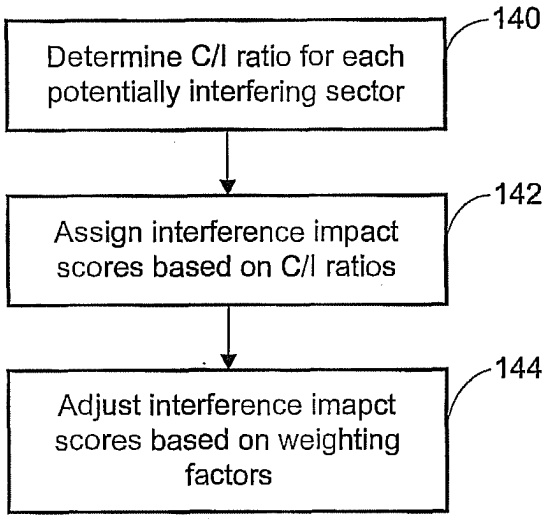

Determine C/I ratio for each potentially interfering sector
140
Assign interference impact scores based on C/I ratios
142
Adjust interference imapct scores based on weighting factors
144

FIG. 6

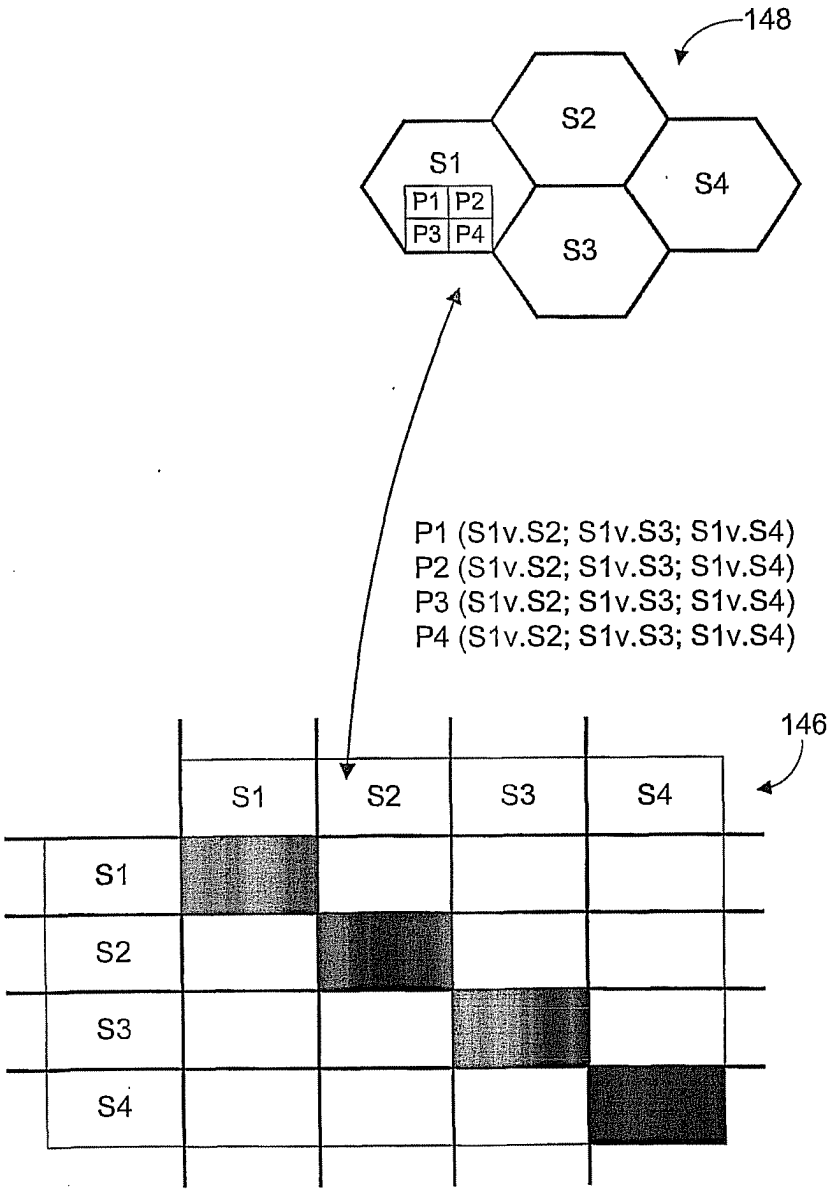

148
S1
S2
S3
S4
P1
P2
P3
P4
P1 (S1v.S2; S1v.S3; S1v.S4)
P2 (S1v.S2; S1v.S3; S1v.S4)
P3 (S1v.S2; S1v.S3; S1v.S4)
P4 (S1v.S2; S1v.S3; S1v.S4)
146
S1
S2
S3
S4
S1
S2
S3
S4

FIG. 7

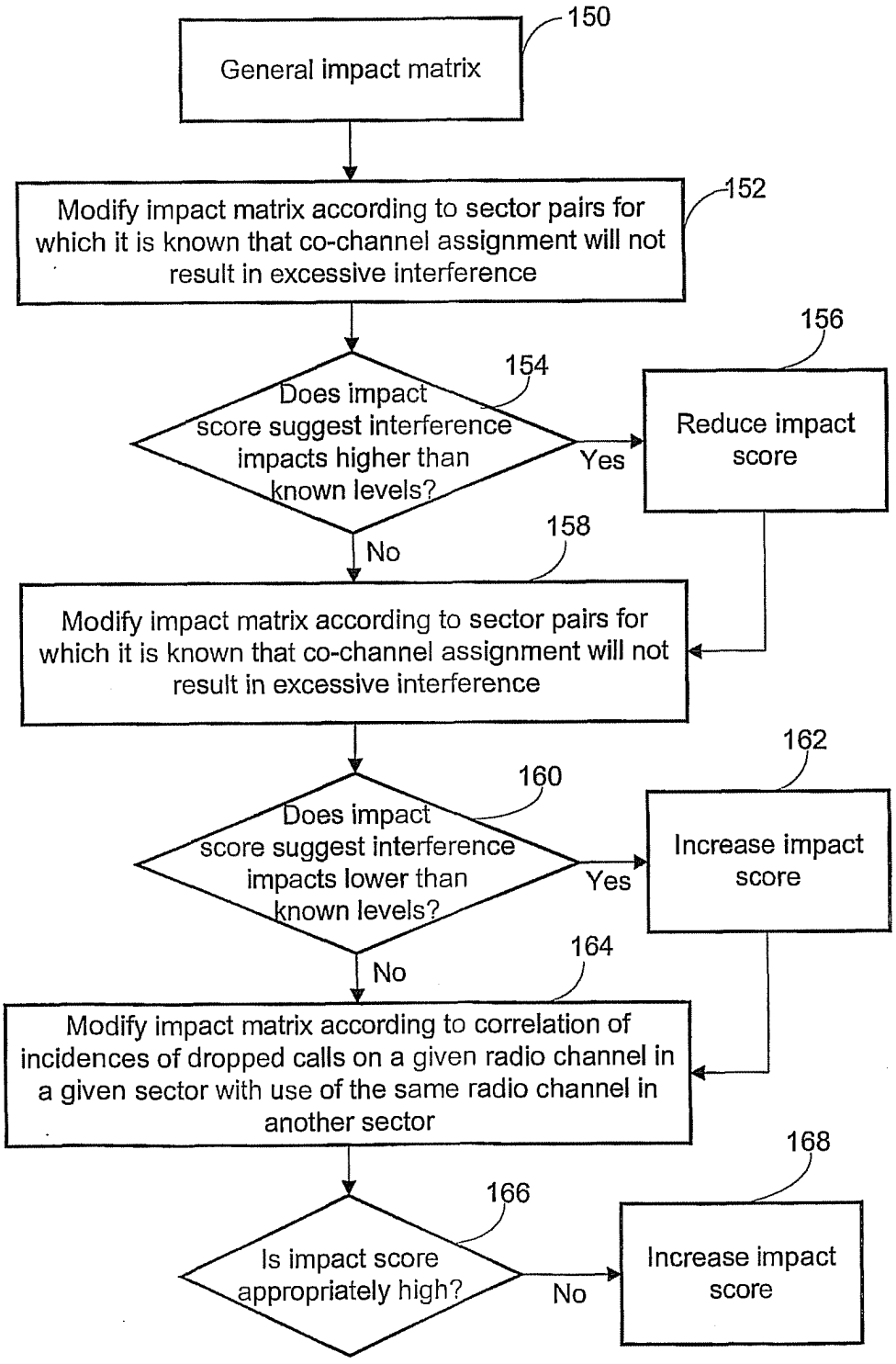

General impact matrix
150
Modify impact matrix according to sector pairs for which it is known that co-channel assignment will not result in excessive interference
152
Does impact score suggest interference impacts higher than known levels?
154
Yes
Reduce impact score
156
No
Modify impact matrix according to sector pairs for which it is known that co-channel assignment will not result in excessive interference
158
Does impact score suggest interference impacts lower than known levels?
160
Yes
Increase impact score
162
No
Modify impact matrix according to correlation of incidences of dropped calls on a given radio channel in a given sector with use of the same radio channel in another sector
164
Is impact score appropriately high?
166
No
Increase impact score
168

FIG. 8

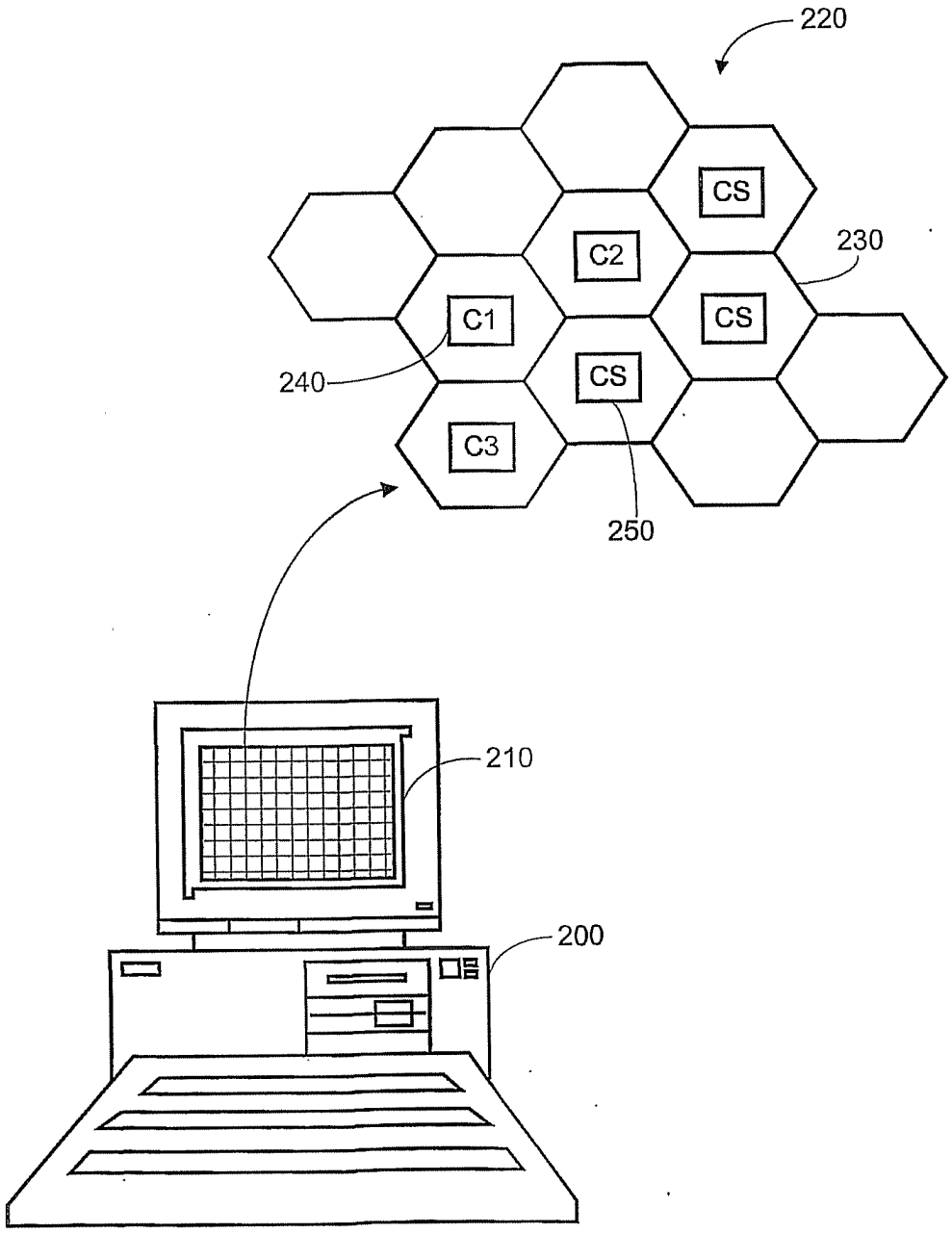


FIG. 9

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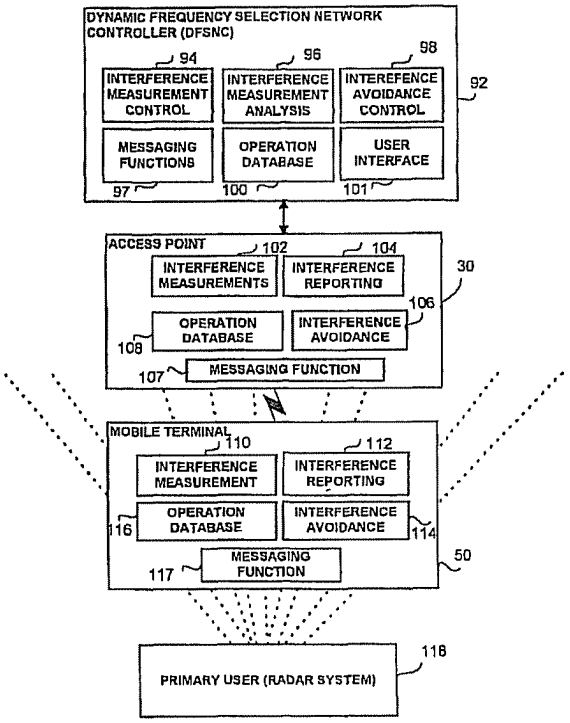
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[Continued on next page]

(54) Title: METHOD AND SYSTEM FOR DETECTION OF AND DYNAMIC ADAPTATION TO RADIO INTERFERENCE IN A SHARED WIRELESS COMMUNICATIONS ENVIRONMENT



(57) Abstract: A method and system for interference detection and for dynamic adaptation and self-adjustment of a wireless communications system in response to the presence of an interfering signal in a communications channel. A controller device communicatively coupled to a network periodically instructs a device implemented in the wireless network to perform interference detection on one or more specified communications channels. The device performs the measurements, and returns the results to the controller. The controller analyzes the results, and determines the state of the measured channels in respect of the presence or the absence of a signal interference. Optionally interference avoidance measures are taken, such as switching the routine data transmission to a vacant communication channel, or utilizing the same channel co-operatively with the interfering signal. The avoidance measures could be implemented on a multi-network level, a single network level, a wireless transmitter level, or a directional sector level.

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Published:
— *with international search report*

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METHOD AND SYSTEM FOR DETECTION OF AND DYNAMIC ADAPTATION TO RADIO INTERFERENCE IN A SHARED WIRELESS COMMUNICATIONS ENVIRONMENT

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to wireless communication systems in general, and to the dynamic detection and self-adjustment of the transmission parameters of a wireless local area network in response to prior controlled detection of radio frequency interference produced by diverse users, such as terrestrial radar, sky-borne radar, satellite transmitters, amateur radio service, or the like, sharing the same frequency band, in particular. The present invention further relates to a coexistence mechanism, which enables diverse radio frequency signal transceiving users to operate in parallel on the same frequency band.

DISCUSSION OF THE RELATED ART

The present invention offers a method and system for identifying signal interference phenomena produced by and applied reciprocally to wireless systems operating in a shared signal environment. The method and system is further operative in the prevention of the effects of the mutual interference to the wireless systems.

The regulating bodies dealing with the utilization of the radio frequency spectrum allocated certain frequency bands such that various wireless systems, such as wireless local area networks (WLANs), radar systems, satellite feeder systems, amateur radio services, and the like, may utilize simultaneously a shared range of frequencies. This commonality poses a strong potential for radio frequency interference in the shared communications environment. Interference occurs when a wireless device associated with a wireless data communications network, such as a WLAN, and a device associated with a another system, such as a radar, a satellite feeder, or a amateur radio transmitter, deployed in geographical

proximity or in effective broadcast range attempt to transmit substantially at the same point in time on the same frequency. In order to provide compatibility and ensure harmonic co-existence among the WLANs and the other systems operating in the same frequency band the regulating bodies attempted to mediate potential frequency conflicts by providing different priorities to different systems in the common band. Some systems, such as terrestrial radar, sky-borne radar, satellite feeders, amateur radio services, and the like, were designated as the "primary users" of the common band while other systems, such as WLANs, cellular phone networks, wireless personal area networks (WPANs), and the like, were designated as the "secondary users" of the same frequency band. The primary users were granted priority over the secondary users. It was further determined that the secondary users must not cause unacceptable interference to the primary users, and that the secondary users must accept all interference from the primary users. Thus, it is the responsibility of the secondary user, such as a WLAN, to avoid collision with a primary user, such as a radar system, a satellite transmitter, an amateur radio service, or the like. Consequently, the secondary user, such as a WLAN, must implement appropriate actions, such as detecting of the presence of an active primary user transmitting on a specific frequency within effective broadcast range, and avoiding transmission on the same frequency in order not to interfere with the primary user.

In an ideal world, timely information regarding radar system parameters, such as transmission frequencies, transmitting periods, and the like, would be routinely supplied to the operators of the functional WLANs to enable proper frequency planning of the wireless network. Such planning would provide the WLAN operators the capability of avoiding the use of frequencies associated with radar emissions, satellite broadcasts, amateur radio transmissions, and the like, in order to comply with regulations. In accordance with up-to-date information received about the activities and operational parameters of primary users deployed within effective range of one or more mobile terminals of a secondary user, such as a WLAN, the secondary user could be manually

pre-configured and periodically re-configured in order to refrain from transmitting on the frequencies utilized by the primary user.

In a realistic environment the situation is more complicated. In some countries for reasons of national security the parameters of certain primary users, such as military radar installations are not publicly available. The re-deployment of mobile radar installation for the duration of military exercises, or for periods of national emergency raises further difficulties. Occasionally transmitting, newly installed, or periodically re-configered primary user transmitters pose additional problems. Furthermore, primary users, such as radar systems, may occupy the bandwidth in a pseudo-random manner in respect to the portion of the bandwidth utilized, and to the bandwidth usage pattern. Thus, secondary users, such as WLANs, have to provide their own autonomous interference detection and avoidance means in order to avoid interference with such sensitive "partners" to the shared frequency band.

Currently, secondary users, such as WLANs, employ the "polling" technique for primary user interference detection. For example, at certain pre-defined points in time, such as at the WLAN system start-up, measurements are taken for the purpose of detecting active radar transmitters. The polling method may present difficulties when for various reasons the radar system is temporarily de-activated. For example, the radar transmitter can be shut down for the duration of maintenance activities or can be made periodically inoperative as a routine part of its standard operating procedure. When the points of time allocated by the WLAN for the performance of interference measurements coincide with or are included within the periods of the radar transmitter's inactivity the detection of the interfering transmission is not a viable option. Failure to detect activity could also be caused by the radar system operating in specific operational modes, such as in "sectorized" mode, where the radar scan is performed across a restricted azimuth range, or as in the "sweep" mode, where the radar scan is performed across the complete 360 degrees azimuth range. If the WLAN measurements period coincide with or contained in that segment rotational

periods during which the radar antenna radiation pattern is directed "away" from the measuring device then the transmission will not be detected.

Detection of a primary user transmission by a secondary user is also problematic due to physical issues, such as "interference asymmetry". Typically, primary users, such as radar systems, do not interfere "significantly enough" with secondary users, such as a WLAN, compared with the interference effected to a primary user, such as a radar system, by the transmission of signals from WLAN devices and reception of the signals by the receiver of a radar system. Due to the longer distances covered by the radar signals (the radar signals may travel a path from the radar transmitter to a reflecting target, and back to a WLAN receiver) in respect to the distance covered by the WLAN signals (typically, half the distance of the radar signals as the WLAN signal path includes single route segment between a WLAN transmitter to a radar receiver), and the resulting asymmetry in the respective propagation losses, the primary user is more interfered with by the WLAN than the WLAN is interfered by the primary user. Furthermore the radar system is more sensitive to interference due to differences in the system-specific modulation techniques. Similar interference asymmetry-related problems may also exist in regard to an interference involving a WLAN and other types of primary users, such as satellite transmitters, amateur radio service, or the like, as well.

WLAN devices are capable of detecting the presence of interfering transmitters and taking suitable actions for the avoidance of mutual signal interference by moving to an unused communication channel. The channel switch is accomplished through the utilization of a set of functions typically referred to as the Dynamic Frequency Selection (DFS) or as the Dynamic Channel Selection (DCS). In the text of this document the DFS acronym will be used.

DFS is a vendor-specific mechanism, without established and published standards but the general principles are known. Currently, the DFS function is mainly based on received signal strength (idle channel RSS) measurement taken during WLAN-idle channel conditions. Access Point (AP)

devices utilized as bridges between a wired and a wireless local area network make the measurements themselves or can require the Mobile Terminals (MT) linked thereto to take the measurements. The measurements can be taken on a channel in use or on another frequency. Interfering signals can be detected by measuring the received signal strength at intervals within a specified time slot and comparing the result to a predefined threshold value. If the idle channel RSS is higher than a maximum allowed value then it can be concluded that a strong interference source, such as a radar transmitter operates in the vicinity.

Co-existence is defined as the ability of a system to perform a task in a shared environment where other systems may or may not be using the same set of rules. Multiple wireless devices are said to co-exist if they can be collocated without significantly impacting the performance of these devices. Providing a co-existence mechanism among secondary users, such as WLANs, and primary users, such as radar systems, is important for the better utilization of the radio frequency spectrum, which is a scarce, costly, and therefore a heavily regulated resource. When signals emitted from a periodic radar transmitter associated with a pulse or sweep radar system are detected by the WLAN in respect to a specific communication channel with an allocated specific frequency, the WLAN takes suitable interference countermeasures such as moving to a vacant channel within its own allocated frequency band. The technique has a drawback such that it is substantially wasteful in terms of the useable bandwidth and in terms of WLAN-performance efficiency. It would be preferable for the WLAN to keep using the channel interfered with and co-exist with the interfering signal.

It would be readily perceived that there is an urgent need for a method and system for the detection of diverse primary users, such as non-pre-configured radar systems by secondary users, such as WLAN's, in a signal environment shared by both systems. There is also a clear and present need for a method and system to provide an improved utilization of the bandwidth available to a wireless communications system by providing a mechanism that enables co-existence of a primary user, such as a radar system, satellite system, amateur radio service, and

the like, and a secondary user, such as a WLAN, where both systems operate on a shared frequency band.

SUMMARY OF THE PRESENT INVENTION

One aspect of the present invention regards a wireless communications environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on an allocated frequency band, at least one primary user transmitting and receiving a radio frequency signal on a substantially alike allocated frequency band, and a method for the detecting and avoiding reciprocal signal interference produced by the radiation of the radio frequency signals emitted by the at least one primary user and by the at least one secondary user. The method includes establishing and dynamically maintaining interference detection and avoidance control and operation information in the at least one secondary user, dynamically and controllably measuring at least one communication channel providing a communication path between at least two wireless devices of the at least one secondary user, analyzing the results of measurements performed on the at least one communications channel in order to determine the interference status of the measured at least one communications channel of the at least one secondary user, dynamically maintaining interference detection and avoidance information in the at least one secondary user, and selectively and controllably performing interference avoidance procedures by the at least one secondary user to prevent reciprocal signal interference in the at least one secondary user and in the at least one primary user.

A second aspect of the present invention regards a communication environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on an allocated frequency band via a wireless or wired link, at least one primary user transmitting and receiving a radio frequency signal on a substantially same allocated frequency band via an unbounded medium, and a system for the dynamic detection of reciprocal signal

interference produced substantially simultaneously by the at least one secondary user and at least one primary user. The system contains at least one primary user interference detection and avoidance controller device, and at least one primary user interference detection and avoidance wireless device.

A third aspect of the present invention regards a wireless communications environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on a allocated frequency band via an air interface, at least one primary user transmitting and receiving a radio frequency signal on a substantially alike allocated frequency band via an air interface, and a method of detecting and avoiding signal interference effected to the at least one primary user by the transmission of the signal emitted by the at least one secondary user. The method includes the steps of dynamically and controllably measuring at least one communications channel utilized the at least one primary user, analyzing the results of the channel measurements performed on the at least one communications channel utilized by the at least one primary user in order to determine the interference status of the measured channel, communicating the results of the analysis to the at least one secondary user interference detection and avoidance controller device, dynamically maintaining interference detection and avoidance information concerning the identity, attributes, locations, directionality, and activity of at least one wireless device associated with at least one secondary user interfering with the at least one measured communications channel associated with the at least one primary user, and selectively and controllably performing interference avoidance measures by the at least one secondary user interference detection and avoidance controller device to prevent signal interference in the at least one communications channel associated with the at least one primary user.

A fourth aspect of the present invention regards a communication environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on allocated frequency band via a wireless or wired link, at least one primary user transmitting and receiving a radio frequency

signal on a substantially same allocated frequency band via an unbounded medium, and a system for the dynamic detection of reciprocal signal interference produced substantially simultaneously by the at least one secondary user and at least one primary user. The system consists of at least one primary user interference detection and avoidance controller device to communicate with and control at least one secondary user activity detection wireless device, and at least one secondary user activity detection wireless device to perform measurements on at least one communication channel utilized by the primary user in order to detect interference produced by the activity of at least one secondary user.

All the above aspects of the present invention provide for the dynamic and controlled detection of a radio frequency signal interference in a secondary user operating in a wireless signal environment.

All the above aspects of the present invention provide for the dynamic and controlled detection of a radio frequency signal interference in a primary user operating in a wireless signal environment.

All the above aspects of the present invention provide for the dynamically and adaptively adjust the transmission parameters of a secondary user operating in a shared signal environment.

All the above aspects of the present invention provide for preventing reciprocal signal interference in a secondary user and in a primary user by utilizing alternative interference avoidance schemes.

All the above aspects of the present invention enable co-existence of an active secondary user and an active primary user on a substantially same communications channel.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

Fig. 1 is a schematic block diagram of a wireless communications environment as known in the art; and

Fig. 2 is a block diagram of an HiperLAN/2 protocol architecture as implemented in a mobile terminal associated with a wireless communications network as known in the art; and

Fig. 3 illustrates the basic Medium Access Control (MAC) frame structure associated with the HiperLAN/2 protocol architecture as known in the art; and

Fig. 4 is a schematic block diagram illustrating an exemplary configuration of the proposed system, in accordance with the preferred embodiment of the present invention; and

Fig. 4A is a schematic block diagram illustrating an exemplary alternative configuration of the proposed system, in accordance with the preferred embodiment of the present invention; and

Fig. 5 is block diagram illustrates an exemplary configuration including a detailed view of the operative components associated with the proposed system, in accordance with the preferred embodiment of the present invention; and

Fig. 6 is a schematic block diagram showing the various tables constituting an exemplary operation database, in accordance with a preferred embodiment of the present invention; and

Fig. 7 is a flow chart depicting an exemplary set of operational steps involved in the performance of interference detection in the DFSNC control mode, in accordance with the first preferred embodiment of the present invention; and

Fig. 8 is a flow chart showing an exemplary set of operations involved in the performance of the interference detection in the wireless device control mode, in accordance with a second preferred embodiment of the present invention; and

Fig. 9 is a flow chart depicting an exemplary set of operational steps involved in the performance of he interference detection in the pattern recognition based interference detection mode, in accordance with a third preferred embodiment of the present invention; and

Fig. 10 is a flow chart depicting an exemplary set of operational steps involved in the performance of the interference detection in the co-existence mode, in accordance with a fourth preferred embodiment of the present invention; and

Fig. 11 is a graphical representation of an exemplary signals collision in a specific WLAN channel and an exemplary frequency re-assignment based solution to the conflict, in accordance to the first, second, and third embodiment of the present invention; and

Fig. 12 is a graphical representation of an exemplary signal collision in a specific WLAN channel and of the exemplary co-existence option based solution to the conflict, in accordance with the fourth embodiment of the present invention; and

Fig. 13 is an block diagram illustrating the operation of an exemplary sectorized detector Access Point device, in accordance with the fifth preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A method and system for remote interference detection and for dynamic adaptation of the operation of a wireless communications network in response to the state of the communications channels thereof affected by the presence of interfering signals in the channels is disclosed. A wireless communications network operating in a shared frequency band dynamically detects interference caused by a primary user, such as a radar system, by controllably taking measurements of one or more communication channels.

The method and system of the present invention are disclosed through the detailed description of several preferred embodiments. The embodiments can be implemented separately or in any functional combination appropriate to the implementation of the proposed system. In the first preferred embodiment of the present invention, the system operates in a specific operational mode, referred to as the DFSNC control mode. A controller device communicatively coupled to the wireless network and having an operation database established therein, periodically submits requests associated with a set of functional parameters held in the operation database to an access point and/or a mobile terminal communicatively linked to the same wireless network in order to perform communications channel measurements. The purpose of the measurements is the detection of the activity of a primary user operating in the same signal environment. The access point and/or the mobile terminal collects the requested channel measurement results produced according to the set of the functional parameters transmitted by the controller device and returns the measurement values obtained to the controller device. The controller device analyses the results of the channel measurement values received from the access point and/or mobile terminal, and in accordance with the products of the analysis and of a predetermined set of rules and data, determines the presence and optionally the power level of an interfering signal generated by the activity of a primary user on the measured communication channel. If a primary user-related interfering signal is detected then, in accordance with the current signal measurement results, the

prior signal measurement results, and a predefined set of data in rules in the operation database, the controller device could instruct the access point and/or mobile terminal to take suitable interference avoidance measures, such as moving to a vacant communication channel within the allocated frequency range, lowering the transmission power, or activating a specific co-existence mechanism. Additionally the controller device updates the operation database with essential information concerning the values of the channel measurements and the products of the analysis process. Subsequently the controller device alerts the network controller and/or the network operators. The controller device may further utilize the results of the analysis as a trigger to issue a set of instructions to other wireless networks, which are known to operate in the environment and are known to utilize the channel being interfered with.

The second preferred embodiment of the present invention the system operates in a specific operational mode referred to as the wireless device control mode. The controller device according to instructions of a network operator downloads a set of parameters functional to the performance of the primary user-related interference detection scheme to an access point and/or a mobile terminal. The downloaded parameters are stored within an operation database established in the access point and/or the mobile terminal. The periodic execution of the interference detection process is performed by the access point and/or the mobile terminal independently of the controller device, and according to the parameter values received from the controller device. The analysis of the channel measurement values, the determination regarding the presence and optionally the power level of an interfering signal generated by a primary user on the measured communications channel, and the necessary actions to be taken, such as channel re-assignments, transmission power adjustments, or co-existence handling, are executed by the access point and/or the mobile terminal and/or the controller device. The access point and/or the mobile terminal update the operation database established therein and optionally upload the essential update information to the controller device.

The third preferred embodiment of the present invention the system operates in a specific operational mode referred to as the pattern-recognition-based interference detection mode. A predefined interference pattern table and a channel parameter table is established on the access point and/or the mobile terminal deployed within the wireless network. In the course of the routine data exchange operations the access point and/or the mobile terminal collects changes sequentially occurring in the standard channel parameters, such as bit error rates, frame error rates, or the like. Additional changes to be collected can be physical layer parameters, such as symbol error rate, mean distance of correlation, mean error of the frequency/phase/amplitude modulation, and the like. The changes in the channel parameters are obtained continuously during any routine data exchanges, such as between the access point and the mobile terminal, or as between different mobile terminals. The changes are recorded in the channel parameter changes table. Then the changes are selectively analyzed in order to detect certain meaningful patterns. When the certain meaningful patterns are detected the access point and/or the mobile terminal and/or the controller device could initiate appropriate interference avoidance techniques, such as moving to a vacant channel within the allocated frequency range, adjusting the transmission power, or activating the co-existence mechanism. Additionally the access point and/or the mobile terminal update the local operation database, optionally upload essential information to the remote network controller concerning the results of the pattern-recognition-based interference detection scheme, and suitably notify the controller device regarding the consequent actions taken. In the third preferred embodiment of the present invention, interference detection is performed by the access point and/or the mobile terminal as an integral part of the normal operation of the wireless device.

In the fourth preferred embodiment of the present invention the system operates in a specific operational mode, referred to as the Detector Device mode. A detector device is a wireless platform co-located with a known primary user, such as a radar system, at the known primary user site, such as a radar

installation. The detector device is coupled to the controller of a wireless communications network via a wireless or a wired link. The detector device is used to detect wireless activity that could interfere with the operation of the primary user. The detector device could further be programmed to collect and store the vital transmission parameters of the primary user, such as the transmission channel, the transmission periods, transmission/reception coverage areas, and the like. This information could be also provided to the detector device by the network operator via a suitable user interface. The detector device is operative in scanning the transmission channel that is known to be used by the primary user for the purpose of detecting wireless communications network transmissions on the same channel such that the transmission could have a significant impact on the performance of the primary user. Subsequent to the detection of such activity the detector device alerts the controller device of the transmitting wireless network. The alert may further include significant control information, such as the network identification, access point identification, transmitting device identification, the periods of the transmission, and the like. The information may also include the transmission parameters of the primary user. In accordance with the received alert and the attached information the wireless network controller identifies the transmitting individual device and may instruct the device to take appropriate interference avoidance measures, such as switching channels, cease transmitting, or suitably adjusting the power level of the transmission.

The detector device could be sectorized. When sectorized the detector device could collect, collate and communicate information having a directional dimension. The information communicated could be based on a RF topology mapping of the signal environment including the location and the permanent or temporary directionality of a primary user and the location of the sectorized or non-sectorized WLAN devices with their existing sectors and sectors' directions. The map could be created manually by a network operator and/or by appropriate interference detection-driven modules implemented on the detector device. The

additional directional information could enable the detector device to control the interference avoidance measures taken by the WLAN devices on a sector level. Thus, a sectorized WLAN device could be instructed to take suitable interference avoidance measures, such as "going silent" on one or more of its sectors, lowering power levels on one or more of its sectors while keep transmitting normally on the rest of its sectors.

Subsequent to the detection of a primary user-related interference alternative interference avoidance schemes can be performed. The interference avoidance measures include but are not limited to channel re-assignment, transmission power adjustment, and the activation of a co-existence mechanism. Alternative interference detection modes can be used in various combinations with the proposed interference avoidance measures. Channel switching and the adjustment of the signal power levels are known techniques. The co-existence mechanism involves the establishment of an interfering signal periodicity table, and a time window table on the access point and/or the mobile terminal and/or the controller device deployed within the wireless network. The tables could be built and maintained by a network operator according to known information concerning the activities of a known primary user in the environment. The tables could also be created and maintained automatically by the access point and/or the mobile terminal and/or the controller device through the utilization of an interference detection scheme. The tables are examined by the access point and/or the mobile terminal and/or the controller in respect to the temporal regularity of the interfering signal in order to determine the interfering signal transmission periods. If periodicity of the interfering signal is established then the co-existence mechanism may be activated. A time window control table is set up on the access point and/or the mobile terminal and/or the controller device. The time window control table is operative in providing time slots specific to the transmission periods of the interfering signal. In these established primary user-specific time slots the entire wireless network i.e., the access points and the mobile terminals thereof, is instructed not to transmit or to lower the transmission power level in

order not to interfere with the primary user's signal. Consequently, the access point and/or the mobile terminal may keep operating on the same channel. By providing the channel periodic silent periods or reduced level of transmission the wireless network avoids interference with the established primary user's signal and thereby achieves co-existence with the primary user.

In the preferred embodiments of the present invention the secondary user is a wireless communication network, and more specifically a wireless local area network (WLAN). The primary user of the shared communications band is a radar system. It would be clear to one with ordinary skills in the art that in other preferred embodiments of the present invention diverse other wireless communications network could be used such as cellular telephone systems, wireless personal area networks, and the like. The primary user of the shared frequency band could be any other transmitting source designated as the system having priority in the utilization of the allocated frequency band, such as Industrial, Scientific, and Medical (ISM) devices, amateur radio services, terrestrial or sky-borne radar systems, satellite feeders, or the like. In the preferred embodiment of the present invention the mobile terminal referred to is a laptop computer, such as a ThinkPad 360 of IBM, a 4000 CT of HP, or the like. The mobile terminal could also be a stand-alone wireless station such as a modem card, or the like. In other preferred embodiments of the invention diverse other devices could be used such as cellular phones, Personal Digital Assistants (PDAs), and the like. The following description is provided to enable a ready understanding of the operations and the functional structure of the system proposed by the present invention and not meant to be limiting such as to exclude diverse other uses that could be contemplated, developed, and based on the underlying concept of the present invention. The scope of the invention is to be limited only by the attached claims.

According to the practices of persons skilled in the art of computer programming, the present invention is described below with reference to actions and symbolic representations of operations that are performed by the processing

computer system. It will be readily understood by one skilled in the art that the actions and the symbolically represented operations include the manipulation of electric signals by a central processing unit (CPU). The electrical signals represent data bits which effect a resulting transformation or reduction of the electrical signal representation, and the maintenance of data bits at memory locations in the memory system to thereby reconfigure or otherwise alter he CPU's operation, as well as other processing of signals. The memory locations are physical locations that have particular electrical, magnetic, or optical, properties corresponding to the data bits. The interference detection and avoidance method includes sets of computer programs implemented on different computing and communicating platforms and consisting of computer software instructions specifically developed for the practice of the present invention. The software installed in the network controller, in the access points, and the mobile terminals causes the controller, the access points, and the mobile terminals respectively to perform the various functions described herein. In the preferred embodiments of the present invention dedicated electronic hardware is made and used to perform all functionality described herein. The interference detection and avoidance method is implemented as firmware by the embedding of the predetermined program instructions and/or appropriate control information and associated data within suitable electronic hardware devices containing application-specific integrated circuits (ASIC).

Referring now to Fig. 1 that illustrates a communications environment in which the preferred embodiments of the present invention can operate. Fig. 1 is illustrative only and it is not the only communications environment in which the various preferred embodiments of the present invention can operate. The environment contains a wired network 10, a wireless network 20, a wireless network 21, a wireless network 23, and a primary user, such as a radar system 62. Wired network 10 is coupled to wireless network 20 via standard communication lines 22, 24, 26, and via link 27. Specific activities of the wireless network 21 and

the wireless network 23 can be controlled by the communication of information from wireless network 20. Therefore, the network 21 and the network 23 are communicatively linked to the wireless network 20 via a link 25', and a link 25'' respectively. Although in the drawing only two wireless networks are shown it would be easily understood that in a realistically configured environment several wireless networks could be coupled to the network 20. Wired network 10 is a Local Area Computer Network (LAN) that includes various computing and communicating devices such as a network manager 14, a network printer 16, and a network terminal 18 linked by fixed communication lines such as one or more coaxial cables, twisted pair, fiber optics, and any other media to support wired communications. In another preferred embodiments a wireless communication network can replace the wired network 10. In yet other embodiments wired network 10 can be a Wide Area Network (WAN). Although in the drawing only three wired network devices are shown it would be easily understood that in a realistically configured wired network a plurality of devices could operate. Network manager 14 includes a computing platform such as a Personal Computer (PC), a Sun workstation, a MacIntosh computer, or a specialized network management device. The network manager 14 includes a memory for storing information and a process for accessing and processing the information. Wired network 10 is linked to Access Points (AP) 28, 30, 32 via respective communication lines 22, 24, 26. AP devices 28, 30, 32 include a computing and communication platform. The function of the Access Points is to bridge traffic from the wired network infrastructure 10 to the mobile terminals. Lines 22, 24, 26 include one or more coaxial cables, twisted pair, fiber optics or any other media to support wired communication. Each AP includes a transceiver (not shown) to support wireless communication and a Dynamic Frequency Selection component (DFS) 34, 36, and 38 to support interference detection and avoidance. The network 10 is communicatively connected to a wireless access point (AP) 31 via a link 27. The AP 31 includes a transceiver (not shown) to support wireless communication and a DFS 33 to support interference detection and avoidance.

The AP 28, 30, 31, 32 are communicatively linked to one or more mobile terminals (MT) 40, 42, 44, 46, 50 via links. Each MT includes a transceiver (not shown) supporting wireless communication and a DFS to support interference detection and avoidance. The AP 28, 30, 31, 32 are controlled by a network manager device 14 and communicate with the MT 40, 42, 44, 46, 50 through radio frequency signals transmitted by their respective transceivers. The primary user of the designated frequency band, such as the radar system 62, functions in the communications environment through the transmission of a continuous or a periodic radio frequency signal typically in the microwave band of the spectrum. It is undesirable that the signals emitted by the radar system 62 received by the wireless networks 20, 21, and 23, as the radar signal will interfere with the WLAN signals. Nevertheless if one or more wireless devices deployed within the wireless networks 20, 21, 23 are in the operational range of the radar system's 62 transmitter the wireless devices may receive the radar signal. The unintended reception of the radar signal will effect interference with the radio frequency signals communicated between the AP devices 28, 30, 31, 32 and the MT devices 40, 42, 44, 46, 50. Similarly the radio frequency signals communicated by the transmitting devices of the WLAN 20, 21, 23 could interfere with the reflected radar signal received by the radar system 62. Such interference could degrade the quality of the communication within the WLAN 20, 21, 23 and could jam the signals transmitted by the radar system 62 and thus cause it to malfunction. Note should be taken that networks 20, 21, and 23 could be deployed in different distances and different directions from the radar system 62. Thus, the strength and the directionality of the signals effecting mutual interference between each of the networks 20, 21, 23 and the radar system 62 could be varied. Note should be also taken that the function of the DFS components 34, 36, 38, 33, 52, 54, 56, 58, 60 is to attempt to minimize the effects of interference between the various inter-network devices, and between devices of different wireless network devices, such as Bluetooth devices, cellular devices, and the like.

In the preferred embodiments of the present invention, the WLAN 20 of Fig. 1 is a HiperLAN/2-type wireless network. HiperLAN/2 is a broadband radio transmission technology operating in the 5 GHz frequency band. Currently frequencies are allocated for HiperLAN networks within in the 5.15-5.825 GHz band depending on geographical area in which the network is implemented. In other embodiments of the present invention alternative technologies could be used such as 802.11a, 802.11h, HiperLAN, OpenAir, HomeRF, HiSWAN (Japan), or the like. The features of the HiperLAN/2 standard are known. In order to enable ready understanding of the method and system suggested by the present invention, a brief and simplified description will be provided concerning the protocol architecture of the HiperLAN/2 radio interface as implemented for a mobile terminal associated with the WLAN 20 of Fig. 1, and the Medium Access Control (MAC) frame structure. The description will deal with those parts of the protocol and the MAC frame that are relevant to the method and system proposed by the present invention.

Referring now to Fig. 2 illustrating the implementation of the HiperLAN/2 protocol stack in a mobile terminal (MT) 81. Using OSI 7 layers model as the reference model, the MT device 81 operates within a WLAN and is communicatively linked to a wired LAN via one or more Access Points (AP) that bridge the WLAN with a wired LAN. The MT 81 includes a Physical Layer (PHY) 90, and a Data Link Control Layer (DLC) 82. The MT 81 could also include transport channels 89, and Convergence Layer (CL) 83. The sub-layer functions as detailed below are of the HiperLAN/2 protocol. In other protocols certain functions may or may not exist, other functions could be added or removed, and the division of the sub-functionality may differ. The PHY 90 supports the electrical or mechanical interface to the physical medium. For example, this layer determines how to put a stream of bits from the DLC layer 82 on to a radio carrier. The physical layer is usually a combination of software and hardware programming and may include electromechanical devices. The functions

of the CL 83 is adapting service requests from the higher protocol layers to the service offered by the DLC 82, and to convert the higher level data packets into a fixed size that is used within the DLC 82. The DLC 82 constitutes the logical link between an Access Point (AP) and the mobile terminal (MT) 81. The DLC 82 assures that an initial connection has been set up, divides output data into data frames, and handles the acknowledgements from a receiver that the data arrived successfully. It also ensures that incoming data has been received successfully by analyzing bit patterns at special places in the frames. The DLC 82 includes functions for medium access and transmission as well as terminal and connection handling. Thus the DLC 82 layer consists of a set of sub-layers: a Medium Access Control (MAC) protocol 88, an Error Control (EC) protocol 86, and a Radio Link Control (RLC) protocol 84. The MAC protocol 88 is used for access to the radio link with the resulting transmission of data onto that medium. EC protocol 86 is used to increase reliability over the radio link by detecting bit errors and re-transmitting the data if such errors are detected. EC 86 also ensures that the data units are delivered in-sequence to the CL 83. RLC 84 gives a transport service to the signaling entities such as Association Control Function (ACF) 95, Radio Resource Control function (RRC) 92, and the Connection Control Function (CCF) 96. RLC 84, ACF 95, RRC 94 and CCF 96 provide for the exchange of signaling messages between an Access Point (AP) and the MT 81. RRC 92 is a group of control functions on the top of the RLC 84 that is responsible for the handling of the radio resources. RRC 92 includes a Dynamic Frequency Selection (DFS) function 94 to provide for the performance of measurements on radio signals received from neighboring mobile terminals as well as to instruct the MT 81 to perform measurements when needed. Subsequently the DFS 94 automatically allocates vacant frequencies to each AP for communication, allows several operators to share the available frequency spectrum, and can be used to avoid the use of interfered frequencies. Note should be taken that the DFS 94 sub-function need not necessarily be part of the RRC 94. RRC 94 could be an independent function or could be embedded within a different sub-functionality.

The air interface in HiperLAN/2 is based on time-division duplex (TTD) and dynamic time-division multiple access (TDMA) methods. The time-slotted structure of the medium allows for simultaneous communications in both downlink and uplink within the same time frame called MAC frame. Time slots for downlink and uplink communication are allocated dynamically depending on the need for transmission resources. The basic MAC frame on the air interface has a fixed duration of 2 ms and comprises transport channels for broadcast control, frame control, access control, downlink (DL) and uplink (UL) data transmission and random access. The MAC frame and the transport channels form the interface between DLC 82 and the PHY 90.

Referring now to Fig. 3 illustrating the basic MAC frame structure. MAC frames 200, 201, 202 each comprise broadcast channel (BCH) 203, frame control channel (FCH) 204, access feedback channel (ACH) 205, DL phase 205, and a UL phase 206, and random access channel 207. The BCH 203 contains control information sent in every MAC frame and reaches all the MTs, such as transmission power levels, AP identifiers, network identifiers, and the like. The FCH 204 contains a description of the resources allocated within the current MAC frame. The ACH 205 conveys information on previous access attempts made in the RCH. Downlink and uplink traffic (DL 206 and UL 207) consist of Protocol Data Unit (PDU) trains to and from the MTs. The RCH 208 is used by the MTs to request transmission resources for the DL phase 206 and the UL phase 207 in the upcoming MAC frames and convey the RLC 84 signaling messages.

Fig. 4 illustrates the components constituting the proposed system and functional to the operation of the proposed method of the present invention. The illustrated configuration is exemplary only and in order to accomplish the objectives of the proposed method and system various other configurations could be used. The method involves the exchange of a plurality of downloaded and uploaded messages between the mobile terminals of the WLAN and a remote

interference detection controller. In addition to the standard data exchange packets the messages include but are not limited to instructions with associated parameters, notifications, requests, replies, reports, measurement parameters such as threshold values, measurement results, range of blocked channels, range of channels to operate with, neighboring channels allocated, operation instructions, and the like. The operation instructions include but are not limited to ceasing transmission in one or more specific sectors, to provide re-adjusting the transmission power of other specific sectors, to increase permanently or temporarily the time allocation to specific sectors, and the like. The WLAN 20 is communicatively coupled to a wireless network 21 and a wireless network 23 via the links 25 and 27 respectively. The WLAN 20 is operative in communicating interference detection information to networks 21, and 23 in order to enable networks 21, 23 to take appropriate interference avoidance measures. Networks 21, and 23 could also communicate relevant information to network 20. The WLAN 20 includes a remote Dynamic Frequency Selection Network Controller (DFSNC) 92, an AP 30 and a MT 44. The DFSNC 92 could be co-located with the AP 30, or with an another AP (not shown) deployed within the network and thus is remote to the set of APs deployed within the network The DFSNC 92 could be also a stand-alone device. The DFSNC 92 includes a computing and communication platform such as a PC and is connected to the AP 30 via a link 24. The DFSNC 92 could include a transceiver (not shown) to support wireless communication. The function of the DFSNC 92 is to control remotely interference detection and avoidance by communicating with the AP 30 and the MT 44. The AP 30 is coupled to the MT 44 via a link 101. Although only one DFSNC, one AP and one MT are shown on the drawing discussed it is understood that a realistically configured network could contain more than one DFSNC and more than one AP devices coupled communicatively to one more MT devices. The AP 30 includes a transceiver (not shown) to support wireless communication and a set of DFS functions 36 to support interference detection and avoidance. The MT 44 includes a transceiver (not shown) to support wireless communication and a

set of DFS functions 56 to support interference detection and avoidance. Periodically, according to pre-defined operational parameters introduced by a WLAN operator, the DFSNC 92 sends suitable instructions via the link 24 to AP 30 and to MT 44 to initiate interference detection. The instruction includes parameters operative in defining the type of detection to be performed, the measurements to be collected, the channel to be measured, the sub-set of potentially usable channels, and the like. Consequently the AP 30 and/or the MT 44 perform the required measurements by utilizing the set of DFS functions 36 and the set of DFS functions 56 respectively. The AP 30 could perform the measurements itself or could instruct the MT 44 to via the link 101 to perform the same. The results of the detection process are returned by the MT 44 and/or by the AP 30 to the DFSNC 92 for analysis. The DFSNC 92 performs the analysis on the results received. The products of the analysis provide information concerning the presence, the absence, and the power level of an interfering signal on a specifically measured channel. When a primary user-generated interference is identified by the DFSNC 92 an instruction is sent from the DFSNC 92 via the link 24 to the AP 30 and/or to the MT 44 regarding the activation of the set of the DFS functions 36 and the set of DFS functions 56 respectively in order to take appropriate interference avoidance measures, such as moving to another channel within the allocated frequency band of the WLAN 20.

Fig. 4A illustrates alternative configuration of the proposed system that is functional to the operation of the proposed method of the present invention. The illustrated configuration is exemplary only and in order to accomplish the objectives of the proposed method and system various other configurations could be used. The WLAN 20 is communicatively coupled to the wireless networks 21 and 23 via links 25, and 27 respectively. The WLAN 20 is operative in communicating interference detection alerts and associated information to networks 21, 23. Similarly, networks 21 and 23 communicate relevant information, such as topology data, identified primary users, and the like, back to

WLAN 20. The WLAN 20 includes a remote Dynamic Frequency Selection Network Controller (DFSNC) 92, and a MT 44. The DFSNC 92 includes a computing and communication platform such as a PC and is connected to the MT 44 via a link 24. The DFSNC 92 may include a transceiver (not shown) to support wireless communication. The function of the DFSNC 92 is to control remotely interference detection and avoidance by communicating with the MT 44. Although only one DFSNC and one MT are shown on the drawing discussed it is understood that a realistically configured network could contain more than one DFSNC coupled communicatively to one or more MT devices. The MT 44 includes a transceiver (not shown) to support wireless communication and a set of DFS functions 56 to support interference detection and avoidance. Periodically, according to pre-defined operational parameters introduced by a WLAN operator, the DFSNC 92 sends suitable instructions via the link 24 to MT 44 to initiate interference detection. The instruction includes parameters operative in defining the type of detection to be performed, the measurements to be collected, the channel to be measured, the sub-set of a potentially usable channels, and the like. Consequently the MT 44 perform the required measurements by utilizing the set of DFS functions 56. The results of the detection process are returned by the MT 44 to the DFSNC 92 for analysis. The DFSNC 92 performs the analysis on the results received. The products of the analysis provide information concerning the presence, the absence, and the power level of an interfering signal on a specifically measured channel. When such an interference is identified by the DFSNC 92 an instruction is downloaded from the DFSNC 92 via the link 24 to the MT 44 regarding the activation of the set of DFS functions 56 in order to take appropriate interference avoidance measures, such as moving to another channel within the allocated frequency band of the WLAN 20. Note should be taken in the above-described configuration no AP device is implemented. Therefore all the functionalities of the AP are implemented in the MT 44 as access point functionality 55.

Fig. 5 provides a detailed view of the operative components associated with the proposed method and system. The illustrated configuration is exemplary only and in order to accomplish the objectives of the proposed method and system various other configurations could be used. The exemplary system configuration presented consists of a remote DFSNC 92, an AP 30, and a MT 50. A primary user device 118 is an interfering source, which is operating near to the WLAN and transmitting radio frequency signals. In the preferred embodiment of the present invention the primary user device 118 is a radar transmitter. The DFSNC 92 is programmable device. The DFSNC is pre-configured and can be periodically re-configured by the network operator utilizing the user interface 101. The re-configuration is effected by the manipulation of the relevant data stored in the operation database 100. Although only one DFSNC is shown on the drawing under discussion more than one such devices could be deployed across the wireless network space when each separate device could be programmed and configured in a different manner according to the network topography, known local interference sources, and the like. The DFSNC 92 is dynamically configured according to the results of the interference detection process performed by the AP 30 and/or the MT 50. The DFSNC 92 is capable of controlling a distinct sub-set of mobile terminals in the network or the entire set of mobile terminals deployed across the WLAN space. The DFSNC 92 includes but not limited to a user interface 101, an interference measurement control 94, an interference measurement analysis 96, an interference avoidance control 98, a messaging function 97, and an operation database 100. The operation database 100 is pre-configured by the wireless network operator and periodically re-configured in accordance with the results of the measurements transmitted by the AP 30, and the MT 50. The operation database 100 stores information concerning the known frequencies used by the operating interfering device 118, measurement parameters to be transmitted to the AP 30 and to the MT 50 to be used as controlling values for the performance of the measurement process. The parameters include but are

not limited to the type of measurement to be made, signal thresholds to be detected, frequencies to check, sub-sets of potentially usable channels, sub-sets of preferred channels, sub-sets of channels used by specific WLANs, geo-locations of specific WLANs with associated RF network topology including sector information, and the like. The operation database 100 is periodically updated by the AP device 30, and/or the MT 50 device with information associated with the detected interference, such as frequencies, interfering signal level, interference periods, error rates, and the like. Interference measurement control 94 is a process designed to manage the interference detection and avoidance functions of the AP device 30 and the MT device 50. The control 94 operates in the application layer level of the HiperLAN/2 protocol. The control 94 is responsible for the overall operation of the DFSNC 92 by coordinating the various functions included therein with the interference detection and avoidance functions implemented in a set of mobile terminal devices. The control 94 operates according to the operating parameters stored within the operation database 100. The control 94 obtains the sub-sets of potentially usable channels from the operation database 100 and communicates the information to the APs. The information may be periodically updated according to channel measurement results and/or the operator's input. The control 94 obtains the measurement parameters from operation database 100 and sends the parameters in association with suitable instruction measurement initiating instructions to the AP device 30 and/or the MT device 50. The interference measurement analysis function 96 is operative in receiving the uploaded result values of the measurements from the AP device 30 and/or the MT device 50, in analyzing the result values, in identifying the presence or absence of an interfering signal on the measured channel and in returning the results produced to the interference measurement control 94. The interference measurement control 94 activates the messaging function 98. The messaging function 98 is responsible for the downloading of the appropriate instructions to the AP device 30 and/or the MT device 50 concerning the initiation of the appropriate interference avoidance actions, such as moving to another channel.

The interference avoidance function 98 sends frequency selection parameters attached to the channel changing instruction, power levels required to the adjustment of transmitted signal levels, and the like. The parameters could also include a range of unusable frequencies, a range of preferred frequencies, RF topology information such as AP locations, AP sectors and the directionality thereof, and the like. In accordance with the geographical location of the AP 30 and the associated mobile terminals thereof different measurement-related or frequency change-related parameters can be downloaded to different mobile terminals. For example, if a known radar transmitter is operating in a defined locality of certain WLANs then APs and/or the mobile terminals within the range of the radar transmitter are instructed not to move to the frequencies known to be used by the radar system. Thus, an on-going dynamic interference detection process is taking place through which the interference-related information in the operation database 100 of the DFSNC is dynamically maintained. The operation database 100 includes but is not limited to a channel parameters changes table, a predefined channel information table, an RF topology information table including APs locations, APs sectors with associated directionality data, a time window control table, and a channel periodicity table. The functionality of the additional tables will be described hereunder in association with the following drawings. Note should be taken that in other embodiments of the present invention other alternative processes, functions, and components could be used, the functionality of the processes can be different, and the operation database and the tables stored therein could be implemented and structured in a number of alternative ways. For example, the user interface unit 101 can be enhanced such as to be utilized in addition to the interactive control of the parameters, for the submission of queries, for producing statistical listings, and the like.

Still referring to Fig. 5 AP 30 includes but not limited to an interference measurement function 102, an interference reporting function 104, an interference avoidance function 106, a messaging function 107, and an operation database 108. The operation database 108 stores diverse measurement

information, channel information, interference information, operating parameters, channel periodicity data, time slot control data, and the like. The operation database 108 enables the AP device 30 to operate independently of the DFSNC 92 under specific circumstances such as in the case of a communication failure between the AP 30 and the DFSNC 92. The table 108 also enables the AP 30 to operate autonomously as defined by the in the different operation modes of the method and system offered by the invention. Thus, following the performance of the required measurements the AP device 30 updates the operation database 108 with the results of the measurement before/after/while sending in the link the information to the DFSNC 92. The interference avoidance function 106 is implemented for activating appropriate interference avoidance options according to the relevant parameters received from the DFSNC 92. The interference measurements function 102 is implemented in the application layer of the protocol stack and is responsible for the activation of the interference detection functions in accordance with the instructions received from the DFSNC 92. The interference reporting function 104 is operative in the sending in the link the results of the measurements to the DFSNC 92. The AP 30 can also instruct the MT 50 to perform the requested interference detection and avoidance operation by sending the necessary parameters to the MT 50. Note should be taken that in other embodiments of the present invention other alternative processes, functions, and components could be used, the functionality of the processes can be different, and the operation database could be implemented in a number of alternative ways.

Still referring to Fig. 5 the MT device 50 consists of but not limited to an interference measurement function 110, an interference reporting function 112, an interference avoidance function 114, a messaging function 117, and an operation database 116. The operation database 116 stores diverse measurement information, channel information, interference information, operating parameters, channel periodicity data, time window control data, and the like. The operation database 112 enables the MT 50 to operate independently of the AP 30, and the DFSNC 92 under specific circumstances such as in the case of a communication

failure along the uplink communication path. The database 116 also enables MT 50 to operate autonomously as defined by the different operation modes of the method and system offered by the invention. Thus, following the performance of the required measurements the MT 50 updates the operation database 116 with the results of the measurements before sending the information to the AP 30. The interference measurements function 110 is implemented in the application layer of the protocol stack and is responsible for the activation of the interference detection functions in accordance with the instructions received from the AP 30. The interference reporting function 112 operative in the sending of the results of the measurements to the AP 30. Note should be taken that in other embodiments of the present invention other alternative processes, functions, and components could be used, the functionality of the processes can be different, and the operation database could be implemented in a number of alternative ways. The substantially modular configuration of the proposed system allows for several varied implementation schemes. Thus, in other embodiments of the invention some or all of the functions implemented in the AP and/or the MT could be implemented in the DFSNC only. Accordingly, a method of interoperability between the mobile terminals of any manufacturer and the DFSNC can be provided. This option enables operators of the WLANs to use third party wireless interference detection solutions from companies that specialize in that area, rather than develop similar solutions in-house.

Still referring to Fig. 5 the AP 30 allocates the channels for operation to the MT 50 according to the instructions received from the DFSNC 92. The AP 30 selects a specific channel for operation by utilizing a list of channels sent by the DFSNC 92. The list contains a sub-set of potentially usable channels and a sub-set of unusable channels. The list could further provide preference information associated with the entries constituting the usable channels sub-set. The AP 30 examines the list, ignores the channels in the unusable channel sub-set and selects a channel from the usable channel sub-set. If preference data is

provided with the usable channel sub-set then the selection could be made in accordance with the preference data.

Fig. 6 illustrates the structure of the operation database implemented on the DFSNC devices, the AP devices, and the MT devices. In different operation modes the structure of the operation database implemented on the different platforms could substantially differ. The operation database 400 includes but not limited to an operating parameters table 402, a measurement parameters table 404, an interference data table 406, a channel data table 408, a channel parameter changes data table 410, a time window data table 412, a network topology table 413, and a channel priority data table 414. The operating parameters table 402 is used for defining the overall interference detection scheme for the interference detection function. The table 402 includes but not limited to lists of installed DFSNCs, APs, MTs, detection process time tables, and the like. The measurement parameters table 404 is utilized by the interference detection mechanism to identify a radar signal. The table 404 includes but is not limited to radar signal characteristics as determined by known radar transmitters, such as frequency, scan rate, pulse width, pulse rise/fall time, power, minimum detectable signal, pulse repetition frequency, pulse recurrence time, pulse duration, and the like. The interference data table 406 includes detected interference values, such as received signal strength, and the like. The data in table 406 is utilized as input to the interference measurement analysis and to channel sub-set allocations. The channel data table 408 includes a list or range of blocked frequencies, a list or range of available frequencies, and the like. The entries in the list or range of frequencies could include preference order and operating conditions, such as date or time of the day. The information stored in the channel data table 406 is used as parameters associated with the interference avoidance instructions sent to the relevant devices. The channel parameter changes table 410 stores lists of changes detected in the channel parameters during the pattern-based detection mode. The time slot data table 412 stores

interfering signal periodicity data. The network topology table 413 includes but not limited to specific network information and device information, such as network identification, device identification, and the like. Table 413 could also include data about the geographical location of the various devices, such as APs, implemented in the network, sector information associated with sectorized devices, such as number of sectors, sector direction, and the like. Table 413 could further include topology information concerning other WLANs in the environment as well as information concerning known, estimated, or identified primary users operating in the vicinity. The primary user information could include known or estimated geographical location, user type, and the like. Table 413 is operative in the creation and maintenance of a transmission/reception coverage map of one or more WLANs. Note should be taken than in other embodiments of the present invention additional tables could be used, such as a historical data table, statistical data table, operators profile table, and the like.

Referring now to FIG. 7 showing an exemplary sequence of functional steps operative in the performance of the interference detection and avoidance process according to the first preferred embodiment of the present invention. The first embodiment implements the DFSNC control mode. At step 119 the operation database implemented on the DFSNC device is updated by the operator of the DFDSNC. The operator is provided with the option of manipulating the parameters of the system in order to enable activation of the interference detection process at certain points in time for the entire set or a limited sub-set of one or more DFSNC devices. The operator of the DFSNC is provided with the capability of inserting, updating and deleting data stored in the operation databases. The data includes but not limited to the set of MT/AP devices to be controlled by one or more DFSNC devices, the set of MT/AP devices required to perform interference detection, a range of frequencies to examine for the presence of interference, a range of frequencies to be used for the re-assignment of the channels being interfered with, or conditionally reassigned, and a range of frequencies blocked or

conditionally blocked for re-assignment or for use. The conditional reassignment or the blocking of the channels can be done in accordance with specific parameter values, such as the date, the time of day, and the like. The operator can further manipulate and modify specific measurement values, such as the examined interference signal threshold levels, and the like. The operator is provided with the option of disabling the interference detection process, of querying the status of the system, of producing varied statistical listings, to change the topology map of the WLAN and/or other neighboring WLANs and/or known/estimated primary users, and the like. Additionally the operator can select the appropriate operation mode of the system, such as the DFSNC control mode, the wireless device control mode, the standard interference measurement (i.e., RSS-based) mode, the pattern-recognition-based interference measurement mode, interference avoidance by the frequency re-assignment option, interference avoidance by transmission power level adjustment, by the activation of the co-existence scheme, and the like. The various operational modes of the proposed method will be described hereunder in association with the respective preferred embodiments of present invention and the accompanying drawings. At step 120 the DFSNC retrieves the necessary parameters from the operation database and at step 122 the DFSNC instructs the specified devices to perform interference detection. The appropriate parameters are sent to the specified devices in association with the instructions. At step 124 a wireless device, such as an AP device and/or an MT device receives the instruction with the accompanying parameter values and at step 126 the AP device and/or the MT device perform interference measurement of a desired specific channel in the specifically defined operation mode in accordance with the measurement parameters received from the DFSNC. The wireless device collects the measurement results, updates the local operation database with the results and at step 128 sends the results to the DFSNC. At step 130 the DFSNC receives the measurement results, analyses the results, updates the operation database, and determines the interference-related status of the examined channel. If the channel measured is recognized such as to include an interfering signal at step 132 the

DFSNC instructs the wireless devices in regard to necessary interference avoidance actions, such as moving to a different channel in the allocated frequency band in order avoid collision between the WLAN channel traffic and the interfering signal therein, to properly adjust transmission power levels in order not to interfere with the transmission/reception of the primary user, or activating the co-existence scheme. At step 134 the wireless device takes the requested avoidance measure updates the local operation database, and notifies the DFSNC by uploading the updates performed.

The proposed method and system provide several operational modes. The different operational modes could be implemented in alternative combinations, and in varied ways, such as being predetermined and pre-set at system generation, or could be dynamically modified by the DFSNC operator at certain points in time according to the circumstances, such as the changing of network topology, the addition, the removal, or the replacement of specific devices, the installation or upgrading of interference detection and avoidance-related functions, new information received concerning a wireless communications system, such as a WLAN, or a primary user, such as a radar system, operating in the vicinity, and the like. A specific operation mode can be uniformly applied across the entire WLAN or several different operation modes could be variably applied to one or more DFSNC devices and associated APs/MTs according to the type of installed devices, the type of functions implemented therein, and the like.

The remote interference detection and avoidance method and system offered by the present invention makes available to the operators of the DFSNCs with the option of dynamic geographical frequency planning. The system and method allows for allocating differential frequency ranges to one or more sets of one or more wireless devices. The allocation can be done dynamically by the network controller according to measurements and feedback received from the devices. The feedback and the measurements results could be used for the building of frequency usage maps, for studies of interference, and for the

diagnostics processes utilized to improve spectrum usage. The method and system advantageously allows the WLAN operators to outsource the interference detection and prevention functions to third party developers having suitable expertise in the specific field and having the capability to centrally implement required modifications, changing basic DFS data, such as information concerning new radar installations, satellite feeder transmitters, recent DFS algorithms, and the like. Outsourcing the process to expert third parties can benefit the entire industry and the regulating bodies by enabling the regulators to inspect and control a substantially limited number of interference detection and avoidance packages rather than obliging each individual WLAN manufacturer to go through extensive testing procedures in order to receive authorization for the utilization of their own interference detection and avoidance systems.

Referring now to Fig. 8 showing an exemplary sequence of functional steps operative in the performance of the interference detection and avoidance process, in accordance with a second preferred embodiment of the present invention. The second preferred embodiment of the present invention implements the wireless device control mode. A set of one or more relevant wireless devices includes a modified version of the DFSNC control functions. A higher-level operation database and a set of specific higher-level operation database-related supporting functions are implemented in the DFSNC. At step 500 the higher-level operation database implemented on the DFSNC is updated by the operator of the DFSNC. The operator is provided with the capability of modifying the parameters of the system to enable activation of the interference detection process at certain points in time for the entire set or a sub-set of one or more wireless devices. The operator can also insert into the operation database parameters, such as a set of one or more of MTs/APs desired to perform interference detection, a range of frequencies to examine, a range of frequencies to be used for the re-assignment of the channels being interfered with, and a range of frequencies blocked for re-assignment or for use. The operator can further manipulate and modify specific

measurement values, such as the examined interference signal threshold level, and the like. The operator is provided with the option of disabling the interference detection process, of querying the status of the system, of producing varied statistical listings, to change the topology map of the WLAN, of the primary users, and the like. At step 502 the parameters from the higher-level operation database of the DFSNC are downloaded to the wireless devices according the instructions of the DFSNC operator. In the wireless device control mode the control of the interference detection and avoidance process is made autonomously by the wireless devices. The process loop describing the operation of the wireless device is described across step 504 through step 516. At step 504 the local interference detection control function implemented in the wireless device retrieves the necessary parameters from the local operation database and at step 506 the local control function initiates the performance of the interference detection process. The appropriate parameters are obtained from the local operation database. At step 508 the wireless device, such as an AP and/or a MT perform interference measurement of the specific channel in the specific operation mode in accordance with the measurement parameters received from the local operation database. The wireless device collects the measurement results, updates the local operation database with the results, at step 510 analyses the results, and determines the interference-related status of the examined channel. If the channel measured is recognized such as to include an interfering signal the wireless field performs the consequent interference avoidance actions, such as clearing the measured channel and moving to a different channel in order avoid collision between the WLAN channel traffic and the interfering signal therein. At step 512 the wireless device performs interference avoidance measures. At step 514 the local operation database of the wireless device are updated and at step 516 the device sends the results of the interference detection and interference avoidance process to the DFSNC in order to update the operation database established therein. Process control then proceeds to step 504 to resume the interference detection loop.

The method according to the second preferred embodiment allows the operators of wireless networks the option of controlling the network adaptively. The operators receive dynamic up-to-date information from the devices concerning primary user-related interference, which was detected by the devices. According to the received information the operators can adaptively control the network, such as manually introduce information concerning known primary users and sending the updated information to the devices.

In the pattern-recognition-based interference detection mode interfering sources in the range of a WLAN transmitting radio signals on the same frequency used by a WLAN channel can be detected without the need to be aware of the identity, and characteristics of the transmitter in order to detect the signals interfering with the signals of the WLAN. The method proposed in the pattern-recognition-based mode is based on the identification of one or more specific patterns discernible in a set of changes occurring on the time axis in the parameters of a measured WLAN channel. The measurement is performed as part of the normal operation of the wireless device, such as an AP device and/or MT device. In the pattern-recognition based mode the wireless device performs interference detection and avoidance simultaneously with the standard data exchange operations taking place between the various devices of the network. Thus, no specific time slots need to be allocated for the performance of the interference detection process.

In yet another operation mode, the wireless device still performs the ongoing measurements, but the pattern recognition is performed at the DFSNC. The wireless device reports the collected channel-specific measured anomalies, such as identified errors. The wireless device sends the data along with associated parameters, such as timestamps, periods, and the like to the DFSNC device. Subsequently, the DFSNC device itself performs the pattern recognition process.

The patterns that can be identified as part of the normal operation of the wireless device are related to the basic channel parameters, such as the error

rate changes including bit error rates, frame error rates, packet error rates, signal-to-noise (SNR) changes, phase shift differentials, and the like. Patterns in the continuously changing channel parameters can be recognized on the data carriers, on the pilot carriers, and optionally on the control carriers. In the pattern-recognition-based mode the wireless device will record changes in the channel parameters and will attempt to detect a pattern in the changes. The pattern recognition method may utilize thresholding functions, statistical analysis functions to account for small fluctuations in the range of the changes and/or in the range of the period in which the changes occur, or Artificial Intelligence (AI) implementations such as used by commercially available neuron networks. Threshold values can be used for defining the time slots during which the changes are to be repeated to form a meaningful pattern and/or for defining the longest time slot without changes. The interference detection can be performed upon any specific combination of the channel parameter changes.

Referring now to Fig. 9 showing an exemplary sequence of functional steps operative in the performance of the interference detection and avoidance process according to the third preferred embodiment of the present invention. In the third preferred embodiment the system implements the pattern-recognition-based interference detection mode. At step 600 a signal is received by the wireless device. At step 602 the signal is sampled and converted to digital format by an analog-digital converter. At step 604 the pattern analysis parameters are read from the operation database. At 606 the pattern analysis is performed by obtaining the suitable channel parameters, such as error rates, SNR changes, and the like, building channel parameters changes lists and processing the lists by appropriate analysis functions, such as the Histerhasys function, the neuron network, or the like. At step 608 an interference pattern is recognized on the examined channel, and appropriate interference avoidance actions are performed, such as moving to a vacant channel within the allocated frequency

band. At step 610 the operation database are updated with the relevant data, and at step 612 the updates are optionally uploaded to an AP and/or the DFSNC.

Note should be taken that in another operational mode the steps 606 through 610 could be performed in the DFSNC device and step 612 could be replaced by a reporting step to the wireless device.

The pattern-recognition-based interference detection mode proposed by the method and system of the present invention is performed on an on-going basis rather than in "interrupted" periods, which may or may not include the interfering signals. The performance of interference detection in this mode requires neither information in respect to the radar systems operating within the range of the WLAN nor decisions by the higher layers of the communications protocol or the remote network controller. Yet the method could be combined with and be assisted by radar system-related information and/or by certain decisions made in the higher layers of the communication protocol. For example, if certain radar systems are known to have a fixed 10 seconds "sweep" rotation period then the wireless devices channel measurements functions could be calibrated such as to perform the channel measurements having the same 10 seconds periodicity. The operational decisions concerning the presence and/or the power level of interference and can be made locally by the low layers of the wireless device based on the locally accumulated and locally analyzed channel parameter information. In addition the information is collected without interrupting the on-going standard data exchange operations of the network.

Note should be taken that in other operational mode the decisions could be made in the DFSNC. Thus, the WLAN operators will be provided with the option to outsource the interference detection and prevention process to a third party.

The co-existence mode relates to the adaptive modification of a WLANs transmission parameters in response to the detection of a periodic interference detected by one of the interference detection schemes described

above, or known in advance. Many of the radar systems transmit periodically. Therefore WLAN devices operating in the vicinity of a periodic radar systems will be periodically effected by the interference caused by the signals emitted from a radar system transmitting on the frequency utilized by a WLAN device, and similarly periodically effect the same radar by the WLAN signals. In current wireless system when a periodic interference detected the channel used by a wireless device is re-assigned to a different channel. The detection of a periodic interference will cause activation of a process in the WLAN that will provide the capability for both systems operating in the same geographical area within broadcast range to keep functioning effectively on the same channel. Thus, a substantially improved utilization of the allocated bandwidth is achieved, which is specifically important in the about 5 GHz spectrum including periodic transmitters, such as pulse/sweep radar systems. Co-existence on the same channel allows better utilization of the allocated spectrum while not compromising the operation of the primary user, such as a radar system. The resulting negative impact on the performance of the wireless communications system, such as a WLAN, is non-existent or negligible.

Fig. 10 illustrates an exemplary sequence of functional steps operative in the performance of the interference detection and avoidance process that implements the co-existence scheme. At step 700 a signal is received by the wireless device of the WLAN. At step 702 the signal is sampled and converted to digital format by an analog-digital converter. At step 704 interference periodicity measurements are performed by the wireless device of the WLAN. At step 706 the interference periodicity measurement results are collected into suitable lists and at step 706 the lists are processed and analyzed in an attempt to recognize systematic periodicity of the interference. At step 708 the systematic periodicity of the interference is established and an appropriate time slot table is set up. In the time slot table the wireless device of the WLAN allocates vacant time slots to its WLAN devices such that the interfering primary user will continue to operate

uninterrupted and the interfered WLAN will keep functioning without interrupting the interfering primary user. Within the allocated time slot stored in the time slot table the entire wireless network associated with the WLAN will be instructed not to transmit or alternatively to adjust its transmission power such as not to interfere with the periodically transmitting primary user, such as a pulse radar. As a result within the allocated time slots the WLAN will not interfere with the signals transmitted by the primary user either by not transmitting or by lowering the power levels of the signals transmitted. At step 710 the time slot table and related information from the operation database uploaded to a network controller for appropriate processing. At step 712 the network controller analyzes the uploaded time information and performs a suitable co-existence related process. The process is designed to allow both the wireless network and the primary user to continue operating on the same channel on a specific frequency by instructing the wireless network not to transmit during the time slots allocated to the signal of the primary user.

Note should be taken that the periodicity measurements, the analysis of the results, and the building of the time window table could be performed in diverse other manners. For example, the appropriate periodicity data could be received from the operators of a known primary user operator and could be inserted into the suitable table by the wireless network operator or the DFSNC operator. Similarly the process of analysis, and the time window table maintenance could be initiated by the wireless network operator or the DFSNC operator. The relevant tables could be then stored on the controller device and could be controllably downloaded when necessary to the wireless device.

Fig. 11 illustrates graphically a signal collision and an exemplary solution thereof in a WLAN channel. Signal 801 is a WLAN signal comprising MAC frames 800, 802, 804, 806, 808 transmitted via a link set up between two or more WLAN devices such as an AP and a MT on an assigned WLAN channel having a specific frequency allocated thereto. Signal 803 is a continuous radar

signal transmitted via air interface by a radar transmitter. Signal 801 and signal 803 are transmitted on the same frequency. The receiving WLAN wireless device, such as a MT device, is deployed such that the device is in the operative range of the radar transmitter emitting signal 803. As a result the WLAN wireless device, such as a MT device, is receiving simultaneously both signals 801 and 803. The signal 801 is overlaid in the specific communication channel associated with the MT device by signal 803 and the resulting signal 805 is a corrupted version of signal 801. The signal 805 is referred to as interference where the interference is created by the unintended reception of signal 802. Similarly, the reception of the WLAN signal 801 by the primary user effects interference to the same primary user. In the preferred embodiment of the present invention the signal 805 is detected by the interference detection method and system described hereinabove. Consequent to the detection of the corrupted signal 805 specific interference avoidance functions are activated and a number of alternative interference countermeasure actions are taken. One such action includes interference avoidance, such as changing the communication path of the signal 801. After a suitable time interval 801 required for the performance of the channel switching operation, the path is changed by switching from channel 807 to a new channel 809 transmitted on an unused frequency 809. The WLAN signal 801 comprising the MAC frames 800, 802, 804, 806, and 806 will be transmitted undisturbed on the newly allocated channel 809 while the radar signal will keep transmitting on the original channel 805.

Fig. 12 illustrates graphically a signal collision and an alternative solution thereof in a WLAN channel according to the preferred embodiment of the present invention. Signal 811 is a WLAN signal comprising MAC frames 800, 802, 804, 806, 808. Signal 811 is transmitted via a link set up between two or more WLAN devices such as an AP and a MT on an assigned WLAN channel having a specific allocated frequency. Signal 814, 816, 818 are a set of periodic radar signal transmitted via air interface by a radar transmitter for radio-location

and ranging purposes. Signal 811 and signals 814, 816, 818 are transmitted on the same frequency. The receiving WLAN wireless device, such as a MT, is deployed such that the device is in the operative range of the radar transmitter emitting periodic signals 814, 816, 818. As a result, the WLAN wireless device, such as a MT device, is receiving simultaneously both signals 811 and periodic signals 814, 816, 818. The signal 811 is overlaid in the specific communication channel associated with the MT device by the periodic signals 814, 816, 818 and the resulting signal 813 is a corrupted version of signal 811. The signal 813 includes periods of interference 812', 812'', and 812'''. that correspond to the reception of the interfering periodic signals 814, 816, 818. Signal 815 represent the WLAN signal train as transmitted in the channel subsequent to the activation and completion of the co-existence option if no channel switch was performed by the WLAN after the detection of the primary user as stated in the other embodiments. Signal 815 comprises intermittent WLAN traffic consisting of MAC frames 822, 826, 830, time guard intervals 823, 823', 823'', 823''', 823'''', and periodic "WLAN silence" time slots 824, 828, and 832. The periodic WLAN silence slots correspond to the duration of the periodic radar signals 814, 816, 818 that were detected, analyzed and collated by the appropriate interference detection functions. In order to enable co-existence with the radar, and to allow undisturbed transmission of the periodic radar signals, for the duration of time slots 824, 826, 828 the transmission of signals between the entire set of WLAN devices is suspended or powered down. The WLAN silence slots 824, 826, 828 are suitably separated by configurable time guard intervals 823, 823', 823'', 823''', and 823''''.

Implementing the co-existence mode provides the operators of a WLAN with the option of spreading out the network across a wide frequency range. Thereby the overall useable bandwidth capacity of the network is increased and a significant improvement is achieved in the utilization of the unlicensed 5 GHz spectrum. The present invention provides operators of a WLAN and the spectrum regulators a mechanism to ensure compliance with the regulations and

with the changing deployments of primary users, such as radar systems, satellites, amateur radio service, and the like. The remote mechanism as offered by the preferred embodiments of the present invention provides the capability to co-exist even on frequencies certain primary users are known to operate thereon.

In wireless network containing on or more sectorized wireless devices basic sector-related information can be provided to the controller device (DFSNC) by multiple network operators. The sector information, such as the list of sectorized devices, the number of sectors included within each device, the directionality of the specific sector, and the like, will be stored within the operation database established on the controller device (DFSNC). The interference detection data communicated by a sectorized wireless device will include information concerning the specific sectors on which the interfering signals were detected. As a result, the controller device will have substantially precise information in respect to the location of the interfering primary user device and/or neighboring WLANs. The location of the devices could be communicated to other wireless networks operating in the same environment but located at a distance further from the interfering source and therefore less likely to detect it. Thus, the controller device can be used as an assessor for the other wireless networks based on the information collected by other wireless networks.

Additionally the interference avoidance measures taken by the wireless devices could be sector specific. For example, when on sector X an interfering source is detected the controller could instruct the reporting wireless device to cease periodically or permanently transmitting only on sector X, or adjust the signal power levels only on sector X while continue normal operations on the other sectors.

Referring now to Fig. 13 illustrating the operation the method and system in accordance with the fourth preferred embodiment of the present invention. The operation described involves a detector AP implemented in association with one or more WLANs having a sectorized or an omnidirectional

mode of operation. The detector AP can operate either in an omnidirectional mode or in a sectorized mode. A sectorized detector AP is used to provide additional information in regard to the directionality of the detected signals. A sectorized detector AP 812 is co-located with a primary user, such as a radar system 802. A sectorized AP 804, a sectorized AP 816, and an omnidirectional AP 808 operate in the environment within various transmission/reception coverage areas and transmission/reception ranges from the radar system 802. The sectorized AP 804 includes a transmission/reception coverage sector 830, a sector 832, a sector 834, a sector 836, a sector 838, and a sector 840. For purposes of readability the sectors included in the sectorized AP 822 are not shown. Each AP 804, 806, 808 has the capability of controlling several MTs. The drawing illustrates that the AP 804 controls a MT 818, a MT 820, the AP 806 controls a MT 814, a MT 822, and the AP 808 controls a MT 824. Although only a limited number of APs and MTs are shown it will be readily understood that in a realistic environment several APs could be implemented controlling several MTs. Note should be taken that the different APs could be associated with different WLANs.

The transmission/reception coverage area of each of the six sectors included in AP 804 is covering an azimuth of about 60 degrees. Lines 854, 856 indicate the limits of the transmission/reception coverage area of the sector 832. When the WLAN AP 804 transmits through the sector 832 the signals may interfere with the radar system 802. When the AP 804 transmits through the other sectors 830, 834, 836, 838, 840 no interference is effected with the radar 802 due to the differential directionality of the transmission. In contrast when the radar 802 is transmitting, the radar signals may interfere with the section 832, and with the section 838, which is within the transmission/reception directional reception line of the radar 802.

The detector AP 812 receives the transmission of the APs 804, 806, 808 via link 850, 846, 852 respectively. Link 850, 846, 852 could be a wireless link or a wired link. In accordance with the diverse transmission/reception ranges between the detector AP 812 and the APs 804, 806, 808 the respective power

levels of the signals received by the detector AP 812 could be different in respect to each of the APs. Under certain circumstances, for example when the APs are deployed such that the detector AP 812 is out of their effective broadcast range, the detector AP 812 may not detect the signals transmitted by specific APs.

A DFSNC 810 is coupled to the WLAN APs 808, 806, 804 via links 840, 842, and 844 respectively, for purposes of communication and control. The DFSNC 810 could be co-located within one the WLAN APs or could be deployed on an independent platform within one of the WLANs. The detector AP 812 is normally instructed to be functionally receptive to signals transmitted on the channel used by the radar system 802. Thus, the detector AP 812 also has the capability of detecting the radar system's transmission periods directed towards each transmission/reception coverage sector associated with the WLAN devices. The detector AP 812 is utilized to detect the "sweep" of the radar or the temporal and directional position of the radar's radiation pattern during the full rotational period of the radar's antenna. The detector AP 812 is also responsible for detecting the transmission of different WLANs operating in the vicinity of the radar system 802 by identifying the radiating sources. Those sources can be APs and the associated MTs thereof implemented across different WLANs operating in the vicinity of the radar system 802. If the detector AP 812 is non-sectorized then the information acquired will have no directional dimension. In contrast, if the detector AP 812 is sectorized then the reception information will have directional dimension. Thus, at a certain point in time the sectorized AP 812 will receive on one of the sectors thereof the radar signal as a part of the radar "sweep" while on the rest of the sectors thereof various WLAN signals will be received. The detector AP 812 is further provided with the capability of detecting various MTs operating in the WLANs that are deployed near the radar system 802. Thus the detector AP 812 acquires further indication of the fact that a WLAN operates on the radar system's 802 channel. Subsequently the detector AP 812 notifies the DFSNC 810 through the link 846 concerning the collected results of the signal detection process performed in the environment.

In a similar manner, the APs 804, 806, 808 sends the results of the interference detection measurements performed thereby to the DFSNC 810 via the links 844, 842, 840. If the APs are sectorized then the uploaded information includes directional dimension. The information received from detector AP 812, AP 804, AP 806, and AP 808 is analyzed by the DFSNC 810 and in combination with the data the DFSNC 810 already has in respect to the location of the various APs, and the directionality of their respective sectors, the channels utilized, the location and parameters of the radar, and other relevant data. The result of the analysis enables the DFSNC 810 to build up a RF topology mapping of the signal environment. In accordance with the "signal environment map" the DFSNC 810 performs specific predefined measures in order to co-ordinate the signaling activities of the diverse wireless devices. For example, in order to accomplish signal harmony in the environment the DFSNC 810 could notify the AP 804, and the AP 806 to cease transmission for specific periods of time following the detector AP 812 notification in regard to the radar system 802 "sweeping" movement in time and space. Utilizing the directional information the DFSNC 810 has concerning the AP 804, and the AP 806, the DFSNC 810 could further specify that only specific sectors need to be "silent", such as sector 832 and sector 836 in AP 804, while the rest of the sectors, such as sector 834, 836, 830 may continue normal or powered down operations. Additionally, due to the dynamic time allocation process within the MAC frame, some APs, such as AP 804 could utilize the time allocated originally for the sector 832 and sector 836 such as to be used by the other sectors, such as sector 843, 836, and 830. As a result the AP over-all time-related capacity is preserved.

The extensive signal environment map data established by DFSNC 810 enables DFSNC 810 to control WLAN devices that are unable to detect interference independently due to their distance from the interfering transmission source. For example, the currently discussed drawing shows AP 808 deployed such that it is more remote from the radar system 812 than the AP 804, and the AP 806. Thus, AP 808 may not be able to detect interfering radar signals emitted

by radar system since the signals received will be having a power level lower than the signal detection threshold provided to the interference measurement mechanism of AP 808. Yet at the same time the transmission of AP 808 may interfere with the radar system 802 due, for example to the higher sensitivity of the radar's receiver. Utilizing the signal environment map the DFSNC 810 can notify the AP 808 to take specific interference avoidance measures, such as to cease transmitting, or to lower the transmission power thereof.

The detector AP 812 co-located with the primary user, such as the radar system 802 can be utilized for detecting the signals transmitted by other WLANs as received at the site of the primary user. Subsequently the detector AP 812 notifies the DFSNC 810 AP-specific information, such as AP identification, network identification, received signal strength (RSS) and the like. If the transmitting AP operates in a sectorized mode then the detector AP 812 sends to the DFSNC 810 the appropriate directional information. The directional information enables the DFSNC 810 to instruct the suitable device, such as the AP, to take predefined interference avoidance measures, such as ceasing transmission, or lowering transmission power on one or more of its existing sectors.

The detector AP 812 co-located with the primary user, such as the radar system 802 is also operative in tracing the primary user, such as radar system 802 "sweeping" movement. Subsequently the detector AP 812 can notify the DFSNC 810 in regard to the temporality and directionality of the "sweep" process. The communicated and analyzed information provides the DFSNC 810 with the capability to instruct the WLANs deployed on the path of the radar antenna's sweep to take predefined interference avoidance measures, such as interrupting transmission or lowering transmission level on one or more existing sectors.

It will be easily perceived by one with ordinary skill in the art that the steps and components mentioned in the foregoing description were provided as examples and were not intended to be limiting. Diverse other components and

methods could be used to accomplish the underlying objectives of the present invention and several enhancements and improvements to the described embodiment could be contemplated within the framework of the general issues inherent in the proposed system.

The above description of the construction and use of systems incorporating a plurality of mobile terminals, access points, network controllers, transceivers, and the like makes particular reference to use in a land-based wireless local area network (WLAN). However, it will be understood that the use of the technique is in no way limited to land-based wireless local area networks and that it is equally applicable to wireless wide area networks, and other fixed and/or mobile wireless communication systems incorporating satellite links.

Persons skilled in the art will appreciate that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims, which follow.

I CLAIM:

1. In a wireless communications environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on an allocated frequency band via an air interface, at least one primary user transmitting and receiving a radio frequency signal on a substantially alike allocated frequency band via an air interface, a method for the detecting and avoiding reciprocal signal interference produced by the radio frequency signals emitted by the at least one primary user and by the at least one secondary user, the method comprising the steps of:

establishing dynamic interference detection and avoidance control and operation information in the at least one secondary user; and

dynamically and controllably measuring at least one communication channel providing a communication path between at least two wireless devices of the at least one secondary user; and

analyzing the results of measurements performed on the at least one communications channel in order to determine the interference status of the measured at least one communications channel of the at least one secondary user; and

dynamically maintaining interference detection and avoidance information in the at least one secondary user; and

selectively performing controllable interference avoidance procedures by the at least one secondary user to prevent reciprocal signal interference in the at least one secondary user and in the at least one primary user.

2. The method of claim 1 further comprising selectably performing a signal co-existence procedure to enable co-existence of the at least one secondary user with the at least one primary user on the substantially alike pre-allocated frequency band in the communications environment.

3. The method of claim 1, further comprising the at least one secondary user communicating interference detection and avoidance information and instructions to at least one other secondary user.

4. The method of claim 1 wherein the step of establishing comprises the steps of:

maintaining communications environment status information in the at least one secondary user; and

creating detected signals information in the at least one secondary user; and

building interference measurement information in the at least secondary user; and

originating interference avoidance information in the at least one secondary user.

5. The method of claim 1, wherein the step of measuring comprises the steps of:

sending interference measurement control information to at least one interference detection and avoidance wireless device by the interference detection and avoidance controller device of the at least one secondary user; and

instructing the at least one interference detection and avoidance wireless device to perform interference measurements with respect to at least one communications channel by the interference detection and avoidance controller device of the at least one secondary user; and

performing interference measurements by the at least one interference detection and avoidance wireless device on the at least one communications channel; and

communicating the results of the interference measurements by the at least one interference detection and avoidance wireless device to the interference detection and avoidance controller of the at least one secondary user.

6. The method of claim 1, wherein the step of measuring comprises the steps of:

examining the parameters of the signal received on the at least one measured communications channel by the at least one interference detection and avoidance wireless device; and

comparing the received signal parameters with the suitable interference detection information communicated by the interference detection and avoidance controller.

7. The method of claim 1, wherein the step of performing comprises the steps of:

modifying the suitable interference avoidance procedure by the interference detection and avoidance controller; and

selecting the suitable interference avoidance procedure by the interference detection and avoidance controller; and

communicating the suitable interference avoidance procedure and attached interference avoidance information to the at least one interference detection and avoidance wireless device by the interference detection and avoidance controller; and

executing the communicated interference avoidance procedure by the at least one interference detection and avoidance wireless device.

8. The method of claim 5, wherein the step of interference measurements performance is executed by the at least one interference detection and avoidance controller device.

9. The method of claim 5, wherein the step of interference avoidance performing is executed by the at least one interference detection and avoidance controller device.

10. The method of claim 1, wherein the step of maintaining interference detection and avoidance control and operation information further comprises:

manually maintaining the interference detection and avoidance information stored in the operation database by an operator of the secondary user in accordance with information received from external sources; and

dynamically maintaining the interference detection and avoidance information stored in operation database by interference detection and avoidance device; and

dynamically maintaining the interference detection and avoidance information stored in operation database by interference detection and avoidance service.

11. In a communication environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on a pre-allocated

frequency band via a link, at least one primary user transmitting and receiving a radio frequency signal on a substantially same pre-allocated frequency band via an unbounded medium, a system for the dynamic detection and avoidance of reciprocal signal interference produced substantially simultaneously by the at least one secondary user and at least one primary user, the system comprising the elements of:

at least one primary user interference detection and avoidance controller device; and

at least one primary user interference detection and avoidance wireless device.

12. The system of claim 11, wherein the at least one controller device comprises the elements of:

an interference measurement control function to instruct at least one interference detection and avoidance wireless device to perform interference detection; and

an interference measurement analysis function to identify the type, the quality, and the source of the measured interference; and

an interference avoidance control function to instruct at least one interference detection and avoidance wireless device to perform interference avoidance procedures; and

a messaging function to communicate the instructions to the at least one interference detection and avoidance wireless device; and

a user interface function to enable an operator to create and maintain the operation database; and

an operation database to hold interference detection parameters, interference avoidance parameters, network information, wireless device information, available channel information, channel periodicity data, primary user information, measurement results, and general operating parameters.

13. The system of claim 12, wherein the operation database comprises the elements of:

an operating parameters table utilized to control interference detection modes, interference avoidance methods, secondary user information, primary user information; and

a measurements parameter table to determine the operative parameters of the interference detection process ; and

an interference information table to provide information in regard of the interference detected on the at least one communication table; and

a channel data table to provide usable and non-usable communication channel information; and

a channel parameter changes table to hold the collection of the channel anomalies; and

a time window data table to indicate operational periods of a periodically operative primary user; and

a channel periodicity table to hold a set of consecutive time slot values functional in enabling the at least one secondary user and the at least one primary user to use co-operatively the same communication channel; and

a network topology data table to provide information concerning the at least one secondary user, the at least one secondary user devices, and the at least one primary user.

14. The system of claim 11, wherein the at least one interference detection and avoidance wireless device comprises the elements of:

an interference measurement function to selectively measure at least one communication channel operative in the linking of at least two wireless devices of the at least one secondary user; and

an interference avoidance function to perform interference avoidance measures; and

an interference reporting function to assemble and structure messages concerning the results of the interference measurement functions; and

an operation database to hold interference detection parameters, interference avoidance parameters, network information, wireless device information,

available channel information, channel periodicity data, primary user information, measurement results, and general operating parameters.

15. The system of claim 11, wherein the at least one interference detection and avoidance device wireless device further comprising a messaging function to communicate the results of the interference measurements performed by the wireless device to the interference detection and avoidance controller device.

16. The system of claim 14, wherein the interference avoidance function comprises the elements of:

a channel re-assignment function to avoid mutual interference between the at least one secondary user and the at least one primary user by providing the at least one communicating wireless devices of the secondary user with an alternative communication channel ; and

a transmission power adjustment function to prevent interference to the at least one primary user dynamically lowering the transmission, power level of the signal radiated by the at least one secondary user; and

a co-existence function suitably dividing the communication channel into mutually exclusive time slots providing the at least one secondary user and the at least one primary user to utilize the channel co-operatively and alternately.

17. The system of claim 14, wherein the interference measurement function comprises the elements of:

a received signal strength measurement function; and

a received signal period measurement function to examine the power level of the signal received on the at least one communications channel; and

a channel anomalies measuring function to collect and collate channel anomalies during the routine data exchange operations on the at least one communications channel; and

a received signal periodicity identifier function to describe the transmission periods at least one periodically transmitting primary source.

18. The system of claim 11, wherein the at least one primary user interference detection and avoidance controller device is collocated with the at least one primary user interference detection and avoidance wireless device.

19. The system of claim 14, wherein the at least one secondary user is a wireless local area network (WLAN).

20. The system of claim 19, wherein the WLAN is a HiperLAN/2-type network.

21. The system of claim 19, wherein the WLAN is an IEEE 802.11a-type network.

22. The system of claim 19, wherein the WLAN comprises at least one transmitting and receiving wireless devices.

23. The system of claim 19, wherein the WLAN comprises at least one sectorized wireless devices operative in transmitting and receiving via at least one operative sectors having different radiation directionality.

24. The system of claim 19, wherein the WLAN is coupled to a wired communications network.

25. The system of claim 24, wherein the wired communications network is a local area network (LAN).

26. The system of claim 24, wherein the wired communication network is wide area network (WAN).

27. The system of claim 19, wherein the WLAN is operative in communicating interference related information and instruction to other secondary users.

28. The system of claim 11, wherein the at least one primary user is a radar system.

29. The system of claim 28, wherein the radar system is a continuous wave (CW) radar system.

30. The system of claim 28, wherein the radar system is a pulse/sweep radar system.

31. The system of claim 11, wherein the at least one primary user is a satellite feeder system.

32. The system of claim 11, wherein the at least one primary user is an amateur radio service.

33. In a wireless communications environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on a pre-allocated frequency band via an air interface, at least one primary user transmitting and receiving a radio frequency signal on a substantially alike pre-allocated frequency band via an air interface, a method of detecting and avoiding signal interference effected to the at least one primary user by the transmission of the signal emitted by the at least one secondary user, the method comprising the steps of:

dynamically and controllably measuring at least one communications channel utilized the at least one primary user; and

analyzing the results of the channel measurements performed on the at least one communications channel utilized by the at least one primary user in order to determine the interference status of the measured channel; and

communicating the results of the analysis to the at least one secondary user interference detection and avoidance controller device; and

dynamically maintaining interference detection and avoidance information concerning the identity, attributes, locations, directionality, and activity of at least one wireless device associated with at least one secondary user interfering with the at least one measured communications channel associated with the at least one primary user;

selectively and controllably performing interference avoidance measures by the at least one secondary user interference detection and avoidance controller device to prevent signal interference in the at least one communications channel associated with the at least one primary user.

34. The method of claim 33 further comprising building and maintaining a functional RF topology mapping of the communication environment.

35. The method of claim 33 further comprising selectably and controllably performing a signal co-existence option to enable shared utilization of the at least one communications channel by the at least one primary user and the at least one secondary user.

36. The method of claim 35, wherein the co-existence of the at least one secondary user with the at least one primary user on the substantially alike at least one communications channel is accomplished by selectively adjusting the transmission power level of the signals radiated by the at least one secondary user.

37. The method of claim 35, wherein the co-existence of the at least one secondary user with the at least one primary user on the substantially alike at least one communications channel is accomplished by selectively ceasing transmission of the signals by the at least one secondary user for the duration of the signals transmitted by the at least one primary user.

38. The method of claim 35, wherein the adjustment of the transmission power level performed specifically for at least one directional sector associated with at least one wireless device associated with the at least one secondary user.

39. The method of claim 35, wherein the interruption of the transmission of the signals by the at least one secondary user performed specifically on at least one directional sector associated with at least one wireless device associated with the at least one secondary user.

40. In a communication environment accommodating at least one secondary user transmitting and receiving a radio frequency signal on a allocated frequency band via a link, at least one primary user transmitting and receiving a radio frequency signal on a substantially same allocated frequency band via an unbounded medium, a system for the dynamic detection of reciprocal signal interference produced substantially simultaneously by the at least one secondary user and at least one primary user, the system comprising the elements of:

at least one primary user interference detection and avoidance controller device to communicate with and control at least one secondary user activity detection wireless device; and

at least one secondary user activity detection wireless device to perform measurements on at least one communication channel utilized by the primary user in order to detect interference produced by the activity of at least one secondary user.

41. The system of claim 40, wherein the at least one primary user interference detection and avoidance device is collocated with the at least one primary user.

42. The system of claim 40, wherein the at least one secondary user is a wireless local area network (WLAN).

43. The system of claim 40, wherein the at least one secondary user is a cellular telephone network.

44. The system of claim 40, wherein the at least one secondary user is a Wireless Personal Area Network (WPAN).

45. The system of claim 42, wherein the WLAN comprises at least one transmitting and receiving wireless device.

46. The system of claim 42, wherein at WLAN comprises at least one sectorized wireless device operative in transmitting and receiving in via the at least one sector having specific radiation directionality.

47. The system of claim 40, wherein the at least one primary user is a radar system.

48. The system of claim 43, wherein the radar system comprises a sweep/pulse radar.

49. The method of claim 1, wherein the wireless communications environment accommodates at least two secondary users.

50. The method of claim 1, wherein the method of detecting and avoiding interference is operative in the detection and avoidance of reciprocal signal

interference produced by the radiation of radio frequency signals emitted by the at least two secondary users.

51. The system of claim 11, wherein the communications environment accommodates at least two secondary systems.

52. The system of claim 11, wherein the system for the detection and avoidance of the signal interference is operative in detecting and avoiding signal interference between at least two secondary systems.

53. The method of claim 33, wherein the wireless communications environment accommodates at lest two secondary users.

54. The system of claim 40, wherein the communication environment accommodates at least two secondary users.

55. The system of claim 12, wherein the operation database is implemented on the primary user detection and avoidance wireless device.

56. The system of claim 13, wherein the network topology data table provides information concerning at least two secondary users and at least two secondary users devices.

57. The system of claim 16, wherein the channel re-assignment function is operative in avoiding mutual interference between at least two secondary users.

58. The system of claim 16, wherein the co-existence function is implemented on the interference detection and avoidance controller device.

59. The system of claim 19, wherein the at least one secondary user is a cellular phone network.

60. The system of claim 19, wherein the at least one secondary user is a Wireless Personal Area Network (WPAN).

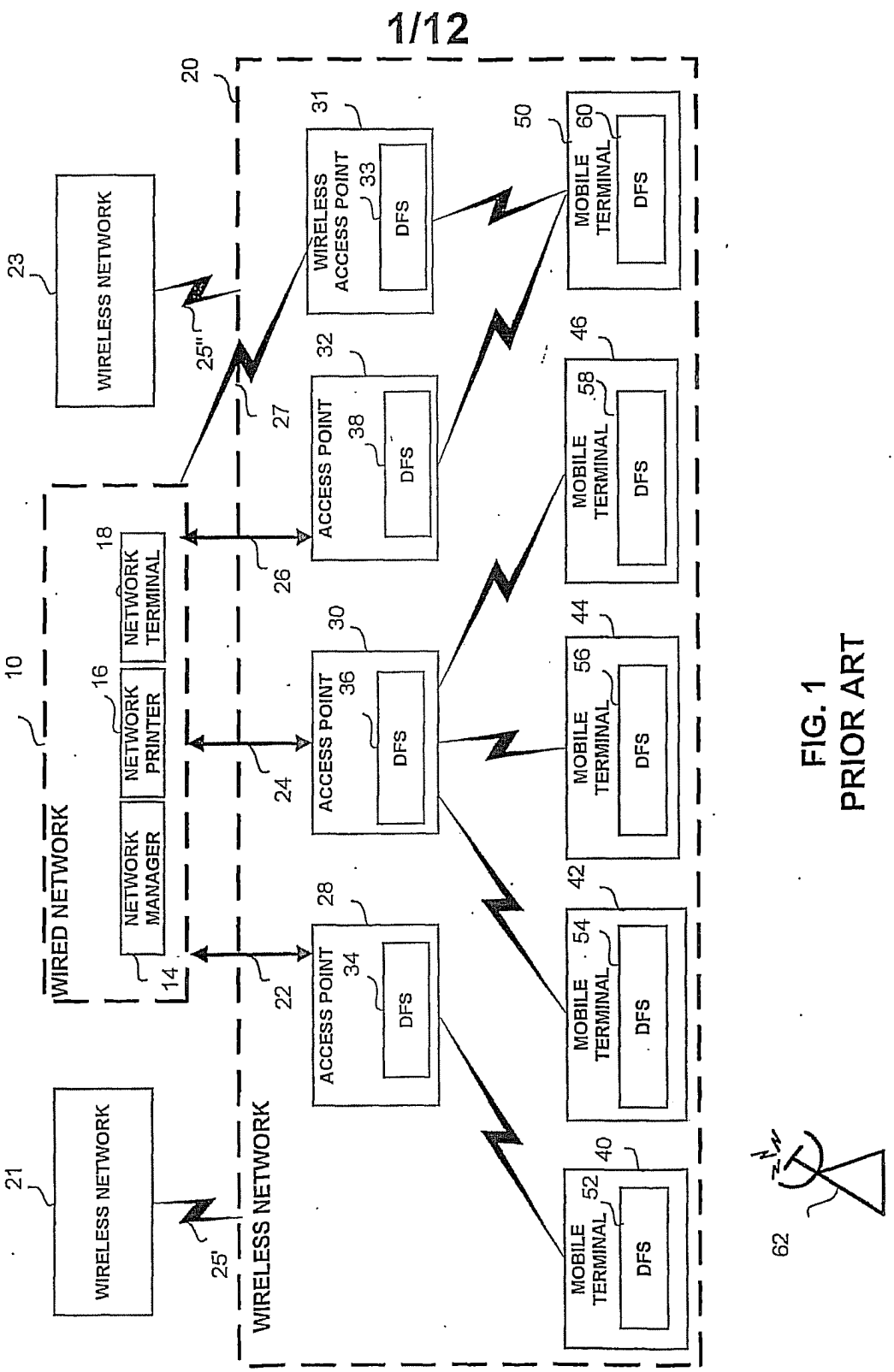


FIG. 1
PRIOR ART

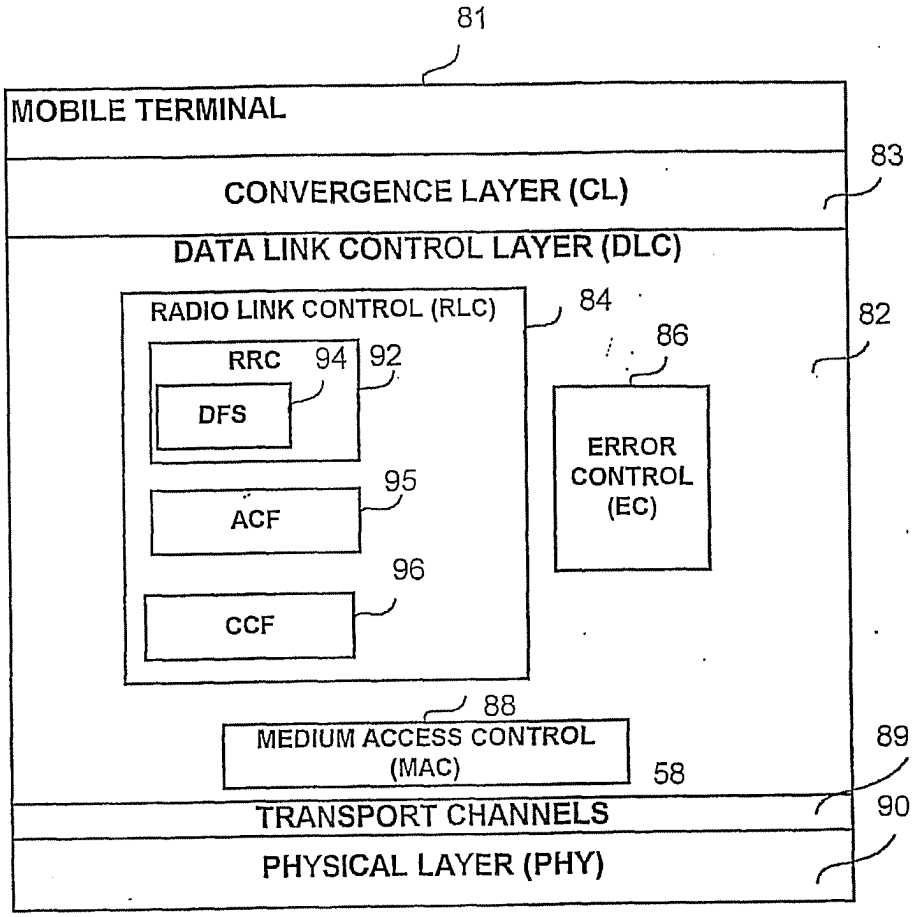


FIG. 2
PRIOR ART

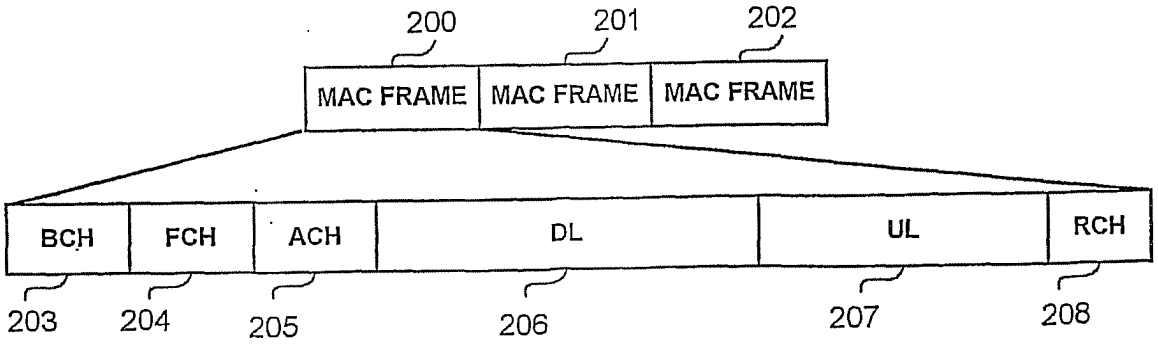


FIG. 3
PRIOR ART

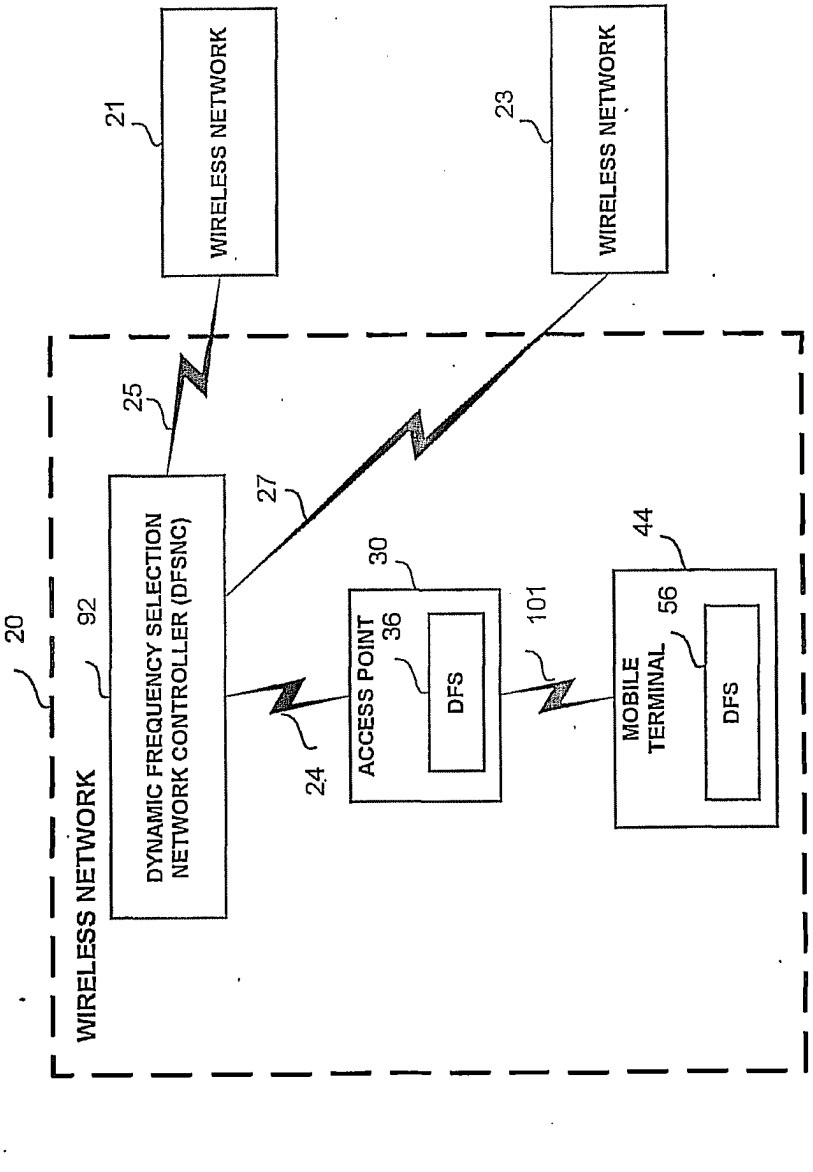

WIRELESS NETWORK
21
WIRELESS NETWORK
23
25
27
20
WIRELESS NETWORK
92
DYNAMIC FREQUENCY SELECTION NETWORK CONTROLLER (DFSNC)
24
30
ACCESS POINT
36
DFS
101
44
MOBILE TERMINAL
56
DFS
78

FIG. 4

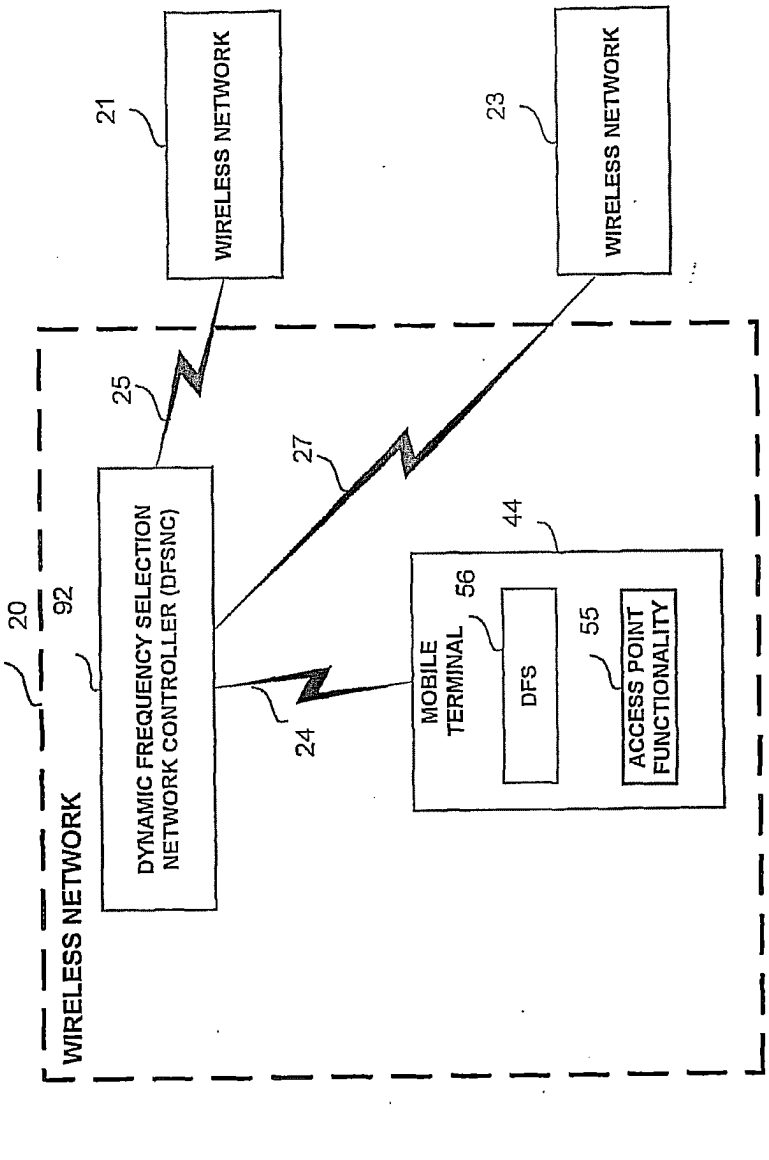

WIRELESS NETWORK
21
WIRELESS NETWORK
23
25
27
20
92
DYNAMIC FREQUENCY SELECTION NETWORK CONTROLLER (DFSNC)
24
44
MOBILE TERMINAL
56
DFS
55
ACCESS POINT FUNCTIONALITY
78

FIG. 4A

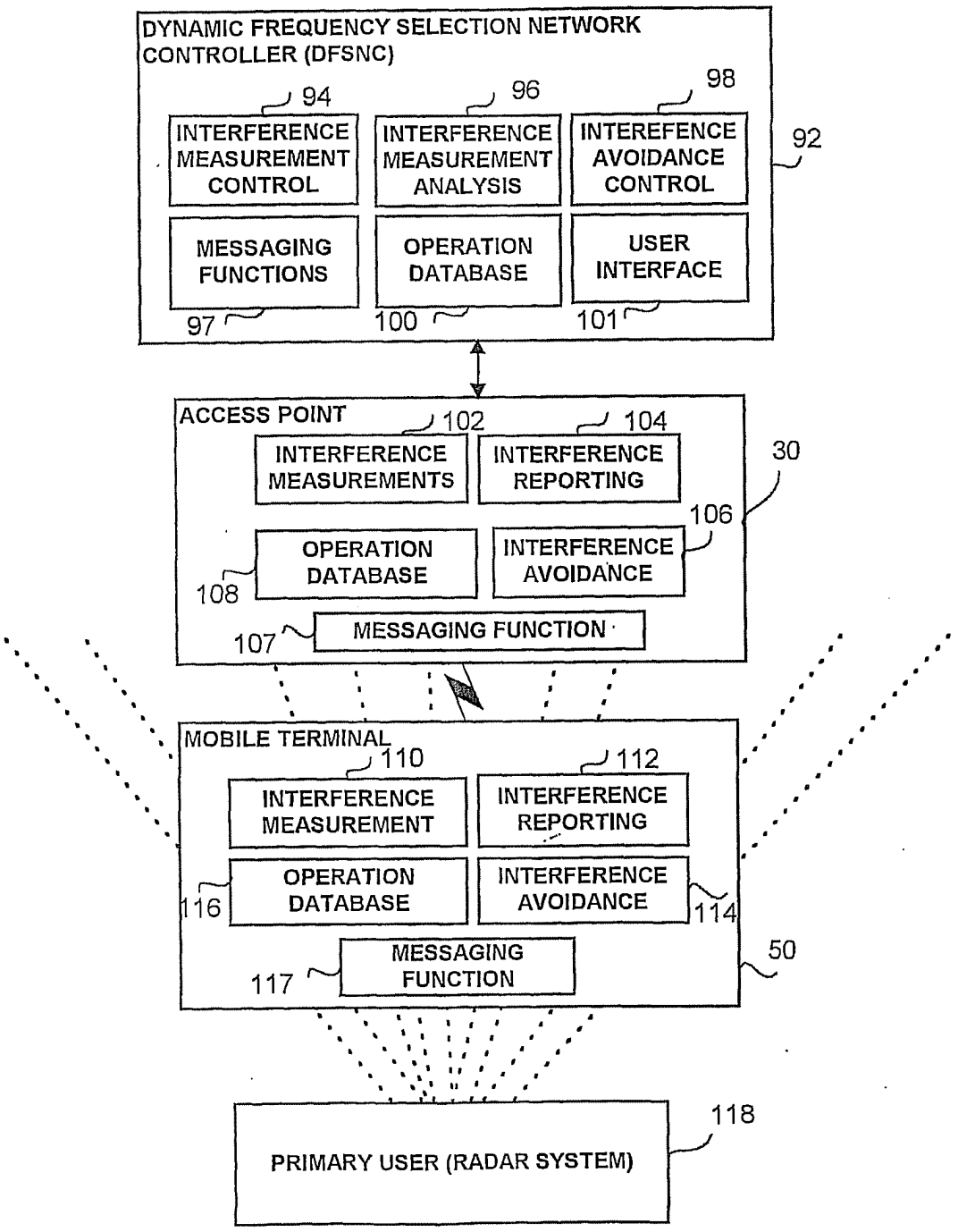

DYNAMIC FREQUENCY SELECTION NETWORK CONTROLLER (DFSNC)
94
96
98
INTERFERENCE MEASUREMENT CONTROL
INTERFERENCE MEASUREMENT ANALYSIS
INTEREFENCE AVOIDANCE CONTROL
92
MESSAGING FUNCTIONS
OPERATION DATABASE
USER INTERFACE
97
100
101
ACCESS POINT
102
104
INTERFERENCE MEASUREMENTS
INTERFERENCE REPORTING
30
106
OPERATION DATABASE
INTERFERENCE AVOIDANCE
108
MESSAGING FUNCTION
107
MOBILE TERMINAL
110
112
INTERFERENCE MEASUREMENT
INTERFERENCE REPORTING
OPERATION DATABASE
INTERFERENCE AVOIDANCE
116
114
MESSAGING FUNCTION
117
50
PRIMARY USER (RADAR SYSTEM)
118

FIG. 5

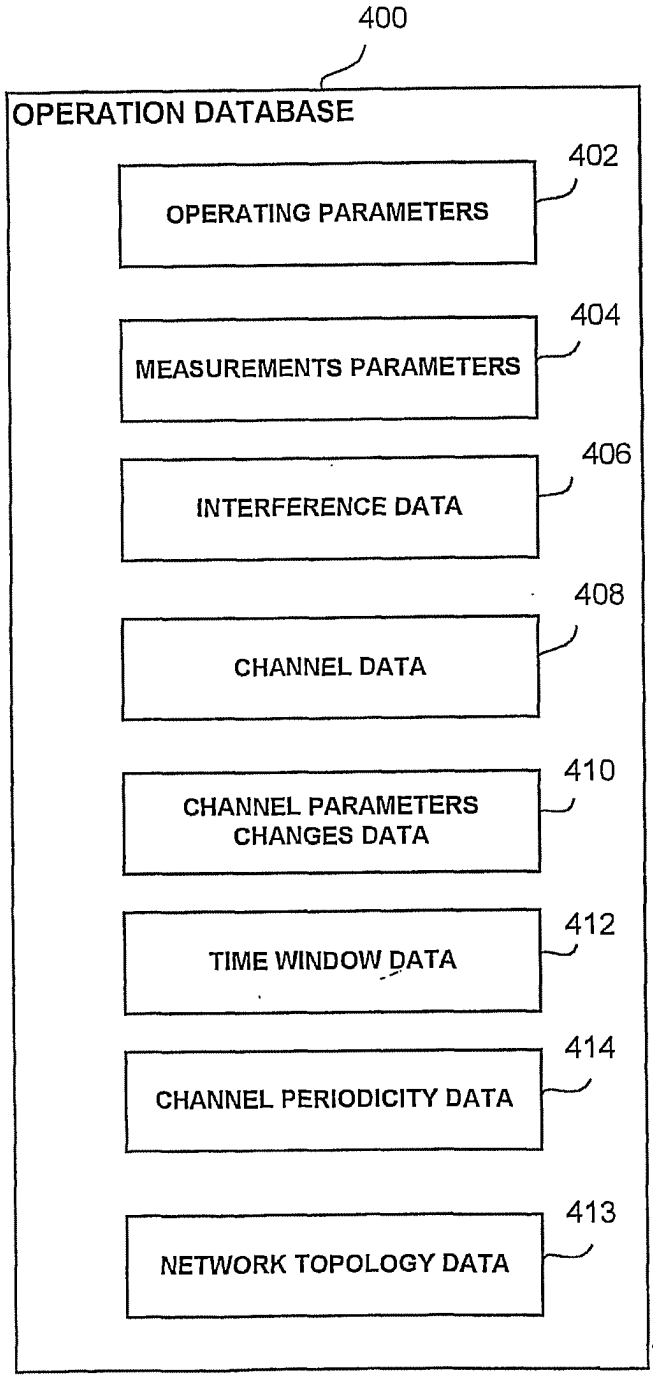

400
OPERATION DATABASE
402
OPERATING PARAMETERS
404
MEASUREMENTS PARAMETERS
406
INTERFERENCE DATA
408
CHANNEL DATA
410
CHANNEL PARAMETERS CHANGES DATA
412
TIME WINDOW DATA
414
CHANNEL PERIODICITY DATA
413
NETWORK TOPOLOGY DATA

FIG. 6

7/12

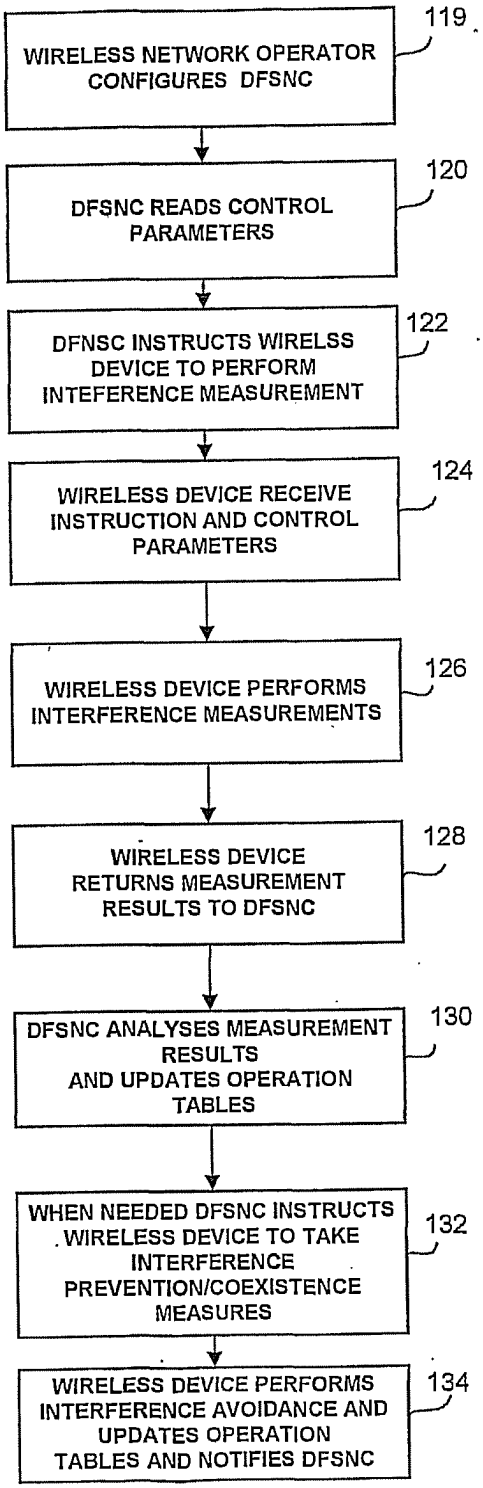

WIRELESS NETWORK OPERATOR CONFIGURES DFSNC
119
DFSNC READS CONTROL PARAMETERS
120
DFNSC INSTRUCTS WIRELSS DEVICE TO PERFORM INTEFERENCE MEASUREMENT
122
WIRELESS DEVICE RECEIVE INSTRUCTION AND CONTROL PARAMETERS
124
WIRELESS DEVICE PERFORMS INTERFERENCE MEASUREMENTS
126
WIRELESS DEVICE RETURNS MEASUREMENT RESULTS TO DFSNC
128
DFSNC ANALYSES MEASUREMENT RESULTS AND UPDATES OPERATION TABLES
130
WHEN NEEDED DFSNC INSTRUCTS WIRELESS DEVICE TO TAKE INTERFERENCE PREVENTION/COEXISTENCE MEASURES
132
WIRELESS DEVICE PERFORMS INTERFERENCE AVOIDANCE AND UPDATES OPERATION TABLES AND NOTIFIES DFSNC
134

FIG. 7

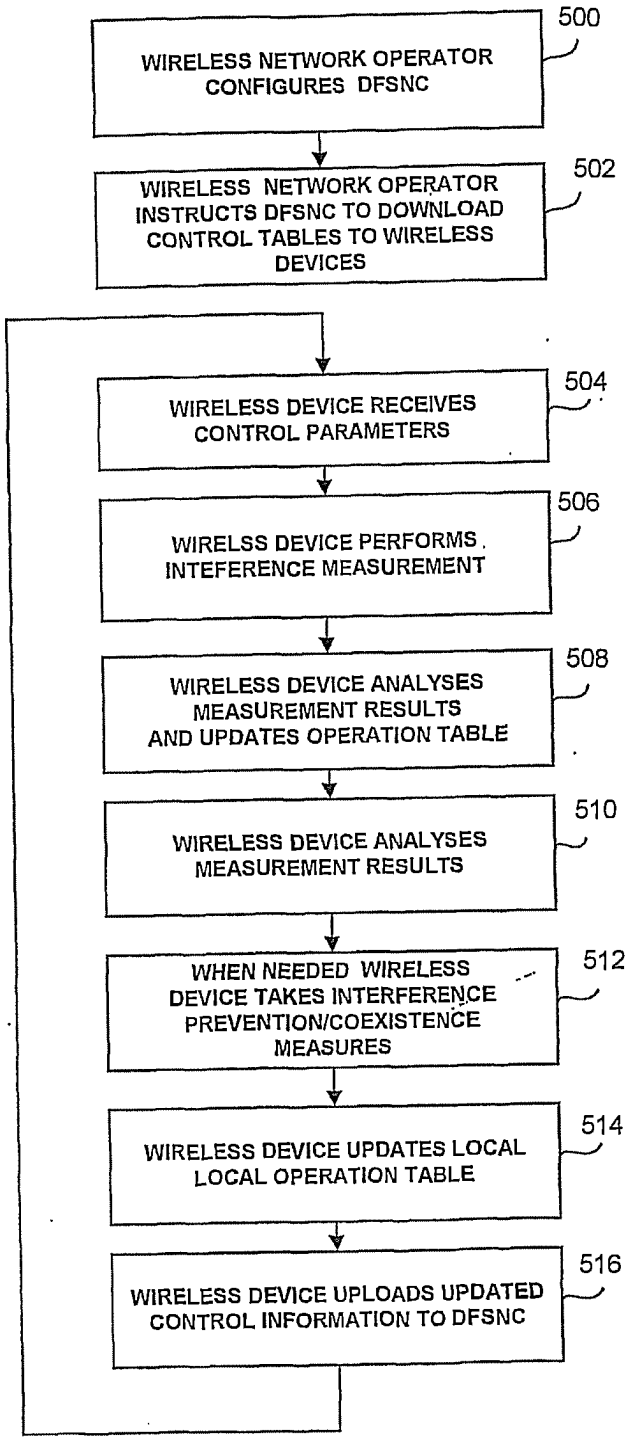

WIRELESS NETWORK OPERATOR CONFIGURES DFSNC
500
WIRELESS NETWORK OPERATOR INSTRUCTS DFSNC TO DOWNLOAD CONTROL TABLES TO WIRELESS DEVICES
502
WIRELESS DEVICE RECEIVES CONTROL PARAMETERS
504
WIRELSS DEVICE PERFORMS INTEFERENCE MEASUREMENT
506
WIRELESS DEVICE ANALYSES MEASUREMENT RESULTS AND UPDATES OPERATION TABLE
508
WIRELESS DEVICE ANALYSES MEASUREMENT RESULTS
510
WHEN NEEDED WIRELESS DEVICE TAKES INTERFERENCE PREVENTION/COEXISTENCE MEASURES
512
WIRELESS DEVICE UPDATES LOCAL LOCAL OPERATION TABLE
514
WIRELESS DEVICE UPLOADS UPDATED CONTROL INFORMATION TO DFSNC
516

FIG. 8

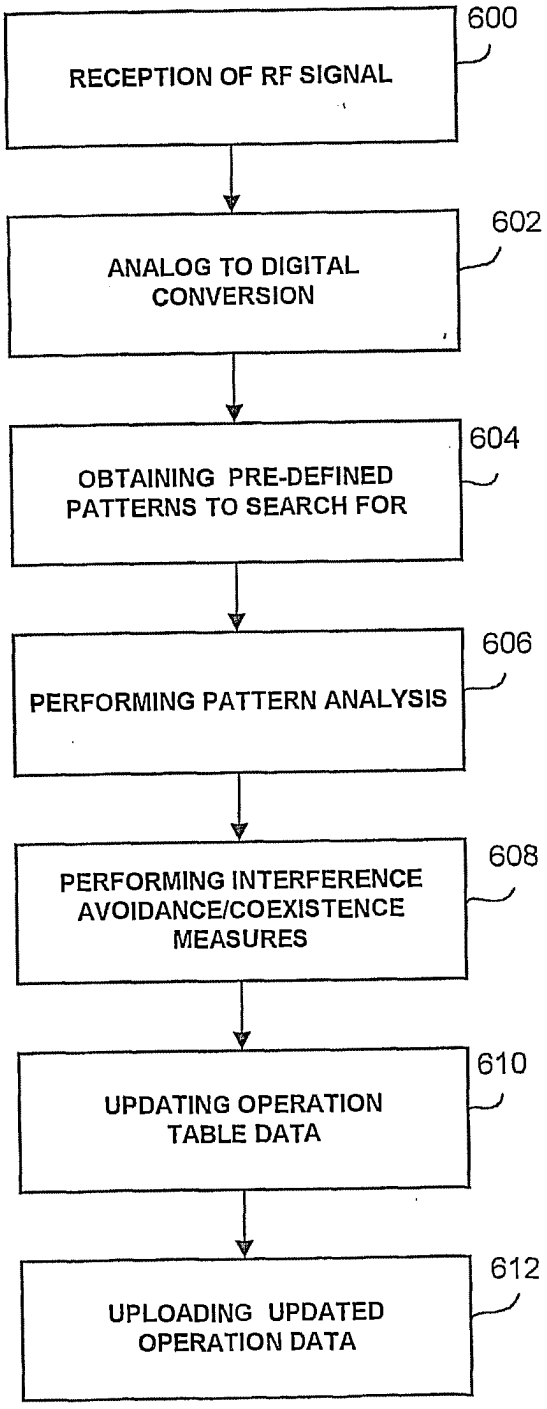

RECEPTION OF RF SIGNAL
600
ANALOG TO DIGITAL CONVERSION
602
OBTAINING PRE-DEFINED PATTERNS TO SEARCH FOR
604
PERFORMING PATTERN ANALYSIS
606
PERFORMING INTERFERENCE AVOIDANCE/COEXISTENCE MEASURES
608
UPDATING OPERATION TABLE DATA
610
UPLOADING UPDATED OPERATION DATA
612

FIG. 9

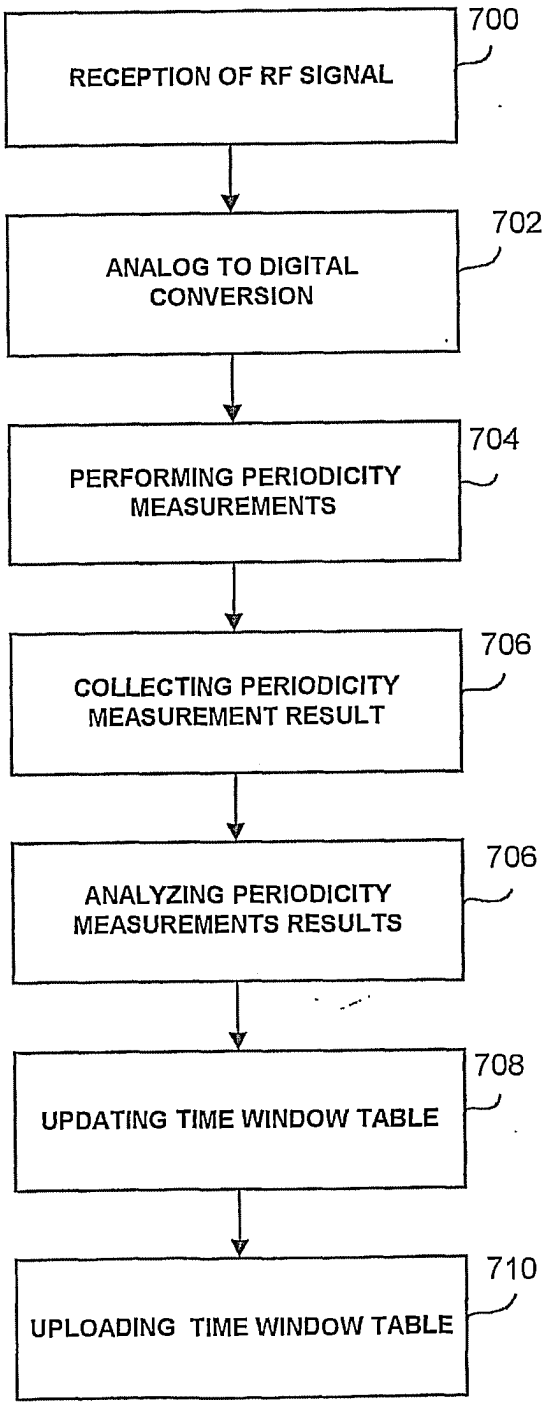

RECEPTION OF RF SIGNAL
700
ANALOG TO DIGITAL CONVERSION
702
PERFORMING PERIODICITY MEASUREMENTS
704
COLLECTING PERIODICITY MEASUREMENT RESULT
706
ANALYZING PERIODICITY MEASUREMENTS RESULTS
706
UPDATING TIME WINDOW TABLE
708
UPLOADING TIME WINDOW TABLE
710

FIG. 10

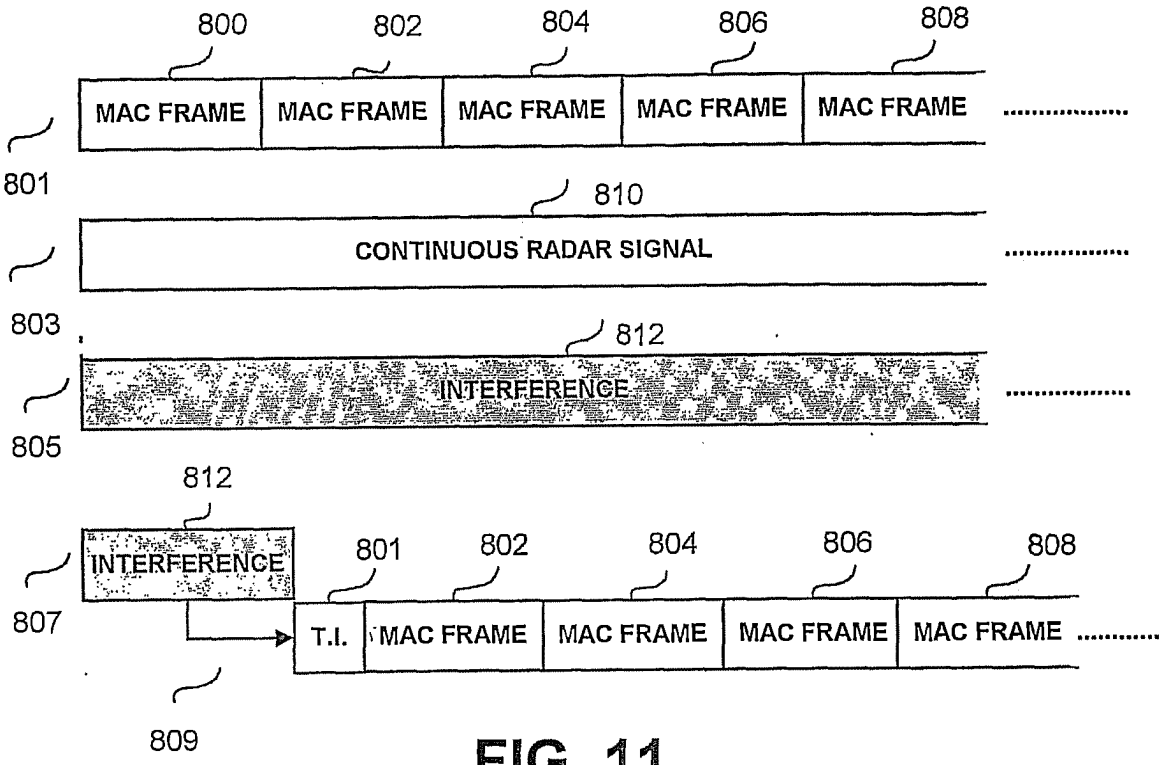

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MAC FRAME
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MAC FRAME
MAC FRAME
MAC FRAME
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810
CONTINUOUS RADAR SIGNAL
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812
INTERFERENCE
805
812
INTERFERENCE
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802
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808
807
T.I.
MAC FRAME
MAC FRAME
MAC FRAME
MAC FRAME
809

FIG. 11

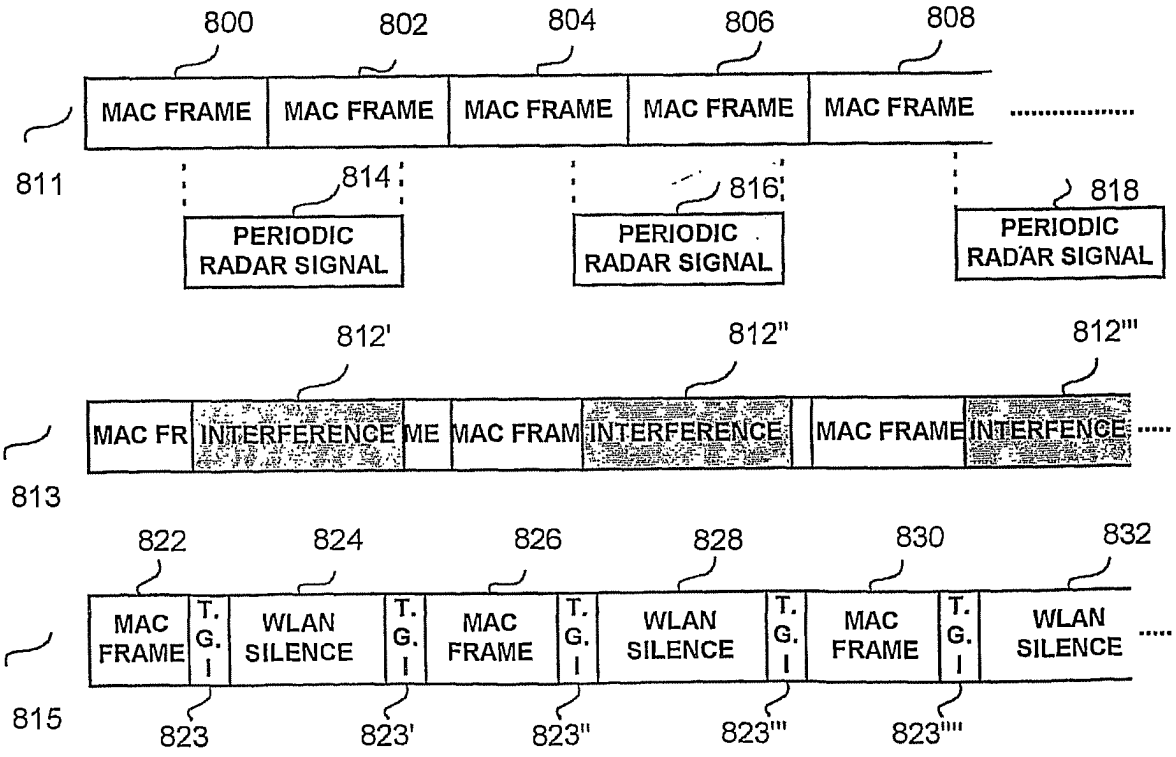

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MAC FRAME
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FIG. 12

12/12

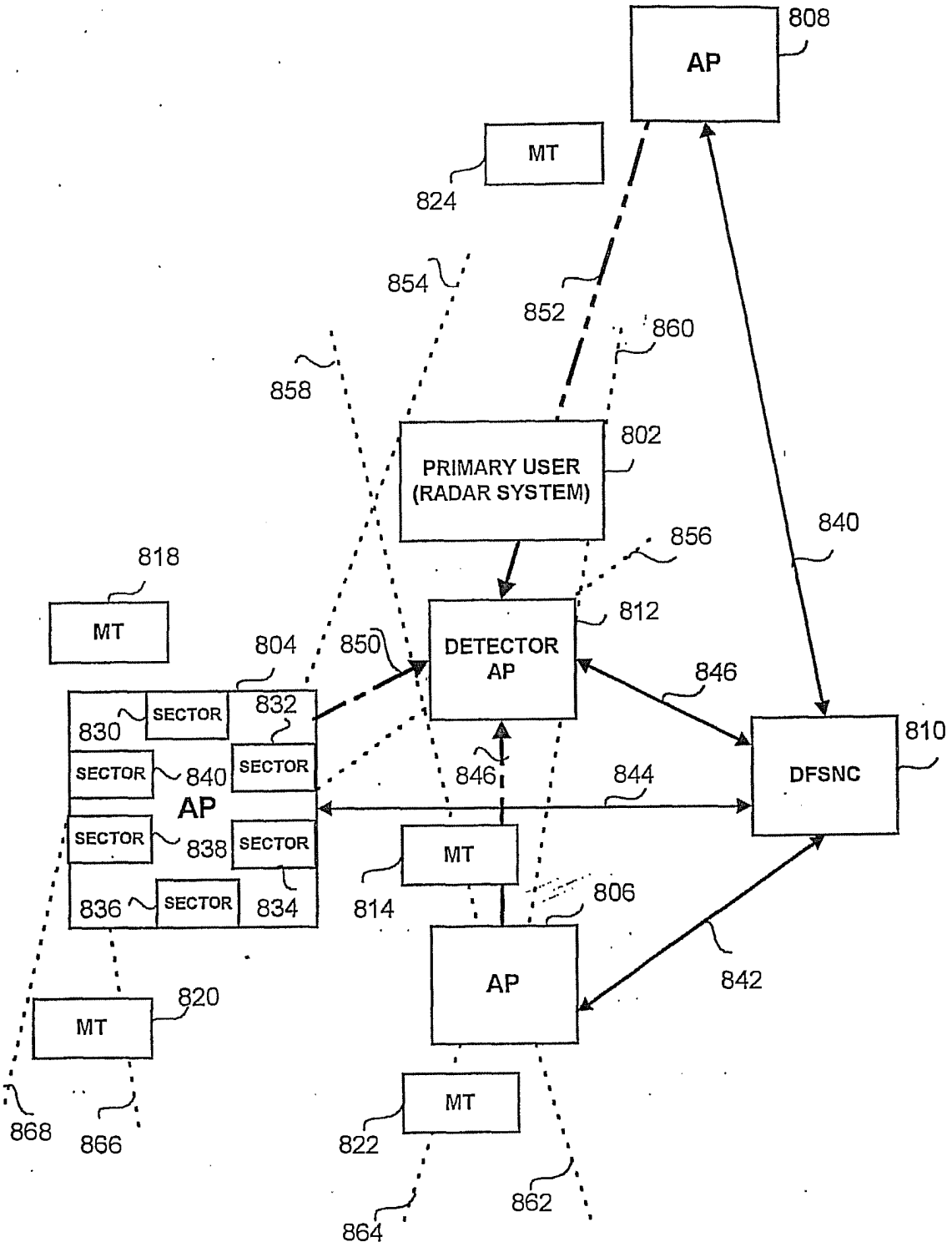

AP
808
MT
824
854
852
860
858
PRIMARY USER
(RADAR SYSTEM)
802
840
856
818
MT
812
804
850
DETECTOR
AP
846
SECTOR
832
830
SECTOR
SECTOR
840
AP
846
844
810
DFSNC
SECTOR
838
SECTOR
MT
814
806
836
SECTOR
834
AP
842
820
MT
MT
868
866
822
862
864

FIG. 13

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/IL 01/00577

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L12/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01 37463 A (NOKIA CORP ;SALOKANNEL JUHA (FI); LAPPETELAEINEN ANTTI (FI); SMOLA) 25 May 2001 (2001-05-25) page 5, line 4 -page 8, line 6 page 10, line 5 - line 25	1-9,11, 14-60
Y	page 14, line 6 -page 16, line 2	10,12,13
X	WO 00 70812 A (NOKIA CORP ;LAPPETELAEINEN ANTTI (FI); SMOLANDER VISA TAPIO (FI)) 23 November 2000 (2000-11-23) page 14, line 7 -page 15, line 20 figure 2	11,40
Y	WO 01 24455 A (MOBILIAN CORP) 5 April 2001 (2001-04-05) abstract	10,12,13

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 February 2002	01/03/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Schneider, G

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	"Broadband Radio Access Networks (BRAN);HIPERLAN Type 2; System Overview" , ETSI TR 101 683 V1.1.1, XX, XX, PAGE(S) 1-20 XP002176358	

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/IL 01/00577

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0137463 A	25-05-2001	FI 992473 A	19-05-2001
		AU 1527401 A	30-05-2001
		WO 0137463 A1	25-05-2001
WO 0070812 A	23-11-2000	FI 991102 A	13-11-2000
		FI 991240 A	13-11-2000
		AU 4570800 A	05-12-2000
		EP 1177652 A1	06-02-2002
		WO 0070812 A1	23-11-2000
WO 0124455 A	05-04-2001	AU 7622200 A	30-04-2001
		AU 7734300 A	30-04-2001
		AU 7734400 A	30-04-2001
		AU 7734500 A	30-04-2001
		AU 7736800 A	30-04-2001
		WO 0124454 A1	05-04-2001
		WO 0124455 A1	05-04-2001
		WO 0124456 A1	05-04-2001
		WO 0124457 A1	05-04-2001
		WO 0124458 A1	05-04-2001
		AU 7736600 A	06-06-2001
		WO 0135578 A1	17-05-2001

Form PCT/ISA/210 (patent family annex) (July 1992)

Electronic Acknowledgement Receipt

EFS ID:	2836541
Application Number:	11920076
International Application Number:	
Confirmation Number:	2431
Title of Invention:	Method and apparatus for determining path loss by active signal detection
First Named Inventor/Applicant Name:	John Arpee
Customer Number:	39290
Filer:	Mark Charles Comtois/Jacquetta McBee
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	AND07 061 US
Receipt Date:	08-FEB-2008
Filing Date:	
Time Stamp:	17:47:44
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement Letter	AND01_062_IDS.pdf	559386 19a09c0da0f763566e4a6d3449f4e6efa9ac250e	no	5

Warnings:	
Information:	

2	Foreign Reference	References.pdf	16783956 14c6e194d36d5d16b170494ffed299dbb4be674f	no	169

Warnings:	
Information:	
Total Files Size (in bytes):	17343342

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IAP12 Rec'd PCT/PTO 08 NOV 2007

PTO-1390 (Rev. 09-2007)
Approved for use through 2/28/2010. OMB 0651-0021
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER AND01 061 US
		U.S. APPLICATION NO. (If known, see 37 CFR 1.5) Unknown 11/920076
INTERNATIONAL APPLICATION NO. PCT/US2006/17517	INTERNATIONAL FILING DATE 2006.05.17	PRIORITY DATE CLAIMED 2005.05.17

TITLE OF INVENTION
METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

APPLICANT(S) FOR DO/EO/US
John Arpee, et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a submission under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a submission under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected (Article 31).
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☑ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☑ A preliminary amendment.
14. ☐ An Application Data Sheet under 37 CFR 1.76.
15. ☐ A substitute specification.
16. ☐ A power of attorney and/or change of address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.2 and 37 CFR 1.821- 1.825.
18. ☐ A second copy of the published International Application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

This collection of information is required by 37 CFR 1.414 and 1.491-1.492. The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 15 minutes to complete, including gathering information, preparing, and submitting the completed form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PTO-1390 (Rev. 09-2007)
Approved for use through 2/28/2010. OMB 0651-0021
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
Unknown 10920076	PCT/US2006/17517	AND01 061 PCT

20. Other items or information:

The following fees have been submitted	CALCULATIONS	PTO USE ONLY
21. ☑ Basic national fee (37 CFR 1.492(a)) **$310**	$ 310.00	
22. ☐ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$210**	$	
23. ☐ Search fee (37 CFR 1.492(b)) If the written opinion of the ISA/US or the International preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority ..... **$100** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB ..... **$410** All other situations **$510**	$	
TOTAL OF 21, 22 and 23 =		

☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)).
The fee is **$260** for each additional 50 sheets of paper or fraction thereof.

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof (round up to a whole number)	RATE	
- 100 =	/50 =		x $260	$

Surcharge of **$130.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	25 - 20 =	5	x $ 50	$ 250.00	
Independent claims	5 - 3 =	2	x $210	$ 410.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $370	$	
			TOTAL OF ABOVE CALCULATIONS =	$ 960.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.					
			SUBTOTAL =	$ 960.00	
Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +				$	
			TOTAL NATIONAL FEE =	$	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
			TOTAL FEES ENCLOSED =	$	
			Amount to be refunded:	$	
			Amount to be charged	$ 960.00	

PTO-1390 (Rev. 09-2007)
Approved for use through 2/28/2010. OMB 0651-0021
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

IAP17 Rec'd PCT/PTO 08 NOV 2007

a. ☐ A check in the amount of $ _____ to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 04-1679. A duplicate copy of this sheet is enclosed.

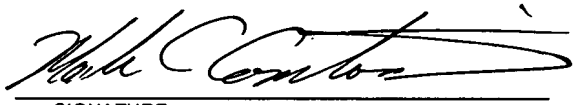
d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended paying fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

SEND ALL CORRESPONDENCE TO:

Mark C. Comtois
Duane Morris LLP
1667 K Street, N.W.
Suite 700
Washington, D.C. 20006



SIGNATURE

Mark C. Comtois

NAME

46,285

REGISTRATION NUMBER

IAP17 Rec'd PCT/PTO 08 NOV 2007

APPLICATION DATA SHEET

Applicant Information

Inventor One Given Name::	John
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Name Suffix::	
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State or Province::	Virginia
Country::	USA
Postal or Zip Code	20171
Citizenship Country::	USA

Inventor Two Given Name::	John Peter
Family Name::	CARLSON
Name Suffix::	
Postal Address Line One::	12006 Trossack Road
Postal Address Line Two::	
City::	Herndon
State or Province::	Virginia
Country::	USA
Postal or Zip Code	20170
Citizenship Country::	USA

Correspondence Information

Correspondence Customer Number:: 39290

Application Information

Title Line One::	METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION
Total Drawing Sheets::	3
Formal Drawings?::	NO
Application Type::	UTILITY
Docket Number::	AND01 061 US

Secrecy Order in Parent Appl?:: NO

DM2/662448.v2

Representative Information

Mark C. Comtois
Duane Morris LLP
1667 K Street, N.W.
Suite 700
Washington, D.C. 20006
Tel.: 202.776.7800
Fax: 202.776.7801

Domestic Priority Information

This application claims filing date priority to ::

U.S. Provisional Application
60/681475 filed
17 May 2005.

11/920076
IAP17 Rec'd PCT/PTO 08 NOV 2006

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Andrew Corporation
International Application No.:	PCT/US06/17517
International Filing Date:	17 May 2006
Title:	Method and Apparatus for Determining Path Loss by Active Signal Detection

PRELIMINARY AMENDMENT

MAIL STOP PCT
U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria, Virginia 22313-1450

Sir:

Prior to examination on the merits of the above-referenced application, please amend the subject application as follows:

Amendments begin on Page 2.

Remarks begin on Page 9.

Amendments to the Specification

Please amend the specification by inserting the title "SUMMARY" after paragraph [003] and before paragraph [0022] of the specification as follows:

[0022] Once all active communication channels have been identified, a final selection can be made based on the attributes of each channel. Among others, the attributes may include having a desirable signal-to-noise ratio ~~("SIR")~~ ("SNR"), signal-to-interference ratio or carrier-to-interference ratio. The selection criteria may also include secondary factors calculated to ensure that the selected active communication channel is substantially free of noise and/or interference. In the event that a substantially interference-free communication channel is not available, the selection criteria should be revised to accommodate communication channels which are relatively interference-free. In the event that a desired active communication channel is affected by, for example co-channel interference, the interfering frequency channel can be reassigned to reduce interference. Frequency channel interference can be caused by, among others, adjacent channel interference, co-channel interference, inter-symbol interference or cross-rail interference.

REMARKS

Applicant submits herewith a preliminary amendment to correct a minor typographical error in the specification. No new matter has been added.

Applicant respectfully submits that the claims are in condition for allowance. A notice to this effect is respectfully requested.

If any point remains that is deemed best resolved through a telephonic conversation, the Office is hereby requested to contact the undersigned directly.

Respectfully submitted,



Mark Comtois Reg. No. 46,285

DUANE MORRIS LLP
1667 K Street, N.W., Suite 700
Washington, DC 20006
Telephone: (202) 776-7800
Facsimile: (202) 776-7801

Dated: November 8, 2007

11/920076
AND01 061 PCT
IAP17 Rec'd PCT/PTO 08 NOV 2007

Method and Apparatus for Determining Path Loss by Active Signal Detection

[0001] The disclosure claims the filing-date benefit of Provisional Application No. 60/681,475 filed May 17, 2005, the specification of which is incorporated herein in its entirety; the disclosure also relates to application entitled "Method and Apparatus for Determining Path Loss by Combining Geolocation with Interference Suppression" and application entitled "Method and Apparatus for Determining Coupled Path Loss" filed simultaneously herewith and assigned to the assignee of the instant disclosure, the specification of each of said related application is incorporated herein in its entirety for background information.

Background

[0002] Path loss is a measure of signal attenuation. Path loss is the difference between the transmitted signal power and the received signal power. Path loss has the units of Decibels (dB) and is a positive quantity which excludes the affects of the antenna gains. In its simplest form, path loss can be defined according to the free-space model of equation (1):

$$PL(dB) = P_t - P_r \qquad (1)$$

where PL denoted path loss, P_t is the signal's transmitted power level and P_r is the signal level recorded at the receiver, measured in units of decibels, such as dBm. Equation (1) assumes that there is no antenna gain at the transmitter and the receiver.

[0003] Path loss is least pronounced where a visible line of sight is available between the transmitter and the receiver where there is little or no electromagnetic interference. Electromagnetic interference is typically in the form of co-channel interference. Conversely, path loss is more pronounced as obstacles and electromagnetic sources interfere with signal propagation. Because path loss is a measure of signal

attenuation, and therefore, bit error rate, it is an important tool in measuring quality of service throughout a wireless network.

[0004] In wireless networks, service quality across geographic areas is audited by conducting drive tests. In such tests, a transmitter is positioned at different locations to send a beacon signal. The transmitter's signal level and the location of the transmitter are recorded. The receivers then record the received signal level. Using the transmitted and received signal levels, path loss between the two locations can be computed.

[0005] Once a frequency channel is dedicated to the path loss measurement, the transmitter's signal strength for the beacon signal and its location are recorded. The receiver then measures and records the received signal strength. Using the transmitted and received signal strengths a processor can determine the path loss value at the transmitter's location.

[0006] Dedicating a specific channel for path loss measurements and rearranging the remaining channels on the frequency use plan to accommodate the path loss-dedicated frequency channel is both costly and inefficient. Thus, there is a need for a method and apparatus for assessing path loss without setting aside an otherwise active frequency channel or disturbing the frequency use plan.

Summary of the Disclosure

[0007] In one embodiment, the disclosure relates to a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel. The method includes: (i) identifying a geographic area where the path loss value is to be determined; (ii) identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; (iii) receiving at said receiver the signal transmitted from said wireless device on said first frequency channel; (iv) receiving at said receiver an indication of transmission signal strength of said signal; (v) measuring at said receiver the received signal strength of said signal; and (vi) determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

[0008] In another embodiment, the disclosure relates to a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector on at least one frequency channel. The method comprises identifying a first frequency channel in an active communication between the wireless device and the receiver; geolocating the wireless device and the receiver; receiving at the receiver the signal transmitted from said wireless device on said first frequency channel; receiving at said receiver an indication of transmission signal strength of said signal; measuring at said receiver the received signal strength of said signal; and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

[0009] In still another embodiment, the disclosure relates to a system for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system comprises a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values. The circuitry is configured with instructions to (i) identify a geographic area where the path loss value is to be determined; (ii) identify a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; (iii) receive at said receiver the signal transmitted from said wireless device on said first frequency channel; (iv) receive at said receiver an indication of transmission signal strength of said signal; (iv) measure at said receiver the received signal strength of said signal; and (v) determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

[0010] In still another embodiment, the disclosure relates to an apparatus for determining a path loss value of a signal transmitted from a wireless device and received by a receiver. The apparatus includes means for identifying an active communication channel supporting at least one desirable attribute; means for identifying the wireless device and the receiver tasked to communicate on said active communication channel; means for locating said wireless device and said receiver; means for identifying a transmitted signal strength for signaling on said active communication channel; means for identifying a received signal strength for signaling on said active communication channel; and means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

Brief Description of the Drawings

[0011] The principles of the disclosure will be discussed in relation with the exemplary and non-limiting representations, in which:

[0012] Fig. 1 is a schematic representation of a conventional cellular communication system;

[0013] Fig. 2 is a flow-diagram schematically representing an embodiment of the disclosure; and

[0014] Fig. 3 is a flow-diagram schematically representing an embodiment of the disclosure.

Detailed Description

[0015] Fig. 1 is a schematic representation of a conventional cellular communication system. Referring to Fig. 1, the geographic area 100 is divided into cells 110, includes cell A and cell B. Receiver 120 is located at cell A. The receiver can include a radio transceiver, a base station or a wireless location system ("WLS"). The receiver can also include a combined base station and WLS. Conventional frequency use plan uses several directional antennas each radiating at a specified sector. In Fig. 1, a directional antenna (not shown) at receiver 120 is radiating at a portion of cell 110 curving sector 130.

[0016] When sectoring is used, as shown in Fig. 1, the frequency channels used in a particular cell are divided into sector groups and are used only within a particular sector. By carefully assigning non-interfering frequency channels to the downstream receivers (not shown) whose broadcast area overlaps with receiver 120, co-channel interference can be further reduced. Sophisticated frequency use plans must account for co-channel interference as well as other possible interferences.

[0017] To obtain the path loss value between wireless device 140 and receiver 120, the transmission signal strength, the received signal strength and the location of the wireless device and the receiver must be known. As briefly discussed, conventional systems determine the path loss value by assigning a dedicated frequency channel to the wireless device and disabling interfering frequency channels within the wireless communication system. Setting aside a dedicated frequency channel also requires revising the frequency use plan for the entire geographic area which is costly and inefficient.

[0018] In one embodiment of the disclosure, a method for accurately determining the received and transmitted signal strengths includes using an active communication channel without disabling the frequency use plan to provide a dedicated frequency channel.

[0019] An active frequency channel (interchangeably, an active communication channel) defines one or more frequency channels which are a part of the frequency use plan and are available for communication to wireless devices within the geographic area. Indeed, the active frequency channel may be engaged in active communication with a receiver or another wireless device while the system is conducting its signal strength studies for path loss determination. Using an existing channel engaged in active communication obviates the need for a dedicated channel and a revised frequency use plan.

[0020] Fig. 2 is a flow-diagram schematically representing an embodiment of the disclosure. According to the embodiment of Fig. 2, a method for determining signal strength of a signal transmitted by a wireless device starts with step 210; that is, determining the area where path loss information is needed. This step can be the result of a study of the network deficiencies or as part of a network-wide analysis. Once the desired area is identified, step 220 identifies one or more active communication channels for the desired area.

[0021] In one embodiment, active communication channels are selected from among all available frequency channels designated for real-time communication between two subscribers or between a subscriber and a receiver. For example, an active communication channel may be a communication channel designated for communication between two subscribers using duplex voice or data transmission. An active communication channel may also provide a simplex communication for traffic information between a base station and a wireless device. An active communication channel can be used, for example, as a reverse control channel or a forward control channel. In another embodiment, the active communication channel may be a dedicated frequency channels assigned for communication between two subscribers.

[0022] Once all active communication channels have been identified, a final selection can be made based on the attributes of each channel. Among others, the

attributes may include having a desirable signal-to-noise ratio ("SIR"), signal-to-interference ratio or carrier-to-interference ratio. The selection criteria may also include secondary factors calculated to ensure that the selected active communication channel is substantially free of noise and/or interference. In the event that a substantially interference-free communication channel is not available, the selection criteria should be revised to accommodate communication channels which are relatively interference-free. In the event that a desired active communication channel is affected by, for example co-channel interference, the interfering frequency channel can be reassigned to reduce interference. Frequency channel interference can be caused by, among others, adjacent channel interference, co-channel interference, inter-symbol interference or cross-rail interference.

[0023] In step 230, once the active communication channel is selected and if the active communication channel is not in use, a subscriber in the desired region may be assigned to the active communication channel. In one embodiment, the location of the wireless device and/or the receiver tasked with the active communication channel is also determined. In an alternative embodiment, only the cell and the sector housing the wireless device is determined.

[0024] In steps 240 and 250, the transmitted and the received signal strengths are determined for communication on the active channel and used for calculating the path loss value in step 260. For example, the receiver can measure the received signal strength and the wireless device can transmit an indication of the transmission signal strength. Using appropriate mathematical relationships (e.g., Equation 1), the path loss value can be then calculated (step 260). Thus, the path loss value between the wireless device and the receiver can be determined. Since the locations of the wireless device and the receiver are also known, the path loss information can be used to form a database of path loss values at different locations throughout the network (step 270). That is, other suitable active communication channels can be identified at the desired area to provide

additional path loss values thereby forming a more comprehensive study of path loss throughout the network.

[0025] By using an active communication channel, the path loss measurement can be conducted without disrupting an existing frequency use plan to allocate a specific frequency channel for path loss calculations. In addition, because the disclosed embodiment determines path loss on an otherwise interference-free communication channel, the results can be as reliable as using a dedicated frequency channel for beacon signaling.

[0026] Fig. 3 is a flow-diagram schematically representing an embodiment of the disclosure directed to a method for determining the path loss value throughout a network by identifying substantially interference-free active communication channels at step 310. Such identification can be random or selective. For example, several active communication channels can be selected at random from among all communication channels serving the wireless network. Alternatively, one or more active communication channels can be selected from among all communication channels serving the cell or the sector and/or based on selection criteria disclosed above. In the event that a desired active communication channel is affected by interference, the interfering frequency channels can be reassigned to reduce interference.

[0027] In step 320, the wireless device and the receiver tasked with the selected active communication channel are located. Any of the conventional locating means can be used for this purpose. In step 330, a signal transmitted on the active communication channel is detected for signal strength measurement, and in steps 340 and 350 the received signal strength and the transmitted signal strength, respectively, are determined. The path loss value can be measured as a function of the received and transmitted signal strength.

[0028] In another embodiment, the method of Figs. 2 and 3 can be expanded to a plurality of receiver. By way of example and with reference to Fig. 1, once an active

communication channel has been identified, all other receivers which can detect the wireless device's signal transmission on said channel can be included in path loss calculation. Assuming that signal transmission to each of the receivers satisfies one or more of the desired attributes, the path loss value between the wireless device and each of the plurality of receivers can be obtained. Because the receivers are disposed at different locations from each other and from the wireless device, path loss values between the wireless device and several different locations can be determined simultaneously.

[0029] A system according to one embodiment of the disclosure may include one or more receivers in communication with a wireless device. The wireless device may include a wireless transmitter, radio frequency transmitter, mobile telephone, cellular telephone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager. The receiver may comprise a base station, a wireless location sensor or a second wireless device.

[0030] The system can have one or more circuits having multiple microprocessors for implementing the principles disclosed herein. In one embodiment the circuitry can be configured with instructions to identify a geographic area where path loss data is needed. The instructions may include identifying a cell and/or a sector associated with the area as well as identifying available communication channels tasked to the area. The same circuits or an associated circuit can identify suitable active communication channels on the basis of attributes described above or on the basis of any suitable criteria. Once the active communication channel has been identified and selected, the system can determine a path loss value based on the transmitted and the received signal strengths of a wireless device signaling thereon.

[0031] An apparatus according to one embodiment of the disclosure can include a first circuit for identifying an active communication channel supporting one or more desirable attributes. The first circuit can be prompted to search for the active communication channel in response to an operator's request or it can be programmed to

randomly scan all frequency communication channels to identify active communication channels supporting at least one desirable attribute. The first circuitry may include an antenna communicating with a radio receiver and a first microprocessor. The apparatus may also include a second circuit for identifying the wireless device and the receiver tasked to communicate on the active communication channel. In the event that two wireless devices are tasked to communicate on the active communication channel, the second circuit may identify each wireless device. The second circuit may include one or more processors programmed with instructions to search a database stored in a digital memory identifying wireless devices using the network. The apparatus may also include a third circuit for locating the wireless devices and the receivers. The third circuit can be a wireless location sensor in communication with the receiver, a geo-positioning system ("GPS"), or a GPS system in communication with the receiver.

[0032] The apparatus may also include a fourth circuit for identifying the transmitted signal strength for signaling on the active communication channel. The fourth circuit can be a receiver adapted to receive an indication from the wireless device defining its transmission signal strength. A fifth circuit can be included to determine the received signal strength. The fifth circuit can comprise any conventional detector for measuring the received signal strength. Finally, the apparatus may include a sixth circuit for calculating path loss value as a function of the transmitted and the received signal strengths.

[0033] Each of the six circuits may define a separate or an integral operating unit. Alternatively, one or more of the circuits may be combined based on their overlapping functions. The circuits may be co-located for ease of operation. Alternatively, the various circuits can be communicably located at different locations without departing from the disclosed principles.

[0034] While the exemplary embodiments of the present invention have been described, it is to be understood that the embodiments described are illustrative only and

that the scope of the invention is to be defined solely by the appended claims when accorded a full range of equivalence, many variations and modifications naturally occurring to those of skill in the art from a perusal hereof.

What is claimed is:

1. In a method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan, wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device and disabling interfering frequency channels within the wireless communication system, the improvement comprising using an active communication channel to determine the signal strength of the wireless device.

2. The method of claim 1, wherein the active communication channel defines any frequency channel capable of a duplex communication.

3. The method of claim 1, wherein the active communication channel defines any frequency channel capable for a simplex communication.

4. The method of claim 1, wherein the active communication channel defines a communication channel within the frequency use plan.

5. The method of claim 1, wherein the active communication channel defines a reverse control channel.

6. The method of claim 1, wherein the active communication channel defines a forward control channel.

7. The method of claim 1, further comprising calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel.

8. The method of claim 1, wherein interfering channels define frequency channels causing at least one of adjacent channel interference, co-channel interference, inter-symbol interference, inter-symbol interference and cross-rail interference.

9. The method of claim 1, wherein the improvement further comprises using an active communication channel without disabling any interfering channel.

10. The method of claim 1, wherein the improvement further comprises using an active channel without disrupting the frequency use plan.

11. A method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the method comprising the steps of:

identifying a geographic area where the path loss value is to be determined;

identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel;

receiving at said receiver the signal transmitted from said wireless device on said first frequency channel;

receiving at said receiver an indication of transmission signal strength of said signal;

measuring at said receiver the received signal strength of said signal; and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

12. The method of claim 11, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel; and

reassigning a second signal using said second frequency channel to a third frequency channel.

13. The method of claim 11, further comprising determining the path loss value for a plurality of geographic areas to compile a database.

14. The method of claim 11, wherein the receiver is a base station.

15. The method of claim 11, wherein the receiver is a wireless location sensor.

16. The method of claim 11, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager.

17. The method of claim 11, wherein the wireless device is engaged in one of a duplex or a simplex communication.

18. The method of claim 11, further comprising randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver.

19. The method of claim 11, further comprising selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute.

20. The method of claim 19, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio and carrier-to-interference ratio.

21. The method of claim 11, further comprising identifying the location of the receiver and the wireless device.

22. A circuitry configured to implement the method of claim 11.

23. A method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system, the method comprising:

identifying a first frequency channel in an active communication between the wireless device and the receiver;

geolocating the wireless device and the receiver;

receiving at the receiver the signal transmitted from said wireless device on said first frequency channel;

receiving at said receiver an indication of transmission signal strength of said signal;

measuring at said receiver the received signal strength of said signal; and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

24. The method of claim 23, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel; and

reassigning a second signal using said second frequency channel to a third frequency channel.

25. The method of claim 23, further comprising determining the path loss value for a plurality of geographic areas to compile a database.

26. The method of claim 23, wherein the first frequency channel in active communication is engaged in a duplex communication.

27. The method of claim 23, wherein the first frequency channel in active communication is engaged in a simplex communication.

28. The method of claim 23, further comprising selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute.

29. The method of claim 28, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio, inter-symbol interference and carrier-to-interference ratio.

30. The method of claim 23, wherein the receiver is a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device.

31. The method of claim 23, wherein the receiver is a base station or a wireless location sensor ("WLS") or a combination of the base station and a WLS.

32. A circuitry configured to implement the method of claim 23.

33. A system for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system comprising:

a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to:

identify a geographic area where the path loss value is to be determined;

identify a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel;

receive at said receiver the signal transmitted from said wireless device on said first frequency channel;

receive at said receiver an indication of transmission signal strength of said signal;

measure at said receiver the received signal strength of said signal; and

determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

34. The method of claim 33, wherein the circuitry is further programmed with instructions to:

determine a second frequency channel which interferes with said first frequency channel; and

reassign a second signal using said second frequency channel to a third frequency channel.

35. The method of claim 33, wherein the circuitry is further programmed with instructions to determine the path loss value for a plurality of geographic areas to compile a database.

36. The method of claim 33, wherein the receiver is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device, pager, base station and wireless location sensor.

37. The method of claim 33, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager.

38. The method of claim 33, wherein the wireless device is engaged in one of a simplex or a duplex communication area.

39. The method of claim 33, wherein the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic.

40. The method of claim 33, wherein the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute.

41. An apparatus for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, comprising:

means for identifying an active communication channel supporting at least one desirable attribute;

means for identifying the wireless device and the receiver tasked to communicate on said active communication channel;

means for locating said wireless device and said receiver;

means for identifying a transmitted signal strength for signaling on said active communication channel;

means for identifying a received signal strength for signaling on said active communication channel; and

means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

42. The apparatus of claim 41, wherein the desirable attribute comprises of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value.

43. The apparatus of claim 41, wherein the means for identifying an active communication channel comprises an antenna, a radio receiver and a microprocessor.

44. The apparatus of claim 41, wherein the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory.

45. The apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a wireless location system.

46. The apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a geo-positioning system ("GPS").

47. The apparatus of claim 41, wherein the transmitted signal strength defines the signal strength at the wireless device.

48. The apparatus of claim 41, wherein the means for identifying a transmitted signal strength for signaling on said active communication channel comprises an antenna and a signal detection circuit.

49. The apparatus of claim 41, wherein means for identifying the wireless device and the receiver further comprises means for tasking the wireless device and the receiver to signal on said active communication channel.

50. The apparatus of claim 41, further comprising means for detecting a second communication channel interfering with the active communication channel.

51. The apparatus of claim 50, further comprising means for reassigning the second communication channel to a third communication channel

Abstract

In one embodiment, the disclosure relates to a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel. The method includes: (i) identifying a geographic area where the path loss value is to be determined; (ii) identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; (iii) receiving at said receiver the signal transmitted from said wireless device on said first frequency channel; (iv) receiving at said receiver an indication of transmission signal strength of said signal; (v) measuring at said receiver the received signal strength of said signal; and (vi) determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

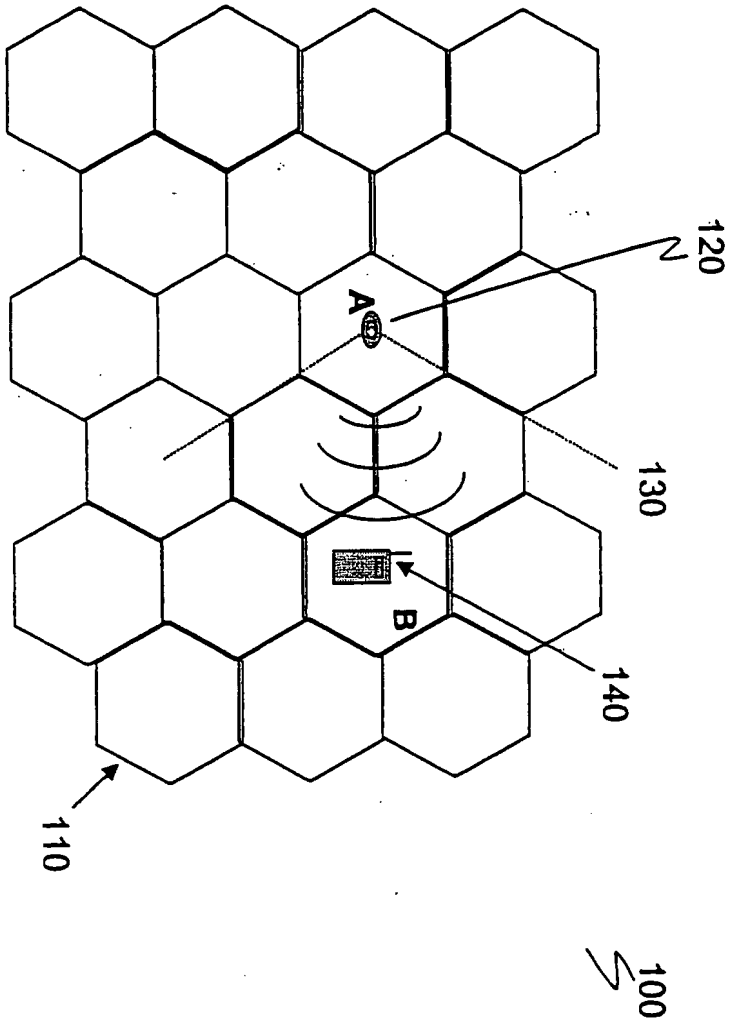


Fig. 1 (Prior Art)

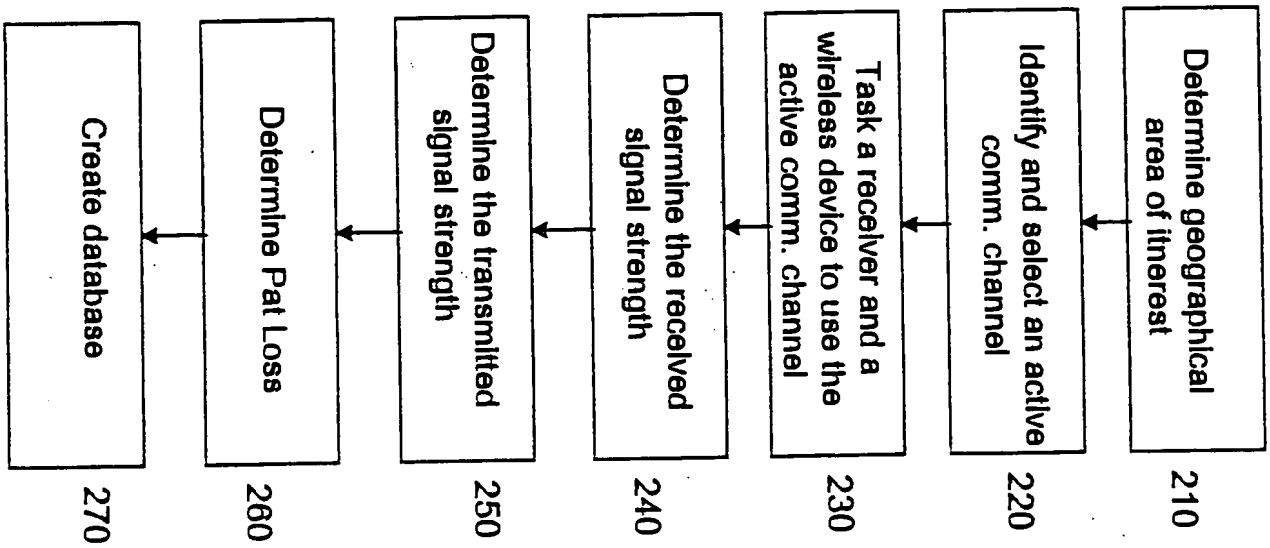

Determine geographical area of interest
210
Identify and select an active comm. channel
220
Task a receiver and a wireless device to use the active comm. channel
230
Determine the received signal strength
240
Determine the transmitted signal strength
250
Determine Pat Loss
260
Create database
270

Fig. 2

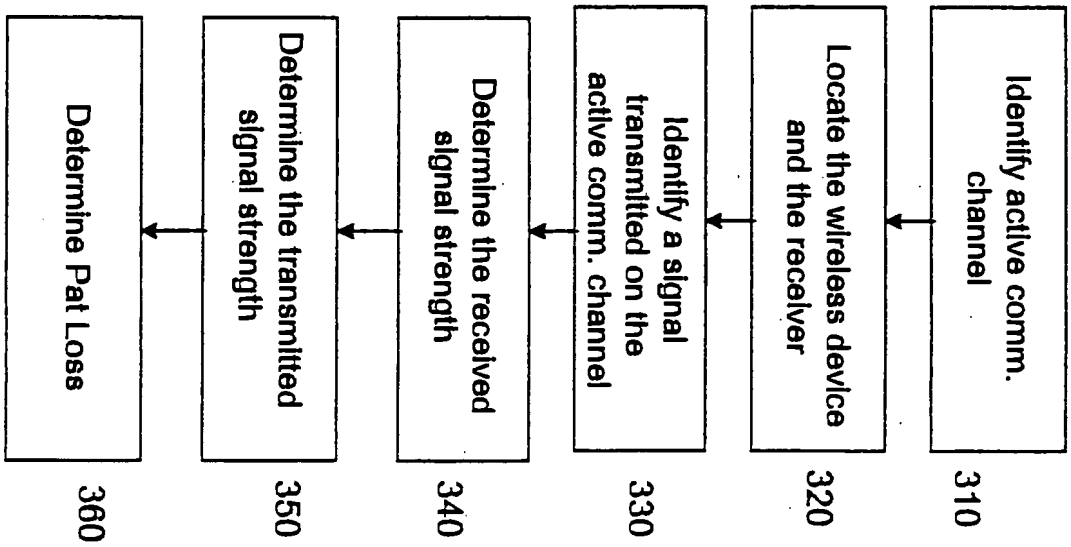

Identify active comm. channel
310
Locate the wireless device and the receiver
320
Identify a signal transmitted on the active comm. channel
330
Determine the received signal strength
340
Determine the transmitted signal strength
350
Determine Pat Loss
360

Fig. 3

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November 8, 2007

Mr. Gilberto Hernandez
Chief Intellectual Property Counsel
Andrew Corporation
Suite 900
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Re: U.S. Non-Provisional Patent Application
Applicant: John Arpee, et al.
Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION
Our Reference: AND01 061US

Dear Gilberto:

We prepared and filed a U.S. non-provisional patent application in the U.S. Patent and Trademark Office on November 1, 2007. Copies of the as-filed papers are enclosed for your records.

Should you have any questions, or require any additional information, please do not hesitate to contact us.

Very truly yours,

Mark C. Comtois

MCC/jlm
Enclosures

PATENT APPLICATION SERIAL NO._____

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

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02 FC:1615 250.00 DA
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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER AND01 061 US
		U.S. APPLICATION NO. (If known, see 37 CFR 1.5) Unknown 11/920076
INTERNATIONAL APPLICATION NO. PCT/US2006/17517	INTERNATIONAL FILING DATE 2006.05.17	PRIORITY DATE CLAIMED 2005.05.17

TITLE OF INVENTION
METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION

APPLICANT(S) FOR DO/EO/US
John Arpee, et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a submission under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a submission under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected (Article 31).
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☑ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☑ A preliminary amendment.
14. ☐ An Application Data Sheet under 37 CFR 1.76.
15. ☐ A substitute specification.
16. ☐ A power of attorney and/or change of address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.2 and 37 CFR 1.821- 1.825.
18. ☐ A second copy of the published International Application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

This collection of information is required by 37 CFR 1.414 and 1.491-1.492. The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 15 minutes to complete, including gathering information, preparing, and submitting the completed form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PTO-1390 (Rev. 09-2007)
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U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
Unknown 10920076	PCT/US2006/17517	AND01 061 PCT

20. Other items or information:

The following fees have been submitted	CALCULATIONS	PTO USE ONLY
21. ☑ Basic national fee (37 CFR 1.492(a)) **$310**	$ 310.00	
22. ☐ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$210**	$	
23. ☐ Search fee (37 CFR 1.492(b)) If the written opinion of the ISA/US or the International preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority ..... **$100** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB ..... **$410** All other situations **$510**	$	
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☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)).
The fee is **$260** for each additional 50 sheets of paper or fraction thereof.

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof (round up to a whole number)	RATE	
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Surcharge of **$130.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	25 - 20 =	5	x $ 50	$ 250.00	
Independent claims	5 - 3 =	2	x $210	$ 410.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $370	$	
			TOTAL OF ABOVE CALCULATIONS =	$ 960.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.					
			SUBTOTAL =	$ 960.00	
Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +				$	
			TOTAL NATIONAL FEE =	$	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
			TOTAL FEES ENCLOSED =	$	
			Amount to be refunded:	$	
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NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

Mark C. Comtois

NAME

46,285

REGISTRATION NUMBER

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July 18, 2006

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APPLICATION NUMBER: *60/681,475*
FILING DATE: *May 17, 2005*
RELATED PCT APPLICATION NUMBER: *PCT/US06/17517*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US60/681,475*

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19281 U.S. PTO
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112948 U.S.PTO
60/681475
051705

ATTORNEY DOCKET NO. AND01 039

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Sir:

Transmitted herewith for filing is the PROVISIONAL APPLICATION

for a patent of Inventor(s):

John Arpee, John Peter Carlson, and Joseph P. Kennedy, Jr.

Title: SYSTEM AND METHOD OF QUANTIFYING AND OPTIMIZING THE PERFORMANCE OF A WIRELESS COMMUNICATION NETWORK

Enclosed are:

[X] A Cover Page, Nine (9) pages of specification, and an Appendix A and Appendix B.

[X] A check in the amount of $200.00 to cover the filing fee.

The Commissioner is hereby authorized to charge payment of any additional fees associated with this communication or to credit any overpayment to Deposit Account No. 04-1679. A duplicate of this sheet is enclosed.

Respectfully submitted,

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WSH\129107.1

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SYSTEM AND METHOD OF QUANTIFYING AND OPTIMIZING THE PERFORMANCE OF A WIRELESS COMMUNICATION NETWORK

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The present disclosure is directed towards quantifying and optimizing the performance of a wireless communication network by collecting, managing and analyzing performance data.

Traditionally, the performance of a wireless communication system could be determined using several methods. The most prevalent method is to "drive test" the network. This typically involved using special test apparatus which is driven to specific geographic positions within the wireless network and collecting communications signals transmitted from the base station. In a wireless communications network, the communication signals transmitted by base stations and received by a mobile telephone are referred to as downlink signals and the transmissions from the mobile telephone to the base station are referred to as uplink signals. During the design and installation of a wireless communication system, signal propagation estimates are used to determine the amount of, and location of, base stations necessary to provide adequate coverage for a specified geographic area. Drive testing confirms that the wireless communication system is performing as predicted by the propagation estimates, or helps identify areas which are not performing as predicted. It can identify geographic areas in need of additional infrastructure resources such as base stations and repeaters. After installation, the wireless communication systems needs to be periodically evaluated to account for changes to topography, i.e., the construction of new buildings or other impediments to signal propagation, an increase in number of users, changes in interference levels, or the aging of the communications

equipment and its associated degradation in performance. While drive testing provides a sampling of the downlink signal propagation, significant resources must be expended to collect sufficient data if a detailed propagation evaluation is required.

However, the collection of data from these traditional sources does not provide the flexibility, robustness and accuracy that are desired in an optimization tool. Recently, wireless geolocation systems have been developed and deployed pursuant to the Federal Communication Commission's mandate that wireless carriers implement the ability to locate wireless phone users making 911 emergency service calls. The deployment of such geolocation systems provide the carrier with a tool for evaluating the uplink performance of its wireless network by measuring the quality of the uplink signals and associating the signal with the corresponding determined location of the mobile phone providing the signals.

The present application collects data from non-traditional sources and provides an improved method of quantitizing the performance of the wireless communications systems. The present application is directed to several aspects. In one aspect, the present system uses the collected geocoded data for optimization of the wireless communications network. For example, the predominant interference experienced during wireless communications between a mobile telephone and a base station may be interference from other mobile telephones operating in the network. By measuring the received power level and subtracting the expected power level, an estimate of the interference signal strength can be

determined. Creating a historical profile of interference levels can help identify when a fault occurs, or when modifications to the system are required due to degradation in performance.

In another aspect, geolocation algorithms can be utilized to assist in the collection of communications data. In order to provide robustness to a wireless communication system, it is necessary that the wireless system provide the ability to reuse frequencies as much as possible, while avoiding interference from multiple mobile phones transmitting on the same frequency. One method of reducing interference is a strict power control protocol. Ideally, the transmit power level of the mobile phone will be controlled to ensure that the signal is strong enough to reach one, but not more than one, base station, thus freeing up the frequency for reuse by other base stations. Such power control protocols made it difficult to develop wireless geolocation systems since the geolocation systems require the receipt of the signal transmitted by the mobile phone at more than one base station, and preferably at many base stations in order to ensure the accuracy required by the E-911 FCC mandate.

In order to overcome this problem of limited reception at a base station other than the serving base station, algorithms were developed to help non serving base stations detect signals that would otherwise not be strong enough. The algorithms typically involve sending assist data from the serving base station to the non-serving (or secondary) base stations to help the secondary base station detect the received signal among the interference that would otherwise be masked.

In another aspect, the present disclosure seeks to take advantage of the ability of the secondary stations to measure the signal strength received at the secondary stations. Where the prior art optimization systems measured the receipt of a signal transmitted from a mobile phone at the serving base station only, the present disclosure measures the signal quality received at each base station using the existing geolocation equipment to assist in identifying and accurately measuring the signal strength at the signal at secondary base stations, even in negative carrier to interference ratio conditions through the use of aforementioned signal processing algorithms. Thus, for a given geolocation position, if the transmitted power is known, an accurate propagation loss estimate can be made for each receiving base station by measuring the received power level and subtracting it from the transmitted power level. For example, a real-time propagation loss model for a geographic area can be created based on power level measurements at a plurality of wireless location sensors (WLS) which receive a signal transmitted from the mobile phone and remove interference using signal processing techniques. The model can be used to identify trends and provide information that was not previously available, i.e., defining obscure propagation conditions, creating customized frequency plans, creating tailored interference avoidance plans, etc.

In another aspect, once interference can be accurately determined using a quantity of coordinated measurements at primary and secondary based stations, the measured interference levels can assist in the collection of optimization data.

For example, once interference levels are known, a channel having the least interference can be identified. It is not uncommon for one channel to have a significantly lower interference level than other channels. If subsequent optimization measurements are measured using the low interference channel, more accurate optimization data can be collected and thus a more accurate frequency plan can be determined. Thus, it is possible to develop a frequency plan which provides for a no/low interference channel to be assigned to each cell/sector to allow interference free measurements to be made. Over time, using interference free measurements provides a more accurate propagation loss plan. For an interference free channel, the propagation loss can be simply determined by subtracting the received power level from the transmitted level.

In another aspect of the present invention, the ability to determine the location of a mobile appliance while it is transmitting also affords the ability to track the mobile appliance while it is moving. Continuous collection of data allows the optimization software to create a relationship between the mobile power and the interference level as the mobile moves around. Thus, a more tailored power control scheme can be developed for phones on the basis of their location. Additionally, using call tracing allows the optimization system to identify anomalies in a geographic area.

In another aspect of the present application, once the performance statistics for a network have been determined, subsequent measurements can assist in the identification of a change in the performance of the network. If change in

performance is detected, the optimization system can assist in determining the cause of the performance change. Importantly, if the cause of the change can not be determined in some situations, the collection methods can be tailored in the area of the change to help pinpoint the cause. Thus, the diagnostic model being used can be adapted to determine the cause of the change.

In yet another aspect of the present application, complex path loss data can also be generated through the use of a "joint histogram" instead of the common single histogram. In cellular network design, the design criteria include coverage, capacity, and quality. Prior art designs have been based on outside measurements. In-building design was typically accomplished by applying a loss factor to account for building penetration based on the assumption that the interference is reduced by the same amount as the serving signals resulting in a net change of zero to the interference levels. In reality, the signal levels are more variable inside the building and one site or another is favored, depending on the location within the building. If the signals are separated and averaged they are each prone to a high error due to the high variability within the buildings. On the other hand if the data is maintained in a coupled manner, the optimization system can take advantage of any correlations between the signals and can certainly discount the weaker signals that are encountered when a sector is not the serving sector. By coupling the data the present optimization system can take advantage of the server versus non-server condition and the correlation between the signals which produces designs with higher quality and capacity than the prior art systems.

For example, in many instances, signal levels are known to change levels dramatically within a distance of 10 meters especially when we consider in-building measurements. Traditional planning tools produce a single estimate of the mean path loss or signal per bin for each sector (or bin) under consideration. However, producing a single measured mean value per bin results in a tremendous amount of valuable information being lost. In particular, when power levels or antennas are being optimized to minimize overall network interference it will be valuable to maintain paired signal levels or path losses. In other words, if a bin contains a tall building, at street level and in the lower levels of the building the serving and interfering signals will both be low. On upper levels of the building the interfering signal levels would increase but so would the serving level. Storing the average signal levels would completely lose this valuable information. Storing the histograms and then treating the serving and interfering signal levels would be a grossly false assumption and would lead to a substantial over-estimate of the severity of the interference.

On the other hand, if the serving cell antenna is nearby at the 2nd or 3rd story height, the serving cell might be substantially stronger and interference quite weak on the lower levels of the building. On the higher levels of the building the serving levels would be lower but the interfering levels would be higher. In this case the serving and interfering signal levels would be negatively correlated. It would be important for the higher floors to be served by a different cell. Thus, not only would it be desirable to store the joint histograms of the serving and

interfering sectors, but it would also be desirable to store separate histograms for each serving sector.

Another benefit of storing the coupled path loss values is a reduction in the effect of the variability in the mobile antenna gain. A mobile phone may report it's transmit power level, but different mobile phones will have different calibrations and the antenna gain could vary substantially. Storing the differences will reduce this source of error. Thus, the essence of this aspect of the present disclosure is to collect and store the paired serving and interfering signal level.

In still another aspect of the present disclosure performance analysis can be based on customer identified problems associated with signal quality. The present system can track and collect geocoded performance data for a specific customer based on time of day, geographic area, etc and compare the collected data with historical database to identify anomalies in the signal quality. Anomalies may be identified as (a) improperly operating customer equipment, (b) cellular area with bad metrics, (c) due to customer usage patterns.

In another aspect of the current disclosure, use of performance data can also be used to monitor business aspects of the cellular telephone system such as identify lost revenue due to unnecessary handoffs to other carriers. For example, the present system can develop a geographic plot of the location of handoffs out of a network and thus map the lines of roaming between carriers and can use the data to expand areas of coverage along the lines of roaming between carriers.

Description of further aspects of the present system can be found in the attached Appendix A, and geo-coded data relationships of the present application can be found in the attached Appendix B.

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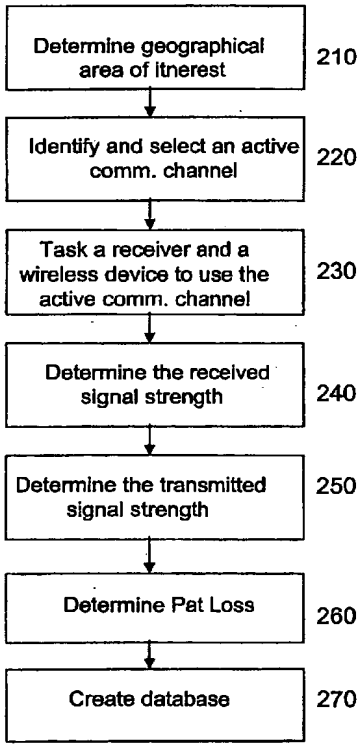
(74) Agent: **COMTOIS, Mark, C.**; DUANE MORRIS LLP, 1667 K STREET, N.W., Suite 700, Washington, DC 20006 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

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[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION



(57) Abstract: A method for determining a path loss value of a signal transmitted from a wireless device to a receiver in a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel. The method includes: (i) identifying a geographic area where the path loss value is to be determined; (ii) identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating With said receiver using said first frequency channel; at the receiver (iii) receiving the signal transmitted from the wireless device on said first frequency channel; (iv) receiving an indication of transmission signal strength; (v) measuring the received signal strength; and (vi) determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US06/17517

A. CLASSIFICATION OF SUBJECT MATTER
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USPC - 455/62
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) H 04 Q 7/20; H 04 B 1/10, 15/00; H 04 L 12/28
USPC - 455/423, 671, 450, 63, 437, 443, 453, 456.1, 452, 448, 434, 426, 62, 400, 34.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

MicroPatent (USG USA EPA EPB WO JP DEG DEA DET DEU GBA FRA): (wireless*3 with locat*5 with sens*5) with GPS*1, IP.com: "inter-symbol interference" and "cross-rail interference" and "vehicle tracking" and "vehicle security", DialogPro: interference

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2002/0058503 A1 (GUTOWSKI) 16 May 2002 (16.05.2002) entire document	11-13 and 16 --- 7, 14-15, 17-51
Y	US 2003/0129987 A1 (TANAY et al) 10 July 2003 (10.07.2003) entire document	1-10
Y	WO 2003/001742 A1 (ALTMAN) 03 January 2003 (03.01.2003) entire document	33-40
Y	US 6,526,279 B1 (DENT) 25 February 2003 (25.02.2003) entire document	2-3, 17-18, 22, 26-27, 32, 38-39 and 48
Y	US 6,138,024 A (EVANS et al) 24 October 2000 (24.10.2000) entire document	5-6
Y	US 6,845,240 B2 (CARLSON et al) 18 January 2005 (18.01.2005) entire document	15, 21, 23-32, 41-51
Y	US 2004/0137912 A1 (LIN) 15 July 2004 (15.07.2004) entire document	33-40
Y	US 5,862,124 A (HOTTINEN et al) 19 January 1999 (19.01.1999) entire document	14
Y	US 6,363,263 B1 (REUDINK et al) 26 March 2002 (26.03.2002) entire document	19-20, 28-29, 40-51
Y	US 6,049,717 A (DUFOUR et al) 11 April 2000 (11.04.2000) entire document	10

☒ Further documents are listed in the continuation of Box C. ☐

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 November 2006	16 JAN 2007
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US06/17517

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,853,842 B1 (WILSON et al) 08 February 2005 (08.02.2005) entire document	1-10
Y	US 6,047,175 A (TROMPOWER) 04 April 2000 (04.04.2000) entire document	43
Y	US 5,497,503 A (RYDBERG et al) 05 March 1996 05.03.1996) entire document	41-51
A	EP 1 191 804 A2 (GUTOWSKI) 27 March 2002 (27.03.2002) entire document	1-51
A	WO 02/13439 A2 (TANAY) 14 February 2002 (14.02.2002) entire document	1-51
A	WO 1999027737 A1 (DESGAGNE et al) 03 June 1999 (3.06.1999) entire document	1-51

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PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference AND01 061 PCT	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2006/017517	International filing date *(day/month/year)* 17 May 2006 (17.05.2006)	Priority date *(day/month/year)* 17 May 2005 (17.05.2005)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant ANDREW CORPORATION		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 10 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 19 November 2007 (19.11.2007)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Simin Baharlou e-mail: pt09.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: MARK C. COMTOIS
DUANE MORRIS LLP
1667 K STREET, N.W.
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WASHINGTON, D.C. 20006

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	16 JAN 2007
Applicant's or agent's file reference AND01061PCT	FOR FURTHER ACTION See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US06/17517	17 May 2006	17 May 2005

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - H 04 B 15/00
USPC - 455/62

Applicant ANDREW CORPORATION

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	16 November 2006	Blaine Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (April 2005)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
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Box No. I Basis of this opinion

1. With regard to the language, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material

      ☐ a sequence listing

      ☐ table(s) related to the sequence listing

   b. format of material

      ☐ on paper

      ☐ in electronic form

   c. time of filing/furnishing

      ☐ contained in the international application as filed

      ☐ filed together with the international application in electronic form

      ☐ furnished subsequently to this Authority for the purposes of search

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table(s) relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

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Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-10, 14-15, 17-51	YES
	Claims	11-13 and 16	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-51	NO
Industrial applicability (IA)	Claims	1-51	YES
	Claims	NONE	NO

2. Citations and explanations:

Claims 11-13 and 16 lack novelty under PCT Article 33(2) as being anticipated by GUTOWSKI (US2002/0058503 A1).

Regarding claim 11, GUTOWSKI discloses a method for determining a path loss value of a signal transmitted (paragraphs 11-20) from a wireless device (paragraphs 2-4) and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the method comprising the steps of: identifying a geographic area where the path loss value is to be determined (paragraphs 25, 48); identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; receiving at said receiver the signal transmitted from said wireless device on said first frequency channel; receiving at said receiver an indication of transmission signal strength of said signal; measuring at said receiver the received signal strength of said signal; determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (paragraphs 22-24).

Regarding claims 12, GUTOWSKI discloses the invention as shown in claim 11, and further teaches determining a second frequency channel which interferes with said first frequency channel; reassigning a second signal using said second frequency channel to a third frequency channel (paragraphs 11-13).

Regarding claims 13, GUTOWSKI discloses the invention as shown in claim 11, and further teaches determining the path loss value for a plurality of geographic areas to compile a database (paragraph 86).

Regarding claim 16, GUTOWSKI discloses the invention as shown in claim 11, and further teaches the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone (paragraph 2), text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager.

Claim 14 lacks an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of HOTTINEN et al (US 5,862,124 A).

Regarding claim 14, GUTOWSKI discloses the invention as shown in claim 11, but lacks the teaching of the receiver is a base station. However, HOTTINEN et al teaches the receiver is a base station (column 1, lines 7-13). HOTTINEN et al further shows that this is relevant for initiating interference cancellation routines (column 5, lines 42-57). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the receiver is a base station with the invention of GUTOWSKI as taught in HOTTINEN et al, for initiating interference cancellation routines (column 5, lines 42-57).

Claims 17-18 and 22, lack an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of DENT (US 6,526,279 B1).

Regarding claim 17, GUTOWSKI discloses the invention as shown in claim 11, but lacks the teaching of the wireless device is engaged in one of a duplex or a simplex communication. However, DENT teaches the wireless device is engaged in one of a duplex or a simplex communication (column 4, lines 9-30). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the wireless device is engaged in one of a duplex or a simplex communication with the invention of GUTOWSKI as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Regarding claim 18, GUTOWSKI discloses the invention as shown in claim 11, but lacks the teaching of randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver. However, DENT teaches randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver and circuitry configured to implement the method of claim 11 (column 4, lines 9-30). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver with the invention of GUTOWSKI as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

(Cont. in Supplemental Box)

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
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Box No. V, 2. Citations and explanations:

Regarding claim 22, GUTOWSKI discloses the invention as shown in claim 11, but lacks the teaching of circuitry configured to implement the method of claim 11. However, DENT teaches the circuitry configured to implement the method of claim 11 (column 6, lines 35-42). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the circuitry configured to implement the method of claim 11 with the invention of GUTOWSKI as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Claims 19-20 lack an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of REUDINK et al (US 6,363,263 B1).

Regarding claim 19, GUTOWSKI discloses the invention as shown in claim 11, but lacks the teachings of selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute. However, REUDINK et al teaches selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area (column 10, lines 55-65) and having at least one desired attribute. REUDINK et al further shows that this is relevant for improving wireless communications signal quality in general (column 6, lines 5-13). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute with the invention of GUTOWSKI as taught in REUDINK et al for improving wireless communications signal quality in general (column 6, lines 5-13).

Regarding claim 20, GUTOWSKI in view of REUDINK et al discloses the invention as shown in claim 19. GUTOWSKI lacks the teaching of the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio and carrier-to- interference ratio. However, REUDINK et al teaches the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio and carrier-to- interference ratio (column 4, lines 3-16). REUDINK et al further shows that this is relevant for improving wireless communications signal quality in general (column 6, lines 5-13). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute with the invention of GUTOWSKI as taught in REUDINK et al for improving wireless communications signal quality in general (column 6, lines 5-13).

Claims 1, 4 and 8-9 lack an inventive step under PCT Article 33(3) as being obvious over TANAY et al (US 2003/0129987 A1) in view of WILSON et al (US 6,853,842 B1).

Regarding claim 1, TANAY et al discloses in a method for determining signal strength (paragraph 38) of a signal transmitted (paragraph 5) by a wireless device in a wireless communication system operating with a predetermined number of frequency channels (paragraph 3) administered according to a frequency use plan (Abstract), wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device (fig. 2A; paragraphs 7, 30). TANAY et al lacks the teachings of disabling interfering frequency channels within the wireless communication system, the improvement comprising using an active communication channel to determine the signal strength of the wireless device. However, WILSON et al teaches disabling interfering frequency channels (column 4, lines 38-54) within the wireless communication system, the improvement comprising using an active communication channel to determine the signal strength (column 6, lines 46-57) of the wireless device. WILSON et al further shows that this is relevant for disabling adjacent RF channels (column 6, line 30). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the disabling interfering frequency channels within the wireless communication system, the improvement comprising using an active communication channel to determine the signal strength of the wireless device with the invention of TANAY et al as taught in WILSON et al for disabling adjacent RF channels (column 6, line 30).

Regarding claim 4, TANAY et al in view of WILSON et al disclose invention as shown in claim 1, and TANAY et al further teaches the active communication channel defines a communication channel within the frequency use plan (paragraphs 30-32, 48).

Regarding claim 8, TANAY et al in view of WILSON et al disclose invention as shown in claim 1, and TANAY et al further teaches interfering channels define frequency channels causing at least one of adjacent channel interference, co-channel interference (paragraph 5), intersymbol interference, inter-symbol interference and cross-rail interference.

Regarding claim 9, TANAY et al in view of WILSON et al disclose invention as shown in claim 1, but TANAY et al lacks the teaching of the improvement further comprises using an active communication channel without disabling any interfering channel. However, WILSON et al teaches the improvement further comprises using an active communication channel without disabling any interfering channel (column 2, lines 60-62).

Claim 10 lacks an inventive step under PCT Article 33(3) as being obvious over TANAY et al (US 2003/0129987 A1) in view of WILSON et al (US 6,853,842 B1) and in further view of DUFOUR et al (US 6,049,717 A).

Regarding claim 10, TANAY et al in view of WILSON et al disclose invention as shown in claim 1, but lack the teaching of the improvement further comprises using an active channel without disrupting the frequency use plan. However, DUFOUR et al teaches the improvement further comprises using an active channel without disrupting the frequency use plan (Fig. 2, item 110 YES; column 6, lines 46-67, column 7, lines 1-15). DUFOUR et al further teaches that this is relevant for considering interference before making any changes in the frequency plan (column 21, lines 5-6). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the improvement further comprises using an active channel without disrupting the frequency use plan with the invention of TANAY et al in view of WILSON et al as taught in DUFOUR et al for considering interference before making any changes in the frequency plan (column 21, lines 5-6).
(Cont. in Next Supplemental Box)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
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Claims 2-3 lack an inventive step under PCT Article 33(3) as being obvious over TANAY et al (US 2003/0129987 A1) in view of WILSON et al (US 6,853,842 B1) and in further view of DENT (US 6,526,279 B1).

Regarding claim 2, TANAY et al in view of WILSON et al disclose the invention as shown in claim 1, but lack the teachings of the active communication channel defines any frequency channel capable of a duplex communication. However, DENT teaches the active communication channel defines any frequency channel capable of a duplex communication (column 4, lines 9-30). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the active communication channel defines any frequency channel capable of a duplex communication with the invention of TANAY et al in view of WILSON et al as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Regarding claim 3, TANAY et al in view of WILSON et al disclose the invention as shown in claim 1, but lack the teachings of the active communication channel defines any frequency channel capable for a simplex communication. However, DENT teaches the active communication channel defines any frequency channel capable for a simplex communication (column 4, lines 9-30. The simplex communication is "one direction of the duplex communications link"). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the active communication channel defines any frequency channel capable for a simplex communication with the invention of TANAY et al in view of WILSON et al as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Claims 5-6 lack an inventive step under PCT Article 33(3) as being obvious over TANAY et al (US 2003/0129987 A1) in view of WILSON et al (US 6,853,842 B1) and in further view of EVANS et al (US 6,138,024 A).

Regarding claim 5, TANAY et al in view of WILSON et al disclose the invention as shown in claim 1, but lack the teachings of the active communication channel defines a reverse control channel. However, EVANS et al teaches the active communication channel defines a reverse control channel (column 5, lines 61-67, column 6, lines 1-2). EVANS et al further shows that this is relevant for optimizing allocated communication channel selection (column 12, lines 35-44). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the active communication channel defines a reverse control channel with the invention of TANAY et al in view of WILSON et al as taught in EVANS et al, for optimizing allocated communication channel selection (column 12, lines 35-44).

Regarding claim 6, TANAY et al in view of WILSON et al disclose the invention as shown in claim 1, but lack the teachings of the active communication channel defines a forward control channel. However, EVANS et al teaches the active communication channel defines a forward control channel (column 5, lines 61-67, column 6, lines 1-2). EVANS et al further shows that this is relevant for optimizing allocated communication channel selection (column 12, lines 35-44). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the active communication channel defines a forward control channel with the invention of TANAY et al in view of WILSON et al as taught in EVANS et al, for optimizing allocated communication channel selection (column 12, lines 35-44).

Claim 7 lacks an inventive step under PCT Article 33(3) as being obvious over TANAY et al (US 2003/0129987 A1) in view of WILSON et al (US 6,853,842 B1) and in further view of GUTOWSKI (US 2002/0058503 A1).

With respect to claim 7, TANAY et al in view of WILSON et al disclose the invention as shown in claim 1, but lack the teachings of calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel. However, GUTOWSKI teaches calculating path loss (paragraphs 3-4, 11, 14-20, 22-24, 44-60, 62, 111) for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel. GUTOWSKI further shows that this is relevant for optimizing the performance of a wireless communication system (paragraph 25). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel with the invention of TANAY et al in view of WILSON et al as taught in GUTOWSKI, for optimizing the performance of a wireless communication system (paragraph 25).

Claims 15, 21, 23-25 and 30-31 lack an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of CARLSON et al (US 6,845,240 B2).

Regarding claim 15, GUTOWSKI discloses the invention as shown in claim 11, but lacks the teaching of the receiver is a wireless location sensor. However, CARLSON et al teaches the receiver is a wireless location sensor (column 2, lines 3-60). CARLSON et al further shows that this is relevant for maximizing geolocation accuracy (column 1, lines 32-55). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the receiver is a wireless location sensor with the invention of GUTOWSKI as taught in CARLSON et al, for determining the position of a wireless terminal maximizing geolocation accuracy (column 1, lines 32-55).

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WRITTEN OPINION OF THE
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Supplemental Box

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Regarding claim 21, GUTOWSKI discloses the invention as shown in claim 11, but lacks the teaching of identifying the location of the receiver and the wireless device. However, CARLSON et al teaches identifying the location of the receiver and the wireless device (column 2, lines 3-60). CARLSON et al further shows that this is relevant for maximizing geolocation accuracy (column 1, lines 32-55). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use identifying the location of the receiver and the wireless device with the invention of GUTOWSKI as taught in CARLSON et al, for determining the position of a wireless terminal maximizing geolocation accuracy (column 1, lines 32-55).

Regarding claims 23, GUTOWSKI discloses a method for determining a path loss value of a signal transmitted (paragraphs 14-20) from a wireless device (paragraphs 2-4) and received by a receiver (paragraph 11-13), where the wireless device and the receiver operate within a wireless communication system, the method comprising: identifying a first frequency channel in an active communication between the wireless device and the receiver; receiving at the receiver the signal transmitted from said wireless device on said first frequency channel; receiving at said receiver an indication of transmission signal strength of said signal; measuring at said receiver the received signal strength of said signal; determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (paragraphs 8, 22-24, 44-60, 62, 66, 86, 111). GUTOWSKI lacks the teaching of geolocating the wireless device and the receiver. However, CARLSON et al teaches geolocating the wireless device and the receiver (column 2, lines 3-60). CARLSON et al further shows that this is relevant for maximizing geolocation accuracy (column 1, lines 32-55). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use geolocating the wireless device and the receiver with the invention of GUTOWSKI as taught in CARLSON et al, for determining the position of a wireless terminal maximizing geolocation accuracy (column 1, lines 32-55).

Regarding claim 24, GUTOWSKI discloses the invention as shown in claim 23, and further teaches determining a second frequency channel which interferes with said first frequency channel and reassigning a second signal using said second frequency channel to a third frequency channel (paragraphs 11-13).

Regarding claim 25, GUTOWSKI discloses the invention as shown in claim 23, and further teaches determining the path loss value for a plurality of geographic areas to compile a database (paragraph 86).

Regarding claim 30, GUTOWSKI discloses the invention as shown in claim 23, and further teaches the receiver is a plurality of receivers (paragraph 8) each disposed at a different location from each other and a different from the location of the wireless device.

Regarding claim 31, GUTOWSKI discloses the invention as shown in claim 23, but lacks the teaching of the receiver is a base station or a wireless location sensor ("WLS") or a combination of the base station and a WLS. However, CARLSON et al also teaches the receiver is a wireless location sensor ("WLS") (column 2, lines 3-60).

Claims 28-29 lack an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of CARLSON et al (US 6,845,240 B2) and in further view of REUDINK et al (US 6,363,263 B1).

Regarding claim 28, GUTOWSKI in view of CARLSON et al discloses the invention as shown in claim 23, but lacks the teaching of selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute. However, REUDINK et al teaches selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute (column 10, lines 55-65). REUDINK et al further shows that this is relevant for improving wireless communications signal quality in general (column 6, lines 5-13). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute with the invention of GUTOWSKI in view of CARLSON et al as taught in REUDINK et al for improving wireless communications signal quality in general (column 6, lines 5-13).

Regarding claim 29, GUTOWSKI in view of CARLSON et al and in further view of REUDINK et al discloses the invention as shown in claim 28. GUTOWSKI lacks the teaching of the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio, inter-symbol interference and carrier-to-interference ratio. However, REUDINK et al also discloses the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio, inter-symbol interference and carrier-to-interference ratio (column 4, lines 3-16).

Claim 44 lacks an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of REUDINK et al (US 6,363,263 B1) in view of RYDBERG et al (US 5,497,503 A) in view of CARLSON et al (US 6,845,240 B2) and in further view of WILSON et al (US 6,853,842 B1).

Regarding claim 44, GUTOWSKI discloses the invention as shown in claim 41, and further teaches means to search a database (paragraphs 161, 168. "elevation is extracted from the terrain database"). GUTOWSKI lacks the teaching of the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory. However, WILSON et al teaches the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions stored in a digital memory (column 9, lines 44-67, column 10, lines 1-6). WILSON et al further shows that this is relevant for disabling adjacent RF channels (column 6, line 30). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory with the invention of GUTOWSKI as taught in WILSON et al for disabling adjacent RF channels (column 6, line 30).

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Supplemental Box

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Claims 41-42, 45-47 and 49-51 lack an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of REUDINK et al (US 6,363,263 B1) in view of RYDBERG et al (US 5,497,503 A) and in further view of CARLSON et al (US 6,845,240 B2).

Regarding claim 41, GUTOWSKI discloses an apparatus for determining a path loss value of a signal transmitted (paragraphs 14-20) from a wireless device and received by a receiver (paragraph 11-13), comprising: means for identifying a transmitted signal strength for signaling on said active communication channel; means for identifying a received signal strength for signaling on said active communication channel and means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength (paragraphs 8, 22-24, 44-60, 62, 66, 86, 111). GUTOWSKI lacks the teaching of means for identifying an active communication channel supporting at least one desirable attribute, means for identifying the wireless device and the receiver tasked to communicate on said active communication channel and means for locating said wireless device and said receiver. However, REUDINK et al teaches means for identifying an active communication channel supporting at least one desirable attribute (column 10, lines 55-65), RYDBERG et al teaches means for identifying the wireless device and the receiver (column 11, lines 42-58) tasked to communicate on said active communication channel (column 7, lines 20-25) and CARLSON et al teaches means for locating said wireless device and said receiver (column 2, lines 3-60). REUDINK et al further shows that this is relevant for improving wireless communications signal quality in general (column 6, lines 5-13), RYDBERG et al further shows that this is relevant for identifying an area within which interference from either the base station or the associated handset is excessive (column 2, lines 42-60) and CARLSON et al further shows that this is relevant for maximizing geolocation accuracy (column 1, lines 32-55). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the means for identifying an active communication channel supporting at least one desirable attribute, means for identifying the wireless device and the receiver tasked to communicate on said active communication channel and means for locating said wireless device and said receiver with the invention of GUTOWSKI as taught in REUDINK et al, for improving wireless communications signal quality in general (column 6, lines 5-13), RYDBERG et al, for identifying an area within which interference from either the base station or the associated handset is excessive (column 2, lines 42-60) and CARLSON et al, for determining the position of a wireless terminal maximizing geolocation accuracy (column 1, lines 32-55).

Regarding claim 42, GUTOWSKI discloses the invention as shown in claim 41, and further teaches some threshold level typically measured in decibels as the S/I ratio (paragraph 8). GUTOWSKI lacks the teaching of the desirable attribute comprises of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value. However, REUDINK et al discloses the desirable attribute comprises of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio (column 4, lines 3-16) below a threshold value.

Regarding claim 45, GUTOWSKI discloses the invention as shown in claim 41, but lacks the teaching of the means for locating said wireless device and said receiver comprises a wireless location system. However, CARLSON et al also teaches means for locating said wireless device and said receiver comprises a wireless location system (column 2, lines 3-60).

Regarding claim 46, GUTOWSKI discloses the invention as shown in claim 41, but lacks the teaching of the means for locating said wireless device and said receiver comprises a geo-positioning system ("GPS"). However, CARLSON et al also teaches means for locating said wireless device and said receiver comprises a geo-positioning system ("GPS") (column 2, lines 3-60).

Regarding claim 47, GUTOWSKI discloses the invention as shown in claim 41, and further teaches the transmitted signal strength defines the signal strength at the wireless device (paragraph 11).

Regarding claim 49, GUTOWSKI discloses the invention as shown in claim 41, and further teaches means for identifying the wireless device and the receiver further comprises means for tasking the wireless device and the receiver to signal on said active communication channel (paragraph 11).

Regarding claim 50, GUTOWSKI discloses the invention as shown in claim 41, and further teaches means for detecting a second communication channel interfering with the active communication channel (paragraphs 11-13).

Regarding claim 51, GUTOWSKI discloses the invention as shown in claim 41, and further teaches means for reassigning the second communication channel to a third communication channel (paragraphs 11-13).

Claim 43 lacks an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of REUDINK et al (US6,363,263 B1) in view of RYDBERG et al (US 5,497,503 A) in view of CARLSON et al (US 6,845,240 B2) and in further view of TROMPOWER (US 6,047,175 A).

Regarding claim 43, GUTOWSKI discloses the invention as shown in claim 41, and further teaches means for identifying an active communication channel comprises an antenna and a radio receiver (paragraph 24). GUTOWSKI lack the teaching of means for identifying an active communication channel comprises an antenna, a radio receiver and a microprocessor. However, TROMPOWER teaches the means for identifying an active communication channel comprises an antenna, a radio receiver and a microprocessor (column 17, lines 66-67, column 18, lines 1-24). TROMPOWER further teaches that this is relevant for identifying those channels which are in use as opposed to identifying those channels which are free of activity (column 23, lines 21-24). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the means for identifying an active communication channel comprises an antenna, a radio receiver and a microprocessor with the invention of GUTOWSKI in view of REUDINK et al in view of RYDBERG et in view of CARLSON et al as taught by TROMPOWER for identifying those channels which are in use as opposed to identifying those channels which are free of activity (column 23, lines 21-24).

(Cont. in Supplemental Box)

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Claims 26-27 and 32, lack an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of CARLSON et al (US 6,845,240 B2) and in further view of DENT (US 6,526,279 B1).

Regarding claim 26, GUTOWSKI in view of CARLSON et al disclose the invention as shown in claim 23, but lack the teaching of the first frequency channel in active communication is engaged in a duplex communication. However, DENT teaches the first frequency channel in active communication is engaged in a duplex communication (column 4, lines 9-30). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the first frequency channel in active communication is engaged in a duplex communication with the invention of GUTOWSKI in view of CARLSON as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Regarding claim 27, GUTOWSKI in view of CARLSON et al disclose the invention as shown in claim 23, but lack the teaching of the first frequency channel in active communication is engaged in a simplex communication. However, DENT teaches the first frequency channel in active communication is engaged in a simplex communication (column 4, lines 9-30). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the first frequency channel in active communication is engaged in a simplex communication with the invention of GUTOWSKI in view of CARLSON as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Regarding claim 32, GUTOWSKI in view of CARLSON et al disclose the invention as shown in claim 23, but lack the teaching of circuitry configured to implement the method of claim 23. However, DENT teaches circuitry configured to implement the method of claim 23 (column 6, lines 35-42). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the circuitry configured to implement the method of claim 23 with the invention of GUTOWSKI in view of CARLSON as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Claim 48, lacks an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of REUDINK et al (US 6,363,263 B1) in view of RYDBERG et al (US 5,497,503 A) in view of CARLSON et al (US 6,845,240 B2) and in further view of DENT (US 6,526,279 B1).

Regarding claim 48, GUTOWSKI in view of REUDINK et al in view of RYDBERG et al in view of CARLSON et al disclose the invention as shown in claim 41, but lack the teaching of the means for identifying a transmitted signal strength for signaling on said active communication channel comprises an antenna and a signal detection circuit. However, DENT teaches the means for identifying a transmitted signal strength for signaling on said active communication channel comprises an antenna and a signal detection circuit (column 4, lines 47-62, column 10, lines 61-67, column 11, lines 1-14). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the identifying a transmitted signal strength for signaling on said active communication channel comprises an antenna and a signal detection circuit with the invention of GUTOWSKI in view of as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Claims 33-37 lack an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of ALTMAN (WO 2003/001742 A1) and in further view of LIN (US 2004/0137912 A1).

Regarding claim 33, GUTOWSKI discloses a system for determining a path loss value of a signal transmitted (paragraphs 14-20) from a wireless device (paragraphs 3-4) and received by a receiver (paragraph 11), where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system comprising: compiling a database (paragraph 86) for receiving the path loss values, a computer to: identify a geographic area where the path loss value is to be determined (paragraph 48); identify a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel (paragraph 11); receive at said receiver the signal transmitted from said wireless device on said first frequency channel; receive at said receiver an indication of transmission signal strength of said signal; measure at said receiver the received signal strength of said signal; determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength (paragraphs 22-24). GUTOWSKI lacks the teaching of a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to: identify a geographic area where the path loss value is to be determined; identify a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; receive at said receiver the signal transmitted from said wireless device on said first frequency channel; receive at said receiver an indication of transmission signal strength of said signal; measure at said receiver the received signal strength of said signal; and determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength. However, ALTMAN teaches a circuitry including a memory for compiling a database, the circuitry configured with instructions (page 12, lines 13-30, page 16, lines 28-30, page 17, lines 1-21) and LIN teaches a circuitry including a microprocessor for compiling a database (paragraphs 169, 174-177). ALTMAN further shows that this is relevant for avoiding transmission on the same frequency (page 1, lines 22-30, page 2, lines 1-20) and LIN further shows that this is relevant for determining the position of a wireless terminal (paragraphs 28,113). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions with the invention of GUTOWSKI as taught in ALTMAN, for avoiding transmission on the same frequency (page 1, lines 22-30, page 2, lines 1-20) and as taught in LIN, for determining the position of a wireless terminal (paragraphs 28,113).
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Supplemental Box

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Regarding claim 34, GUTOWSKI discloses the invention as shown in claim 33, and further teaches determine a second frequency channel which interferes with said first frequency channel; and reassign a second signal using said second frequency channel to a third frequency channel (paragraphs 11-13).

Regarding claim 35, GUTOWSKI discloses the invention as shown in claim 33, and further teaches to determine the path loss value for a plurality of geographic areas to compile a database (paragraph 86).

Regarding claim 36, GUTOWSKI discloses the invention as shown in claim 33, and further teaches the receiver is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone (paragraphs 2, 11), text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device, pager, base station and wireless location sensor.

Regarding claim 37, GUTOWSKI discloses the invention as shown in claim 33, and further teaches the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone (paragraph 2), text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager;

Claim 40 lacks an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of ALTMAN (WO 2003/001742 A1) in view of LIN (US 2004/0137912 A1) and in further view of REUDINK et al (US 6,363,263 B1).

Regarding claim 40, GUTOWSKI discloses the invention as shown in claim 33, but lacks the teaching of the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute. However, REUDINK et al teaches the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute (column 10, lines 55-65). REUDINK et al further shows that this is relevant for improving wireless communications signal quality in general (column 6, lines 5-13). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute with the invention of GUTOWSKI as taught in REUDINK et al for improving wireless communications signal quality in general (column 6, lines 5-13).

Claims 38-39 lack an inventive step under PCT Article 33(3) as being obvious over GUTOWSKI (US 2002/0058503 A1) in view of ALTMAN (WO 2003/001742 A1) in view of LIN (US 2004/0137912 A1) and in further view of DENT (US 6,526,279 B1).

Regarding claims 38, GUTOWSKI in view of ALTMAN and in further view of LIN disclose the invention as shown in claim 33, but lack the teachings of the wireless device is engaged in one of a simplex or a duplex communication area. However, DENT teaches the wireless device is engaged in one of a simplex or a duplex communication area (column 4, lines 9-30). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the wireless device is engaged in one of a simplex or a duplex communication area with the invention of GUTOWSKI in view of ALTMAN in view of LIN and as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Regarding claim 39, GUTOWSKI in view of ALTMAN and in further view of LIN disclose the invention as shown in claim 33, but lack the teachings of the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic. However, DENT teaches the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic (column 4, lines 9-30). DENT further shows that this is relevant for generating a measure of the strength of received signals (column 4, lines 47-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic with the invention of GUTOWSKI in view of ALTMAN in view of LIN and as taught in DENT, for generating a measure of the strength of received signals (column 4, lines 47-67).

Claims 1-51 meet the criteria set out in PCT Article 33(2)-(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

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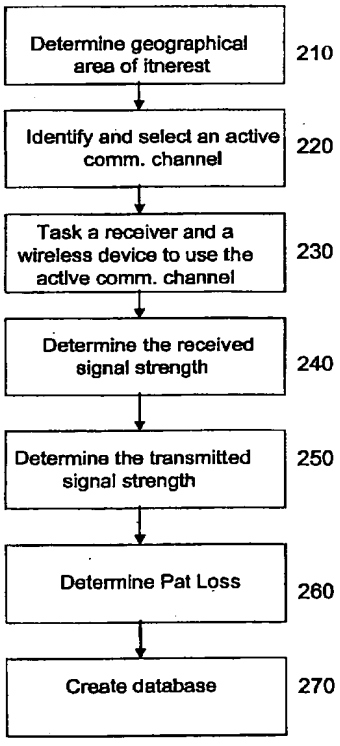
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(54) Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION



(57) Abstract: In one embodiment, the disclosure relates to a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel. The method includes: (i) identifying a geographic area where the path loss value is to be determined; (ii) identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; (iii) receiving at said receiver the signal transmitted from said wireless device on said first frequency channel; (iv) receiving at said receiver an indication of transmission signal strength of said signal; (v) measuring at said receiver the received signal strength of said signal; and (vi) determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

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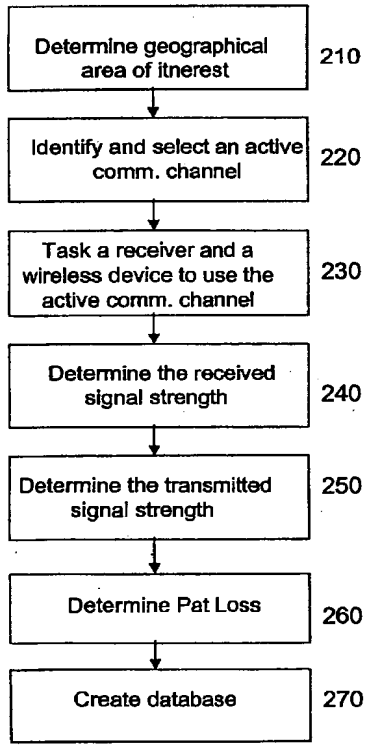
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[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION



(57) Abstract: In one embodiment, the disclosure relates to a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel. The method includes: (i) identifying a geographic area where the path loss value is to be determined; (ii) identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; (iii) receiving at said receiver the signal transmitted from said wireless device on said first frequency channel; (iv) receiving at said receiver an indication of transmission signal strength of said signal; (v) measuring at said receiver the received signal strength of said signal; and (vi) determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

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Method and Apparatus for Determining Path Loss by Active Signal Detection

[0001] The disclosure claims the filing-date benefit of Provisional Application No. 60/681,475 filed May 17, 2005, the specification of which is incorporated herein in its entirety; the disclosure also relates to application entitled "Method and Apparatus for Determining Path Loss by Combining Geolocation with Interference Suppression" and application entitled "Method and Apparatus for Determining Coupled Path Loss" filed simultaneously herewith and assigned to the assignee of the instant disclosure, the specification of each of said related application is incorporated herein in its entirety for background information.

Background

[0002] Path loss is a measure of signal attenuation. Path loss is the difference between the transmitted signal power and the received signal power. Path loss has the units of Decibels (dB) and is a positive quantity which excludes the affects of the antenna gains. In its simplest form, path loss can be defined according to the free-space model of equation (1):

$$PL(dB) = P_t - P_r \qquad (1)$$

where PL denoted path loss, P_t is the signal's transmitted power level and P_r is the signal level recorded at the receiver, measured in units of decibels, such as dBm. Equation (1) assumes that there is no antenna gain at the transmitter and the receiver.

[0003] Path loss is least pronounced where a visible line of sight is available between the transmitter and the receiver where there is little or no electromagnetic interference. Electromagnetic interference is typically in the form of co-channel interference. Conversely, path loss is more pronounced as obstacles and electromagnetic sources interfere with signal propagation. Because path loss is a measure of signal

attenuation, and therefore, bit error rate, it is an important tool in measuring quality of service throughout a wireless network.

[0004] In wireless networks, service quality across geographic areas is audited by conducting drive tests. In such tests, a transmitter is positioned at different locations to send a beacon signal. The transmitter's signal level and the location of the transmitter are recorded. The receivers then record the received signal level. Using the transmitted and received signal levels, path loss between the two locations can be computed.

[0005] Once a frequency channel is dedicated to the path loss measurement, the transmitter's signal strength for the beacon signal and its location are recorded. The receiver then measures and records the received signal strength. Using the transmitted and received signal strengths a processor can determine the path loss value at the transmitter's location.

[0006] Dedicating a specific channel for path loss measurements and rearranging the remaining channels on the frequency use plan to accommodate the path loss-dedicated frequency channel is both costly and inefficient. Thus, there is a need for a method and apparatus for assessing path loss without setting aside an otherwise active frequency channel or disturbing the frequency use plan.

Summary of the Disclosure

[0007] In one embodiment, the disclosure relates to a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel. The method includes: (i) identifying a geographic area where the path loss value is to be determined; (ii) identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; (iii) receiving at said receiver the signal transmitted from said wireless device on said first frequency channel; (iv) receiving at said receiver an indication of transmission signal strength of said signal; (v) measuring at said receiver the received signal strength of said signal; and (vi) determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

[0008] In another embodiment, the disclosure relates to a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector on at least one frequency channel. The method comprises identifying a first frequency channel in an active communication between the wireless device and the receiver; geolocating the wireless device and the receiver; receiving at the receiver the signal transmitted from said wireless device on said first frequency channel; receiving at said receiver an indication of transmission signal strength of said signal; measuring at said receiver the received signal strength of said signal; and determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

[0009] In still another embodiment, the disclosure relates to a system for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system comprises a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values. The circuitry is configured with instructions to (i) identify a geographic area where the path loss value is to be determined; (ii) identify a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; (iii) receive at said receiver the signal transmitted from said wireless device on said first frequency channel; (iv) receive at said receiver an indication of transmission signal strength of said signal; (iv) measure at said receiver the received signal strength of said signal; and (v) determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

[0010] In still another embodiment, the disclosure relates to an apparatus for determining a path loss value of a signal transmitted from a wireless device and received by a receiver. The apparatus includes means for identifying an active communication channel supporting at least one desirable attribute; means for identifying the wireless device and the receiver tasked to communicate on said active communication channel; means for locating said wireless device and said receiver; means for identifying a transmitted signal strength for signaling on said active communication channel; means for identifying a received signal strength for signaling on said active communication channel; and means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

Brief Description of the Drawings

[0011] The principles of the disclosure will be discussed in relation with the exemplary and non-limiting representations, in which:

[0012] Fig. 1 is a schematic representation of a conventional cellular communication system;

[0013] Fig. 2 is a flow-diagram schematically representing an embodiment of the disclosure; and

[0014] Fig. 3 is a flow-diagram schematically representing an embodiment of the disclosure.

Detailed Description

[0015] Fig. 1 is a schematic representation of a conventional cellular communication system. Referring to Fig. 1, the geographic area 100 is divided into cells 110, includes cell A and cell B. Receiver 120 is located at cell A. The receiver can include a radio transceiver, a base station or a wireless location system ("WLS"). The receiver can also include a combined base station and WLS. Conventional frequency use plan uses several directional antennas each radiating at a specified sector. In Fig. 1, a directional antenna (not shown) at receiver 120 is radiating at a portion of cell 110 curving sector 130.

[0016] When sectoring is used, as shown in Fig. 1, the frequency channels used in a particular cell are divided into sector groups and are used only within a particular sector. By carefully assigning non-interfering frequency channels to the downstream receivers (not shown) whose broadcast area overlaps with receiver 120, co-channel interference can be further reduced. Sophisticated frequency use plans must account for co-channel interference as well as other possible interferences.

[0017] To obtain the path loss value between wireless device 140 and receiver 120, the transmission signal strength, the received signal strength and the location of the wireless device and the receiver must be known. As briefly discussed, conventional systems determine the path loss value by assigning a dedicated frequency channel to the wireless device and disabling interfering frequency channels within the wireless communication system. Setting aside a dedicated frequency channel also requires revising the frequency use plan for the entire geographic area which is costly and inefficient.

[0018] In one embodiment of the disclosure, a method for accurately determining the received and transmitted signal strengths includes using an active communication channel without disabling the frequency use plan to provide a dedicated frequency channel.

[0019] An active frequency channel (interchangeably, an active communication channel) defines one or more frequency channels which are a part of the frequency use plan and are available for communication to wireless devices within the geographic area. Indeed, the active frequency channel may be engaged in active communication with a receiver or another wireless device while the system is conducting its signal strength studies for path loss determination. Using an existing channel engaged in active communication obviates the need for a dedicated channel and a revised frequency use plan.

[0020] Fig. 2 is a flow-diagram schematically representing an embodiment of the disclosure. According to the embodiment of Fig. 2, a method for determining signal strength of a signal transmitted by a wireless device starts with step 210; that is, determining the area where path loss information is needed. This step can be the result of a study of the network deficiencies or as part of a network-wide analysis. Once the desired area is identified, step 220 identifies one or more active communication channels for the desired area.

[0021] In one embodiment, active communication channels are selected from among all available frequency channels designated for real-time communication between two subscribers or between a subscriber and a receiver. For example, an active communication channel may be a communication channel designated for communication between two subscribers using duplex voice or data transmission. An active communication channel may also provide a simplex communication for traffic information between a base station and a wireless device. An active communication channel can be used, for example, as a reverse control channel or a forward control channel. In another embodiment, the active communication channel may be a dedicated frequency channels assigned for communication between two subscribers.

[0022] Once all active communication channels have been identified, a final selection can be made based on the attributes of each channel. Among others, the

attributes may include having a desirable signal-to-noise ratio ("SIR"), signal-to-interference ratio or carrier-to-interference ratio. The selection criteria may also include secondary factors calculated to ensure that the selected active communication channel is substantially free of noise and/or interference. In the event that a substantially interference-free communication channel is not available, the selection criteria should be revised to accommodate communication channels which are relatively interference-free. In the event that a desired active communication channel is affected by, for example co-channel interference, the interfering frequency channel can be reassigned to reduce interference. Frequency channel interference can be caused by, among others, adjacent channel interference, co-channel interference, inter-symbol interference or cross-rail interference.

[0023] In step 230, once the active communication channel is selected and if the active communication channel is not in use, a subscriber in the desired region may be assigned to the active communication channel. In one embodiment, the location of the wireless device and/or the receiver tasked with the active communication channel is also determined. In an alternative embodiment, only the cell and the sector housing the wireless device is determined.

[0024] In steps 240 and 250, the transmitted and the received signal strengths are determined for communication on the active channel and used for calculating the path loss value in step 260. For example, the receiver can measure the received signal strength and the wireless device can transmit an indication of the transmission signal strength. Using appropriate mathematical relationships (e.g., Equation 1), the path loss value can be then calculated (step 260). Thus, the path loss value between the wireless device and the receiver can be determined. Since the locations of the wireless device and the receiver are also known, the path loss information can be used to form a database of path loss values at different locations throughout the network (step 270). That is, other suitable active communication channels can be identified at the desired area to provide

additional path loss values thereby forming a more comprehensive study of path loss throughout the network.

[0025] By using an active communication channel, the path loss measurement can be conducted without disrupting an existing frequency use plan to allocate a specific frequency channel for path loss calculations. In addition, because the disclosed embodiment determines path loss on an otherwise interference-free communication channel, the results can be as reliable as using a dedicated frequency channel for beacon signaling.

[0026] Fig. 3 is a flow-diagram schematically representing an embodiment of the disclosure directed to a method for determining the path loss value throughout a network by identifying substantially interference-free active communication channels at step 310. Such identification can be random or selective. For example, several active communication channels can be selected at random from among all communication channels serving the wireless network. Alternatively, one or more active communication channels can be selected from among all communication channels serving the cell or the sector and/or based on selection criteria disclosed above. In the event that a desired active communication channel is affected by interference, the interfering frequency channels can be reassigned to reduce interference.

[0027] In step 320, the wireless device and the receiver tasked with the selected active communication channel are located. Any of the conventional locating means can be used for this purpose. In step 330, a signal transmitted on the active communication channel is detected for signal strength measurement, and in steps 340 and 350 the received signal strength and the transmitted signal strength, respectively, are determined. The path loss value can be measured as a function of the received and transmitted signal strength.

[0028] In another embodiment, the method of Figs. 2 and 3 can be expanded to a plurality of receiver. By way of example and with reference to Fig. 1, once an active

communication channel has been identified, all other receivers which can detect the wireless device's signal transmission on said channel can be included in path loss calculation. Assuming that signal transmission to each of the receivers satisfies one or more of the desired attributes, the path loss value between the wireless device and each of the plurality of receivers can be obtained. Because the receivers are disposed at different locations from each other and from the wireless device, path loss values between the wireless device and several different locations can be determined simultaneously.

[0029] A system according to one embodiment of the disclosure may include one or more receivers in communication with a wireless device. The wireless device may include a wireless transmitter, radio frequency transmitter, mobile telephone, cellular telephone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager. The receiver may comprise a base station, a wireless location sensor or a second wireless device.

[0030] The system can have one or more circuits having multiple microprocessors for implementing the principles disclosed herein. In one embodiment the circuitry can be configured with instructions to identify a geographic area where path loss data is needed. The instructions may include identifying a cell and/or a sector associated with the area as well as identifying available communication channels tasked to the area. The same circuits or an associated circuit can identify suitable active communication channels on the basis of attributes described above or on the basis of any suitable criteria. Once the active communication channel has been identified and selected, the system can determine a path loss value based on the transmitted and the received signal strengths of a wireless device signaling thereon.

[0031] An apparatus according to one embodiment of the disclosure can include a first circuit for identifying an active communication channel supporting one or more desirable attributes. The first circuit can be prompted to search for the active communication channel in response to an operator's request or it can be programmed to

randomly scan all frequency communication channels to identify active communication channels supporting at least one desirable attribute. The first circuitry may include an antenna communicating with a radio receiver and a first microprocessor. The apparatus may also include a second circuit for identifying the wireless device and the receiver tasked to communicate on the active communication channel. In the event that two wireless devices are tasked to communicate on the active communication channel, the second circuit may identify each wireless device. The second circuit may include one or more processors programmed with instructions to search a database stored in a digital memory identifying wireless devices using the network. The apparatus may also include a third circuit for locating the wireless devices and the receivers. The third circuit can be a wireless location sensor in communication with the receiver, a geo-positioning system ("GPS"), or a GPS system in communication with the receiver.

[0032] The apparatus may also include a fourth circuit for identifying the transmitted signal strength for signaling on the active communication channel. The fourth circuit can be a receiver adapted to receive an indication from the wireless device defining its transmission signal strength. A fifth circuit can be included to determine the received signal strength. The fifth circuit can comprise any conventional detector for measuring the received signal strength. Finally, the apparatus may include a sixth circuit for calculating path loss value as a function of the transmitted and the received signal strengths.

[0033] Each of the six circuits may define a separate or an integral operating unit. Alternatively, one or more of the circuits may be combined based on their overlapping functions. The circuits may be co-located for ease of operation. Alternatively, the various circuits can be communicably located at different locations without departing from the disclosed principles.

[0034] While the exemplary embodiments of the present invention have been described, it is to be understood that the embodiments described are illustrative only and

that the scope of the invention is to be defined solely by the appended claims when accorded a full range of equivalence, many variations and modifications naturally occurring to those of skill in the art from a perusal hereof.

What is claimed is:

1. In a method for determining signal strength of a signal transmitted by a wireless device in a wireless communication system operating with a predetermined number of frequency channels administered according to a frequency use plan, wherein the signal strength of the wireless device is determined by assigning one of the predetermined channels to the wireless device and disabling interfering frequency channels within the wireless communication system, the improvement comprising using an active communication channel to determine the signal strength of the wireless device.

2. The method of claim 1, wherein the active communication channel defines any frequency channel capable of a duplex communication.

3. The method of claim 1, wherein the active communication channel defines any frequency channel capable for a simplex communication.

4. The method of claim 1, wherein the active communication channel defines a communication channel within the frequency use plan.

5. The method of claim 1, wherein the active communication channel defines a reverse control channel.

6. The method of claim 1, wherein the active communication channel defines a forward control channel.

7. The method of claim 1, further comprising calculating path loss for the wireless device's location as a function of the transmission signal strength and a received signal strength of a signal transmitted on the active communication channel.

8. The method of claim 1, wherein interfering channels define frequency channels causing at least one of adjacent channel interference, co-channel interference, inter-symbol interference, inter-symbol interference and cross-rail interference.

9. The method of claim 1, wherein the improvement further comprises using an active communication channel without disabling any interfering channel.

10. The method of claim 1, wherein the improvement further comprises using an active channel without disrupting the frequency use plan.

11. A method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the method comprising the steps of:

identifying a geographic area where the path loss value is to be determined;

identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel;

receiving at said receiver the signal transmitted from said wireless device on said first frequency channel;

receiving at said receiver an indication of transmission signal strength of said signal;

measuring at said receiver the received signal strength of said signal; and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

12. The method of claim 11, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel; and

reassigning a second signal using said second frequency channel to a third frequency channel.

13. The method of claim 11, further comprising determining the path loss value for a plurality of geographic areas to compile a database.

14. The method of claim 11, wherein the receiver is a base station.

15. The method of claim 11, wherein the receiver is a wireless location sensor.

16. The method of claim 11, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager.

17. The method of claim 11, wherein the wireless device is engaged in one of a duplex or a simplex communication.

18. The method of claim 11, further comprising randomly selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and engaged in active communication with said receiver.

19. The method of claim 11, further comprising selecting said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute.

20. The method of claim 19, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio and carrier-to-interference ratio.

21. The method of claim 11, further comprising identifying the location of the receiver and the wireless device.

22. A circuitry configured to implement the method of claim 11.

23. A method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system, the method comprising:

identifying a first frequency channel in an active communication between the wireless device and the receiver;

geolocating the wireless device and the receiver;

receiving at the receiver the signal transmitted from said wireless device on said first frequency channel;

receiving at said receiver an indication of transmission signal strength of said signal;

measuring at said receiver the received signal strength of said signal; and

determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

24. The method of claim 23, further comprising the steps of:

determining a second frequency channel which interferes with said first frequency channel; and

reassigning a second signal using said second frequency channel to a third frequency channel.

25. The method of claim 23, further comprising determining the path loss value for a plurality of geographic areas to compile a database.

26. The method of claim 23, wherein the first frequency channel in active communication is engaged in a duplex communication.

27. The method of claim 23, wherein the first frequency channel in active communication is engaged in a simplex communication.

28. The method of claim 23, further comprising selecting said first frequency channel from among a plurality of frequency channels having at least one desired attribute.

29. The method of claim 28, wherein the attribute is selected from the group consisting of signal-to-noise ratio, signal-to-interference ratio, inter-symbol interference and carrier-to-interference ratio.

30. The method of claim 23, wherein the receiver is a plurality of receivers each disposed at a different location from each other and a different from the location of the wireless device.

31. The method of claim 23, wherein the receiver is a base station or a wireless location sensor ("WLS") or a combination of the base station and a WLS.

32. A circuitry configured to implement the method of claim 23.

33. A system for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel, the system comprising:

a circuitry including a microprocessor and a memory for compiling a database for receiving the path loss values, the circuitry configured with instructions to:

identify a geographic area where the path loss value is to be determined;

identify a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel;

receive at said receiver the signal transmitted from said wireless device on said first frequency channel;

receive at said receiver an indication of transmission signal strength of said signal;

measure at said receiver the received signal strength of said signal; and

determine the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

34. The method of claim 33, wherein the circuitry is further programmed with instructions to:

determine a second frequency channel which interferes with said first frequency channel; and

reassign a second signal using said second frequency channel to a third frequency channel.

35. The method of claim 33, wherein the circuitry is further programmed with instructions to determine the path loss value for a plurality of geographic areas to compile a database.

36. The method of claim 33, wherein the receiver is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device, pager, base station and wireless location sensor.

37. The method of claim 33, wherein the wireless devices is selected from the group consisting of wireless transmitter, radio frequency transmitter, mobile telephone, cellular phone, text messaging device, portable computer, laptop computer, personal digital assistant, vehicle security device, vehicle tracking device and pager.

38. The method of claim 33, wherein the wireless device is engaged in one of a simplex or a duplex communication area.

39. The method of claim 33, wherein the circuitry is further programmed with instructions to randomly select said first frequency channel from among a plurality of frequency channels associated with said geographic.

40. The method of claim 33, wherein the circuitry is further programmed with instructions to select said first frequency channel from among a plurality of frequency channels associated with said geographic area and having at least one desired attribute.

41. An apparatus for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, comprising:

means for identifying an active communication channel supporting at least one desirable attribute;

means for identifying the wireless device and the receiver tasked to communicate on said active communication channel;

means for locating said wireless device and said receiver;

means for identifying a transmitted signal strength for signaling on said active communication channel;

means for identifying a received signal strength for signaling on said active communication channel; and

means for calculating the path loss value as a function of the transmitted signal strength and the received signal strength.

42. The apparatus of claim 41, wherein the desirable attribute comprises of at least one of a signal-to-noise ratio, a signal-to-interference ratio, an inter-symbol interference and a carrier-to-interference ratio below a threshold value.

43. The apparatus of claim 41, wherein the means for identifying an active communication channel comprises an antenna, a radio receiver and a microprocessor.

44. The apparatus of claim 41, wherein the means for identifying the wireless device and the receiver comprises a microprocessor programmed with instructions to search a database stored in a digital memory.

45. The apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a wireless location system.

46. The apparatus of claim 41, wherein the means for locating said wireless device and said receiver comprises a geo-positioning system ("GPS").

47. The apparatus of claim 41, wherein the transmitted signal strength defines the signal strength at the wireless device.

48. The apparatus of claim 41, wherein the means for identifying a transmitted signal strength for signaling on said active communication channel comprises an antenna and a signal detection circuit.

49. The apparatus of claim 41, wherein means for identifying the wireless device and the receiver further comprises means for tasking the wireless device and the receiver to signal on said active communication channel.

50. The apparatus of claim 41, further comprising means for detecting a second communication channel interfering with the active communication channel.

51. The apparatus of claim 50, further comprising means for reassigning the second communication channel to a third communication channel

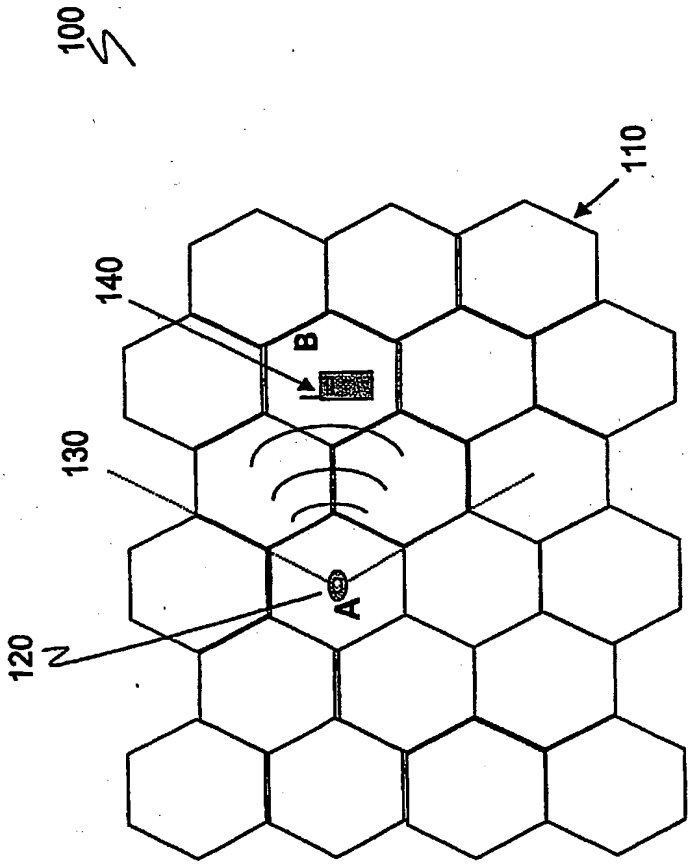


Fig. 1 (Prior Art)

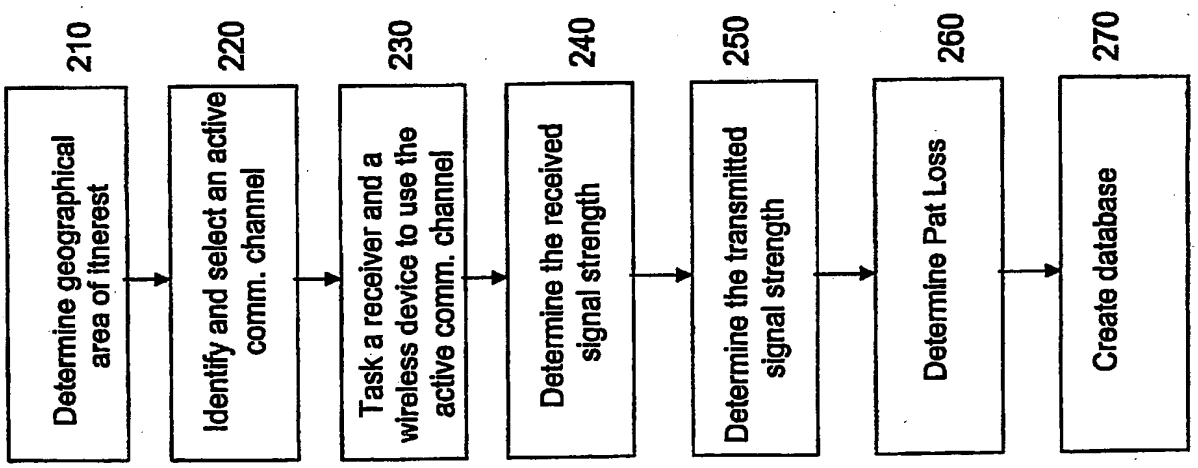

210
Determine geographical area of itnerest
220
Identify and select an active comm. channel
230
Task a receiver and a wireless device to use the active comm. channel
240
Determine the received signal strength
250
Determine the transmitted signal strength
260
Determine Pat Loss
270
Create database

Fig. 2

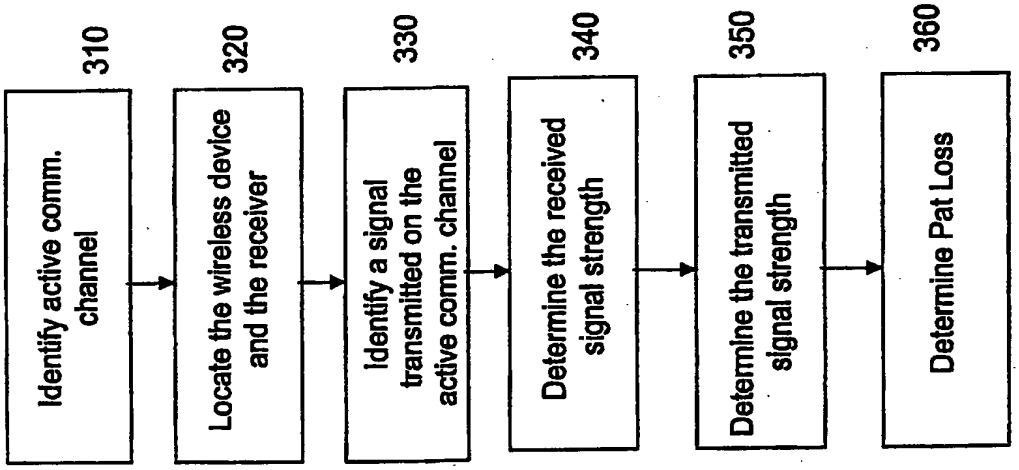

310
Identify active comm. channel
320
Locate the wireless device and the receiver
330
Identify a signal transmitted on the active comm. channel
340
Determine the received signal strength
350
Determine the transmitted signal strength
360
Determine Pat Loss

Fig. 3

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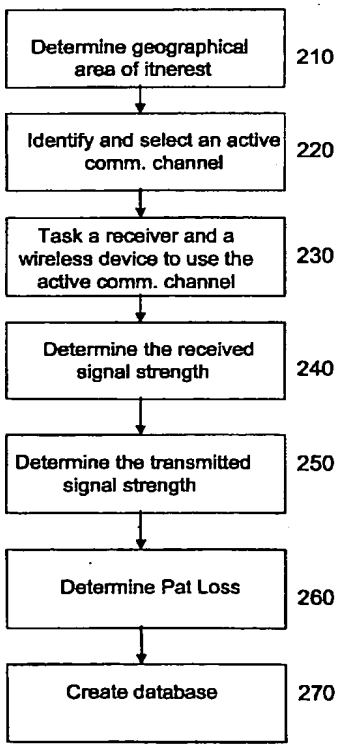
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[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR DETERMINING PATH LOSS BY ACTIVE SIGNAL DETECTION



(57) Abstract: In one embodiment, the disclosure relates to a method for determining a path loss value of a signal transmitted from a wireless device and received by a receiver, where the wireless device and the receiver operate within a wireless communication system having at least one cell having at least one sector operating on at least one frequency channel. The method includes: (i) identifying a geographic area where the path loss value is to be determined; (ii) identifying a first cell, a first sector, and a first frequency channel associated with the geographic area wherein said wireless device is actively communicating with said receiver using said first frequency channel; (iii) receiving at said receiver the signal transmitted from said wireless device on said first frequency channel; (iv) receiving at said receiver an indication of transmission signal strength of said signal; (v) measuring at said receiver the received signal strength of said signal; and (vi) determining the path loss value of said first frequency channel as a function of the indication of transmission signal strength and the received signal strength.

WO 2006/124341 A2

PATENT APPLICATION FEE DETERMINATION RECORD

Effective September 30, 2007

Application or Docket Number: 11/920076

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)	SMALL ENTITY TYPE ☐ RATE	SMALL ENTITY FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY FEE
U.S. NATIONAL STAGE FEES							
BASIC FEE	SMALL ENT. = $ 150	LARGE ENT. = $ 300	BASIC FEE	$155	OR	BASIC FEE	$310
EXAMINATION FEE	Satisfies PCT Article 33(1)-(4) = $ 50 / $ 100	All other situations = $ 100 / $ 200	EXAM. FEE	$105		EXAM. FEE	$210
SEARCH FEE	U.S. is ISA = $ 50 / $ 100 ALL other countries = $ 200 / $ 400	ALL other situations = $ 250 / $ 500	SEARCH FEE	$205		SEARCH FEE	100 ~~$410~~
FEE FOR EXTRA SPEC. PGS.	minus 100 =	/ 50 =	X $ 130 =			X $ 260 =	
TOTAL CHARGEABLE CLAIMS	51 minus 20 =	* 31	X $ 25 =		OR	X $ 50 =	1550
INDEPENDENT CLAIMS	5 minus 3 =	* 2	X $ 105 =		OR	X $ 210 =	420
MULTIPLE DEPENDENT CLAIM PRESENT			+ $ 185 =		OR	+ $ 370 =	
			TOTAL		OR	TOTAL	2590 2720

* If the difference in column 1 is less than zero, enter "0" in column 2

CLAIMS AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
AMENDMENT A	Total	*	Minus	**	=
	Independent	*	Minus	***	=
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐				

SMALL ENTITY RATE	SMALL ENTITY ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY ADDITIONAL FEE
X $ 25 =		OR	X $ 50 =	
X $ 100 =		OR	X $ 200 =	
+ $ 180 =		OR	+ $ 360 =	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
AMENDMENT B	Total	*	Minus	**	=
	Independent	*	Minus	***	=
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐				

RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
X $ 25 =		OR	X $ 50 =	
X $ 100 =		OR	X $ 200 =	
+ $ 180 =		OR	+ $ 360 =	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than '20', enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than '3', enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET

(FOR USE WITH FORM PTO-875)

SERIAL NO. 11/920076

FILING DATE

APPLICANT(S)

CLAIMS

	AS FILED		AFTER 1st AMENDMENT		AFTER 2nd AMENDMENT	
	IND.	DEP.	IND.	DEP.	IND.	DEP.
1	1					
2		1				
3		1				
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39		1				
40		1				
41	1					
42		1				
43		1				
44		1				
45		1				
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47		1				
48		1				
49		1				
50		1				
TOTAL IND.	5	⬇		⬇		⬇
TOTAL DEP.		⬅		⬅		⬅
TOTAL CLAIMS						

	AS FILED		AFTER 1st AMENDMENT		AFTER 2nd AMENDMENT	
	IND.	DEP.	IND.	DEP.	IND.	DEP.
51		1				
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100						
TOTAL IND.	5	⬇		⬇		⬇
TOTAL DEP.	46	⬅		⬅		⬅
TOTAL CLAIMS	51					

U.S. Appl. No. 11/920076 5/3 Internatio Appl No. US 06/017517

Application filed by: ☐ 20 months ☑ 30 months

INTERNATIONAL APPLICATION PAPERS IN THE APPLICATION FILE:

- ☑ International application (RECORD COPY)
- ☐ Article 19 amendments
- ☐ PCT/IB/331
- → ☐ PCT/IPEA/409 237 IPER (PCT/IPEA/416 on front)
- ☐ Annexes to 409
- ☑ Priority document(s) No. 1
- ☐ INTERNATIONAL APPLICATION ON DOUBLE SIDED PAPER (COPIES MADE)
- ☐ Request form PCT/RO/101
- ☐ PCT/IB/302
- ☑ PCT/ISA/210-Search Report
- ☑ Search Report references
- ☐ Other _____

RECEIPTS FROM THE APPLICANT: (other than checked above)

- ☑ Basic National Fee (paid or authorized to charge)
- Translation of international application as filed:
  - ☑ Description
  - ☑ Claims
  - ☑ Words in the drawing figure(s)
  - ☐ Article 19 amendments
  - ☐ Annexes to 409
- ☐ Oath / Declaration
- ☐ DNA diskette
- ☐ Preliminary amendment(s) filed
- ☑ Information Disclosure Statement
- ☑ Assignment document
- ☑ Power of attorney/Change of address
- ☐ Substitute specification
- ☐ Verified small status claim
- ☐ Other _____

Notes: Use IA from IB

35 U.S.C. 371 - Receipt of Request (PTO-1390)	08 Nov '07
Date acceptable oath / declaration received	
Date complete 35 U.S.C 371 requirements met	
102(e) Date	
Date of completion of DO/EO 906 - Notification of Missing 102(e) Requirements	
Date of completion of DO/EO 907 - Notification of Acceptance for 102(e) date	
Date of completion of DO/EO 911 - Application accepted under 35 U.S.C. 1.11	
Date of completion of DO/EO 905 - Notification of Missing Requirements	
Date of completion of DO/EO 916 - Notification of Defective Response	
Date of completion of DO/EO 903 - Notification of Acceptance	
Date of completion of DO/EO 909 - Notification of Abandonment	

WIPO Publication
Publication No.
WO06/124341 A2

Publication Date
23 Nov '06

Publication Language
English

Not Published
☑ U.S. only
Designated
☐ EP request

Screening done by: SA

PTO/SB/06 (07-06)
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
11/920,076	12/15/2008	

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY ☐ FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT 11/08/2007	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 51	Minus	** 51	= 0	X $ =		OR	X $50=	0
Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $ =		OR	X $210=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/DIANE WILLIAMS/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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