US007561104C1

(12) EX PARTE REEXAMINATION CERTIFICATE (10261st)

United States Patent
Alles et al.

(10) **Number: US 7,561,104 C1**
(45) **Certificate Issued: Aug. 18, 2014**

(54) **METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE UNIT**

(75) Inventors: **Martin Alles**, Vienna, VA (US); **John Carlson**, Dulles, VA (US); **George Maher**, Herndon, VA (US); **Seleuk Mazlum**, Leesburg, VA (US)

(73) Assignee: **JPMorgan Chase Bank, N.A.**, New York, NY (US)

Reexamination Request:
No. 90/012,694, Sep. 24, 2012

Reexamination Certificate for:

Patent No.:	**7,561,104**
Issued:	**Jul. 14, 2009**
Appl. No.:	**12/026,333**
Filed:	**Feb. 5, 2008**

Related U.S. Application Data

(60) Provisional application No. 60/899,379, filed on Feb. 5, 2007.

(51) **Int. Cl.**
G01S 3/02 (2006.01)

(52) **U.S. Cl.**
USPC **342/451**; 342/457

(58) **Field of Classification Search**
None
See application file for complete search history.

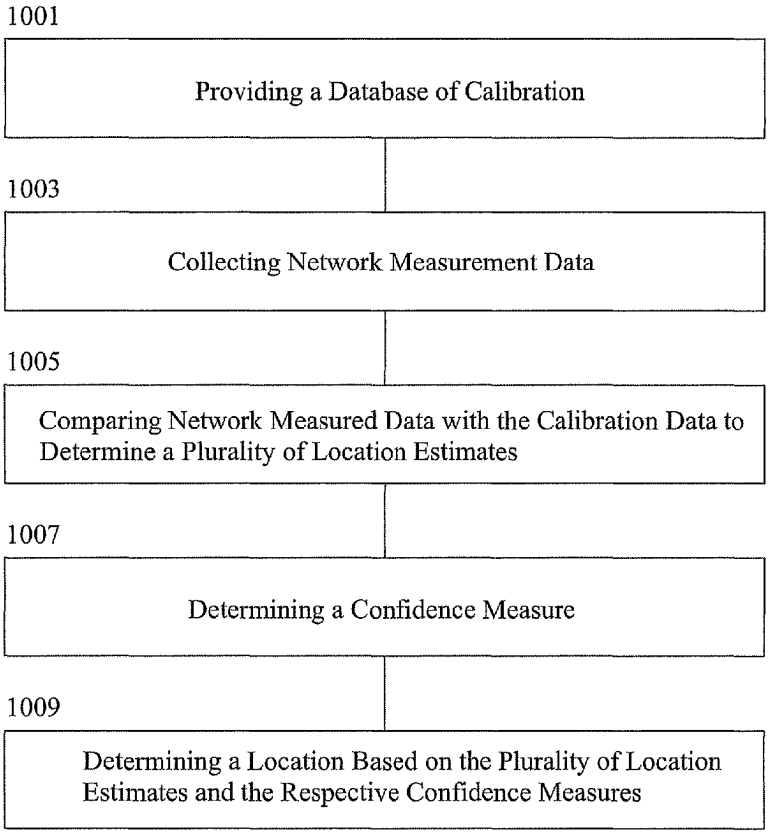
(56) **References Cited**

To view the complete listing of prior art documents cited during the proceeding for Reexamination Control Number 90/012,694, please refer to the USPTO's public Patent Application Information Retrieval (PAIR) system under the Display References tab.

Primary Examiner — Angela M Lie

(57) **ABSTRACT**

A method of modifying calibration data used to geo-locate a mobile station located in an indoor environment is disclosed. When a mobile station is located indoors, the signal strength of signals received and/or transmitted by the mobile station have the tendency to be lower than the strength of the signals received by a mobile station located outdoors. As a result of these lower signal strengths, geo-location efforts which rely on signal strengths may result in unsatisfactory location accuracy. Modifying pre-existing calibration data obtained outdoors may provide a way to simulate indoor calibration data characteristics.



GOOGLE EXHIBIT 1019
Google v. Geoscope

EX PARTE REEXAMINATION CERTIFICATE ISSUED UNDER 35 U.S.C. 307

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

The patentability of claims **1-14** is confirmed.

Claims **15-21** are cancelled.

* * * * *

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
90/012,694	09/24/2012	7,561,104 B2	466-333us1	6575

79172 7590 07/23/2014

Duane Morris LLP
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Washington, DC 20004

EXAMINER	
LIE, ANGELA M	
ART UNIT	PAPER NUMBER
3992	
MAIL DATE	DELIVERY MODE
07/23/2014	PAPER

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Holmdel, NJ 07733

EX PARTE REEXAMINATION COMMUNICATION TRANSMITTAL FORM

REEXAMINATION CONTROL NO. *90/012,694*.

PATENT NO. *7,561,104 B2 E*.

ART UNIT *3992*.

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above identified *ex parte* reexamination proceeding (37 CFR 1.550(f)).

Where this copy is supplied after the reply by requester, 37 CFR 1.535, or the time for filing a reply has passed, no submission on behalf of the *ex parte* reexamination requester will be acknowledged or considered (37 CFR 1.550(g)).

Notice of Intent to Issue Ex Parte Reexamination Certificate	Control No.	Patent Under Reexamination	
	90/012,694	7,561,104 B2 E	
	Examiner	Art Unit	AIA (First Inventor to File) Status
	ANGELA M. LIE	3992	No

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

1. ☒ Prosecution on the merits is (or remains) closed in this *ex parte* reexamination proceeding. This proceeding is subject to reopening at the initiative of the Office or upon petition. *Cf.* 37 CFR 1.313(a). A Certificate will be issued in view of
   - (a) ☐ Patent owner's communication(s) filed: _____.
   - (b) ☒ Patent owner's failure to file an appropriate timely response to the Office action mailed: *30 January 2014*.
   - (c) ☐ Patent owner's failure to timely file an Appeal Brief (37 CFR 41.31).
   - (d) ☐ The decision on appeal by the ☐ Board of Patent Appeals and Interferences ☐ Court dated _____
   - (e) ☐ Other: _____.
2. The Reexamination Certificate will indicate the following:
   - (a) Change in the Specification: ☐ Yes ☒ No
   - (b) Change in the Drawing(s): ☐ Yes ☒ No
   - (c) Status of the Claim(s):
     - (1) Patent claim(s) confirmed: *1-14*.
     - (2) Patent claim(s) amended (including dependent on amended claim(s)): _____
     - (3) Patent claim(s) canceled: *15-21*.
     - (4) Newly presented claim(s) patentable: _____.
     - (5) Newly presented canceled claims: _____.
     - (6) Patent claim(s) ☐ previously ☐ currently disclaimed: _____
     - (7) Patent claim(s) not subject to reexamination: _____.
3. ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.
4. ☐ Note the attached statement of reasons for patentability and/or confirmation. Any comments considered necessary by patent owner regarding reasons for patentability and/or confirmation must be submitted promptly to avoid processing delays. Such submission(s) should be labeled: "Comments On Statement of Reasons for Patentability and/or Confirmation."
5. ☐ Note attached NOTICE OF REFERENCES CITED (PTO-892).
6. ☐ Note attached LIST OF REFERENCES CITED (PTO/SB/08 or PTO/SB/08 substitute).
7. ☐ The drawing correction request filed on _____ is: ☐ approved ☐ disapproved.
8. ☐ Acknowledgment is made of the priority claim under 35 U.S.C. § 119(a)-(d) or (f).
   a)☐ All b)☐ Some* c)☐ None of the certified copies have
   - ☐ been received.
   - ☐ not been received.
   - ☐ been filed in Application No. _____.
   - ☐ been filed in reexamination Control No. _____.
   - ☐ been received by the International Bureau in PCT Application No. _____.

   * Certified copies not received: _____.
9. ☒ Note attached Examiner's Amendment.
10. ☐ Note attached Interview Summary (PTO-474).
11. ☐ Other: _____.

All correspondence relating to this reexamination proceeding should be directed to the **Central Reexamination Unit** at the mail, FAX, or hand-carry addresses given at the end of this Office action.

/ANGELA M LIE/
Primary Examiner, Art Unit 3992

cc: Requester (if third party requester)

The present application is being examined under the pre-AIA first to invent provisions.

EXAMINER'S AMENDMENT

1.550 Conduct of ex parte reexamination proceedings.

(d) If the patent owner fails to file a timely and appropriate response to any Office action or any written statement of an interview required under § 1.560(b) , the prosecution in the *ex parte* reexamination proceeding will be a terminated prosecution, and the Director will proceed to issue and publish a certificate concluding the reexamination proceeding under § 1.570 in accordance with the last action of the Office.

The claims have been amended as follows:

Cancel claims 15-21.

In the Advisory Action mailed on January 30th, 2014, the Examiner concluded that claims 1-14 are confirmed and claims 15-21 remain rejected. The Patent Owner did not reply to the Advisory Action within predetermined period of time (4 month from the mailing date of the final rejection which is October 25, 2013) therefore the Examiner follows up with the Examiner's Amendment wherein the rejected claims are to be canceled. See 37 CFR 1.550(d) and MPEP §2266.

Statement of Reasons for Patentability and/or Confirmation

Claims 1-14 are confirmed.

The following is an Examiner's statement of reasons for patentability and/or confirmation of the claims found patentable in this reexamination proceeding:

Regarding claim 1, Benes fails to teach the following limitation:

"… comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station"

Wherein network measurement data includes:

"a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter".

Benes teaches comparing "antenna gain difference" (i.e. calibration data) to the "signal difference" (paragraph [0027]), however the "signal difference" is not modified ERP (i.e. measurement data), therefore Benes fails teaching comparing the modified network measurement data with the calibration data.

With respect to Gordon's reference, Gordon fails to teach the following limitations:

Claim 1: "...determining which of said first and second signal characteristic has greater magnitude; modifying said observed network measurement data using the greater magnitude signal characteristic ...".

Gordon teaches modifying measurement data (measure traits) via calibration function C(R, K Q) (column 13, lines 53-61 and column 18, lines 13-17) and then

comparing this modified measurement to the calibration data (i.e. expected values) (column 11, lines 39-49 and column 16, lines 37-48). However Gordon does not explicitly teach that it is determined which signal has a greater magnitude and then using the greater magnitude signal to modify observed measurement data.

Regarding claim 12, Benes and Gordon fail to teach the observed network measurement data including the data set as disclosed in claim 12.

With respect to claims 2-11 and 13-14, those claims are also confirmed by the virtue of their dependency on claim 1.

Conclusion

The patent owner is reminded of the continuing responsibility under 37 CFR 1.565(a) to apprise the Office of any litigation activity, or other prior or concurrent proceeding, involving Patent No. 7,561,104 throughout the course of this reexamination proceeding. The third party requester is also reminded of the ability to similarly apprise the Office of any such activity or proceeding throughout the course of this reexamination proceeding. See MPEP §§ 2207, 2282 and 2286.

Any document filed by the Patent Owner must be served on the third party requester (or requesters in a merged proceeding) in the reexamination proceeding in the manner provided by 37 C.F.R. § 1.248. See 37 C.F.R. § 1.550(f) and MPEP § 2266.03.

All correspondence relating to this *ex parte* reexamination proceeding should be directed:

By EFS-Web: Registered Users may submit correspondence via EFS-Web, at https://efs.uspto.gov/efile/myportal/efs-registered.

By Mail to: Mail Stop *Ex Parte* Reexam
Central Reexamination Unit
Commissioner for Patents
United States Patent & Trademark Office
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Alexandria, VA 22313-1450

By FAX to: (571) 273-9900
Central Reexamination Unit

By hand: Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

EFS-Web offers the benefit of quick submission to the particular area of the Office that needs to act on the correspondence. Also, EFS-Web submissions are "soft-scanned" (i.e., electronically uploaded) directly into the official file for the reexamination proceeding, which offers parties the opportunity to review the content of their submission after the "soft scanning" process is complete.

Any inquiry concerning this communication should be directed to the Central Reexamination Unit at telephone number 571-272-7705.

/ANGELA M LIE/

Primary Examiner, Art Unit 3992

/Luke S. Wassum/
Primary Examiner, Art Unit 3992

/SUDHANSHU PATHAK/
Supervisory Patent Examiner, Art Unit 3992

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BIB DATA SHEET

CONFIRMATION NO. 6575

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
90/012,694	09/24/2012	342	3992	466-333us1

APPLICANTS

INVENTORS

7,561,104 B2, Residence Not Provided;
COMMSCOPE, INC. OF NORTH CAROLINA (OWNER), HICKORY, NC;
KENNETH OTTESEN (3RD PTY. REQ.), HOLMDEL, NJ;
KENNETH OTTESEN, HOLMDEL, NJ

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

This application is a REX of 12/026,333 02/05/2008 PAT 7561104
which claims benefit of 60/899,379 02/05/2007

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

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

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☐ No Verified and Acknowledged /ANGELA M LIE/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
				21	2

ADDRESS

Duane Morris LLP
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Suite 1000
Washington, DC 20004
UNITED STATES

TITLE

Method to modify calibration data used to locate a mobile unit

FILING FEE RECEIVED		
17750	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).

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	90012694	7,561,104 B2 ET AL.
	Examiner	Art Unit
	ANGELA M LIE	3992

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
review of patented file's prosecution history	12/10/2012	AL

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

Reexamination	Application/Control No. 90012694	Applicant(s)/Patent Under Reexamination 7,561,104 B2 ET AL.
	Certificate Date	Certificate Number

Requester Correspondence Address:	☐ Patent Owner	☒ Third Party

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LITIGATION REVIEW ☒	/A.M.L/ (examiner initials)	12/12/2012 (date)
Case Name		Director Initials
none		

COPENDING OFFICE PROCEEDINGS	
TYPE OF PROCEEDING	NUMBER

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	90012694	7,561,104 B2 ET AL.
	Examiner	**Art Unit**
	ANGELA M LIE	3992

CPC						
Symbol					**Type**	**Version**
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CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
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NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	14	
/ANGELA M LIE/ Primary Examiner.Art Unit 3992	07/17/2014	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	10

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	90012694	7,561,104 B2 ET AL.
	Examiner	**Art Unit**
	ANGELA M LIE	3992

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
342	451	G	0	1	S	3 / 02 (2006.01.01)						
CROSS REFERENCE(S)												
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)											
342	457											

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	14	
/ANGELA M LIE/ Primary Examiner.Art Unit 3992	07/17/2014	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	10

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	90012694	7,561,104 B2 ET AL.
	Examiner	**Art Unit**
	ANGELA M LIE	3992

☒ 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

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 14	
/ANGELA M LIE/ Primary Examiner.Art Unit 3992 (Primary Examiner)	07/17/2014 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 10

ATTORNEY DOCKET NO. AND01 082 RE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of: Martin Alles, et al.

Serial No.: 90/012,694 Art Unit: 3992

Confirmation No: 6575

Filed: 24 September 2012 Examiner: Angela M. Lie

Title: METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE DEVICE

SUPPLEMENTAL AMENDMENT

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

Sir:

In response to the Office Action dated 25 October 2013 and pursuant to the telephone call with Examiner Lie on 6 January 2014, Patent Holder submits herewith the following Supplemental Amendment correcting the amendments to the claims in the previously submitted amendment of 24 December 2013:

Patent Holder's **Amendment to the Claims** begin on sheet 2 of this paper; and

Patent Holder's **Remarks** begin on sheet 5 of this paper.

Do not enter.
/A.M.L/

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
90/012,694	09/24/2012	7,561,104 B2	466-333us1	6575

79172 7590 01/30/2014

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EXAMINER	
LIE, ANGELA M	
ART UNIT	**PAPER NUMBER**
3992	
MAIL DATE	**DELIVERY MODE**
01/30/2014	PAPER

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EX PARTE REEXAMINATION COMMUNICATION TRANSMITTAL FORM

REEXAMINATION CONTROL NO. *90/012,694*.

PATENT NO. *7,561,104 B2 E*.

ART UNIT *3992*.

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above identified *ex parte* reexamination proceeding (37 CFR 1.550(f)).

Where this copy is supplied after the reply by requester, 37 CFR 1.535, or the time for filing a reply has passed, no submission on behalf of the *ex parte* reexamination requester will be acknowledged or considered (37 CFR 1.550(g)).

This action is directed to claims 1-21 for which reexamination has been requested and substantial new question of patentability has been determined to exist. The considered claims are 1-21 in US Patent No. 7,561,104 to Alles et al. (hereinafter referred to as '104 patent). Claims 1-14 are confirmed and claim 15-21 remain rejected.

Prosecution History

The request for the Ex Parte reexamination of claims 1-21 in the US Patent No. 7,561,104 to Alles at al. has been requested on September 24, 2012.

In response, on December 12, 2012, the Examiner has issued order granting reexamination of claims 1-21.

Then on June 20, 2013 the Examiner has issued a Non-Final rejection wherein claims 1-21 have been rejected as being anticipated and/or obvious over Benes, Gordon, Spain and Krumm.

In response, the Patent Owner has responded on August 20, 2013 traversing the proposed rejections. No claims have been amended.

In addition, on August 20, 2013 the Patent Owner has also filed 1.132 Affidavit of Dr. Saul A. Torrico wherein it has been submitted that Benes does not teach determining the location of the mobile station. The declaration has not been found persuasive.

On October 25th, 20131, the Final rejection has been mailed.

On December 2nd, 2013, the interview has been held between the Examiner, Mr. Pathak (Supervisor), Mr. Wassum (Primary Examiner) and Mr. Muldoon (Attorney).

On December 24, 2013, the Patent Owner has filed the remarks along with the amended claims. However the claim amendment has been found non-compliant with the amendment practice because of the double square brackets.

On January 6, 2014, the Patent Owner filed supplemental after final response, correcting previous deficiencies with respect to the claim amendments.

The References

(1) Benes et al; U.S. Patent Publication No. 2004/0203539; Date Filed: December 11, 2002; Date Published: October 14, 2004 (Benes, hereinafter).

(2) Spain; US Patent No. 7,460,505; Date Filed: February 4, 2003; Date Published: December 2, 2008.

(3) Gordon et al; US Patent No. 7,433,695; Date Filed: May 22, 2006; Date Published: October 7, 2008 (Gordon, hereinafter).

(4) Krumm et al; US Patent No. 7,250,907; Date Filed: June 30, 2003; Date Published: July 31, 2007 (Krumm, hereinafter).

Response to Arguments

ISSUE I. <u>The arguments directed to rejections under 35 U.S.C. 102(b) and 103(a) with Benes as a base reference</u>,

The Patent Owner submits:" *Along with Benes' failure to disclose the observed network measurement data, Benes also fails to disclose modifying the observed network measurement and, further still, modifying the observed network measured data with the signal of greater magnitude". (page 25)*

The Examiner's response: The Examiner does not find the above argument persuasive, however based on the submitted claim amendments and further reconsideration, the Examiner concluded that Benes does not teach the following limitations:

Claim 1: "...comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station."

Wherein network measurement data includes:

"a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter".

More specifically, Benes teaches comparing "antenna gain difference" to the "signal difference" (paragraph [0027]), however the "signal difference" is not modified ERP (i.e. measurement data), therefore Benes fails teaching comparing the modified network measurement data with the calibration data.

Consequently, rejections of claims 1-11 in view of Benes are withdrawn.

ISSUE II. Arguments directed to rejections under 35 U.S.C. 102(a) and 103(a) based on Gordon.

The Patent Owner contends: *"Gordon explicitly explains that in order to account for these situational errors, pattern matching with the measurements are not undertaken, but rather pair-wise differentials of the measurements are matched with pair-wise differentials of the expected values … the differential does not modify any data … First, the claim requires the modified network measurement data to be compared, and, as noted above, the data received from the transmitters is not modified. Second, Gordon expressly states for situational errors the network measurements are not compared to expected values ... The observed measurement data is not changed or modified, but rather a difference is computed. thus, the Office's rational "the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part is based on the strongest signal is incorrect … First, the claim requires the modified network measurement data to be compared, and as noted above, the data received from the transmitters is not modified. Second, Gordon expressly states for situational errors the network measurements are not compared to expected values" (pages 32-33).*

The Examiner's response: Although the Examiner does not agree with position disclosed above, nevertheless after further consideration the Examiner concluded that, the network measurement data modified via the calibration function (column 13, lines 53-61) does not utilize the signal with the greater magnitude but instead the calibration is conducted for each measurement of traits irrespectively of its magnitude. More specifically it appears that Gordon does not teach following limitations:

Claim 1: "...determining which of said first and second signal characteristic has greater magnitude; modifying said observed network measurement data using the greater magnitude signal characteristic ...".

Accordingly the rejections of claims 1-11 are withdrawn with respect to Gordon reference.

ISSUE III. Arguments directed to rejections under 35 U.S.C. 102(a) of claim 15 based on Gordon.

The Patent Owner contends: *"Gordon does not disclose a confidence measure. The Office's argument equates "confidence measure" of the claims with "probabilities of location" of Gordon. However, the confidence measure of a location as used in the specification and as known in the art is not the same as a probability location being the actual location of a mobile station as described in Gordon". (page 37)*

The Examiner response: The Examiner disagrees with the above argument. In particular, the Patent Owner failed to point out the difference between claimed "confidence measure" and "probability" or "likelihood" taught in Gordon. Just as the Patent Owner cited on page 38, the '104 patent states "*A confidence measure may also be used to represent the accuracy of a mobile station's estimated location*". Similarly Gordon teaches that likelihood function (i.e. probability distribution) being utilized to generate estimate of the location (column 26, lines 25-36). In other words, both "confidence measure" and "likelihood" signify the certainty level that the location has been correctly identified, therefore the likelihood behaves just as confidence measure.

Accordingly, the Examiner maintains that Gordon teaches confidence measure as claimed.

Rejections

The rejections of claims 15-21 in view of Gordon have been previously presented in the Final Rejection. However, for the convenience purposes, the rejections are reproduced below.

The Requester proposed rejection of claims 15-21 under 35 U.S.C. 102(a) as being anticipated by Gordon (See Request, Pages 18-22).

With respect to claim 15, Gordon discloses a method for determining a location of a mobile station (Abstract), comprising: providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network (column 6, lines 45-49, wherein data has to be previously gathered to form a database); collecting network measurement data (column 16, lines 49-51 and 63-64, wherein measurement data corresponds to data about signal strength); comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station (column 16, lines 9-18, wherein "database calibration" corresponds to "expected values") determining a confidence measure for each of the plurality of location estimates (column 22, lines 4-7, wherein "confidence measure" corresponds to "probabilities of locations"); determining

the location of the mobile station based on the plurality of location estimates and the respective confidence measures (column 26, lines 25-35, wherein Li refers to each probability distribution corresponding to each possible location, generated earlier (see column 25, lines 53-55)).

With respect to claim 16, Gordon discloses the method of claim 15, wherein the step of determining the location based on the plurality of location estimates and the respective confidence measures comprises selecting the location estimate having the highest respective confidence measure as the location of the mobile station (column 26, lines 25-35, wherein maximum likelihood corresponds to the "highest confidence measure").

With respect to claim 17, Gordon discloses the method of claim 15, wherein the step of determining the location based on the plurality of location estimates and their respective confidence measures comprises weighing the plurality location estimates based on their respective confidence measures and obtaining a weighted average as the location of the mobile (column 25, lines 53-60).

With respect to claim 18, Gordon discloses the method of 15, wherein the confidence measures comprises one or more of the group

consisting of a pdf (probability distribution function)(column 16, lines 9-18) the Mahalanobis distance, and a distortion measure.

With respect to claim 19, Gordon discloses the method of claim 15, wherein the step of collecting network propagation data further comprises modifying the network propagation data (column 18, lines 17-24, wherein modifying corresponds to correcting and information about signal corresponds to propagation data).

With respect to claim 20, Gordon teaches the method of claim 15, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further comprises modifying said calibration data prior to the comparison (column 18, lines 28-30, wherein differentials of measurements are utilized in contrast to the actual signal strength).

With respect to claim 21, Gordon discloses the method of claim 20, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further comprises modifying said calibration data prior to the comparison (column 18, lines 28-30, wherein differentials of measurements are utilized in contrast to the actual signal strength).

Statement of Reasons for Patentability and/or Confirmation

Claims 1-14 are confirmed.

The following is an Examiner's statement of reasons for patentability and/or confirmation of the claims found patentable in this reexamination proceeding:

Regarding claim 1, Benes fails to teach the following limitation:

"… comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station"

Wherein network measurement data includes:

"a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter".

Benes teaches comparing "antenna gain difference" to the "signal difference" (paragraph [0027]), however the "signal difference" is not modified ERP (i.e. measurement data), therefore Benes fails teaching comparing the modified network measurement data with the calibration data.

With respect to Gordon's reference, Gordon fails to teach the following limitations:

Claim 1: "...determining which of said first and second signal characteristic has greater magnitude; modifying said observed

network measurement data using the greater magnitude signal characteristic ...".

Gordon teaches modifying measurement data (measure traits) via calibration function C(R, K Q) (column 13, lines 53-61 and column 18, lines 13-17) and then comparing this modified measurement to the calibration data (i.e. expected values) (column 11, lines 39-49 and column 16, lines 37-48). However Gordon does not explicitly teach that it is determined which signal has a greater magnitude and then using the greater magnitude signal to modify observed measurement data.

Regarding claim 12, Benes and Gordon fail to teach the observed network measurement data including the data set as disclosed in claim 12.

With respect to claims 2-11 and 13-14, those claims are also confirmed by the virtue of their dependency on claim 1.

Conclusion

The patent owner is reminded of the continuing responsibility under 37 CFR 1.565(a) to apprise the Office of any litigation activity, or other prior or concurrent proceeding, involving Patent No. 5,724,092 throughout the course of this reexamination proceeding. The third party requester is also reminded of the ability to similarly apprise the Office of any such activity or proceeding throughout the course of this reexamination proceeding. See MPEP §§ 2207, 2282 and 2286.

Any document filed by the Patent Owner must be served on the third party requester (or requesters in a merged proceeding) in the reexamination proceeding in the manner provided by 37 C.F.R. § 1.248. See 37 C.F.R. § 1.550(f) and MPEP § 2266.03.

All correspondence relating to this *ex parte* reexamination proceeding should be directed:

By EFS-Web: Registered Users may submit correspondence via EFS-Web, at
https://efs.uspto.gov/efile/myportal/efs-registered.

By Mail to: Mail Stop *Ex Parte* Reexam
Central Reexamination Unit
Commissioner for Patents
United States Patent & Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

By FAX to: (571) 273-9900
Central Reexamination Unit

By hand: Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

EFS-Web offers the benefit of quick submission to the particular area of the Office that needs to act on the correspondence. Also, EFS-Web submissions are “soft-scanned” (i.e., electronically uploaded) directly into the official file for the reexamination proceeding, which offers parties the opportunity to review the content of their submission after the "soft scanning" process is complete.

Any inquiry concerning this communication should be directed to the Central

Reexamination Unit at telephone number 571-272-7705.

/ANGELA M LIE/

Primary Examiner, Art Unit 3992

Conferees:

/Luke S. Wassum/
Primary Examiner, Art Unit 3992

/SUDHANSHU PATHAK/
Supervisory Patent Examiner, Art Unit 3992

Ex Parte Reexamination Advisory Action *Before the Filing of an Appeal Brief*	**Control No.** 90/012,694	**Patent Under Reexamination** 7,561,104 B2 E	
	Examiner ANGELA M. LIE	**Art Unit** 3992	**AIA (First Inventor to File) Status** No

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

THE PROPOSED RESPONSE FILED *06 January 2014* FAILS TO OVERCOME ALL OF THE REJECTIONS IN THE FINAL REJECTION MAILED *25 October 2013*.

1. ☒ Unless a timely appeal is filed, or other appropriate action by the patent owner is taken to overcome all of the outstanding rejection(s), this prosecution of the present *ex parte* reexamination proceeding WILL BE TERMINATED and a Notice of Intent to Issue *Ex Parte* Reexamination Certificate will be mailed in due course. Any finally rejected claims, or claims objected to, will be CANCELLED.

   THE PERIOD FOR RESPONSE IS EXTENDED TO RUN *4* MONTHS FROM THE MAILING DATE OF THE FINAL REJECTION. Extensions of time are governed by 37 CFR 1.550(c).

NOTICE OF APPEAL

2. ☐ An Appeal Brief is due two months from the date of the Notice of Appeal filed on _____ to avoid dismissal of the appeal. See 37 CFR 41.37(a). Extensions of time are governed by 37 CFR 1.550(c). See 37 CFR 41.37(e).

AMENDMENTS

3. ☒ The proposed amendment(s) filed after a final action, but prior to the date of filing a brief, will not be entered because:
   (a) ☒ They raise new issues that would require further consideration and/or search (see NOTE below);
   (b) ☐ They raise the issue of new matter (see NOTE below);
   (c) ☐ They are not deemed to place the proceeding in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   (d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.
   NOTE: _____ (See 37 CFR 1.116 and 41.33(a)).
4. ☒ Patent owner's proposed response filed *06 January 2014* has overcome the following rejection(s):*see the office action*
5. ☐ The proposed new or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
6. ☒ For purposes of appeal, the proposed amendment(s) a)☒ will not be entered, or b)☐ will be entered and an explanation of how the new or amended claim(s) would be rejected is provided below or appended.
   The status of the claim(s) is (or will be) as follows:
   Claim(s) patentable and/or confirmed: *1-14*
   Claim(s) objected to: _____
   Claim(s) rejected: *15-21*
   Claim(s) not subject to reexamination: _____

AFFIDAVIT OR OTHER EVIDENCE

7. ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.
8. ☐ The affidavit or other evidence filed after a final action, but before or on the date of filing a Notice of Appeal will not be entered because patent owner failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
9. ☐ The affidavit or other evidence filed after the date of filing a Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence fails to overcome all rejections under appeal and/or appellant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
10. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

11. ☐ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: _____.
12. ☐ Note the attached Information Disclosure Statement(s), PTO/SB/08, Paper No(s) _____.
13. ☒ Other:*see the office action .*

/ANGELA M LIE/ Primary Examiner, Art Unit 3992	/Luke S. Wassum/ Primary Examiner, Art Unit 3992	/SUDHANSHU PATHAK/ Supervisory Patent Examiner, Art Unit 3992

cc: Requester (if third party requester)

Reexamination	Application/Control No. 90012694	Applicant(s)/Patent Under Reexamination 7,561,104 B2 ET AL.
	Certificate Date	Certificate Number

Requester Correspondence Address:	☐ Patent Owner	☒ Third Party

Kaplan, Breyer, Schwarz & Ottesen, LLP
Suite 250
100 Commons Way
Holmdel, NJ 07733

LITIGATION REVIEW ☒	/A.M.L/ (examiner initials)	12/12/2012 (date)
Case Name		Director Initials
none		

COPENDING OFFICE PROCEEDINGS	
TYPE OF PROCEEDING	NUMBER

ATTORNEY DOCKET NO. AND01 082 RE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of: Martin Alles, et al.

Serial No.: 90/012,694 Art Unit: 3992

Confirmation No: 6575

Filed: 24 September 2012 Examiner: Angela M. Lie

Title: METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE DEVICE

SUPPLEMENTAL AMENDMENT

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

Sir:

In response to the Office Action dated 25 October 2013 and pursuant to the telephone call with Examiner Lie on 6 January 2014, Patent Holder submits herewith the following Supplemental Amendment correcting the amendments to the claims in the previously submitted amendment of 24 December 2013:

Patent Holder's **Amendment to the Claims** begin on sheet 2 of this paper; and

Patent Holder's **Remarks** begin on sheet 5 of this paper.

Amendment to the Claims:

1. (Amended) A method for determining a location of a mobile station, comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

receiving a signal from said first transmitter and receiving another signal from said second transmitter,

collecting observed network measurement data including a first signal characteristic of the signal measured by the mobile station from said first transmitter and a second signal characteristic of the another signal measured by the mobile station from said second transmitter;

determining which of said first and second signal characteristics has a greater magnitude;

modifying said observed network measurement data using the greater magnitude signal characteristic; and

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

8. (Amended) The method of Claim 7 wherein the modifying of said [calibration] observed network measurement data uses a difference between said first or second signal characteristics.

11. (Amended) The method of Claim 1, wherein the observed network measurement data includes received signal strength of said transmitters [as] at said mobile station.

12. (Amended) A method for determining a location of a mobile station, comprising:

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

determining which of said first and second signal characteristics has a greater magnitude;

modifying said observed network measurement data using the greater magnitude signal characteristic; and

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station;

[The method of Claim 1] wherein said observed network measurement data includes a data set comprising:

$[P_1, P_2..., P_n, TA]$

where:

P_1 represents the signal strength of said first transmitter as measured at said mobile station,

P_2 represents a signal strength of said second transmitter as measured at said mobile station wherein $P_2 > P_1$,

P_n represents a signal strength of a n^{th} transmitter as measured at said mobile station wherein $P_2 > P_n$, and

TA represents a timing advance parameter;

and wherein said modified network measurement data includes a data set comprising:

$[P_2-P_1, 0, P_2-P_n, TA]$

where:

P_2-P_1 represents a difference between P_2 and P_1,

0 represents a difference between P_2 and P_2, and

P_2-P_n represents a difference between P_2 and P_n.

15. (Amended) A method for determining a location of a mobile station, comprising:

providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network;

measuring characteristics of the network by the mobile station at the location to obtain [collecting] network measurement data;

comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station

determining a confidence measure for each of the plurality of location estimates;

determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.

REMARKS

I. INTRODUCTION

Claims 1-21 of U.S. Patent No. 7,561,104 (" '104") are pending.

The proposed rejections have been maintained for Claims 1-11 and 15-21, the proposed rejections of Claims 12-14 have been withdrawn.

Claims 1, 8, 11, 12 and 15 have been amended.

Claim 12 has been rewritten into independent form, including all the limitations of the base claim.

The portions of Claim 12 in brackets that are not to be deleted are:

[P1, P2..., Pn, TA]

And

[P2-P1, 0, P2-Pn, TA]

Claims 1 and 15 have been amended to more clearly recite the observed network measurement data is measured by the mobile at the location. Specifically, Claim 1 as amended recites *inter alia*:

> receiving a signal from said first transmitter and receiving another signal from said second transmitter,
>
> collecting observed network measurement data including a first signal characteristic of the signal measured by the mobile station from said first transmitter and a second signal characteristic of the another signal measured by the mobile station from said second transmitter;

and Claim 15 recites *inter alia*:

> measuring characteristics of the network by the mobile station at the location to obtain network measurement data;

Support for these amendments are found throughout the Specification and specifically in the Abstract, Col. 1 ll. 33-40, 55-60;Col. 5, ll. 33-57; Col. 6, ll. 24-52; Col 7, ll. 20-30 and Col. 10, ll. 58-60.

These amendments are included to address concerns of the panel discussed during the interview. A summary of the interview is included as a separate sheet in this response.

Claims 8 and 11 have been amended to correct typographic errors.

No new matter has been added.

II. RESPONSE TO OFFICE'S COMMENTS

A. Declaration

The Office found the Affidavit by Dr. Torrico unpersuasive. However, the Office as evident from the interview, failed to understand the content and purpose of the Affidavit. The Patent Holder's purpose in submitting the Affidavit was to demonstrate that one skilled in the art would not consider Benes to be useful in locating a mobile device and thus would not look to Benes in creating a location system that had a reasonable chance for success. The fundamental underpinning of an obviousness type rejection is to achieve success.[1]

The Office recognizes a fundamental truth: "It is correct that the location of the mobile station cannot be determined solely based on the information about characteristics of the transmitters" (FOA p. 5), which reflects Declaration No. 7. The Office offers in rebuttal to the Affidavit "This is precisely the reason why the mobile device determines an effective radiated power (ERP) based on the respective signals' strength values" and thus "Consequently, the characteristics about the source along with the magnitude of the received signals allow determining the location of the mobile device". (citing to paragraph [0021])

If (*aguendo*) the ERP determined by Benes was based on the mobile station's measurement of the signal strength of the received signals (magnitude of the received signals), the Patent Holder's Arguments would indeed ring hollow. However, ERP[2,3] by definition is not

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[1] Where there is a reason to modify or combine the prior art to achieve the claimed invention, the claims may be rejected as *prima facie* obvious provided there is also a reasonable expectation of success. In re Merck & Co., Inc., 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986)

[2] effective radiated power (e.r.p.) (in a given direction): 1. The power supplied to an antenna multiplied by the antenna gain in a given direction. (188) Note 1: If the direction is not specified, the direction of maximum gain is assumed. Note 2: The type of reference antenna must be specified. 2. The product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction. (Institute for Telecommunication Sciences. Retrieved 2008-08-29)

[3] In electromagnetic transmission systems, especially those dealing with telecommunications, effective radiated power or equivalent radiated power (ERP) is a standardized theoretical

(Continued...)

based, nor can it be based, on the signal strength of the received signal. Absent from Benes is any contrary disclosure which creates a new meaning to ERP. Therefore, it follows from the Office's own remarks, along with assertions offered in the affidavit, that the location "cannot be determined" and thus Benes is inoperative for the purpose for which it is intended. This is exactly what the affidavit points out.

The ERPs are determined from "the information":

> Upon receiving **the information** associated with the plurality of sectors, the mobile station 160 may determine a power parameter associated with each of the plurality of antennas. For example, the mobile station 160 may determine an effective radiated power (ERP) associated with each of a first sector 202 and a second sector 204 based on their respective signal strength values. *Id.* [0021] (emphasis added)

Paragraph [0021] demonstrates that the ERP is determined from "the information." This information ("the information') as noted in Benes is automatically provided by the base station or the mobile station may request "the information" from the base station.

> ....A mobile station within the communication cell may automatically receive information associated with the plurality of sectors from the base station. **The information** associated with the plurality of sectors may include, but is not limited to, an antenna pattern, a boresight, a downtilt, and a signal strength value associated with each one of the plurality of antennas. The mobile station may receive **the information** associated with the plurality of sectors via a pilot signal strength measurement message or a measurement report message. Alternatively, the mobile station may request for **the information** associated with the plurality of sectors from the base station. Benes [0011] (emphasis added)

(Continued...)

> measurement of radio frequency (RF) energy[1][2] using the SI unit watts, and is determined by subtracting system losses and adding system gains. ERP takes into consideration transmitter power output (TPO), transmission line attenuation (electrical resistance and RF radiation), RF connector insertion losses, and antenna directivity, but not height above average terrain (HAAT). ERP is typically applied to antenna systems.

> ...In response to the request, the mobile station 160 at step 1020 may receive information associated with the plurality of sectors. In particular, **the information** associated with the plurality of sectors may include, but is not limited to, antenna patterns, boresights, downtilts, and signal strength values associated with the plurality of antennas. Alternatively, the mobile station 160 may automatically receive **the information** associated with the plurality of sectors from the base station (i.e., without a request).*Id* [0028] (emphasis added)

Benes further explains the ERPs are associated with downlink signals 802, 804 and 806.

> In particular, a downlink signal 802 from the antenna associated with the first sector 202 has a boresight of 160 degree azimuth (i.e., degrees from north) and an effective radiated power (ERP) of -80 dB, a downlink signal 804 from the antenna associated with the second sector 204 has a boresight of 230 degree. azimuth and an ERP of -70 dB, and a downlink signal 806 from the antenna associated with the third sector 206 has a boresight of 100 degrees and an ERP of -110 dB....[0026]

These ERP's are determined from calibration data and not from measurements at the mobile station. The ERP's of -70, -80 and -110 cannot possibly be measured by the mobile station, as these occur at the boresight of each antenna (240, 160, and 100, respectively) and the mobile station CANNOT be at the three locations at once as shown in Figure 8. (See also Declaration No. 8)

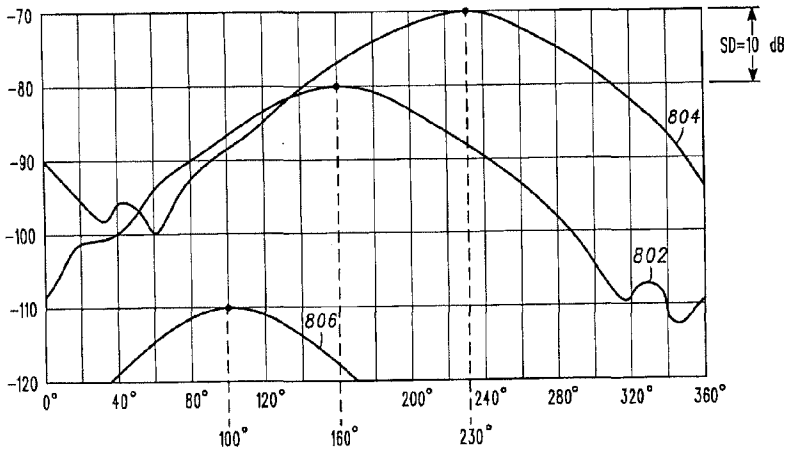

FIG. 8

Thus, Benes does not measure the received signal strength by the mobile station which is to be located (See Declaration No 6), and thus in addition to failing to meet the claim limitations as previously intended and now amended, cannot be used in an obviousness type rejections as there is no probability of success.[4,5] As the Office states "the location of the mobile station cannot be determined solely based on the information about characteristics of the transmitters" which is precisely what Benes seeks to do (See Declaration No. 10).

In addition, the Evidence presented by the Office has been rebutted, and thus the Affidavit should be persuasive to overcome the *prima facie* case of obviousness.[6]

B. Interpretation of "Collecting Observed Network Measurement data"

The Office, as revealed in the interview, broadly interpreted "the collection of observed Network measurement data" as not requiring such data to be observed/measured by the mobile station and thus was indistinguishable from the stored calibration data that was previously gathered.

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[4] Life Tech. v. Clontech Labs., 224 F.3d 1320. Reasonable expectation of success is assessed from the perspective of the person of ordinary skill in the art.

[5] Otsuka Pharm. Co. v. Sandoz, Inc. 678 F.3d 1280. The second inquiry in the analysis is whether the prior art would have supplied one of ordinary skill in the art with a reason or motivation to modify a lead compound to make the claimed compound with a reasonable expectation of success"

[6] *Consideration of evidence.* Evidence traversing rejections, when timely presented, must be considered by the examiner whenever present. All entered affidavits, declarations, and other evidence traversing rejections are acknowledged and commented upon by the examiner in the next succeeding action. The extent of the commentary depends on the action taken by the examiner. Where an examiner holds that the evidence is sufficient to overcome the *prima facie* case, the comments should be consistent with the guidelines for statements of reasons for allowance. *See* MPEP § 1302.14. Where the evidence is insufficient to overcome the rejection, the examiner must specifically explain why the evidence is insufficient. General statements such as "the declaration lacks technical validity" or "the evidence is not commensurate with the scope of the claims" without an explanation supporting such findings are insufficient. [MPEP § 716.01 (B)]

Given this interpretation, the Office justified its reliance upon Benes as anticipating Claims 1, 3, and 11, and further the obviousness type rejections of Claims 2, 4-7, and 9-11.

The Claims have been amended to ameliorate the Office's concerns regarding the interpretation of Collecting Observed Network Measurement data.

> 1. A method for determining a location of a mobile station, comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;
>
> receiving a signal from said first transmitter and receiving another signal from said second transmitter,
>
> collecting observed network measurement data including a first signal characteristic of the signal measured by the mobile station from said first transmitter and a second signal characteristic of the another signal measured by the mobile station from said second transmitter;
>
> determining which of said first and second signal characteristics has a greater magnitude;
>
> modifying said observed network measurement data using the greater magnitude signal characteristic; and
>
> comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Claim 1 as amended clearly requires the mobile station (the location of which is to be determined) to receive and measure characteristics of the signals to determine the observed network measurement data, thus the observed network measurement data is distinguished from the previously gathered calibration data.

C. The Office's assertion that Benes teaches "observed network measurement data"

In response to the Patent Holder's assertion that Benes does not disclose measuring signals received at the mobile station to determine Observed network measurement data, the Office states that Benes teaches:

1. "observed network measurement data" in paragraphs [0026] wherein effective radiated power measured in dB corresponds to signal (i.e. downlink signal) characteristic

and

2. furthermore, there are multiple antennas (i.e. transmitters) and each of them has its corresponding signal strength received at the mobile stations. (FOA, p. 6)

With respect to the first assertion, paragraph [0026] does not disclose that the ERP is determined from measuring a received signal, but rather from "the information". Benes states:

> [0026] Based on the antenna patterns, the mobile station 160 may autonomously determine an angle of arrival (AOA) estimation by comparing ERPs between the antennas of at least two sectors in a communication cell. To illustrate the concept of determining an AOA estimation, downlink signals from antennas associated with the first sector 202 and the second sector 204 are shown in FIGS. 8 and 9 (i.e., FIGS. 8 and 9 are linear plots whereas FIGS. 4-7 are polar plots). In particular, a downlink signal 802 from the antenna associated with the first sector 202 has a bore sight of 160 degree. azimuth (i.e., degrees from north) and an effective radiated power (ERP) of -80 dB, a downlink signal 804 from the antenna associated with the second sector 204 has a bore sight of 230 degree azimuth and an ERP of -70 dB, and a downlink signal 806 from the antenna associated with the third sector 206 has a bore sight of 100 degree and an ERP of -110 dB. As noted above, persons of ordinary skill in the art will readily appreciate that the ERPs may be compensated for gain differences of the antennas and losses from cables and connectors coupled to the antennas. Based on the ERPs, the mobile station 160 may calculate a signal difference (SD) between the peaks of the downlink signals 802, 804 associated with the antennas corresponding to the first and second sectors 202, 204. For example, the mobile station 160 may determine a signal difference of 10 dB between the first sector 202 and the second sector 204. With stronger peak ERPs in the downlink signals 802, 804 from the antennas associated with the first and second sectors 202, 204, downlink signals with weaker peak ERPs such as the downlink signal 806 from the antenna associated with the third sector 206 may not be necessary to determine the AOA estimation. (emphasis added)

Benes, as discussed previously, uses only "the information" received from the base station to determine ERPs and then uses ERPs to calculate a signal difference SD.

In the underlined portions above, Benes discusses downlink signals from the antennas are shown in Figures 8 and 9. The downlink signals shown in Figures 8 and 9 are based on previously collected calibration data and in no manner serve as a disclosure of receiving a signal and measuring characteristics of the signal by the mobile to be located. Furthermore, Benes calculates a signal difference between the peaks of the downlink signals. Such a feat is only possible using previously collected calibration data such as that provided in the NMR. If the downlink signals were received and measured by the mobile station at its location, the peaks would not be ascertainable, rather only two points would be determinable, the first characteristic and the second characteristic. The reference to downlink signals in Benes is not to the signal as received but rather the properties of the downlink signals transmitted. As noted above, Benes is inoperable and returns to the same location regardless of the mobiles actual location (Declaration No. 7), because it does not receive a signal and then determine its characteristics by measuring.

With respect to the second assertion, there is no argument that each downlink signal has a received signal strength when received by a receiver. However, the disclosure of Benes does not measure or determine the actual received signal strength but rather relies upon what "the information" reports as the signal strength. Nowhere in the disclosure of Benes is a disclosure for receiving a signal, measuring characteristics of the signal, and using those measurements to determine observed network measurement data. The Office attempts to read into Benes disclosures that are simply not there.

D. Benes does not disclose modifying the Observed Network Measurement data.

The Office states:

> The "observed network measurement data" is modified via the step of normalization as described in paragraph [0027].

However, in [0027], as previously described, "the mobile station normalize the downlink signal 802 and 804 from the antennas associated with the first and second sectors 202, 204" and as an example of this normalization, Benes describes "For example, the peak ERPs of the normalized downlink signals 902, 904 may be calibrated to 0 dB. Based on the antenna gain difference, the mobile station 160 may determine an angle of arrival (AOA) estimation." As noted previously the peaks are normalized as shown in Figure 9.

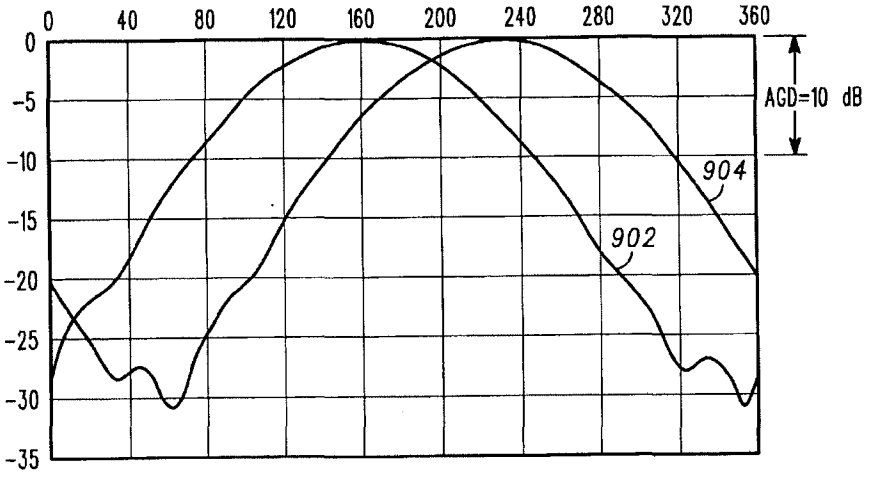

FIG. 9

Clearly the only data normalized in Figure 9 is that received from the base station represented in Figure 8. Benes further describes "the mobile station 160 may determine that the downlink signal 804 from the antenna associated with the second sector 204 is stronger than the downlink signal 802 from the antenna associated with the first sector 202 (i.e., a peak ERP of -70 dB is greater a peak ERP of -80 dB, respectively)" which again may only be surmised from the information received from the base stations and not measuring (observing) characteristic of the received signal at the particular mobile station. The Office's use of ERP to demonstrate the observed or measured received signal strength is erroneous.

Benes' normalization of the peaks thus is not modification of the observed network measurement data but rather modification of the calibration data.

E. The information is not based on the location of the mobile station with respect to the transmitter.

The Office, in response to the Patent Holders argument that the information is not based on the location of the mobile station with respect to the transmitter, argues that:

1. Benes teaches the information being based on the location of the mobile station with respect to the transmitter citing paragraph [0022];

2. Benes teaches that the mobile station determined an effective radiated power associated with each sector based on their respective signal strength values citing paragraph [0021].

The Patent Holder asserts the Office's understanding of Benes is incorrect.

The information sent by the base station, as discussed in [0022] of Benes, is of the characteristics of the antennas, and not specific to the location of the mobile.

> [0022] Referring to FIG. 4, an antenna pattern 410 (i.e., physical property of an antenna) associated with an antenna is shown. The antenna pattern 410 may indicate the variation of field intensity of an antenna as an angular function with respect to an axis, i.e., either a horizontal or vertical plane. In particular, the antenna pattern 410 may have a reference boresight (i.e., a direction in which the antenna may be pointed) of 0 degree.. Although the embodiments disclosed herein are particularly well suited for use with horizontal patterns, persons of ordinary skill in the art will readily appreciate that the teachings of this disclosure are in no way limited to the horizontal patterns shown in FIGS. 4, 5, 6 and 7. On the contrary, persons of ordinary skill in the art will readily appreciate that the teachings of this disclosure can be employed with a vertical pattern of the antenna. Depending on the desired accuracy and/or the available storage capacity, the antenna pattern 310 may be entirely digitized and stored with the mobile station 160.

The Office simply cannot base its argument on paragraph [0022].

With respect to the Office's second assertion that Benes uses the "respective signal strength values" to calculate the ERP, the Office's inference is incorrect. In order for the Office's statement regarding Benes to have any bearing on the rejection, the "respective signal strength values" must be read as "respective received signal strength of the received signal," but such is not the case. As noted above and in the previous response, ERP is not calculated from received signal strength, there is no disclosure in Benes that the ERPs are determined based on the signal strength of the received signal. Paragraph [0021] upon which the Office relies states:

> [0021] Upon receiving the information associated with the plurality of sectors, the mobile station 160 may determine a power parameter **associated with each of the plurality of antennas.** For example, the mobile station 160 may determine an effective radiated power (ERP) associated with each of a first sector 202 and a second sector 204 based on their respective signal strength values. Persons of ordinary skill in the art will readily appreciate that the ERPs may be compensated for gain differences of the antennas and losses from cables and connectors coupled to the antennas. (emphasis added)

The ERP is, and can only be associated with the antennas and determined from the information provided and not from received signal strength measurements.

F. Non-Uniform Grid

The Office maintains the rejection of Claim 2 because Gordon teaches "any number of locations of any size shape and arrangement" is a teaching of "calibration data for one or more non-uniform grid points within the region."

During the interview, the panel noted that an explicit or inherent disclosure was not necessary, nor was a motivation required under KSR[7], instead it would be obvious to try.

The Patent Holder asserts that the cited passage from Gordon is not an explicit or inherent disclosure and a motivation is necessary under KSR.

Claim 2, recites *inter alia*:

> wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

[7] *KSR Int'l v Teleflex Inc* 550 U.S. 398

The cited portion of Gordon recites:

> With these considerations in mind, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that partition geographic region 220 into any **number of locations of any size, shape, and arrangement.** Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use embodiments of the present invention in which the **locations are identical in size and shape.** Gordon Col. 9, 11, 9-16. (emphasis added)

There is nothing in Gordon, much less the cited portion, regarding the use of non-uniform grid points as recited in the claim.

The portion relied upon by the Office, at best, discloses that the locations may be in any arrangement, which if taken broadly enough to encompass non-uniform grid arrangement as claimed would also encompass every other arrangement known to man: rows, columns, diagonals, stacks, zig zags, alternating, honeycomb, checkerboard, star, octagonal, circular, rectangular, square, diamond, elliptical, etc. etc. Therefore, at best, Gordon discloses the broad concept of arranging locations in an infinite array of possible locations. Thus, the Office's rational for the rejection fails for two reasons, admittedly there is no recited motivation to modify Benes to use a non-uniform grid, and the interview panel's reliance on KSR is mistaken.

As noted by the Federal Circuit in *Bayer Schering Pharma AG v. Barr Labs*, 575 F.3d 1347 "First, an invention would not have been obvious to try when the inventor would have had to try all possibilities in a field unreduced by direction of the prior art" and "where the prior art gave either no indication of which parameters were critical or no direction as to which of many possible choices is likely to be successful, an invention would not have been obvious." The court goes further to state "It is consistent with our interpretation that KSR requires the number of options to be small or easily traversed."

As demonstrated above, there is no guidance in Gordon or the other cited prior art to use non-uniform grids, nor are the possible arrangements small or limited. Rather, Gordon expresses a generic statement that any possible arrangement could be used and that encompasses an infinite number of possible solutions, and therefore does not meet the KSR criteria.

Thus, absent a teaching, or motivation, or limited possible solutions, a *prima facie* case of obviousness has not been established under Deere or KSR.

G. Gordon does not disclose collection of observed measurement data within a structure.

The Office states:

> Gordon teaches wireless device (i.e. mobile terminal) which may move, and which can receive information allowing to locate the device, from a variety of different locations (see column 4, lines 28-36 and Column 12, lines 9-20) Consequently wireless device may be moved into and out of a building. In which case, the measurements **could be** conducted inside or outside of the building. Furthermore restricting the positioning function only to a specific geographical location would be very limiting and in fact would greatly impact the usefulness of the positioning capability. FOA p. 11 (emphasis added)

The Office's rational for maintaining its rejection in view of the Patent Holder's comments fails for two reasons. First, the ability of wireless devices to move into and out of buildings is not a disclosure of collecting/measuring signal characteristics inside a building, as they perform their primary function in or out of buildings; second, the proposition that the measurements **could be** taken is not an inherent[8] disclosure. Thus, there remains no disclosure on the record that Gordon teaches collecting the claimed observed network measurement data within a structure.

H. Gordon does not teach determining which of said first and second signal characteristics has a greater magnitude, and there is no motivation to combine the teachings of Krumm with Gordon.

The Office asserts that Gordon discloses "determine which of said first and second signal characteristic has a greater magnitude" and cites col. 18, lines 56-61, as a basis. Yet, the Office then acknowledges that if Gordon does not teach the same step, then "Krumm cures this deficiency by teaching a system and method for determining the location of portable devices

[8] "To establish inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.' " In re Robertson, 169 F.3d 743, 745, 49 USPQ2d 1949, 1950-51 (Fed. Cir. 1999)

wherein it is determined which of the first and second characteristics has a greater magnitude, and cites col. 22, lines 65-66, as a basis.

In response to the Patent Holder's arguments on this limitation, the Office remains silent regarding these positions.

The rejection suggested that Krumm cures any deficiency in Gordon regarding this limitation, stating "it would have been obvious to one of ordinary skill....to modify Gordon invention and determine and utilize the signal with strongest magnitude, as taught by Krum, for the purpose of generating the most accurate result." However, in Gordon the differential between the signals is used to pattern match and thus whether the greater magnitude signal in the pair-wise differential is subtracted from the smaller signal, or the smaller signal is subtracted from the larger magnitude signal, is irrelevant and would have no effect on the accuracy of the results. Therefore, there is no correlation between the modification and the motivation, thus a *prima facie* case of obviousness has not been made.

I. Gordon does not teach modifying the observed network measurement data and comparing the modified observed network measurement data with the calibrated network data.

In response to the Patent Holder's comment, the Office now asserts "More specifically, after further consideration, the Examiner maintains that Gordon teaches data modification because using data value in an equation, in this case differential, does modify the data element." However, the Office goes on to recognize that the modified data is not compared to the calibration data, but rather modified calibration data stating:

> Both the measured characterizes and the expected values (i.e. calibration data) are inputted into differential equations in order to compare the results and facilitate correction of a situational error, Therefore, both characteristics and calibration data is modified.

Therefore, the Office acknowledges that in Gordon the modified network measurement data is not compared with the calibration data that was previously gathered as required in the claim. Furthermore, Gordon expressly states for situational errors the network measurements are not compared to expected values. Thus, the comparing step is admittedly not found in the combination.

J. Location probability and confidence measure are not equivalent.

Probability is defined as "a measure or estimation of likelihood of occurrence of an event.[9] Confidence Measure, on the other hand, is defined as a measure of reliability or quality. The two are not equivalent and the Office improperly based its equivalence argument on the assumed fact that the two are similar. Similar and equivalent are not the same and cannot serve as a basis to establish an explicit, implicit, or inherent disclosure required for a *prima facie* case of obviousness.

III. PROPOSED REJECTIONS BASED ON BENES

Benes discloses a method in which the mobile station using information associated with sectors of a base station, determines a signal difference ("SD"), then normalizes that information and compares the signal difference with an antenna gain difference associated with the sectors in order to autonomously determine its location with respect to the base station. Specifically, Benes, using the information, generates effective radiated power ("ERP") metrics for first downlink signals associated with a first antenna in the first sector and generates ERP metrics for second downlink signals associated with a second antenna in the second sector. Benes determines the peak for the first downlink signal ERP ("peak ERP") and determines the peak for the second downlink signal ERP. The difference between the peaks is defined as the signal difference (SD). Benes then calibrates the ERPs of the signals such that the peaks are both 0 dB. Figure 9 shows the calibrated first and second downlink signal ERPs of Figure 8. The angle of arrival ("AoA") of the first signal is estimated as the angle at which the signal difference (SD) between the first and second signals equals the antenna gain difference ("AGD"). In Figure 8 the signal difference (SD) is shown as 10 dB and in Figure 9 the AGD between 904 and 902 at 240 degrees is shown as approximately 10 db. Thus, the AoA of 904 is estimated as 240.

A. Proposed rejections under 35 U.S.C. §102

The Office's proposed rejection of Claims 1, 3, and 11 under 35 U.S.C. §102(b) as being anticipated by Benes is improper.

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[9] "Probability". Webster's Revised Unabridged Dictionary. G & C Merriam, 1913

Benes fails to provide each of the features recited in Claims 1, 3, and 11 and thus these claims are not anticipated[10].

Claim 1, as amended, recites:

> A method for determining a location of a mobile station, comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;
>
> receiving a signal from said first transmitter and receiving another signal from said second transmitter,
>
> collecting observed network measurement data including a first signal characteristic of the signal measured by the mobile station from said first transmitter and a second signal characteristic of the another signal measured by the mobile station from said second transmitter;
>
> determining which of said first and second signal characteristics has a greater magnitude;
>
> modifying said observed network measurement data using the greater magnitude signal characteristic; and
>
> comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Claim 1 requires three types of data: (i) previously-gathered calibration data, (ii) observed network measurement data, and (iii) modified network measurement data. Among other issues regarding the deficiency of the proposed rejection, the latter two types of data are entirely missing from the Benes reference.

"Observed network measurement data" is discussed in the current specification as representing a network characteristic observed (measured) by a mobile station at a particular region, and, as specifically amended, measured by the mobile station.

[10] "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." Verdegaal Bros. v. Union Oil Co. of California, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987).

> Observed network measurement data may be collected (operation 201). The observed data would typically be the same or similar to the data in a network measurement report (NMR). The network measurement data represents at least one network characteristic observed by the mobile station operating at a particular location within a region. 104 Col 9, ll. 41-47
>
> Network measurement data may be then observed and measured typically by a mobile station or any other wireless device (operation 703). *Id* Col. 18, ll. 58-60.
>
> Network measurement data from transmitters may be observed and collected including a signal characteristic from each of the transmitters (operation 903). *Id.* Col. 11, ll. 23-25

As recited in the claims and consistent with the specification, it is the observed network measurement data that is modified to become the "modified network measurement data."

In the proposed rejection, the Office cites Benes [0028] and states the information about the antennas' radiation patterns and the signals' strength correspond to the claimed calibration data. This information ("the information") as noted in Benes may be automatically provided by the base station or the mobile station may request "the information" from the base station.

> ...A mobile station within the communication cell may automatically receive information associated with the plurality of sectors from the base station. **The information** associated with the plurality of sectors may include, but is not limited to, an antenna pattern, a boresight, a downtilt, and a signal strength value associated with each one of the plurality of antennas. The mobile station may receive **the information** associated with the plurality of sectors via a pilot signal strength measurement message or a measurement report message. Alternatively, the mobile station may request for **the information** associated with the plurality of sectors from the base station. Benes [0011] (emphasis added)
>
> ...In response to the request, the mobile station 160 at step 1020 may receive information associated with the plurality of sectors. In particular, **the information** associated with the plurality of sectors may include, but is not limited to, antenna patterns, boresights, downtilts, and signal strength values associated with the plurality of antennas. Alternatively, the mobile station 160 may automatically receive **the information** associated with the plurality of sectors from the base station (i.e., without a request).*Id* [0028] (emphasis added)

It is "the information" (antenna patterns as shown in Figures 4-7 and specifically the antenna patterns in sectors 202 and 204 shown in Figures 8 and 9) received from the base station that the mobile station may use to determine the AoA.

> ...Based on the antenna patterns, the mobile station 160 may autonomously determine an angle of arrival (AOA) estimation by comparing ERPs between the antennas of at least two sectors in a communication cell. *Id.* [0026]

The ERPs are determined from "the information" and by definition (as noted above) are not determined from received signal strength:

> Upon receiving the information associated with the plurality of sectors, the mobile station 160 may determine a power parameter associated with each of the plurality of antennas. For example, the mobile station 160 may determine an effective radiated power (ERP) associated with each of a first sector 202 and a second sector 204 based on their respective signal strength values. *Id.* [0021]

The signal difference (SD) in Benes is determined from "the information":

> ...In particular, a downlink signal 802 from the antenna associated with the first sector 202 has a boresight of 160 degree. azimuth (i.e., degrees from north) and an effective radiated power (ERP) of -80 dB, a downlink signal 804 from the antenna associated with the second sector 204 has a boresight of 230 degree. azimuth and an ERP of -70 dB, and a downlink signal 806 from the antenna associated with the third sector 206 has a boresight of 100 degree. and an ERP of -110 dB. As noted above, persons of ordinary skill in the art will readily appreciate that the ERPs may be compensated for gain differences of the antennas and losses from cables and connectors coupled to the antennas. Based on the ERPs, the mobile station 160 may calculate a signal difference (SD) between the peaks of the downlink signals 802, 804 associated with the antennas corresponding to the first and second sectors 202, 204. For example, the mobile station 160 may determine a signal difference of 10 dB between the first sector 202 and the second sector 204. *Id.* [0026]

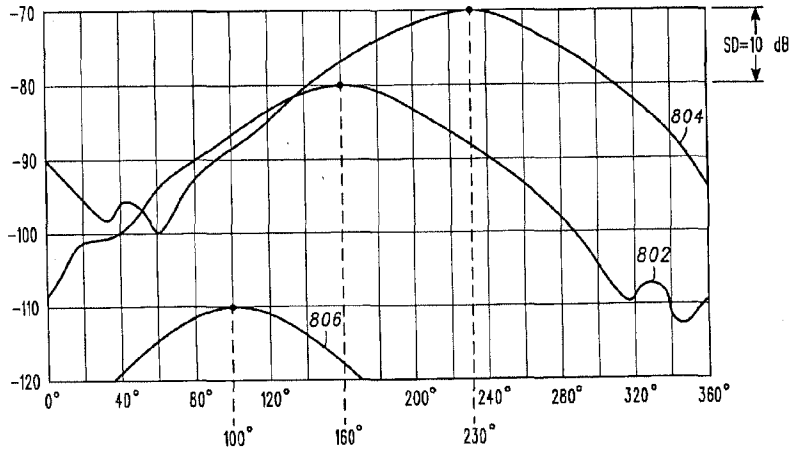

FIG. 8

The signal difference, as shown in Figure 8, is taken as the difference from the Peak ERPs of 804 and 802:

> ...Based on the ERPs, the mobile station 160 may calculate a signal difference (e.g., a change in dB) between the first and second downlink signals. That is, the mobile station 160 may compare the peak ERPs of the first and second downlink signals. *Id.* [0029]

The antenna gain difference (AGD) is also determined from "the information":

> Based on the information associated with the plurality of sectors, the mobile station 160 at step 1030 may determine an antenna gain difference. *Id.* [0029]

Specifically, the antenna gain difference (AGD) is determined from the calibration of the ERP peaks (normalized downlink signals 902 and 904) as shown in Figure 9:

> To determine an antenna gain difference (AGD) for comparison with the signal difference, the mobile station 160 may normalize the downlink signals 802, 804 from the antennas associated with the first and second sectors 202, 204 (shown as 902 and 904, respectively, in FIG. 9). For example, the peak ERPs of the normalized downlink signals 902, 904 may be calibrated to 0 dB. *Id.* [0027]

All the metrics used by the Office in applying Benes to the current claims are taken solely from "the information" provided by the base station. As a result, Benes fails to provide

teachings for the claimed "observed network measurement data" and the "modified network measurement data," which, as noted previously, are measured at the mobile station.

Along with Benes' failure to disclose the observed network measurement data, Benes also fails to disclose modifying the observed network measurements and, further still, modifying the observed network measured data with the signal of greater magnitude.

The Office, in applying Benes to the modifying limitation, cites [0027] and states "wherein normalization corresponds to the step of modification and Figure 9 wherein signals are adjusted using the greater magnitude." However, the normalization disclosed in [0027] of Benes is without regards to the magnitude of the signal with the greater ERP.

Benes recites:

> To determine an antenna gain difference (AGD) for comparison with the signal difference, the mobile station 160 may normalize the downlink signals 802, 804 from the antennas associated with the first and second sectors 202, 204 (shown as 902 and 904, respectively, in FIG. 9). For example, the peak ERPs of the normalized downlink signals 902, 904 may be calibrated to 0 dB. Benes [0027]

Figure 9 below shows both 904 (the greater peak ERP) and 902 (the smaller peak ERP) were simply normalized to a nominal 0 dB, 804 (of Figure 8) was offset by 70 dB and 802 (Figure 8) was offset by 80 dB, to arrive at 904 and 902 respectively.

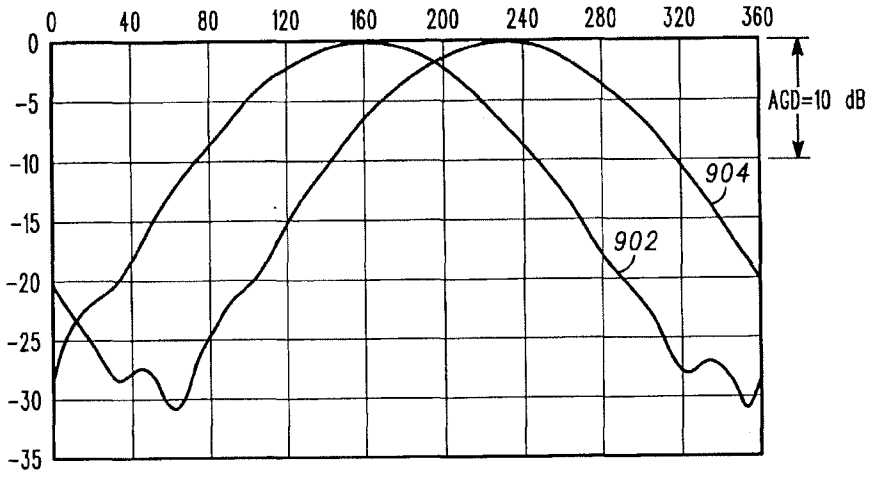

FIG. 9

The modification (normalization) of Benes that the Office relies upon fails for two reasons. First, the modification is not on the observed network measurement data as required in the claims but rather on the data that the Office used for the claimed calibration data, as demonstrated above. Second, the ERPs calculated from the information are not modified "using the greater magnitude signal characteristic." Both ERP peaks are simply calibrated to 0 dB, as shown above. Thus there is no disclosure for the limitation of "modifying said observed network measurement data using the greater magnitude signal characteristic."

Claims 3 and 11 depend from Claim 1 and thus are not anticipated by Benes for at least the same reasons as elaborated above and irrespective of the additional features recited therein. Nonetheless, several of the additional distinctions between Benes and the dependent claims are addressed below.

Claim 3 recites the further limitations of "wherein said observed network measurement data includes data collected at the mobile station."

The Office argues that Benes discloses this limitation because the "mobile station received information associated with the plurality of sectors from a base station" and cites [0028] as a basis.

However [0028] is discussing "the information" received from the base station and not the observed network measurement data that is measured and collected at the mobile station.

Claim 11 recites the further limitations of "the observed network measurement data includes received signal strength of said transmitters as said mobile station."

The Office argues that the "mobile station may receive information about signal strength from multiple transmitters (i.e. antennas). The information is based on the location of the mobile station with respect to the transmitters" and cites [0011] as a basis.

First, the Office's assertion that the information is based on the location of the mobile station with respect to the transmitter is not supported by the referenced citation, nor is it relevant to the disposition of the limitation. Second, the claim specifically recites "received signal strength [at] said mobile station." Received signal strength has a particular meaning to one skilled in the art and it is the strength of the signal as received, as opposed to the signal strength as transmitted[11].

The signal strength reference in [0011] is "a signal strength value associated with each one of the plurality of antennas" and this value is provided by the base station and reflects the nominal transmission power of the respective antenna (a physical property of the antenna). The information received from the base station upon which the Office relies cannot be considered as the received signal strength at the mobile station under any reasonable interpretation[12].

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[11] "[T]he ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, i.e., as of the effective filing date of the patent application." Phillips v. AWH Corp., 415 F.3d 1303, 1313, 75 USPQ2d 1321, 1326 (Fed. Cir. 2005) (en banc); Sunrace Roots Enter. Co. v. SRAM Corp., 336 F.3d 1298, 1302, 67 USPQ2d 1438, 1441 (Fed. Cir. 2003); Brookhill-Wilk 1, LLC v. Intuitive Surgical, Inc., 334 F.3d 1294, 1298 67 USPQ2d 1132, 1136 (Fed. Cir. 2003

[12] During examination, the claims must be interpreted as broadly as their terms reasonably allow. In re American Academy of Science Tech Center, 367 F.3d 1359, 1369, 70 USPQ2d 1827, 1834 (Fed. Cir. 2004) (The USPTO uses a different standard for construing claims than that used by district courts; during examination the USPTO must give claims their broadest reasonable interpretation in light of the specification.).This means that the words of the claim must be given their plain meaning unless the plain meaning is inconsistent

(Continued...)

Benes does not meet each and every limitation within Claims 1, 3 and 11 and therefore cannot anticipate these claims.

B. Proposed rejections under 35 U.S.C. §103

The Office's proposed rejections of Claims 2, 4-7, and 9-11 under 35 U.S.C. §103(a) as being obvious over Benes in view of Gordon are improper.

To establish a *prima facie* case of obviousness, the Office is required to present "some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness."[13] Towards that end, the Office's rational to modify Benes with Gordon is for the purposes of (i) accounting for real-world wireless network coverage regions [in determining location]; (ii) to consider outdoor location of the mobile station [in determining location]; (iii) to consider indoor locations of the mobile [in determining location]; (iv) to use a readily-available signal characteristic for determining the location of the mobile station; and (v) to use a readily-available source of a signal from which to measure signal strength [in determining the location of the mobile station].

However, one skilled in the art would recognize the disclosure of Benes is inoperative to determine the location of a mobile station, as supported in the accompanying §1.132 affidavit. Therefore, one skilled in the art would not be motivated to look at Benes for the purpose of locating a mobile and certainly would understand that the modifications proposed by the Office would not render Benes operable and thus there would be no reasonable expectation of success[14].

(Continued...)

with the specification. In re Zletz, 893 F.2d 319, 321, 13 USPQ2d 1320, 1322 (Fed. Cir. 1989) (discussed below); Chef America, Inc. v. Lamb-Weston, Inc., 358 F.3d 1371, 1372, 69 USPQ2d 1857 (Fed. Cir. 2004)

[13] "'[R]ejections 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 ___, 82 USPQ2d at 1396.

[14] Where there is a reason to modify or combine the prior art to achieve the claimed invention, the claims may be rejected as *prima facie* obvious provided there is also a reasonable expectation of success. In re Merck & Co., Inc., 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986)

Absent such a motivation, a *prima facie* case of obviousness cannot be maintained. For at least this reason the proposed rejections of Claims 2, 4-7, and 9-11 as being obvious over Benes in view of Gordon cannot be maintained.

Claims 2, 4-7, and 9-11 all depend from Claim 1 and the Office depends upon Benes to provide the limitations of Claim 1 (the Office states "Benes teaches all the limitations disclosed in Claim 1"). However, Gordon does not obviate the deficiencies of Benes with respect to Claim 1 as explained above and thus the proposed combination fails to disclose each and every limitation. For at least this reason, a *prima facie* case of obviousness over Benes in view of Gordon cannot be maintained and the proposed rejection is improper. Irrespective of the deficiencies of Benes in view of Gordon addressed above, each one of which on its own sufficiently overcomes the Office's proposed rejection, several additional distinctions between Benes in view of Gordon and the dependent claims are addressed below.

Claim 2, recites *inter alia*:

> wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

The Office, while acknowledging that Benes does not disclose the above limitation, suggests that Gordon teaches that the previously gathered calibration data is for one or more non-uniform grid points within said region and cites col. 9, ll. 9-13 as a basis.

The cited portion of Gordon recites:

> With these considerations in mind, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that partition geographic region 220 into any number of locations of any size, shape, and arrangement. Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use embodiments of the present invention in which the **locations are identical in size and shape.** Gordon Col. 9, 11, 9-16. (emphasis added)

There is nothing in Gordon, much less the cited portion, regarding the use of non-uniform grid points as recited in the claim. There must be either an express or inherent disclosure and clearly there is no express disclosure. There is also no rational, expressed, or existing reason why a non-uniform grid is necessarily present, thus there is also no inherent disclosure. To the

contrary, the passage, as highlighted above, suggests quite the opposite in that the locations are uniform (identical in size and shape). Therefore, at least for this reason the proposed rejection of Claim 2 is improper.

Claim 5 recites *inter alia*:

> said observed network measurement data is collected at a mobile station located within a structure.

The Office relies upon Gordon to provide a disclosure for this limitation stating "locations such as 'four-story building' or 'two-story building' correspond to a location within a structure" and citing col. 9, ll. 17-41. However, these passages in Gordon are with respect to calibration data which the Office acknowledges in the rejection ("It would have been obvious...to modify Benes's method and include **calibration data** gathered at a predetermined points located within a structure" (emphasis added)). Claim 5 requires the collection of **observed network measurement data, not calibration data** within a structure. Furthermore, Claim 5, which depends from Claim 4, requires the collection of calibration data outdoors and observed network measurement data indoors, a combination that is absent in both Benes and Gordon.

Therefore the proposed rejection of Claim 5 as being obvious over Benes and Gordon is improper.

Claims 9 and 10, respectively, recite *inter alia*:

> wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station" and "wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

Thus, the claims require the signal characteristic be the signal strength of **a control channel.** The Office relies upon Gordon to meet this limitation. The Office cites col. 8, ll. 56-59, stating:

> Wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitter (radio stations A and B)

Gordon in the cited passage recites:

> If a given wireless terminal with a broken antenna and at an unknown location receives Radio Station A at -47 dBm and Radio Station B at -61 dBm, then it registers Radio Station A as 14 dBm stronger than Radio Station B. Gordon, Col. 8, ll. 56-59.

Both the rational provided by the Office and the cited portion of Gordon are void of any disclosure of control channel or signal strength of the control channel. Thus, a *prima facie* case of obviousness has not been established.

The Office's proposed rejection of Claims 8-10 and 12-14 under 35 U.S.C. §103(a) as being obvious over Benes in view of Gordon and further in view of Spain is improper.

The Office's rational to modify Benes and Gordon with Spain is for the purpose of determining location of the mobile device. However, as discussed above, one skilled in the art would recognize the disclosure of Benes is inoperative to determine the location of a mobile station. Therefore, one skilled in the art would not be motivated to look at Benes for the purpose of locating a mobile and certainly would understand that the modifications proposed by the Office from Spain would not render Benes operable. Therefore, in addition to having no reasonable expectation of success, a motivation to combine is absent. Absent such a motivation, a *prima facie* case of obviousness cannot be maintained.

For at least this reason the proposed rejections of Claims 8-10 as being obvious over Benes in view of Gordon and further in view of Spain cannot be maintained.

Claims 8-10 depend from Claim 1 and the Office depends upon Benes to provide the limitations of Claim 1 (the Office states "Benes teaches all the limitations disclosed in Claim 1"). However, Gordon and Spain do not obviate the deficiencies of Benes with respect to Claim 1 as explained above and thus the proposed combination fails to disclose each and every limitation. Therefore for at least this reason, a *prima facie* case of obviousness over Benes in view of Gordon and further in view of Spain cannot be maintained and the proposed rejection is improper. Irrespective of the deficiencies of Benes in view of Gordon and further in view of Spain addressed above, at least one of the several distinctions between Benes, Gordon, and Spain and the dependent claims is further addressed below.

Furthermore, Benes does not modify observed network measurement data, nor use differentials of observed network measurement data, and thus the modification proposed would not improve Benes, and thus there is no proper motivation.

IV. PROPOSED REJECTIONS BASED ON GORDON

A. Proposed rejections under 35 U.S.C. §103

The Office incorrectly rejected Claims 1-11 under 35 U.S.C. §103(a) as being obvious over Gordon in view of Krumm.

Claim 1 recites *inter alia*:

> modifying said observed network measurement data using the greater magnitude signal characteristic;
>
> comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

The Office, citing col. 18, lines 17-25, states that Gordon's "correcting situational errors in the measurements is considered data modification" and that the "correction is based on differentials which are essentially the difference between signals" meets the modifying limitation. The Office further states "the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part is based on the strongest signal."

The Office also suggests that Gordon discloses the comparing limitation citing column 16, lines 9-18 and stating "the expected values" are those stored in the database and "measurements" are the data received from transmitters."

However, the Office is incorrect regarding the teachings of Gordon.

Gordon describes a method of using non-GPS techniques for generating location-specific assistance data. The assistance data is used to acquire GPS signals to estimate the mobile device's location. In the portions of Gordon relied upon by the Office, Gordon describes correcting for situational error. Situational errors (broken antennae, low battery, inside a car) are addressed by Gordon by computing differentials.

> In accordance with process 1103, location server 214 computes the differentials, in those cases that are appropriate, of the measurements to correct the situational errors in the measurements received in process 1001. Many factors, including the condition of wireless terminal 201's antenna, the state of its battery, and whether or not the terminal is inside a vehicle can introduce situational measurement errors. This is particularly true for measurements of pathloss and signal strength. Gordon at col. 18, ll. 18-25

Gordon explicitly explains that in order to account for these situational errors, pattern matching with the measurements are not undertaken, but rather pair-wise differentials of the measurements are matched with pair-wise differentials of the expected values:

> The illustrative embodiment ameliorates the effects of these factors by pattern matching not the measurements themselves...to the expected values for those trails, but by pattern matching the pair-wise differentials of those measurements to the pair-wise differentials of the expected values for those traits. *Id* Col. 18, ll. 26-34

The correction relied upon by the Office is not of the observed measurement data, but of the situation. The observed measurement data is not changed or modified, but rather a difference is computed. Thus, the Office's rational "the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part is based on the strongest signal" is incorrect. Simply stated, **the differential does not modify any data.**

The Office's suggestion that the "measurements" (data received from transmitters) are compared with the "expected values", which meets the comparing limitation, is insufficient. First, the claim requires the modified network measurement data to be compared, and, as noted above, the data received from the transmitters is not modified. Second, Gordon expressly states for situational errors the network measurements are not compared to expected values. *See Id.*

Gordon provides an illustrative example, where the observed measurements from radio A and radio B are neither modified nor compared with the expected values, but rather the differential between radio A and radio B (without respect to which has the greater magnitude) is compared with the difference between the expected values of radio A and radio B:

A simple example involving signal strengths illustrates this approach. A first radio station, Radio Station A, can be received at -56 dBm at Location 1, -42 dBm at Location 2, -63 dBm at Location 3, and -61 dBm at Location 4, and a second radio station, Radio Station B, can be received at -63 dBm at Location 1, -56 dBm at Location 2, -65 dBm at Location 3, and -52 dBm at Location 4. This information is summarized in the table below and forms the basis for a map or database that correlates location to signal strength. Col. 18, ll. 36-44

TABLE 3

Illustrative Location-Trait Database (Differential Reception)

	Radio Station A	Radio Station B	Difference
Location 1	−56 dBm	−63 dBm	−7 dB
Location 2	−42 dBm	−56 dBm	−14 dB
Location 3	−63 dBm	−65 dBm	−2 dB
Location 4	−61 dBm	−52 dBm	9 dB

If a given wireless terminal with a broken antenna and at an unknown location receives Radio Station A at -47 dBm and Radio Station B at -61 dBm, then it registers Radio Station A as 14 dBm stronger than Radio Station B. This suggests that the wireless terminal is more likely to be at Location 2 than it is at Location 1, 3, or 4. If the measured signal strengths themselves were pattern matched into Location-Trait Database 313, the resulting probability distribution for the location of wireless terminal 201 might not be as accurate. col. 18, ll. 56-64

Gordon, in much the same manner as the Office recognized in Spain, determines a difference between observed network measurement data but does not modify the first and second signal characteristics that make up the observed network measurement data. Additionally, neither the observed network measurement data nor the computed difference is compared with the collected calibration data as required by the claim.

Claim 1 further recites:

> determining which of said first and second signal characteristics has a greater magnitude;

The Office suggests that Krumm cures any deficiency in Gordon regarding this limitation, stating "it would have been obvious to one of ordinary skill....to modify Gordon invention and determine and utilize the signal with strongest magnitude, as taught by Krum, for the purpose of generating the most accurate result." However, in Gordon, the differential between the signals is used to pattern match, and thus whether the greater magnitude signal in the pair-wise differential is subtracted from the smaller signal, or the smaller signal is subtracted from the larger magnitude signal, is irrelevant and would have no effect on the accuracy of the results. Therefore, there is no correlation between the modification and the motivation, thus a *prima facie* case of obviousness has not been made.

Claims 2-11 depend from Claim 1 and thus are not obvious over Gordon in view of Krumm for at least the same reasons as elaborated above, irrespective of the additional features recited. Nonetheless, several of the additional distinctions between Gordon in view of Krumm and the dependent claims are addressed.

Claim 2 recites *inter alia*:

> wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

As discussed with respect to the proposed rejection of Claim 2 over Benes in view of Gordon (see above), Gordon does not expressly or inherently disclose the use of non-uniform grid points as recited in the claims. Therefore at least for this reason, the proposed rejection of Claim 2 is improper.

Claim 8 recites *inter alia*:

> wherein the modifying of said calibration data uses a difference between said first or second signal characteristics.

The Office cites col. 18, ll. 17-25 and states that Gordon teaches "differentials are used to correct the error in measurements and differential is a difference between two signals."

Irrespective that the measurements described in that portion of Gordon are not modified, as discussed previously, the differential in measurements that Gordon is describing is not related to the calibration data (expected values) as required in the claims but relates to a differential in observed network measurement data. Therefore the proposed rejection is improper.

Claims 9 and 10, respectively, recite *inter alia*:

> wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station" and "wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

The claims require that the signal characteristic be the signal strength of **a control channel.** The Office relies upon Gordon to meet this limitation. The Office, citing Col. 8, ll. 56-59, states:

> Wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitter (radio stations A and B)

As discussed regarding the proposed rejection of Claims 9 and 10 with respect to Benes in view of Gordon, both the rationale provided by the Office and the cited portion of Gordon are void of any disclosure of control channel or signal strength of the control channel. Thus, a *prima facie* case of obviousness has not been established.

The Office's proposed rejection of Claims 8-10 and 12-14 under 35 U.S.C. §103(a) as being obvious over Gordon in view of Krumm and further in view of Spain are improper.

Claims 8-10 and 12-14 all depend from Claim 1 and the Office depends upon Gordon and Krumm to provide the limitations of Claim 1. However, Spain does not obviate the deficiencies of Gordon in view of Krumm with respect to Claim 1, as explained above, and thus the proposed combination fails to disclose each and every limitation. Therefore, for at least this reason, a *prima facie* case of obviousness over Gordon in view of Krumm and further in view of Spain cannot be maintained and the proposed rejection is improper.

Irrespective of the deficiencies of Gordon in view of Krumm and further in view of Spain addressed above, at least one of the several distinctions between Gordon, Krumm, and Spain and the dependent claims is addressed below.

The Office acknowledges that Gordon in view of Krumm does not disclose the features of Claim 12 and relies upon Spain to provide the disclosure.

The Office incorrectly asserts that Gordon teaches a data set comprising signal strength differentials which are used to modify measurement data and cites to col 18, ll. 17-25. However, as discussed previously, the differentials are not used to modify the measurement data.

Gordon also does not teach that the observed network measurement data includes "TA representing a timing advance parameter." As discussed previously, the round trip time and the ΔT are not timing advance parameters.

Spain fails to disclose a modified network measurement data set as claimed as described earlier with respect to the proposed rejection of Claim 12 with Benes, Gordon, and Spain. Therefore, a *prima facie* case of obviousness has not been established.

B. Proposed rejections under 35 U.S.C. 102(a)

The proposed rejection of Claims 15-21 under 35 U.S.C. 102(a) as being anticipated by Gordon is improper.

Claim 15 recites *inter alia*:

> determining a confidence measure for each of the plurality of location estimates;
>
> determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.

The Claim requires the determination of a confidence measure and determining the location of the mobile station at least based on the confidence measure. Gordon does not disclose a confidence measure.

The Office's argument equates "confidence measure" of the claims with "probabilities of location" of Gordon. However, the confidence measure of a location as used in the specification and as known in the art is not the same as a probability location being the actual location of a mobile station as described in Gordon.

The '104 patent states:

> A confidence measure may also be used to represent the accuracy of a mobile station's estimated location. col 7, ll. 65-67.

Gordon does not discuss confidence measure, Gordon however describes the probability as the likelihood that a mobile station will be in a location. Gordon recites:

> The term "staying probability" is defined as an estimate of the probability P.sub.S(b, T, N, W) that wireless terminal W in location b at calendrical time T will still be in location b at time T+.DELTA.t, given environmental conditions, N. The term "moving probability" is defined as an estimate of the probability P.sub.M(b, T, N, W, c) that wireless terminal W in location b at calendrical time T will be in adjacent location c at time T+.DELTA.t, given environmental conditions, N. col. 3, ll. 52-60

While confidence measure and probability may be related, they are not the same and the Office has only presented conclusory statements of their equality. A disclosure of a probability is not a disclosure of a confidence measure for the purposes of an anticipation rejection.

Claims 16-21 depend from Claim 15 and thus each require a confidence measure which is absent from Gordon. Therefore, for at least the same reason articulated with respect to Claim 15, the proposed rejections of Claims 16-21 are also improper.

CONCLUSION

Patent Holder has demonstrated that the anticipation and obviousness rejections proposed by the Office fail to meet the statutory requirements and thus should not be maintained. Benes, Gordon, Spain, and Krum alone or in combination have not been demonstrated to disclose each and every limitation recited in the claims. The Patent Holder's arguments have not been rebutted. The claims are allowable and a reexamination certificate should be issued accordingly.

If the Examiner believes that any additional changes would place the application in better condition for allowance, the Examiner is invited to contact the undersigned attorney at the telephone number listed below.

Respectfully submitted,

/Mark C. Comtois/

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Dated: 6 January 2014

Certificate of Service

I hereby certify that on 6 January 2014, I caused to be mailed, by First Class Mail, a copy of the Supplemental Amendment in the Reexamination of U.S. Patent 7,561,104, Reexamination Control Number 90/012,694, as submitted to the United States Patent and Trademark Office, to the Third Party Requestor:

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Electronic Acknowledgement Receipt

EFS ID:	17830625
Application Number:	90012694
International Application Number:	
Confirmation Number:	6575
Title of Invention:	Method to modify calibration data used to locate a mobile unit
First Named Inventor/Applicant Name:	7,561,104 B2
Customer Number:	79172
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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Supplemental Response or Supplemental Amendment	and01082resuppamend.pdf	3630957 c963262ecf2c3c7b2612ac99f0c9eb6099ec0bb2	no	40

Warnings:	
Information:	

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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 Martin Alles, et al.

Serial No.: 90/012,694 Art Unit: 3992 Confirmation No: 6575

Filed: 24 September 2012 Examiner: Angela M. Lie

Title: METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE DEVICE

AMENDMENT

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

Sir:

In response to the Office Action dated 25 October 2013, Patent Holder submits the following:

Patent Holder's **Amendment to the Claims** begin on sheet 2 of this paper; and

Patent Holder's **Remarks** begin on sheet 5 of this paper.

Amendment to the Claims:

1. (Amended) A method for determining a location of a mobile station, comprising:

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

receiving a signal from said first transmitter and receiving another signal from said second transmitter,

collecting observed network measurement data including a first signal characteristic of the signal measured by the mobile station from said first transmitter and a second signal characteristic of the another signal measured by the mobile station from said second transmitter;

determining which of said first and second signal characteristics has a greater magnitude;

modifying said observed network measurement data using the greater magnitude signal characteristic; and

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

8. (Amended) The method of Claim 7 wherein the modifying of said [[calibration]] observed network measurement data uses a difference between said first or second signal characteristics.

11. (Amended) The method of Claim 1, wherein the observed network measurement data includes received signal strength of said transmitters [[as]] at said mobile station.

12. (Amended) A method for determining a location of a mobile station, comprising:

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

determining which of said first and second signal characteristics has a greater magnitude;

modifying said observed network measurement data using the greater magnitude signal characteristic; and

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station;

[[The method of Claim 41]] wherein said observed network measurement data includes a data set comprising:

$[P_1, P_2..., P_n, TA]$

where:

P_1 represents the signal strength of said first transmitter as measured at said mobile station,

P_2 represents a signal strength of said second transmitter as measured at said mobile station wherein $P_2 > P_1$,

P_n represents a signal strength of a n^{th} transmitter as measured at said mobile station wherein $P_2 > P_n$, and

TA represents a timing advance parameter;

and wherein said modified network measurement data includes a data set comprising:

$[P_2-P_1, 0, P_2-P_n, TA]$

where:

P_2-P_1 represents a difference between P_2 and P_1,

0 represents a difference between P_2 and P_2, and

P_2-P_n represents a difference between P_2 and P_n.

15. (Amended) A method for determining a location of a mobile station, comprising:

providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network;

measuring characteristics of the network by the mobile station at the location to obtain [[obtaining]] network measurement data;

comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station

determining a confidence measure for each of the plurality of location estimates;

determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.

REMARKS

I. INTRODUCTION

Claims 1-21 of U.S. Patent No. 7,561,104 (" '104") are pending.

The proposed rejections have been maintained for Claims 1-11 and 15-21, the proposed rejections of Claims 12-14 have been withdrawn.

Claims 1, 8, 11, 12 and 15 have been amended.

Claim 12 has been rewritten into independent form, including all the limitations of the base claim.

Claims 1 and 15 have been amended to more clearly recite the observed network measurement data is measured by the mobile at the location. Specifically, Claim 1 as amended recites *inter alia*:

> receiving a signal from said first transmitter and receiving another signal from said second transmitter,
>
> collecting observed network measurement data including a first signal characteristic of the signal measured by the mobile station from said first transmitter and a second signal characteristic of the another signal measured by the mobile station from said second transmitter;

and Claim 15 recites *inter alia*:

> measuring characteristics of the network by the mobile station at the location to obtain network measurement data;

Support for these amendments are found throughout the Specification and specifically in the Abstract, Col. 1 ll. 33-40, 55-60;Col. 5, ll. 33-57; Col. 6, ll. 24-52; Col 7, ll. 20-30 and Col. 10, ll. 58-60.

These amendments are included to address concerns of the panel discussed during the interview. A summary of the interview is included as a separate sheet in this response.

Claims 8 and 11 have been amended to correct typographic errors.

II. RESPONSE TO OFFICE'S COMMENTS

A. Declaration

The Office found the Affidavit by Dr. Torrico unpersuasive. However, the Office as evident from the interview, failed to understand the content and purpose of the Affidavit. The Patent Holder's purpose in submitting the Affidavit was to demonstrate that one skilled in the art would not consider Benes to be useful in locating a mobile device and thus would not look to Benes in creating a location system that had a reasonable chance for success. The fundamental underpinning of an obviousness type rejection is to achieve success.[1]

The Office recognizes a fundamental truth: "It is correct that the location of the mobile station cannot be determined solely based on the information about characteristics of the transmitters" (FOA p. 5), which reflects Declaration No. 7. The Office offers in rebuttal to the Affidavit "This is precisely the reason why the mobile device determines an effective radiated power (ERP) based on the respective signals' strength values" and thus "Consequently, the characteristics about the source along with the magnitude of the received signals allow determining the location of the mobile device". (citing to paragraph [0021])

If (*aguendo*) the ERP determined by Benes was based on the mobile station's measurement of the signal strength of the received signals (magnitude of the received signals), the Patent Holder's Arguments would indeed ring hollow. However, ERP[2,3] by definition is not

---

[1] Where there is a reason to modify or combine the prior art to achieve the claimed invention, the claims may be rejected as *prima facie* obvious provided there is also a reasonable expectation of success. In re Merck & Co., Inc., 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986)

[2] effective radiated power (e.r.p.) (in a given direction): 1. The power supplied to an antenna multiplied by the antenna gain in a given direction. (188) Note 1: If the direction is not specified, the direction of maximum gain is assumed. Note 2: The type of reference antenna must be specified. 2. The product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction. (Institute for Telecommunication Sciences. Retrieved 2008-08-29)

[3] In electromagnetic transmission systems, especially those dealing with telecommunications, effective radiated power or equivalent radiated power (ERP) is a standardized theoretical

(Continued...)

based, nor can it be based, on the signal strength of the received signal. Absent from Benes is any contrary disclosure which creates a new meaning to ERP. Therefore, it follows from the Office's own remarks, along with assertions offered in the affidavit, that the location "cannot be determined" and thus Benes is inoperative for the purpose for which it is intended. This is exactly what the affidavit points out.

The ERPs are determined from "the information":

> Upon receiving **the information** associated with the plurality of sectors, the mobile station 160 may determine a power parameter associated with each of the plurality of antennas. For example, the mobile station 160 may determine an effective radiated power (ERP) associated with each of a first sector 202 and a second sector 204 based on their respective signal strength values. *Id.* [0021] (emphasis added)

Paragraph [0021] demonstrates that the ERP is determined from "the information." This information ("the information') as noted in Benes is automatically provided by the base station or the mobile station may request "the information" from the base station.

> ....A mobile station within the communication cell may automatically receive information associated with the plurality of sectors from the base station. **The information** associated with the plurality of sectors may include, but is not limited to, an antenna pattern, a boresight, a downtilt, and a signal strength value associated with each one of the plurality of antennas. The mobile station may receive **the information** associated with the plurality of sectors via a pilot signal strength measurement message or a measurement report message. Alternatively, the mobile station may request for **the information** associated with the plurality of sectors from the base station. Benes [0011] (emphasis added)

(Continued...)

> measurement of radio frequency (RF) energy[1][2] using the SI unit watts, and is determined by subtracting system losses and adding system gains. ERP takes into consideration transmitter power output (TPO), transmission line attenuation (electrical resistance and RF radiation), RF connector insertion losses, and antenna directivity, but not height above average terrain (HAAT). ERP is typically applied to antenna systems.

> ...In response to the request, the mobile station 160 at step 1020 may receive information associated with the plurality of sectors. In particular, **the information** associated with the plurality of sectors may include, but is not limited to, antenna patterns, boresights, downtilts, and signal strength values associated with the plurality of antennas. Alternatively, the mobile station 160 may automatically receive **the information** associated with the plurality of sectors from the base station (i.e., without a request).*Id* [0028] (emphasis added)

Benes further explains the ERPs are associated with downlink signals 802, 804 and 806.

> In particular, a downlink signal 802 from the antenna associated with the first sector 202 has a boresight of 160 degree azimuth (i.e., degrees from north) and an effective radiated power (ERP) of -80 dB, a downlink signal 804 from the antenna associated with the second sector 204 has a boresight of 230 degree. azimuth and an ERP of -70 dB, and a downlink signal 806 from the antenna associated with the third sector 206 has a boresight of 100 degrees and an ERP of -110 dB....[0026]

These ERP's are determined from calibration data and not from measurements at the mobile station. The ERP's of -70, -80 and -110 cannot possibly be measured by the mobile station, as these occur at the boresight of each antenna (240, 160, and 100, respectively) and the mobile station CANNOT be at the three locations at once as shown in Figure 8. (See also Declaration No. 8)

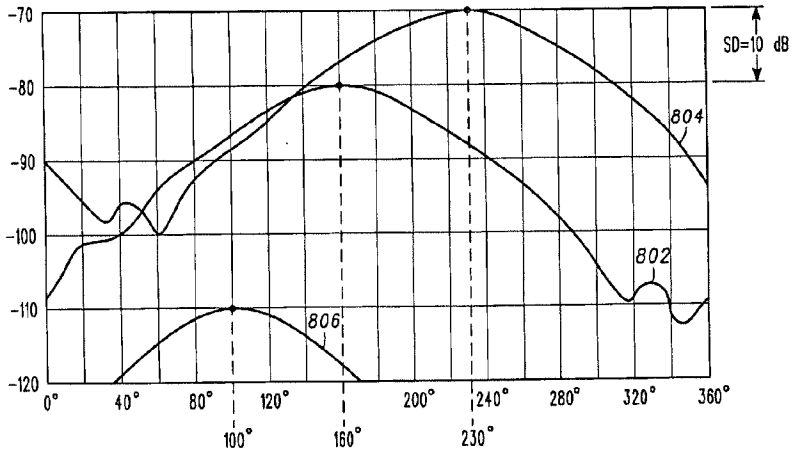

FIG. 8

Thus, Benes does not measure the received signal strength by the mobile station which is to be located (See Declaration No 6), and thus in addition to failing to meet the claim limitations as previously intended and now amended, cannot be used in an obviousness type rejections as there is no probability of success.[4,5] As the Office states "the location of the mobile station cannot be determined solely based on the information about characteristics of the transmitters" which is precisely what Benes seeks to do (See Declaration No. 10).

In addition, the Evidence presented by the Office has been rebutted, and thus the Affidavit should be persuasive to overcome the *prima facie* case of obviousness.[6]

B. Interpretation of "Collecting Observed Network Measurement data"

The Office, as revealed in the interview, broadly interpreted "the collection of observed Network measurement data" as not requiring such data to be observed/measured by the mobile station and thus was indistinguishable from the stored calibration data that was previously gathered.

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[4] Life Tech. v. Clontech Labs., 224 F.3d 1320. Reasonable expectation of success is assessed from the perspective of the person of ordinary skill in the art.

[5] Otsuka Pharm. Co. v. Sandoz, Inc. 678 F.3d 1280. The second inquiry in the analysis is whether the prior art would have supplied one of ordinary skill in the art with a reason or motivation to modify a lead compound to make the claimed compound with a reasonable expectation of success"

[6] *Consideration of evidence.* Evidence traversing rejections, when timely presented, must be considered by the examiner whenever present. All entered affidavits, declarations, and other evidence traversing rejections are acknowledged and commented upon by the examiner in the next succeeding action. The extent of the commentary depends on the action taken by the examiner. Where an examiner holds that the evidence is sufficient to overcome the *prima facie* case, the comments should be consistent with the guidelines for statements of reasons for allowance. *See* MPEP § 1302.14. Where the evidence is insufficient to overcome the rejection, the examiner must specifically explain why the evidence is insufficient. General statements such as "the declaration lacks technical validity" or "the evidence is not commensurate with the scope of the claims" without an explanation supporting such findings are insufficient. [MPEP § 716.01 (B)]

Given this interpretation, the Office justified its reliance upon Benes as anticipating Claims 1, 3, and 11, and further the obviousness type rejections of Claims 2, 4-7, and 9-11.

The Claims have been amended to ameliorate the Office's concerns regarding the interpretation of Collecting Observed Network Measurement data.

> 1. A method for determining a location of a mobile station, comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;
>
> receiving a signal from said first transmitter and receiving another signal from said second transmitter,
>
> collecting observed network measurement data including a first signal characteristic of the signal measured by the mobile station from said first transmitter and a second signal characteristic of the another signal measured by the mobile station from said second transmitter;
>
> determining which of said first and second signal characteristics has a greater magnitude;
>
> modifying said observed network measurement data using the greater magnitude signal characteristic; and
>
> comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Claim 1 as amended clearly requires the mobile station (the location of which is to be determined) to receive and measure characteristics of the signals to determine the observed network measurement data, thus the observed network measurement data is distinguished from the previously gathered calibration data.

C. The Office's assertion that Benes teaches "observed network measurement data"

In response to the Patent Holder's assertion that Benes does not disclose measuring signals received at the mobile station to determine Observed network measurement data, the Office states that Benes teaches:

1. "observed network measurement data" in paragraphs [0026] wherein effective radiated power measured in dB corresponds to signal (i.e. downlink signal) characteristic

and

2. furthermore, there are multiple antennas (i.e. transmitters) and each of them has its corresponding signal strength received at the mobile stations. (FOA, p. 6)

With respect to the first assertion, paragraph [0026] does not disclose that the ERP is determined from measuring a received signal, but rather from "the information". Benes states:

> [0026] Based on the antenna patterns, the mobile station 160 may autonomously determine an angle of arrival (AOA) estimation by comparing ERPs between the antennas of at least two sectors in a communication cell. To illustrate the concept of determining an AOA estimation, downlink signals from antennas associated with the first sector 202 and the second sector 204 are shown in FIGS. 8 and 9 (i.e., FIGS. 8 and 9 are linear plots whereas FIGS. 4-7 are polar plots). In particular, a downlink signal 802 from the antenna associated with the first sector 202 has a bore sight of 160 degree. azimuth (i.e., degrees from north) and an effective radiated power (ERP) of -80 dB, a downlink signal 804 from the antenna associated with the second sector 204 has a bore sight of 230 degree azimuth and an ERP of -70 dB, and a downlink signal 806 from the antenna associated with the third sector 206 has a bore sight of 100 degree and an ERP of -110 dB. As noted above, persons of ordinary skill in the art will readily appreciate that the ERPs may be compensated for gain differences of the antennas and losses from cables and connectors coupled to the antennas. Based on the ERPs, the mobile station 160 may calculate a signal difference (SD) between the peaks of the downlink signals 802, 804 associated with the antennas corresponding to the first and second sectors 202, 204. For example, the mobile station 160 may determine a signal difference of 10 dB between the first sector 202 and the second sector 204. With stronger peak ERPs in the downlink signals 802, 804 from the antennas associated with the first and second sectors 202, 204, downlink signals with weaker peak ERPs such as the downlink signal 806 from the antenna associated with the third sector 206 may not be necessary to determine the AOA estimation. (emphasis added)

Benes, as discussed previously, uses only "the information" received from the base station to determine ERPs and then uses ERPs to calculate a signal difference SD.

In the underlined portions above, Benes discusses downlink signals from the antennas are shown in Figures 8 and 9. The downlink signals shown in Figures 8 and 9 are based on previously collected calibration data and in no manner serve as a disclosure of receiving a signal and measuring characteristics of the signal by the mobile to be located. Furthermore, Benes calculates a signal difference between the peaks of the downlink signals. Such a feat is only possible using previously collected calibration data such as that provided in the NMR. If the downlink signals were received and measured by the mobile station at its location, the peaks would not be ascertainable, rather only two points would be determinable, the first characteristic and the second characteristic. The reference to downlink signals in Benes is not to the signal as received but rather the properties of the downlink signals transmitted. As noted above, Benes is inoperable and returns to the same location regardless of the mobiles actual location (Declaration No. 7), because it does not receive a signal and then determine its characteristics by measuring.

With respect to the second assertion, there is no argument that each downlink signal has a received signal strength when received by a receiver. However, the disclosure of Benes does not measure or determine the actual received signal strength but rather relies upon what "the information" reports as the signal strength. Nowhere in the disclosure of Benes is a disclosure for receiving a signal, measuring characteristics of the signal, and using those measurements to determine observed network measurement data. The Office attempts to read into Benes disclosures that are simply not there.

D. Benes does not disclose modifying the Observed Network Measurement data.

The Office states:

> The "observed network measurement data" is modified via the step of normalization as described in paragraph [0027].

However, in [0027], as previously described, "the mobile station normalize the downlink signal 802 and 804 from the antennas associated with the first and second sectors 202, 204" and as an example of this normalization, Benes describes "For example, the peak ERPs of the normalized downlink signals 902, 904 may be calibrated to 0 dB. Based on the antenna gain difference, the mobile station 160 may determine an angle of arrival (AOA) estimation." As noted previously the peaks are normalized as shown in Figure 9.

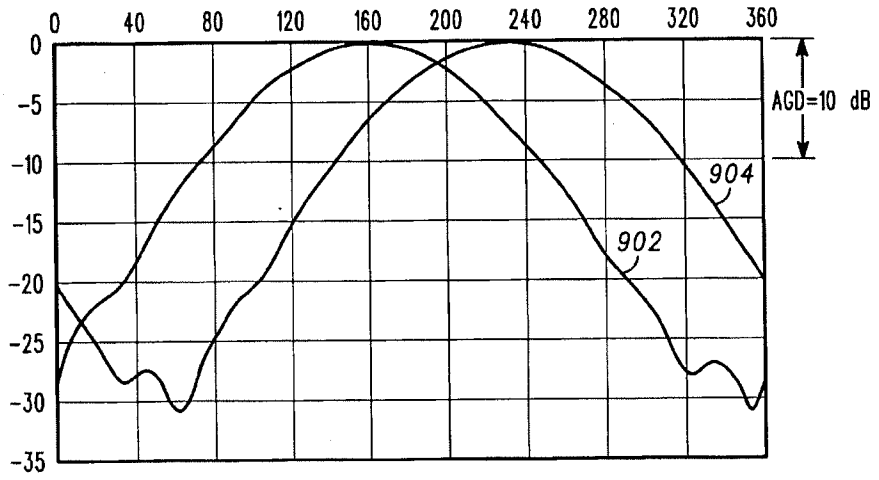

FIG. 9

Clearly the only data normalized in Figure 9 is that received from the base station represented in Figure 8. Benes further describes "the mobile station 160 may determine that the downlink signal 804 from the antenna associated with the second sector 204 is stronger than the downlink signal 802 from the antenna associated with the first sector 202 (i.e., a peak ERP of -70 dB is greater a peak ERP of -80 dB, respectively)" which again may only be surmised from the information received from the base stations and not measuring (observing) characteristic of the received signal at the particular mobile station. The Office's use of ERP to demonstrate the observed or measured received signal strength is erroneous.

Benes' normalization of the peaks thus is not modification of the observed network measurement data but rather modification of the calibration data.

E. The information is not based on the location of the mobile station with respect to the transmitter.

The Office, in response to the Patent Holders argument that the information is not based on the location of the mobile station with respect to the transmitter, argues that:

1. Benes teaches the information being based on the location of the mobile station with respect to the transmitter citing paragraph [0022];

2. Benes teaches that the mobile station determined an effective radiated power associated with each sector based on their respective signal strength values citing paragraph [0021].

The Patent Holder asserts the Office's understanding of Benes is incorrect.

The information sent by the base station, as discussed in [0022] of Benes, is of the characteristics of the antennas, and not specific to the location of the mobile.

> [0022] Referring to FIG. 4, an antenna pattern 410 (i.e., physical property of an antenna) associated with an antenna is shown. The antenna pattern 410 may indicate the variation of field intensity of an antenna as an angular function with respect to an axis, i.e., either a horizontal or vertical plane. In particular, the antenna pattern 410 may have a reference boresight (i.e., a direction in which the antenna may be pointed) of 0 degree.. Although the embodiments disclosed herein are particularly well suited for use with horizontal patterns, persons of ordinary skill in the art will readily appreciate that the teachings of this disclosure are in no way limited to the horizontal patterns shown in FIGS. 4, 5, 6 and 7. On the contrary, persons of ordinary skill in the art will readily appreciate that the teachings of this disclosure can be employed with a vertical pattern of the antenna. Depending on the desired accuracy and/or the available storage capacity, the antenna pattern 310 may be entirely digitized and stored with the mobile station 160.

The Office simply cannot base its argument on paragraph [0022].

With respect to the Office's second assertion that Benes uses the "respective signal strength values" to calculate the ERP, the Office's inference is incorrect. In order for the Office's statement regarding Benes to have any bearing on the rejection, the "respective signal strength values" must be read as "respective received signal strength of the received signal," but such is not the case. As noted above and in the previous response, ERP is not calculated from received signal strength, there is no disclosure in Benes that the ERPs are determined based on the signal strength of the received signal. Paragraph [0021] upon which the Office relies states:

> [0021] Upon receiving the information associated with the plurality of sectors, the mobile station 160 may determine a power parameter **associated with each of the plurality of antennas.** For example, the mobile station 160 may determine an effective radiated power (ERP) associated with each of a first sector 202 and a second sector 204 based on their respective signal strength values. Persons of ordinary skill in the art will readily appreciate that the ERPs may be compensated for gain differences of the antennas and losses from cables and connectors coupled to the antennas. (emphasis added)

The ERP is, and can only be associated with the antennas and determined from the information provided and not from received signal strength measurements.

F. Non-Uniform Grid

The Office maintains the rejection of Claim 2 because Gordon teaches "any number of locations of any size shape and arrangement" is a teaching of "calibration data for one or more non-uniform grid points within the region."

During the interview, the panel noted that an explicit or inherent disclosure was not necessary, nor was a motivation required under KSR[7], instead it would be obvious to try.

The Patent Holder asserts that the cited passage from Gordon is not an explicit or inherent disclosure and a motivation is necessary under KSR.

Claim 2, recites *inter alia*:

> wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

[7] *KSR Int'l v Teleflex Inc* 550 U.S. 398

The cited portion of Gordon recites:

> With these considerations in mind, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that partition geographic region 220 into any **number of locations of any size, shape, and arrangement.** Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use embodiments of the present invention in which the **locations are identical in size and shape.** Gordon Col. 9, 11, 9-16. (emphasis added)

There is nothing in Gordon, much less the cited portion, regarding the use of non-uniform grid points as recited in the claim.

The portion relied upon by the Office, at best, discloses that the locations may be in any arrangement, which if taken broadly enough to encompass non-uniform grid arrangement as claimed would also encompass every other arrangement known to man: rows, columns, diagonals, stacks, zig zags, alternating, honeycomb, checkerboard, star, octagonal, circular, rectangular, square, diamond, elliptical, etc. etc. Therefore, at best, Gordon discloses the broad concept of arranging locations in an infinite array of possible locations. Thus, the Office's rational for the rejection fails for two reasons, admittedly there is no recited motivation to modify Benes to use a non-uniform grid, and the interview panel's reliance on KSR is mistaken.

As noted by the Federal Circuit in *Bayer Schering Pharma AG v. Barr Labs*, 575 F.3d 1347 "First, an invention would not have been obvious to try when the inventor would have had to try all possibilities in a field unreduced by direction of the prior art" and "where the prior art gave either no indication of which parameters were critical or no direction as to which of many possible choices is likely to be successful, an invention would not have been obvious." The court goes further to state "It is consistent with our interpretation that KSR requires the number of options to be small or easily traversed."

As demonstrated above, there is no guidance in Gordon or the other cited prior art to use non-uniform grids, nor are the possible arrangements small or limited. Rather, Gordon expresses a generic statement that any possible arrangement could be used and that encompasses an infinite number of possible solutions, and therefore does not meet the KSR criteria.

Thus, absent a teaching, or motivation, or limited possible solutions, a *prima facie* case of obviousness has not been established under Deere or KSR.

G. Gordon does not disclose collection of observed measurement data within a structure.

The Office states:

> Gordon teaches wireless device (i.e. mobile terminal) which may move, and which can receive information allowing to locate the device, from a variety of different locations (see column 4, lines 28-36 and Column 12, lines 9-20) Consequently wireless device may be moved into and out of a building. In which case, the measurements **could be** conducted inside or outside of the building. Furthermore restricting the positioning function only to a specific geographical location would be very limiting and in fact would greatly impact the usefulness of the positioning capability. FOA p. 11 (emphasis added)

The Office's rational for maintaining its rejection in view of the Patent Holder's comments fails for two reasons. First, the ability of wireless devices to move into and out of buildings is not a disclosure of collecting/measuring signal characteristics inside a building, as they perform their primary function in or out of buildings; second, the proposition that the measurements **could be** taken is not an inherent[8] disclosure. Thus, there remains no disclosure on the record that Gordon teaches collecting the claimed observed network measurement data within a structure.

H. Gordon does not teach determining which of said first and second signal characteristics has a greater magnitude, and there is no motivation to combine the teachings of Krumm with Gordon.

The Office asserts that Gordon discloses "determine which of said first and second signal characteristic has a greater magnitude" and cites col. 18, lines 56-61, as a basis. Yet, the Office then acknowledges that if Gordon does not teach the same step, then "Krumm cures this deficiency by teaching a system and method for determining the location of portable devices

[8] "To establish inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.' " In re Robertson, 169 F.3d 743, 745, 49 USPQ2d 1949, 1950-51 (Fed. Cir. 1999)

wherein it is determined which of the first and second characteristics has a greater magnitude, and cites col. 22, lines 65-66, as a basis.

In response to the Patent Holder's arguments on this limitation, the Office remains silent regarding these positions.

The rejection suggested that Krumm cures any deficiency in Gordon regarding this limitation, stating "it would have been obvious to one of ordinary skill....to modify Gordon invention and determine and utilize the signal with strongest magnitude, as taught by Krum, for the purpose of generating the most accurate result." However, in Gordon the differential between the signals is used to pattern match and thus whether the greater magnitude signal in the pair-wise differential is subtracted from the smaller signal, or the smaller signal is subtracted from the larger magnitude signal, is irrelevant and would have no effect on the accuracy of the results. Therefore, there is no correlation between the modification and the motivation, thus a *prima facie* case of obviousness has not been made.

I. Gordon does not teach modifying the observed network measurement data and comparing the modified observed network measurement data with the calibrated network data.

In response to the Patent Holder's comment, the Office now asserts "More specifically, after further consideration, the Examiner maintains that Gordon teaches data modification because using data value in an equation, in this case differential, does modify the data element." However, the Office goes on to recognize that the modified data is not compared to the calibration data, but rather modified calibration data stating:

> Both the measured characterizes and the expected values (i.e. calibration data) are inputted into differential equations in order to compare the results and facilitate correction of a situational error, Therefore, both characteristics and calibration data is modified.

Therefore, the Office acknowledges that in Gordon the modified network measurement data is not compared with the calibration data that was previously gathered as required in the claim. Furthermore, Gordon expressly states for situational errors the network measurements are not compared to expected values. Thus, the comparing step is admittedly not found in the combination.

J. Location probability and confidence measure are not equivalent.

Probability is defined as "a measure or estimation of likelihood of occurrence of an event.[9] Confidence Measure, on the other hand, is defined as a measure of reliability or quality. The two are not equivalent and the Office improperly based its equivalence argument on the assumed fact that the two are similar. Similar and equivalent are not the same and cannot serve as a basis to establish an explicit, implicit, or inherent disclosure required for a *prima facie* case of obviousness.

III. PROPOSED REJECTIONS BASED ON BENES

Benes discloses a method in which the mobile station using information associated with sectors of a base station, determines a signal difference ("SD"), then normalizes that information and compares the signal difference with an antenna gain difference associated with the sectors in order to autonomously determine its location with respect to the base station. Specifically, Benes, using the information, generates effective radiated power ("ERP") metrics for first downlink signals associated with a first antenna in the first sector and generates ERP metrics for second downlink signals associated with a second antenna in the second sector. Benes determines the peak for the first downlink signal ERP ("peak ERP") and determines the peak for the second downlink signal ERP. The difference between the peaks is defined as the signal difference (SD). Benes then calibrates the ERPs of the signals such that the peaks are both 0 dB. Figure 9 shows the calibrated first and second downlink signal ERPs of Figure 8. The angle of arrival ("AoA") of the first signal is estimated as the angle at which the signal difference (SD) between the first and second signals equals the antenna gain difference ("AGD"). In Figure 8 the signal difference (SD) is shown as 10 dB and in Figure 9 the AGD between 904 and 902 at 240 degrees is shown as approximately 10 db. Thus, the AoA of 904 is estimated as 240.

A. Proposed rejections under 35 U.S.C. §102

The Office's proposed rejection of Claims 1, 3, and 11 under 35 U.S.C. §102(b) as being anticipated by Benes is improper.

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[9] "Probability". Webster's Revised Unabridged Dictionary. G & C Merriam, 1913

Benes fails to provide each of the features recited in Claims 1, 3, and 11 and thus these claims are not anticipated[10].

Claim 1, as amended, recites:

> A method for determining a location of a mobile station, comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;
>
> receiving a signal from said first transmitter and receiving another signal from said second transmitter,
>
> collecting observed network measurement data including a first signal characteristic of the signal measured by the mobile station from said first transmitter and a second signal characteristic of the another signal measured by the mobile station from said second transmitter;
>
> determining which of said first and second signal characteristics has a greater magnitude;
>
> modifying said observed network measurement data using the greater magnitude signal characteristic; and
>
> comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Claim 1 requires three types of data: (i) previously-gathered calibration data, (ii) observed network measurement data, and (iii) modified network measurement data. Among other issues regarding the deficiency of the proposed rejection, the latter two types of data are entirely missing from the Benes reference.

"Observed network measurement data" is discussed in the current specification as representing a network characteristic observed (measured) by a mobile station at a particular region, and, as specifically amended, measured by the mobile station.

[10] "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." Verdegaal Bros. v. Union Oil Co. of California, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987).

> Observed network measurement data may be collected (operation 201). The observed data would typically be the same or similar to the data in a network measurement report (NMR). The network measurement data represents at least one network characteristic observed by the mobile station operating at a particular location within a region. 104 Col 9, ll. 41-47
>
> Network measurement data may be then observed and measured typically by a mobile station or any other wireless device (operation 703). *Id* Col. 18, ll. 58-60.
>
> Network measurement data from transmitters may be observed and collected including a signal characteristic from each of the transmitters (operation 903). *Id.* Col. 11, ll. 23-25

As recited in the claims and consistent with the specification, it is the observed network measurement data that is modified to become the "modified network measurement data."

In the proposed rejection, the Office cites Benes [0028] and states the information about the antennas' radiation patterns and the signals' strength correspond to the claimed calibration data. This information ("the information") as noted in Benes may be automatically provided by the base station or the mobile station may request "the information" from the base station.

> ...A mobile station within the communication cell may automatically receive information associated with the plurality of sectors from the base station. **The information** associated with the plurality of sectors may include, but is not limited to, an antenna pattern, a boresight, a downtilt, and a signal strength value associated with each one of the plurality of antennas. The mobile station may receive **the information** associated with the plurality of sectors via a pilot signal strength measurement message or a measurement report message. Alternatively, the mobile station may request for **the information** associated with the plurality of sectors from the base station. Benes [0011] (emphasis added)
>
> ...In response to the request, the mobile station 160 at step 1020 may receive information associated with the plurality of sectors. In particular, **the information** associated with the plurality of sectors may include, but is not limited to, antenna patterns, boresights, downtilts, and signal strength values associated with the plurality of antennas. Alternatively, the mobile station 160 may automatically receive **the information** associated with the plurality of sectors from the base station (i.e., without a request).*Id* [0028] (emphasis added)

It is "the information" (antenna patterns as shown in Figures 4-7 and specifically the antenna patterns in sectors 202 and 204 shown in Figures 8 and 9) received from the base station that the mobile station may use to determine the AoA.

> ...Based on the antenna patterns, the mobile station 160 may autonomously determine an angle of arrival (AOA) estimation by comparing ERPs between the antennas of at least two sectors in a communication cell. *Id.* [0026]

The ERPs are determined from "the information" and by definition (as noted above) are not determined from received signal strength:

> Upon receiving the information associated with the plurality of sectors, the mobile station 160 may determine a power parameter associated with each of the plurality of antennas. For example, the mobile station 160 may determine an effective radiated power (ERP) associated with each of a first sector 202 and a second sector 204 based on their respective signal strength values. *Id.* [0021]

The signal difference (SD) in Benes is determined from "the information":

> ...In particular, a downlink signal 802 from the antenna associated with the first sector 202 has a boresight of 160 degree. azimuth (i.e., degrees from north) and an effective radiated power (ERP) of -80 dB, a downlink signal 804 from the antenna associated with the second sector 204 has a boresight of 230 degree. azimuth and an ERP of -70 dB, and a downlink signal 806 from the antenna associated with the third sector 206 has a boresight of 100 degree. and an ERP of -110 dB. As noted above, persons of ordinary skill in the art will readily appreciate that the ERPs may be compensated for gain differences of the antennas and losses from cables and connectors coupled to the antennas. Based on the ERPs, the mobile station 160 may calculate a signal difference (SD) between the peaks of the downlink signals 802, 804 associated with the antennas corresponding to the first and second sectors 202, 204. For example, the mobile station 160 may determine a signal difference of 10 dB between the first sector 202 and the second sector 204. *Id.* [0026]

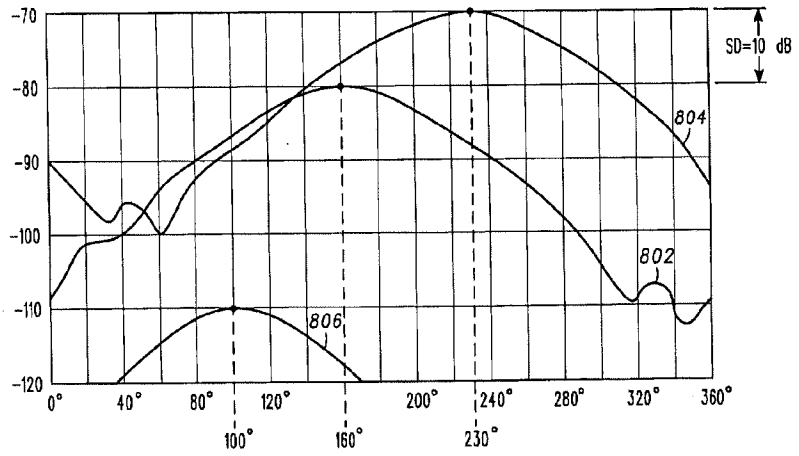

FIG. 8

The signal difference, as shown in Figure 8, is taken as the difference from the Peak ERPs of 804 and 802:

> ...Based on the ERPs, the mobile station 160 may calculate a signal difference (e.g., a change in dB) between the first and second downlink signals. That is, the mobile station 160 may compare the peak ERPs of the first and second downlink signals. *Id.* [0029]

The antenna gain difference (AGD) is also determined from "the information":

> Based on the information associated with the plurality of sectors, the mobile station 160 at step 1030 may determine an antenna gain difference. *Id.* [0029]

Specifically, the antenna gain difference (AGD) is determined from the calibration of the ERP peaks (normalized downlink signals 902 and 904) as shown in Figure 9:

> To determine an antenna gain difference (AGD) for comparison with the signal difference, the mobile station 160 may normalize the downlink signals 802, 804 from the antennas associated with the first and second sectors 202, 204 (shown as 902 and 904, respectively, in FIG. 9). For example, the peak ERPs of the normalized downlink signals 902, 904 may be calibrated to 0 dB. *Id.* [0027]

All the metrics used by the Office in applying Benes to the current claims are taken solely from "the information" provided by the base station. As a result, Benes fails to provide

teachings for the claimed "observed network measurement data" and the "modified network measurement data," which, as noted previously, are measured at the mobile station.

Along with Benes' failure to disclose the observed network measurement data, Benes also fails to disclose modifying the observed network measurements and, further still, modifying the observed network measured data with the signal of greater magnitude.

The Office, in applying Benes to the modifying limitation, cites [0027] and states "wherein normalization corresponds to the step of modification and Figure 9 wherein signals are adjusted using the greater magnitude." However, the normalization disclosed in [0027] of Benes is without regards to the magnitude of the signal with the greater ERP.

Benes recites:

> To determine an antenna gain difference (AGD) for comparison with the signal difference, the mobile station 160 may normalize the downlink signals 802, 804 from the antennas associated with the first and second sectors 202, 204 (shown as 902 and 904, respectively, in FIG. 9). For example, the peak ERPs of the normalized downlink signals 902, 904 may be calibrated to 0 dB. Benes [0027]

Figure 9 below shows both 904 (the greater peak ERP) and 902 (the smaller peak ERP) were simply normalized to a nominal 0 dB, 804 (of Figure 8) was offset by 70 dB and 802 (Figure 8) was offset by 80 dB, to arrive at 904 and 902 respectively.

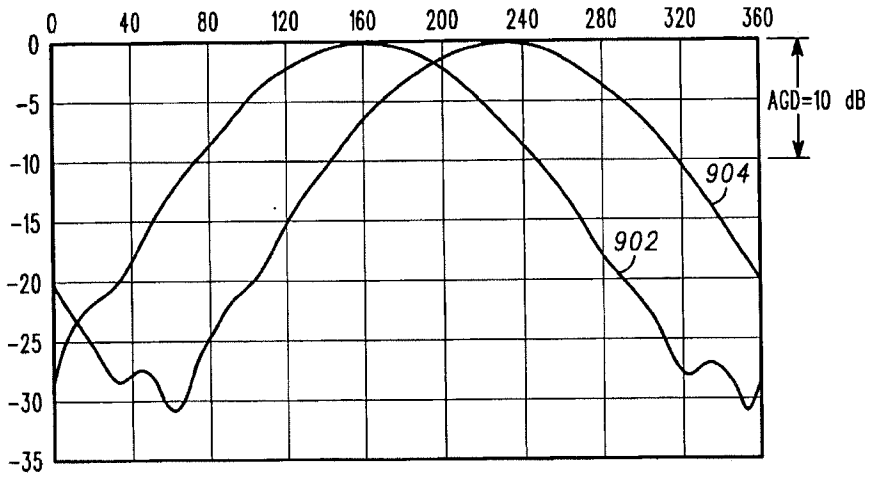

FIG. 9

The modification (normalization) of Benes that the Office relies upon fails for two reasons. First, the modification is not on the observed network measurement data as required in the claims but rather on the data that the Office used for the claimed calibration data, as demonstrated above. Second, the ERPs calculated from the information are not modified "using the greater magnitude signal characteristic." Both ERP peaks are simply calibrated to 0 dB, as shown above. Thus there is no disclosure for the limitation of "modifying said observed network measurement data using the greater magnitude signal characteristic."

Claims 3 and 11 depend from Claim 1 and thus are not anticipated by Benes for at least the same reasons as elaborated above and irrespective of the additional features recited therein. Nonetheless, several of the additional distinctions between Benes and the dependent claims are addressed below.

Claim 3 recites the further limitations of "wherein said observed network measurement data includes data collected at the mobile station."

The Office argues that Benes discloses this limitation because the "mobile station received information associated with the plurality of sectors from a base station" and cites [0028] as a basis.

However [0028] is discussing "the information" received from the base station and not the observed network measurement data that is measured and collected at the mobile station.

Claim 11 recites the further limitations of "the observed network measurement data includes received signal strength of said transmitters as said mobile station."

The Office argues that the "mobile station may receive information about signal strength from multiple transmitters (i.e. antennas). The information is based on the location of the mobile station with respect to the transmitters" and cites [0011] as a basis.

First, the Office's assertion that the information is based on the location of the mobile station with respect to the transmitter is not supported by the referenced citation, nor is it relevant to the disposition of the limitation. Second, the claim specifically recites "received signal strength [at] said mobile station." Received signal strength has a particular meaning to one skilled in the art and it is the strength of the signal as received, as opposed to the signal strength as transmitted[11].

The signal strength reference in [0011] is "a signal strength value associated with each one of the plurality of antennas" and this value is provided by the base station and reflects the nominal transmission power of the respective antenna (a physical property of the antenna). The information received from the base station upon which the Office relies cannot be considered as the received signal strength at the mobile station under any reasonable interpretation[12].

---

[11] "[T]he ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, i.e., as of the effective filing date of the patent application." Phillips v. AWH Corp., 415 F.3d 1303, 1313, 75 USPQ2d 1321, 1326 (Fed. Cir. 2005) (en banc); Sunrace Roots Enter. Co. v. SRAM Corp., 336 F.3d 1298, 1302, 67 USPQ2d 1438, 1441 (Fed. Cir. 2003); Brookhill-Wilk 1, LLC v. Intuitive Surgical, Inc., 334 F.3d 1294, 1298 67 USPQ2d 1132, 1136 (Fed. Cir. 2003

[12] During examination, the claims must be interpreted as broadly as their terms reasonably allow. In re American Academy of Science Tech Center, 367 F.3d 1359, 1369, 70 USPQ2d 1827, 1834 (Fed. Cir. 2004) (The USPTO uses a different standard for construing claims than that used by district courts; during examination the USPTO must give claims their broadest reasonable interpretation in light of the specification.).This means that the words of the claim must be given their plain meaning unless the plain meaning is inconsistent

(Continued...)

Benes does not meet each and every limitation within Claims 1, 3 and 11 and therefore cannot anticipate these claims.

B. Proposed rejections under 35 U.S.C. §103

The Office's proposed rejections of Claims 2, 4-7, and 9-11 under 35 U.S.C. §103(a) as being obvious over Benes in view of Gordon are improper.

To establish a *prima facie* case of obviousness, the Office is required to present "some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness."[13] Towards that end, the Office's rational to modify Benes with Gordon is for the purposes of (i) accounting for real-world wireless network coverage regions [in determining location]; (ii) to consider outdoor location of the mobile station [in determining location]; (iii) to consider indoor locations of the mobile [in determining location]; (iv) to use a readily-available signal characteristic for determining the location of the mobile station; and (v) to use a readily-available source of a signal from which to measure signal strength [in determining the location of the mobile station].

However, one skilled in the art would recognize the disclosure of Benes is inoperative to determine the location of a mobile station, as supported in the accompanying §1.132 affidavit. Therefore, one skilled in the art would not be motivated to look at Benes for the purpose of locating a mobile and certainly would understand that the modifications proposed by the Office would not render Benes operable and thus there would be no reasonable expectation of success[14].

(Continued...)

with the specification. In re Zletz, 893 F.2d 319, 321, 13 USPQ2d 1320, 1322 (Fed. Cir. 1989) (discussed below); Chef America, Inc. v. Lamb-Weston, Inc., 358 F.3d 1371, 1372, 69 USPQ2d 1857 (Fed. Cir. 2004)

[13] "'[R]ejections 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 ___, 82 USPQ2d at 1396.

[14] Where there is a reason to modify or combine the prior art to achieve the claimed invention, the claims may be rejected as *prima facie* obvious provided there is also a reasonable expectation of success. In re Merck & Co., Inc., 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986)

Absent such a motivation, a *prima facie* case of obviousness cannot be maintained. For at least this reason the proposed rejections of Claims 2, 4-7, and 9-11 as being obvious over Benes in view of Gordon cannot be maintained.

Claims 2, 4-7, and 9-11 all depend from Claim 1 and the Office depends upon Benes to provide the limitations of Claim 1 (the Office states "Benes teaches all the limitations disclosed in Claim 1"). However, Gordon does not obviate the deficiencies of Benes with respect to Claim 1 as explained above and thus the proposed combination fails to disclose each and every limitation. For at least this reason, a *prima facie* case of obviousness over Benes in view of Gordon cannot be maintained and the proposed rejection is improper. Irrespective of the deficiencies of Benes in view of Gordon addressed above, each one of which on its own sufficiently overcomes the Office's proposed rejection, several additional distinctions between Benes in view of Gordon and the dependent claims are addressed below.

Claim 2, recites *inter alia*:

> wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

The Office, while acknowledging that Benes does not disclose the above limitation, suggests that Gordon teaches that the previously gathered calibration data is for one or more non-uniform grid points within said region and cites col. 9, ll. 9-13 as a basis.

The cited portion of Gordon recites:

> With these considerations in mind, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that partition geographic region 220 into any number of locations of any size, shape, and arrangement. Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use embodiments of the present invention in which the **locations are identical in size and shape.** Gordon Col. 9, 11, 9-16. (emphasis added)

There is nothing in Gordon, much less the cited portion, regarding the use of non-uniform grid points as recited in the claim. There must be either an express or inherent disclosure and clearly there is no express disclosure. There is also no rational, expressed, or existing reason why a non-uniform grid is necessarily present, thus there is also no inherent disclosure. To the

contrary, the passage, as highlighted above, suggests quite the opposite in that the locations are uniform (identical in size and shape). Therefore, at least for this reason the proposed rejection of Claim 2 is improper.

Claim 5 recites *inter alia*:

> said observed network measurement data is collected at a mobile station located within a structure.

The Office relies upon Gordon to provide a disclosure for this limitation stating "locations such as 'four-story building' or 'two-story building' correspond to a location within a structure" and citing col. 9, ll. 17-41. However, these passages in Gordon are with respect to calibration data which the Office acknowledges in the rejection ("It would have been obvious...to modify Benes's method and include **calibration data** gathered at a predetermined points located within a structure" (emphasis added)). Claim 5 requires the collection of **observed network measurement data, not calibration data** within a structure. Furthermore, Claim 5, which depends from Claim 4, requires the collection of calibration data outdoors and observed network measurement data indoors, a combination that is absent in both Benes and Gordon.

Therefore the proposed rejection of Claim 5 as being obvious over Benes and Gordon is improper.

Claims 9 and 10, respectively, recite *inter alia*:

> wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station" and "wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

Thus, the claims require the signal characteristic be the signal strength of **a control channel.** The Office relies upon Gordon to meet this limitation. The Office cites col. 8, ll. 56-59, stating:

> Wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitter (radio stations A and B)

Gordon in the cited passage recites:

> If a given wireless terminal with a broken antenna and at an unknown location receives Radio Station A at -47 dBm and Radio Station B at -61 dBm, then it registers Radio Station A as 14 dBm stronger than Radio Station B. Gordon, Col. 8, ll. 56-59.

Both the rational provided by the Office and the cited portion of Gordon are void of any disclosure of control channel or signal strength of the control channel. Thus, a *prima facie* case of obviousness has not been established.

The Office's proposed rejection of Claims 8-10 and 12-14 under 35 U.S.C. §103(a) as being obvious over Benes in view of Gordon and further in view of Spain is improper.

The Office's rational to modify Benes and Gordon with Spain is for the purpose of determining location of the mobile device. However, as discussed above, one skilled in the art would recognize the disclosure of Benes is inoperative to determine the location of a mobile station. Therefore, one skilled in the art would not be motivated to look at Benes for the purpose of locating a mobile and certainly would understand that the modifications proposed by the Office from Spain would not render Benes operable. Therefore, in addition to having no reasonable expectation of success, a motivation to combine is absent. Absent such a motivation, a *prima facie* case of obviousness cannot be maintained.

For at least this reason the proposed rejections of Claims 8-10 as being obvious over Benes in view of Gordon and further in view of Spain cannot be maintained.

Claims 8-10 depend from Claim 1 and the Office depends upon Benes to provide the limitations of Claim 1 (the Office states "Benes teaches all the limitations disclosed in Claim 1"). However, Gordon and Spain do not obviate the deficiencies of Benes with respect to Claim 1 as explained above and thus the proposed combination fails to disclose each and every limitation. Therefore for at least this reason, a *prima facie* case of obviousness over Benes in view of Gordon and further in view of Spain cannot be maintained and the proposed rejection is improper. Irrespective of the deficiencies of Benes in view of Gordon and further in view of Spain addressed above, at least one of the several distinctions between Benes, Gordon, and Spain and the dependent claims is further addressed below.

Furthermore, Benes does not modify observed network measurement data, nor use differentials of observed network measurement data, and thus the modification proposed would not improve Benes, and thus there is no proper motivation.

IV. PROPOSED REJECTIONS BASED ON GORDON

A. Proposed rejections under 35 U.S.C. §103

The Office incorrectly rejected Claims 1-11 under 35 U.S.C. §103(a) as being obvious over Gordon in view of Krumm.

Claim 1 recites *inter alia*:

> modifying said observed network measurement data using the greater magnitude signal characteristic;
>
> comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

The Office, citing col. 18, lines 17-25, states that Gordon's "correcting situational errors in the measurements is considered data modification" and that the "correction is based on differentials which are essentially the difference between signals" meets the modifying limitation. The Office further states "the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part is based on the strongest signal."

The Office also suggests that Gordon discloses the comparing limitation citing column 16, lines 9-18 and stating "the expected values" are those stored in the database and "measurements" are the data received from transmitters."

However, the Office is incorrect regarding the teachings of Gordon.

Gordon describes a method of using non-GPS techniques for generating location-specific assistance data. The assistance data is used to acquire GPS signals to estimate the mobile device's location. In the portions of Gordon relied upon by the Office, Gordon describes correcting for situational error. Situational errors (broken antennae, low battery, inside a car) are addressed by Gordon by computing differentials.

> In accordance with process 1103, location server 214 computes the differentials, in those cases that are appropriate, of the measurements to correct the situational errors in the measurements received in process 1001. Many factors, including the condition of wireless terminal 201's antenna, the state of its battery, and whether or not the terminal is inside a vehicle can introduce situational measurement errors. This is particularly true for measurements of pathloss and signal strength. Gordon at col. 18, ll. 18-25

Gordon explicitly explains that in order to account for these situational errors, pattern matching with the measurements are not undertaken, but rather pair-wise differentials of the measurements are matched with pair-wise differentials of the expected values:

> The illustrative embodiment ameliorates the effects of these factors by pattern matching not the measurements themselves...to the expected values for those trails, but by pattern matching the pair-wise differentials of those measurements to the pair-wise differentials of the expected values for those traits. *Id* Col. 18, ll. 26-34

The correction relied upon by the Office is not of the observed measurement data, but of the situation. The observed measurement data is not changed or modified, but rather a difference is computed. Thus, the Office's rational "the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part is based on the strongest signal" is incorrect. Simply stated, **the differential does not modify any data.**

The Office's suggestion that the "measurements" (data received from transmitters) are compared with the "expected values", which meets the comparing limitation, is insufficient. First, the claim requires the modified network measurement data to be compared, and, as noted above, the data received from the transmitters is not modified. Second, Gordon expressly states for situational errors the network measurements are not compared to expected values. *See Id.*

Gordon provides an illustrative example, where the observed measurements from radio A and radio B are neither modified nor compared with the expected values, but rather the differential between radio A and radio B (without respect to which has the greater magnitude) is compared with the difference between the expected values of radio A and radio B:

A simple example involving signal strengths illustrates this approach. A first radio station, Radio Station A, can be received at -56 dBm at Location 1, -42 dBm at Location 2, -63 dBm at Location 3, and -61 dBm at Location 4, and a second radio station, Radio Station B, can be received at -63 dBm at Location 1, -56 dBm at Location 2, -65 dBm at Location 3, and -52 dBm at Location 4. This information is summarized in the table below and forms the basis for a map or database that correlates location to signal strength. Col. 18, ll. 36-44

TABLE 3

Illustrative Location-Trait Database (Differential Reception)

	Radio Station A	Radio Station B	Difference
Location 1	-56 dBm	-63 dBm	-7 dB
Location 2	-42 dBm	-56 dBm	-14 dB
Location 3	-63 dBm	-65 dBm	-2 dB
Location 4	-61 dBm	-52 dBm	9 dB

If a given wireless terminal with a broken antenna and at an unknown location receives Radio Station A at -47 dBm and Radio Station B at -61 dBm, then it registers Radio Station A as 14 dBm stronger than Radio Station B. This suggests that the wireless terminal is more likely to be at Location 2 than it is at Location 1, 3, or 4. If the measured signal strengths themselves were pattern matched into Location-Trait Database 313, the resulting probability distribution for the location of wireless terminal 201 might not be as accurate. col. 18, ll. 56-64

Gordon, in much the same manner as the Office recognized in Spain, determines a difference between observed network measurement data but does not modify the first and second signal characteristics that make up the observed network measurement data. Additionally, neither the observed network measurement data nor the computed difference is compared with the collected calibration data as required by the claim.

Claim 1 further recites:

> determining which of said first and second signal characteristics has a greater magnitude;

The Office suggests that Krumm cures any deficiency in Gordon regarding this limitation, stating "it would have been obvious to one of ordinary skill....to modify Gordon invention and determine and utilize the signal with strongest magnitude, as taught by Krum, for the purpose of generating the most accurate result." However, in Gordon, the differential between the signals is used to pattern match, and thus whether the greater magnitude signal in the pair-wise differential is subtracted from the smaller signal, or the smaller signal is subtracted from the larger magnitude signal, is irrelevant and would have no effect on the accuracy of the results. Therefore, there is no correlation between the modification and the motivation, thus a *prima facie* case of obviousness has not been made.

Claims 2-11 depend from Claim 1 and thus are not obvious over Gordon in view of Krumm for at least the same reasons as elaborated above, irrespective of the additional features recited. Nonetheless, several of the additional distinctions between Gordon in view of Krumm and the dependent claims are addressed.

Claim 2 recites *inter alia*:

> wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

As discussed with respect to the proposed rejection of Claim 2 over Benes in view of Gordon (see above), Gordon does not expressly or inherently disclose the use of non-uniform grid points as recited in the claims. Therefore at least for this reason, the proposed rejection of Claim 2 is improper.

Claim 8 recites *inter alia*:

> wherein the modifying of said calibration data uses a difference between said first or second signal characteristics.

The Office cites col. 18, ll. 17-25 and states that Gordon teaches "differentials are used to correct the error in measurements and differential is a difference between two signals."

Irrespective that the measurements described in that portion of Gordon are not modified, as discussed previously, the differential in measurements that Gordon is describing is not related to the calibration data (expected values) as required in the claims but relates to a differential in observed network measurement data. Therefore the proposed rejection is improper.

Claims 9 and 10, respectively, recite *inter alia*:

> wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station" and "wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

The claims require that the signal characteristic be the signal strength of **a control channel.** The Office relies upon Gordon to meet this limitation. The Office, citing Col. 8, ll. 56-59, states:

> Wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitter (radio stations A and B)

As discussed regarding the proposed rejection of Claims 9 and 10 with respect to Benes in view of Gordon, both the rationale provided by the Office and the cited portion of Gordon are void of any disclosure of control channel or signal strength of the control channel. Thus, a *prima facie* case of obviousness has not been established.

The Office's proposed rejection of Claims 8-10 and 12-14 under 35 U.S.C. §103(a) as being obvious over Gordon in view of Krumm and further in view of Spain are improper.

Claims 8-10 and 12-14 all depend from Claim 1 and the Office depends upon Gordon and Krumm to provide the limitations of Claim 1. However, Spain does not obviate the deficiencies of Gordon in view of Krumm with respect to Claim 1, as explained above, and thus the proposed combination fails to disclose each and every limitation. Therefore, for at least this reason, a *prima facie* case of obviousness over Gordon in view of Krumm and further in view of Spain cannot be maintained and the proposed rejection is improper.

Irrespective of the deficiencies of Gordon in view of Krumm and further in view of Spain addressed above, at least one of the several distinctions between Gordon, Krumm, and Spain and the dependent claims is addressed below.

The Office acknowledges that Gordon in view of Krumm does not disclose the features of Claim 12 and relies upon Spain to provide the disclosure.

The Office incorrectly asserts that Gordon teaches a data set comprising signal strength differentials which are used to modify measurement data and cites to col 18, ll. 17-25. However, as discussed previously, the differentials are not used to modify the measurement data.

Gordon also does not teach that the observed network measurement data includes "TA representing a timing advance parameter." As discussed previously, the round trip time and the ΔT are not timing advance parameters.

Spain fails to disclose a modified network measurement data set as claimed as described earlier with respect to the proposed rejection of Claim 12 with Benes, Gordon, and Spain. Therefore, a *prima facie* case of obviousness has not been established.

B. Proposed rejections under 35 U.S.C. 102(a)

The proposed rejection of Claims 15-21 under 35 U.S.C. 102(a) as being anticipated by Gordon is improper.

Claim 15 recites *inter alia*:

> determining a confidence measure for each of the plurality of location estimates;
>
> determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.

The Claim requires the determination of a confidence measure and determining the location of the mobile station at least based on the confidence measure. Gordon does not disclose a confidence measure.

The Office's argument equates "confidence measure" of the claims with "probabilities of location" of Gordon. However, the confidence measure of a location as used in the specification and as known in the art is not the same as a probability location being the actual location of a mobile station as described in Gordon.

The '104 patent states:

> A confidence measure may also be used to represent the accuracy of a mobile station's estimated location. col 7, ll. 65-67.

Gordon does not discuss confidence measure, Gordon however describes the probability as the likelihood that a mobile station will be in a location. Gordon recites:

> The term "staying probability" is defined as an estimate of the probability P.sub.S(b, T, N, W) that wireless terminal W in location b at calendrical time T will still be in location b at time T+.DELTA.t, given environmental conditions, N. The term "moving probability" is defined as an estimate of the probability P.sub.M(b, T, N, W, c) that wireless terminal W in location b at calendrical time T will be in adjacent location c at time T+.DELTA.t, given environmental conditions, N. col. 3, ll. 52-60

While confidence measure and probability may be related, they are not the same and the Office has only presented conclusory statements of their equality. A disclosure of a probability is not a disclosure of a confidence measure for the purposes of an anticipation rejection.

Claims 16-21 depend from Claim 15 and thus each require a confidence measure which is absent from Gordon. Therefore, for at least the same reason articulated with respect to Claim 15, the proposed rejections of Claims 16-21 are also improper.

CONCLUSION

Patent Holder has demonstrated that the anticipation and obviousness rejections proposed by the Office fail to meet the statutory requirements and thus should not be maintained. Benes, Gordon, Spain, and Krum alone or in combination have not been demonstrated to disclose each and every limitation recited in the claims. The Patent Holder's arguments have not been rebutted. The claims are allowable and a reexamination certificate should be issued accordingly.

If the Examiner believes that any additional changes would place the application in better condition for allowance, the Examiner is invited to contact the undersigned attorney at the telephone number listed below.

Respectfully submitted,

/Mark C. Comtois/

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Dated: 24 December 2013

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of Martin Alles, et al.

Serial No.: 90/012,694 Art Unit: 3992 Confirmation No: 6575

Filed: 24 September 2012 Examiner: Angela M. Lie

Title: METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE DEVICE

INTERVIEW SUMMARY

Interview of 4 December 2013
Attorney: Patrick Muldoon
Panel Members: Angela M. Lie; Luke Wassum; Sudhanshu Pathak

§ 102 over Benes

Claim 1 was discussed with the panel, specifically regarding the Patent Owner's assertion that the limitation of observed network measurement data was not taught by Benes. The Patent Owner noted that all of the data relied upon by Benes in the location of the mobile station was received by the base station and not "observed" by the mobile station.

The panel opinion was that nothing in the claim required the observed network measurement data to be any different than the previously-gathered calibration data, as the calibration data was "observed" at one time, and thus the Patent Owner's arguments alone would not overcome the reference. The panel agreed that the arguments presented were supported, but suggested that the claims would need to be amended to require measurement by the mobile if the Patent Owner wanted to rely on that argument.

Claim 3 was also discussed which requires the data be collected at the mobile station. The panel offered that the previously-gathered calibration data in Benes was collected at a mobile station as well.

Claim 11 was discussed regarding the limitation of received signal strength. The Patent owner asserted that the received signal strength was not taught in Benes, but the panel argued

that the signal strength measurements were included in the message sent from the base station. The panel argued that the signal strength of the signals are part of the calibration data.

§ 103 Benes in view of Gordon

Claim 2 was discussed with respect to the non-uniform grid limitations. The Patent Owner asserted that there was no disclosure and no motivation to combine.

The panel responded that Gordon disclosed that any arrangement could be used and thus under KSR it would have been obvious to try. The Patent Owner pointed out that under the Panel's interpretation of KSR any generic disclosure would be a disclosure of each and every possible species regardless of the number of possible species involved even an infinite number of possible species. The panel suggested that while KSR reasoning was not provided in the rejection, the Patent Owners response should address that issue.

Claim 5 was briefly discussed regarding the "within a structure" limitation, however, for the same reasons described with respect to "observed" vs. "calibration" data, the panel felt the proposed rejection was proper.

Claims 9 and 10 were discussed with respect to the control channel. The panel suggested that the specification did not specifically describe the control channel or its definition and thus the proposed rejections' use of the signal received from the base station as the control channel was proper. The Patent Owner suggested that the term "control channel" was a term of art and therefore not required to be specifically defined.

§ 103 Gordon in view of Krumm

Claim 1 was discussed. The Patent Owner argued that Gordon taught against comparing modified observed network measurement data with previously-gathered calibration data. Specifically, the differences discussed in Gordon are not a comparison of modified observed data to previously gathered calibration data as required by the claim. The Patent Owner also argued that there is no determination of a signal of greater magnitude as described in the claim.

The panel understood the argument, but suggested the use of differences was disclosed in Gordon and suggested they were probably stored, and thus previously gathered.

Declaration

The Patent Owner described how Benes was not operable for its intended purpose, as described by the previously-filed Declaration and thus could not form the basis of an obviousness type rejection since the probability of success requirement is lacking. The Panel stated that regardless of the Declaration, if Benes could be used for a 102 rejection, it could be used for a 103 rejection. The Panel did not agree that probability of success was required and suggested that the Patent Owner expand upon this reasoning in its response.

Respectfully submitted,

/Patrick C. Muldoon /

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Dated: 24 December 2013

Certificate of Service

I hereby certify that on 24 December 2013, I caused to be mailed, by First Class Mail, a copy of the Amendment and Interview Summary in the Reexamination of U.S. Patent 7,561,104, Reexamination Control Number 90/012,694, as submitted to the United States Patent and Trademark Office, to the Third Party Requestor:

Kenneth Ottensen
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On 24 December 2013

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Electronic Acknowledgement Receipt

EFS ID:	17753836
Application Number:	90012694
International Application Number:	
Confirmation Number:	6575
Title of Invention:	Method to modify calibration data used to locate a mobile unit
First Named Inventor/Applicant Name:	7,561,104 B2
Customer Number:	79172
Filer:	Mark Charles Comtois/laureen ponder
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	466-333us1
Receipt Date:	24-DEC-2013
Filing Date:	24-SEP-2012
Time Stamp:	13:52:00
Application Type:	Reexam (Patent Owner)

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Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		AND01082REDecAmdtIS.pdf	3905441 3e703a1fa53180f9710a719f53abae592bdc497e	yes	42

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Reexam Response to Final Rejection	1	1
	Claims	2	4
	Applicant Arguments/Remarks Made in an Amendment	5	38
	Applicant summary of interview with examiner	39	41
	Reexam Certificate of Service	42	42

Warnings:	
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
90/012,694	09/24/2012	7,561,104 B2	466-333us1	6575

79172 7590 12/12/2013

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EXAMINER	
LIE, ANGELA M	
ART UNIT	PAPER NUMBER
3992	
MAIL DATE	DELIVERY MODE
12/12/2013	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.

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EX PARTE REEXAMINATION COMMUNICATION TRANSMITTAL FORM

REEXAMINATION CONTROL NO. *90/012,694*.

PATENT NO. *7,561,104 B2 E*.

ART UNIT *3992*.

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above identified *ex parte* reexamination proceeding (37 CFR 1.550(f)).

Where this copy is supplied after the reply by requester, 37 CFR 1.535, or the time for filing a reply has passed, no submission on behalf of the *ex parte* reexamination requester will be acknowledged or considered (37 CFR 1.550(g)).

Ex Parte Reexamination Interview Summary	Control No.	Patent Under Reexamination
	90/012,694	7,561,104 B2 E
	Examiner	Art Unit
	ANGELA M. LIE	3992

All participants (USPTO personnel, patent owner, patent owner's representative):

(1) *ANGELA M. LIE*	(3) *Sudhanshu Pathak*
(2) *Luke Wassum*	(4) *Patrick Muldoon*

Date of Interview: *04 December 2013*

Type: a)☐ Telephonic b)☐ Video Conference
c)☒ Personal (copy given to: 1)☐ patent owner 2)☐ patent owner's representative)

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

Agreement with respect to the claims f)☐ was reached. g)☐ was not reached. h)☒ N/A.
Any other agreement(s) are set forth below under "Description of the general nature of what was agreed to…"

Claim(s) discussed: *1,2 and 9*.

Identification of prior art discussed: *Benes, Grodon and Krumm*.

Description of the general nature of what was agreed to if an agreement was reached, or any other comments:
See Continuation Sheet.

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims patentable, if available, must be attached. Also, where no copy of the amendments that would render the claims patentable is available, a summary thereof must be attached.)

A FORMAL WRITTEN RESPONSE TO THE LAST OFFICE ACTION MUST INCLUDE PATENT OWNER'S STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. (See MPEP § 2281). IF A RESPONSE TO THE LAST OFFICE ACTION HAS ALREADY BEEN FILED, THEN PATENT OWNER IS GIVEN **ONE MONTH** FROM THIS INTERVIEW DATE TO PROVIDE THE MANDATORY STATEMENT OF THE SUBSTANCE OF THE INTERVIEW (37 CFR 1.560(b)). THE REQUIREMENT FOR PATENT OWNER'S STATEMENT CAN NOT BE WAIVED. **EXTENSIONS OF TIME ARE GOVERNED BY 37 CFR 1.550(c).**

/ANGELA M LIE/ Primary Examiner, Art Unit 3992		

cc: Requester (if third party requester)

Continuation of Description of the general nature of what was agreed to if an agreement was reached, or any other comments: During the interview, the Patent Owner's representative has discussed plurality of issues pertaining to the final rejection mailed on 10/25/2013. First, it has been contended that Benes teaches only the base station data and there is no teaching about measuring data at the mobile stations. In other words, it has been alleged that Benes does not collect observed data. The Examiner did not agree with that allegation because according to paragraphs [0026] and [0027], the Angle of Arrival (AOA) is determined based on downlink signals from antennas associated with respective signals and on contrary to what the Patent Owner alleges, those signals are not pre-stored data which is always the same. For instance paragraph [0011] clearly discloses that the mobile station receives information associated with plurality of sectors via "a pilot signal strength measurement message or a measurement report message. Accordingly this information pertains to the signal's strength as recorded instead of pre-stored general data associated with an antenna.

Secondly, the Patent Owner's representative also discussed "non-uniform grid" disclosed in claim 2, contending that Gordon does not teach this limitation because cited passage "geographic region 220 into any number of locations of any size, shape and arrangement" is not specific enough and does not explicitly disclose "non-uniform grid". The Examiner disagreed because having locations of any arrangements encompass non-uniform grid.

In the third argument, claim 9 has been disclosed and more specifically "control channel". The Patent Owner's representative stated that prior art teaches signal, however the signal is not control channel. The Examiner explained that based on Spain's reference "signal used from any base station is the control channel because it is broadcast at a constant power and because wireless terminal 201 can distinguish it from every other control channel" (column 7, lines 44-51). Accordingly, the Examiner maintains that Benes in view of Gordon teaches "control channel".

Then rejection of claim 1, over Gordon in view of Krumm has been discussed. More specifically, the Patent Owner's representative contended that Gordon in view of Krumm does not teach storing differentials of the respective signals as calibration data. The Examiner clarified that the "expected valued" are considered to be the calibration data, and that the claim language does not require that the differentials of that calibration data must be stored. Furthermore, since the measured values are compared with the expected values, this data must be stored at least temporally to enable matching. Consequently, the Examiner maintains that calibrated data stored in a database is taught by Gordon in view of Krumm.

Lastly the Patent Owner's representative submitted that Benes cannot be used in obviousness rejection because the claimed invention is inoperable. The Examiner disagrees with this allegation. As mentioned above Benes teaches receiving measurements of the signals' strengths associated with respective antennas. This information allows calculating Angel of Arrival (AOA). Furthermore, the measurement data is dependent upon the strength of the signal and it can be the same at all time as location of the mobile device changes and the signal strength varies with it. Accordingly, the Examiner maintains that the obviousness rejection is proper.

In addition, the Examiner would like to remind that Patent Owner is given one month from this interview date (December 4/2013) to provide the mandatory statement of the substance of the interview (37 CFR 1.560(b)). Failure to submit timely response would result in termination of the proceedings. .

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02

CENTRAL REEXAMINATION UNIT

FACSIMILE TRANSMITTAL SHEET

TO:	Angela M. Lie
FIRM/COMPANY:	USPTO
FACSIMILE NUMBER:	571.273.9900
CONFIRMATION TELEPHONE:	
FROM:	Patrick Craig Muldoon
DIRECT DIAL:	202 776 7840
DATE:	December 2, 2013
USER NUMBER:	
FILE NUMBER:	
TOTAL # OF PAGES: (INCLUDING COVERSHEET)	2
MESSAGE:	U.S. Appln No: 90/012,694 Agenda for 4 December 2013 Interview with Attorney Patrick C. Muldoon

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CENTRAL REEXAMINATION UNIT

Agenda for Interview of Dec 4, 2013

Application No 90/012694

Attorney: Patrick Muldoon

§ 102 over Benes

Claim 1

Observed network measurement data

Claim 3

Data collected at the mobile station.

Claim 11

Received signal strength.

§ 103 Benes in view of Gordon

Claim 2

Non-uniform grid points

Claim 5

Observed network measurement data collected within a structure.

Claim 9&10

Control channel

§ 103 Gordon in view of Krumm

Claim 1

Modifying observed network measurement data and comparing the modified network measurement data with the database of calibration data

Determining signal of greater magnitude

Declaration

Benes is not operable for its intended purpose..

PAGE 2/2 * RCVD AT 12/2/2013 1:39:30 PM [Eastern Standard Time] * SVR:W-PTOFAX-001/41 * DNIS:2739900 * CSID:2027767801 * DURATION (mm-ss):00-23

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
90/012,694	09/24/2012	7,561,104 B2	466-333us1	6575

79172 7590 11/08/2013

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

EXAMINER	
LIE, ANGELA M	
ART UNIT	PAPER NUMBER
3992	
MAIL DATE	DELIVERY MODE
11/08/2013	PAPER

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EX PARTE REEXAMINATION COMMUNICATION TRANSMITTAL FORM

REEXAMINATION CONTROL NO. *90/012,694*.

PATENT NO. *7,561,104 B2 E*.

ART UNIT *3992*.

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above identified *ex parte* reexamination proceeding (37 CFR 1.550(f)).

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APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
90/012,694	24 September, 2012	7,561,104 B2 ET AL.	466-333us1

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

EXAMINER	
ANGELA M. LIE	
ART UNIT	PAPER
3992	20131028

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Commissioner for Patents

This communication is issued to clarify the deadline for response to the Final Office action mailed on October 25th, 2013. The response is due within 2 months from the mailing date of the Final Rejection. The Examiner also wishes to apologize for any confusion about the response period.

Thank you

/ANGELA M LIE/
Primary Examiner
Art Unit: 3992

PTO-90C (Rev.04-03)

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79172 7590 10/25/2013

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EXAMINER	
LIE, ANGELA M	
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DETAILED ACTION

The present application is being examined under the pre-AIA first to invent provisions.

This action is directed to claims 1-21 for which reexamination has been requested and substantial new question of patentability has been determined to exist. The considered claims are 1-21 in US Patent No. 7,561,104 to Alles et al. (hereinafter referred to as '104 patent). **Claims 1-11 and 15-21 are rejected and claims 12-14 are confirmed.**

THIS ACTION IS MADE FINAL.

A shortened statutory period for response to this action is set to expire one month from the mailing date of this action.

Extensions of time under 37 CFR 1.136(a) do not apply in reexamination proceedings. The provisions of 37 CFR 1.136 apply only to "an applicant" and not to parties in a reexamination proceeding. Further, in 35 U.S.C. 305 and in 37 CFR 1.550(a), it is required that reexamination proceedings "will be conducted with special dispatch within the Office."

Extensions of time in reexamination proceedings are provided for in 37 CFR 1.550(c). A request for extension of time must be filed on or before the day on which a response to this action is due, and it must be accompanied by the petition fee set forth in 37 CFR 1.17(g). The mere filing of a request will not effect any extension of

time. An extension of time will be granted only for sufficient cause, and for a reasonable time specified.

The filing of a timely first response to this final rejection will be construed as including a request to extend the shortened statutory period for an additional month, which will be granted even if previous extensions have been granted. In no event however, will the statutory period for response expire later than SIX MONTHS from the mailing date of the final action. See MPEP § 2265.

Prosecution History

The request for the Ex Parte reexamination of claims 1-21 in the US Patent No. 7,561,104 to Alles at al. has been requested on September 24, 2012.

In response, on December 12, 2012, the Examiner has issued order granting reexamination of claims 1-21.

Then on June 20, 2013 the Examiner has issued a Non-Final rejection wherein claims 1-21 have been rejected as being anticipated and/or obvious over Benes, Gordon, Spain and Krumm.

In response, the Patent Owner has responded on August 20, 2013 traversing the proposed rejections. No claims have been amended.

In addition, on August 20, 2013 the Patent Owner has also filed 1.132 Affidavit of Dr. Saul A. Torrico wherein it has been submitted that Benes does not teach determining the location of the mobile station. The declaration has not been found persuasive.

This action is a response to the Patent Owner's remarks filed in August.

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The References

(1) Benes et al; U.S. Patent Publication No. 2004/0203539; Date Filed: December 11, 2002; Date Published: October 14, 2004 (Benes, hereinafter).

(2) Spain; US Patent No. 7,460,505; Date Filed: February 4, 2003; Date Published: December 2, 2008.

(3) Gordon et al; US Patent No. 7,433,695; Date Filed: May 22, 2006; Date Published: October 7, 2008 (Gordon, hereinafter).

(4) Krumm et al; US Patent No. 7,250,907; Date Filed: June 30, 2003; Date Published: July 31, 2007 (Krumm, hereinafter).

Declaration

On August 20, 2013 the Patent Owner has submitted the 1.132 Affidavit of Dr. Saula Torrico, in which Dr, Torrico alleged that "the information received by the mobile station from the base station is not determinative of a mobile station's actual location as the information is generic to all mobile devices in the sectors served by the base station" (page 1)

It is correct that the location of the mobile station cannot be determined solely based on the information about characteristics of the transmitters. This is precisely the reason why the mobile device determines an effective radiated power (ERP) based on the respective signals' strength values (paragraph [0021]). Consequently, the characteristics about the source along with the magnitude of the received signals allow determining the location of the mobile device.

Furthermore, the Figures 8 and 9 in Benes's disclosure illustrate exemplary values with respect to the mobile station discussed in the original specification. Thus, stating that the values would remain the same for any mobile station, is a mere allegation having no factual support. On contrary to the Dr. Torrico's submission, the graphs illustrated in Figures 8 and 9 are based on the difference of respective ERPs, which are determined by a particular mobile station, hence they are not generic.

Consequently, the Examiner did not find the Affidavit by Dr. Torrico persuasive.

Response to Arguments

ISSUE I. (35 U.S.C. 102 rejections) A.

The Patent Owner contends: "*All the metrics used by the Office in applying Benes to the current claims are taken solely from "the information" provided by the base station. As a result, Benes fails to provide teachings for the claimed "observed network measurement data" and the "modified network measurement data," which, as noted previously, are measured at the mobile station. Along with Benes' failure to disclose observed network measurement data, Benes also fails to disclose modifying the observed network measured data with the signal of greater magnitude … However, the normalization disclosed in [0027] of Benes is without regards to the magnitude of the signal with the greater ERP". (page 6)*

The Examiner's response: The Examiner disagrees with the Patent Owner's allegation. First, Benes teaches "previously gathered calibration data" in paragraph [0028] ("the information associated with the plurality of sectors may include, but is not limited to, antenna patterns, boresights, downtilts, and signal strength values associated with the plurality of antennas"). Second, Benes teaches "observed network measurement data" in paragraphs [0026], wherein effective radiated power measured in dB corresponds to signal (i.e. downlink signal) characteristic. Furthermore, there are multiple antennas (i.e. transmitters) and each of them has its corresponding signal strength received at the mobile station. Third, the "observed network measurement data" is modified via the step of normalization as described in paragraph [0027]. Thus, on contrary to what the Patent Owner contends, Benes teaches using **not only** "the information" but the existing calibration data as well as the "dynamic" signal

characteristics corresponding to the received signals' strengths to establish location of the mobile station.

In addition, the Patent Owner alleges that normalization disclosed in Benes is without regards to the magnitude of the signal, this is incorrect. One of ordinary skill in the art knows that step of normalization requires determining maximum and minimum in order to transform an existing scale to another. As described in paragraph [0027], it is recognized which signal has a greater ERP (effective radiated power) magnitude, and then "the mobile station may determine where along the normalized downlink signal 904 from the antenna associated with the second sector 204 the antenna gain difference matches the signal difference". Accordingly, the normalization is based at least partially on the greater magnitude signal characteristic

.

ISSUE I. B.

The Patent Owner contends: *"First, the modification is not on the observed network measurement data as required in the claims but rather on the data that the Office used for the claimed calibration data, as demonstrated above. Secondly, the ERP calculated from the information are not modified "using the greater magnitude signal characteristic." Both ERP peaks are simply calibrated to 0 dB, as shown above. Thus there is no disclosure for the limitation of "modifying said observed network measurement data using the greater magnitude signal characteristic". (page 7)*

The Examiner's response: The Examiner disagrees with the above assertion. As explained in response to the previous argument, Benes teaches ""observed network

measurement" which is the ERP of the downlink signal as described in paragraph [0026]. In contrast, "the calibration" data is described in paragraph [0028] and some examples include the antenna patterns, boresights etc. Furthermore, as disclosed in paragraph [0027], the "observed network measurements" are normalized (i.e. modified) and as explained above, in order to perform the step of normalization maximum and minimum must be determined in order to transform the scale. Even though, both signals may be calibrated to 0dB at peak, the transformation (i.e. modification) uses the greater magnitude signal at least in part, just as the claim language recites ("modifying said observed network measurement data using the greater magnitude signal characteristic").

ISSUE I. C.

The Patent Owner contends: *"First, the Office assertion that the information is based on the location of the mobile station with respect to the transmitter is not supported by the referenced citation, nor is it relevant to the disposition of the limitation. Secondly, the claim specifically recites "received signal strength [at] said mobile station." Received signal strength has a particular meaning to one skilled in the art and it is the strength of the signal as received, as opposed to the signal strength as transmitted … The information received from the base station upon which the Office relies cannot be considered as the received signal strength at the mobile station under any reasonable interpretation". (page 8)*

The Examiner's response: The Examiner disagrees with the Patent Owner's assertion. Benes also teaches the information being based on the location of the mobile station with respect to the transmitter. As disclosed in paragraph [0020], the location of the mobile station may be identified starting with requesting for information associated with plurality of transmitters and determining ERP associated with "each of a first sector 202 and a second sector 204 based on their respective signal strength values" (paragraph [0021]). Furthermore, Benes also teaches that the mobile station determined an effective radiated power associated with each sector based on their respective signal strength values, therefore the mobile station determines the strength received from the respective transmitters. If the mobile station would just read the strength of the transmitted signals, as the Patent Owner contends, then the mobile station could just receive this information along with the other characteristics. Instead, as disclosed in paragraph [0021], the mobile station determines the ERP, therefore the magnitude of the received signal is determined and not the ERP as transmitted.

Accordingly, the Examiner maintains rejection of claims 1, 3 and 11as being anticipated by Benes.

ISSUE II. (35 U.S.C. 103(a) rejections) A.

The Patent Owner contends: *"one skilled in the art would recognize the disclosure of Benes is inoperative to determine the location of a mobile station, as supported in the accompanying §1.132 affidavit. Therefore, one skilled in the art would not be motivated to look at Benes for the purpose of locating a mobile and certainly*

would understand that the modifications proposed by the Office would not render Benes operable and thus there would be no reasonable expectation of success". (page 9)

The Examiner's response: As explained above in the Declaration section, the Examiner has not been persuaded by the comments made by Dr. Torrico. Accordingly, the Examiner maintains that Benes teaches determining location of the mobile device (see paragraph [0020]) and it would be have been obvious to one of ordinary skill in the art to further modify Benes's teaching.

ISSUE II. (Claim 2) B.

The Patent Owner contends: *"The Office … suggests that Gordon teaches that the previously gathered calibration data is for one or more non-uniform grid points within said region ... There must be either an express or inherent disclosure and clearly there is no express disclosure … To the contrary, the passage, as highlighted above suggests quite the opposite in that locations are uniform (identical in size and shape)". (page 10)*

The Examiner's response: The Examiner disagrees with the Patent Owner's assertion. The Patent Owner only underlined the part mentioning identical size and shape while the citation relied upon which explains the embodiment wherein geographic region may be partitioned into **any number of locations of any size, shape and arrangement**, has been left out (see Gordon, column 9, lines 12-13). Accordingly, the Examiner maintains that Gordon teaches calibration data for one or more non-uniform grid points within the region.

ISSUE II. C.

The Patent Owner contends: *"The Office relies upon Gordon to provide a disclosure for this limitation stating "locations such as 'four-story building' or 'two-story building' correspond to a location within a structure" and citing Col. 9, ll, 17-41. However these passages in Gordon are with respect to calibration data, which the Office acknowledges in the rejection ("It would have been obvious … to modify Benes's method and include calibration data gathered at a predetermined points located within a structure" (emphasis added)). Claim 5 requires the collection of observed network measurement data, not calibration data within a structure. Furthermore, Claim 5, which depends from Claim 4, requires the collection of calibration data outdoors and observed network measurement data indoors, a combination that is absent in both Benes and Gordon". (page 11)*

The Examiner's response: The Examiner disagrees with the Patent Owner's assertion. In particular, Gordon teaches wireless device (i.e. mobile terminal) which may move, and which can receive information allowing to locate the device, from a variety of different locations (see column 4, lines 28-36 and column 12, lines 9-20). Consequently wireless device may be moved into and out of a building. In which case, the measurements could be conducted inside or outside of the building. Furthermore restricting the positioning function only to a specific geographical location would be very limiting and in fact it would greatly impact the usefulness of the positioning capability.

Accordingly, the Examiner maintains the rejection of claim 5.

ISSUE II. (Claims 9 and 10) D.

The Patent Owner contends: *"the claims require the signal characteristic [to] be the signal strength of a control signal … Both the rational provided by the Office and cited portion of Gordon are void of any disclosure of control channel or signal strength of the control channel". (page 11)*

The Examiner's response: The Examiner disagrees with the Patent Owner's allegations because signal used from the base station is a control channel since it is broadcasted at a constant power and is distinguishable by the mobile device from other control signals.

ISSUE II. E.

The Patent Owner contends: *"one skilled in the art would recognize the disclosure of Benes is inoperative to determine the location of a mobile station. Therefore, one skilled in the art would not be motivated to look at Benes for the purpose of locating a mobile and certainly would understand that the modifications proposed by the Office from Spain would not render Benes operable". (page 12)*

The Examiner's response: As explained above in the Declaration section, the Examiner has not been persuaded by the comments made by Dr. Torrico. Accordingly, the Examiner maintains that Benes teaches determining location of the mobile device (see paragraph [0020]) and it would be have been obvious to one of ordinary skill in the art to further modify Benes's teaching.

ISSUE II. (Claim 12) F.

***The Patent Owner contends**:" The Office incorrectly asserts that Gordon teaches a data set comprising signal strength differentials which are used to modify measurement data ... However, while Gordon "computes the differentials, in those cases that are appropriate, of the measurements to correct the situational errors in the measurements received" the differentials are not used to modify the measurement data ... The Office incorrectly asserts that Gordon teaches the observed network measurement data "TA representing a timing advance parameter" … The cited portions of Gordon however relate respectively to the round trip time through the base station, and a Δ T that is the time between successive measurements; neither of which are a timing advance parameter (the terms TA and Timing Advance are not found in Gordon, nor is a discussion of a timing advance parameter [Timing advance corresponds to the length of time a signal takes to reach the base station from a mobile phone and is used to avoid interference in a TDMA system]". (page 13)*

The Examiner's response: The Examiner agrees with the Patent Owner that the TA disclosed in Gordon pertains to a "roundtrip time" and not to the length of time a signal takes to reach the base station from a mobile phone as defined in the US Patent '104 in column 4, lines 19-21. Consequently, the **rejection of claim 12 is withdrawn**. In addition **rejection of claims 13-14 is also withdrawn** by the virtue of their dependency on claim 12.

ISSUE II. G.

***The Patent Owner contends**: ""Spain only teaches using signal measurements to calculate signal differential." However, doing so does not result in measurement*

modification. In other words, the received data is used in calculation of differentials and the actual measurements remain the same ... unlike Claim 12, the operator modifying each of the measurements is P1 rather than P2". (page 14)

The Examiner's response: The Patent Owner's argument has not been found persuasive because claim 8 discloses "modifying of said calibration data" and not "measurement data" as the Patent Owner argues. Moreover, the Examiner also concluded that Spain does teach modification of the calibration data, because both the actual measurements and the expected values (i.e. calibration data) stored in a database, are used in differential equations which modify the initial values (see Spain, column 11, lines 1-22) . Accordingly, the rejection of claim 8 is maintained.

ISSUE III. (rejections under 35 U.S.C.103(a) over Gordon in view Krumm, claims 1-11) A.

The Patent Owner contends: *"The Office … states that Gordon's "correcting situational errors in the measurements is considered data modification" and the "correction is based on differentials which are essentially the difference between signals" meets the modifying limitation … Gordon explicitly explains that in order to account for these situational errors, pattern matching with the measurements are not undertaken, but rather pair-wise differentials of the measurements are matched with pair-wise differentials of the expected values … the Office's rational "the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part is based on the*

strongest signal" is incorrect. Simply stated, the differential does not modify any data ... the claim requires the modified network measurement data to be compared and, as noted above, the data received from the transmitters is not modified. Secondly, Gordon expressly states for situational errors the network measurements are not compared to expected values … Gordon provides an illustrative example, where the observed measurements from ratio A and B are neither modified nor compared with the expected values, but rather the differential between radio A and radio B (without respect to which has the greater magnitude) is compared with the difference between the expected values of radio A and radio B … Gordon, in much the same manner as the Office recognized in Spain, determines a difference between observed network measurement data but does not modify the first and second signal characteristic that make up the observed network measurement data … However, in Gordon, the differential between the signals is used to pattern match, and thus whether the greater magnitude signal in the pair-wise differential is subtracted from smaller signal, or the smaller signal is subtracted from the larger magnitude signal is irrelevant and would have no effect on the accuracy of the results … Irrespective that the measurements described in that portion of Gordon are not modified, as discussed previously, the differential in measurements that Gordon is describing is not related to the calibration data (expected values) as required in the claims but relates to a differential in observed network measurement data ". (pages 16-18)

The Examiner's response: The Examiner is not persuaded by the Patent Owner's argument. More specifically, after further consideration, the Examiner

maintains that Gordon teaches data modification because using data value in an equation, in this case differential, does modify the data element. Similarly, as recited in Gordon, column 18, lines 17-35, both the measured characteristics and the expected values (i.e. calibration data) are inputted into differential equation in order to compare the results and facilitate correction of a situational error. Therefore, both characteristic and calibration data is modified. Consequently, the **rejections of claims 1-11 over Gordon in view of Krumm are maintained**.

ISSUE III. B.

The Patent Owner contends: *"with respect to Benes in view of Gordon both the rationale provided by the Office and the cited portion of Gordon are void of any disclosure of control channel or signal strength of the control channel … Gordon also does not teach that the observed network measurement data includes "TA representing a timing advance parameter." As discussed previously, the round trip time and the ΔT are not timing advance parameters." (page 19)*

The Examiner's response: The Examiner agrees with the Patent Owner that the TA disclosed in Gordon pertains to a "roundtrip time" and not to the length of time a signal takes to reach the base station from a mobile phone as defined in the US Patent '104 in column 4, lines 19-21. Consequently, the **rejection of claim 12 is withdrawn**. In addition **rejection of claims 13-14 is also withdrawn** by the virtue of their dependency on claim 12.

ISSUE IV. (Claim 15) A.

The Patent Owner contends: *"The Office's argument equates "confidence measure" of the claims with "probabilities of location" of Gordon. However, the confidence measure of a location as used in the specification and as known in the art is not the same as a probability location being the actual location of a mobile station as described in Gordon … While confidence measure and probability may be related, they are not the same and the Office has only presented conclusory statements of their equality". (page 20)*

The Examiner's response: The Examiner disagrees with the Patent Owner. Confidence measure corresponds to a probability that the location of the mobile device has been correctly allocated, similarly to the location probability. Furthermore, the claim language does not recite any additional equation or language which would suggest that the confidence measure is calculated differently from the probability of the location. Thus location probability and confidence measure are considered equivalent.

Statutes

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of pre-AIA 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.
>
> (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.
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claim Rejections - 35 USC § 103

The following is a quotation of pre-AIA 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.

Proposed Rejections

A. Benes (U.S. Patent Publication No. 2004/0203539)

1. The Requester proposed rejection of claims 1, 3 and 11 under 35 U.S.C. 102(b) as being anticipated by Benes.

(See Request, Pages 5-7)

With respect to claim 1, Benes discloses a method for determining a location of a mobile station (paragraphs [0019] and [0020], wherein location

of a mobile station may be determined autonomously), comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network (paragraph [0028], wherein information about antennas' radiation patterns and signals' strength correspond to the claimed calibration data), wherein said network includes a first transmitter and a second transmitter (Figure 10, wherein there is a plurality of antennas and each antenna corresponds to a transmitter as it supports communication services); collecting observed network measurement data including a first signal characteristic from said first transmitter (paragraph [0026] and [0029], wherein "downlink signals" are received from the respective antennas and compared such that signal difference may be calculated) and a second signal characteristic from said second transmitter (paragraph [0026], wherein downlink signal is received from plurality of antennas); determining which of said first and second signal characteristics has a greater magnitude (paragraphs [0026] and [0027], wherein the greater ERP signal peak is determined); modifying said observed network measurement data using the greater magnitude signal characteristic (paragraph [0027], wherein normalization corresponds to the step of modification and Figure 9, wherein signals are adjusted using the greater magnitude); and comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station (paragraph [0027], wherein antenna gain

difference is compared (i.e. matched to) with the signal difference (see paragraph [0012], which explains how the signal difference is obtained)).

With respect to claim 3, Benes teaches the method of claim 1 wherein said observed network measurement data includes data collected at the mobile station (paragraph [0028], wherein mobile station receives information associated with plurality of sectors from a base station).

With respect to claim 11, Benes teaches the method of claim 1, wherein the observed network measurement data includes received signal strength of said transmitters as said mobile station (paragraph [0011], wherein mobile station may receive information about signal strength from multiple transmitters (i.e. antennas). The information is based on the location of the mobile station with respect to transmitters).

2. The Requester proposed rejection of claims 2, 4-7 and 9-11 under 35 U.S.C. 103(a) as being obvious over Benes in view of Gordon.

With respect to claim 2, Benes teaches all the limitations disclosed in claim 1, however he does not explicitly teach the method wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region. On the other hand Gordon teaches the method wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region (column 9, lines 9-13). It would have been

obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's method and utilize the partitions of various sizes, shapes, and arrangements taught by Gordon, in order to account for real-world wireless network coverage regions.

With respect to claim 4, Benes does not explicitly teach the method of claim 1 wherein said previously-gathered calibration data includes calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point is not located within a structure. On the other hand, Gordon teaches the method of claim 1 wherein said previously-gathered calibration data includes calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point is not located within a structure (column 9, lines 17-41, wherein features such as fountain or park are not located within a structure. In other words the region may be partitioned into plurality of locations and certain points may be outside the structure in question). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's method and include calibration data gathered at a predetermined points not located within a structure, as taught by Gordon, in order to consider outdoor locations of the mobile station.

With respect to claim 5, Benes does not explicitly teach that observed network measurement data is collected at a mobile station location within structure. On the other

hand, Gordon teaches the method of claim 4 wherein said observed network measurement data is collected at a mobile station located within a structure (column 9, lines 17-41, wherein locations such as “four-story building" or "two-story building" correspond to location within a structure). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes’s method and include calibration data gathered at a predetermined points located within a structure, as taught by Gordon, in order to consider indoor locations of the mobile station.

With respect to claim 6, furthermore Benes does not explicitly teach first signal characteristic being signal strength, however Gordon teaches first signal characteristic being signal strength (column 16, lines 49-64, wherein the signal strength of all the signals is received). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Bene’s method with Gordon’s teaching about first signal characteristic being signal strength, in order to use a readily-available signal characteristic for determining the location of the mobile station.

With respect to claim 7, furthermore Benes does not explicitly teach the second signal characteristic being signal strength, however Gordon teaches the second signal characteristic being signal strength (column 16, lines 49-64, wherein signal strength is received from signals originated from all the transmitters, therefore this characteristic is measured for first and second

signals). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Bene's method with Gordon's teaching about the second signal characteristic being signal strength, in order to use a readily-available signal characteristic for determining the location of the mobile station.

With respect to claim 9, furthermore Benes does not teach first signal characteristic being signal strength of a control channel transmitted by said first transmitter and received by said mobile station, then Gordon explicitly teaches the first signal characteristic being signal strength of a control channel transmitted by said first transmitter and received by said mobile station (column 18, lines 56-59, wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitters (radio stations A and B)). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's method with Gordon's teaching about utilizing signal strength as a control signal, in order to use readily-available source of a signal of which to measure signal strength.

With respect to claim 10, furthermore Benes does not teach the second signal characteristic being signal strength of a control channel transmitted by said second transmitter and received by said mobile station, then Gordon explicitly teaches the second signal

characteristic being signal strength of a control channel transmitted by said second transmitter and received by said mobile station (column 18, lines 56-59, wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitters (radio stations A and B)). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's method with Gordon's teaching about utilizing signal strength as a control signal, in order to use readily-available source of a signal of which to measure signal strength.

With respect to claim 11, if for some reason, one would conclude that Benes does not explicitly teach the method of claim 1, wherein the observed network measurement data includes received signal strength of said transmitters as said mobile station, then Gordon cures this deficiency by explicitly teaching receiving signal strength of all the signals received by wireless terminal (column 16, lines 49-64). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's signal processing means by including signal strength of the transmitter, as taught by Gordon, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

3. The Requester proposed rejection of claims 8-10 under 35 U.S.C. 103(a) as being obvious over Benes in view of Gordon and further in view of Spain.

With respect to claim 8, Benes does not explicitly teach `modifying of said calibration data using a difference between said first or second signal characteristics`**.** On the other hand**,** Spain cures this deficiency by explicitly teaching modifying calibration data using a difference between first and second signals (column 10, lines 51-60, wherein differential is calculated by subtracting one signal from another (i.e. S_K and S_1)). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's teaching with Spain disclosure about modifying calibration data because Benes teaches using differential for the purpose of error correction and specifically explains how the differentials are calculated.

With respect to claim 9, the Examiner maintains that Benes in view of Gordon teaches all the limitations recited in claim 9, however, Spain also teaches receiving measurements of signal strength from each from each base station, wherein the signal from each base station is the control signal (column 7, lines 44-50). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's signal processing means and to use signal characteristics such as signal strength as taught by Spain, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

With respect to claim 10, the Examiner maintains that Benes in view of Gordon teaches all the limitations recited in claim 10, however, Spain also teaches receiving measurements of signal strength from each from each base station, wherein the signal from each base station is the control signal (column 7, lines 44-50). It would have been

obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's signal processing means and to use signal characteristics such as signal strength, as taught by Spain, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

B. Spain in view of Krumm

1. The Requester proposed rejection of claims 1-14 under 35 U.S.C. 103(a) as being obvious over Spain in view of Krumm (See Request, Pages 7-8). After detailed consideration, the Examiner concluded that Spain in view of Krumm by itself or in combination, fail to teach all the limitation disclosed in claim 1. More specifically, Spain and Krumm fail to teach following limitation:

> "modifying said observed network measurement data using the greater magnitude signal characteristic".

Spain teaches a system and method for estimating location of wireless terminals through pattern matching of signal-strength differentials. There is no mention about modifying the observed network measurement data using greater magnitude signal characteristic. On contrary, Spain only teaches using signal measurements to calculate signal differential. However doing that, does not result in measurement modification. In other words, the received data is used in calculation of differentials and the actual measurements remain the same.

With respect to claims 2-14, *Spain in view of Krumm also fails to teach the content of those claims, by the virtue of their dependency on claim 1.*

C. Gordon in view of Krumm

1. The Requester proposed rejection of claims 1-11 under 35 U.S.C. 103(a) as being obvious over Gordon in view of Krumm (See Request, Pages 8-11).

With respect to claim 1, Gordon teaches a method for determining a location of a mobile station (Abstract), comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network (Table 3 in column 18, lines

45-55 and lines 61-64), wherein said network includes a first transmitter and a second transmitter (as illustrated in Figure 3, in column 18, lines 45-55, there are at least two transmitters (i.e. “Radio Station A” and “Radio Station B”)); collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter (column 16, lines 63-65); determining which of said first and second signal characteristics has a greater magnitude (column 18, lines 56-61); modifying said observed network measurement data using the greater magnitude signal characteristic (column 18, lines 17-25, , wherein correcting situational errors in the measurements is considered data modification. Note that correction is based on differentials which are essentially the difference between signals. Furthermore, the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part, is based on the strongest signal); and comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station (column 16, lines 9-18, wherein the “expected values” are those stored in the database and “measurements” are data received from transmitters).

If one would determine that Grodon does not teach the step of: determining which of said first and second signal characteristics has a greater magnitude, Krumm cures this deficiency by teaching a system and

method for determining the location of portable devices wherein it is determined which of the first and second signal characteristics has a greater magnitude (column 22, lines 65-66).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Gordon invention and determine and utilize the signal with strongest magnitude, as taught by Krumm, for the purpose of generating the most accurate results.

With respect to claim 2, Gordon teaches the method wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region (column 9, lines 9-13).

With respect to claim 3, Gordon teaches the method of claim 1 wherein said observed network measurement data includes data collected at the mobile station (column 2, lines 38-40, wherein measurement of a first characteristic of a signal is processed by the wireless terminal (i.e. mobile station), and wherein in order to process information, it has to be first received).

With respect to claim 4, Gordon teaches the method of claim 1 wherein said previously-gathered calibration data includes calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point

is not located within a structure (column 9, lines 17-41, wherein features such as fountain or park are not located within a structure. In other words the region may be partitioned into plurality of locations and certain points may be outside the structure in question).

With respect to claim 5, Gordon teaches the method of claim 4 wherein said observed network measurement data is collected at a mobile station located within a structure (column 9, lines 17-41, wherein locations such as “four-story building" or "two-story building" correspond to location within a structure).

With respect to claim 6, Gordon teaches the method of claim 4 wherein said first signal characteristic is signal strength (column 16, lines 49-64, wherein the signal strength of all the signals is received).

With respect to claim 7, Gordon teaches the method of claim 6 wherein said second signal characteristic is signal strength (column 16, lines 49-64, wherein signal strength is received from signals originated from all the transmitters, therefore this characteristic is measured for first and second signals).

With respect to claim 8, Gordon teaches the method of claim 7 wherein the modifying of said calibration data uses a difference between said first or second signal characteristics (Column 18,

lines 17-25, wherein differentials are used to correct the error in measurements and differential is a difference between two signals as explained in column 18, lines 61).

With respect to claim 9, Gordon teaches the method of claim 7 wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station (column 18, lines 56-59, wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitters (radio stations A and B)).

With respect to claim 10, Gordon teaches the method of claim 9 wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station (column 18, lines 56-59, wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitters (radio stations A and B)).

With respect to claim 11, Gordon teaches the method of claim 1, wherein the observed network measurement data includes received signal strength of said transmitters as said mobile station (column 16, lines 49-51, wherein location server receives measurements associated with wireless terminal (i.e. mobile station) including the signal strength of all the signals received by wireless terminal (column 16, lines 63-64)).

2. The Requester proposed rejection of claims 8-10 and 12-14 under 35 U.S.C. 103(a) as being obvious over Gordon in view of Krumm and further in view of Spain.

With respect to claim 8, the Examiner maintains that Gordon and Krumm teach all the limitations recited in claim 8, however, Spain also teaches `modifying of said calibration data using a difference between said first or second signal characteristics` (column 10, lines 51-60, wherein differential is calculated by subtracting one signal from another (i.e. S_K and S_1)). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Gordon's teaching with Spain disclosure about modifying calibration data because Gordon teaches pattern matching the pair-wise differentials of signal-strength measurements (i.e., modified measurements) with pair-wise differentials of expected signal-strength values.

With respect to claim 9, the Examiner maintains that Gordon in view of Krumm teach all the limitations recited in claim 9, however, Spain also teaches `the first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station` (column 7, lines 44-50). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Gordon's signal processing means and to use signal characteristics such as signal strength as taught by Spain, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

With respect to claim 10, the Examiner maintains that Gordon in view of Krumm teach all the limitations recited in claim 10, however, Spain also the second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station (column 7, lines 44-50). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Gordon's signal processing means and to use signal characteristics such as signal strength as taught by Spain, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

D. Gordon

1. The Requester proposed rejection of claims 15-21 under 35 U.S.C. 102(a) as being anticipated by Gordon (See Request, Pages 18-22).

With respect to claim 15, Gordon discloses a method for determining a location of a mobile station (Abstract), comprising: providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network (column 6, lines 45-49, wherein data has to be previously gathered to form a database); collecting network measurement data (column 16, lines 49-51 and 63-64, wherein measurement data corresponds to data about signal strength); comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station (column 16, lines 9-18, wherein "database calibration" corresponds

to "expected values") determining a confidence measure for each of the plurality of location estimates (column 22, lines 4-7, wherein "confidence measure" corresponds to "probabilities of locations"); determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures (column 26, lines 25-35, wherein Li refers to each probability distribution corresponding to each possible location, generated earlier (see column 25, lines 53-55)).

With respect to claim 16, Gordon discloses the method of claim 15, wherein the step of determining the location based on the plurality of location estimates and the respective confidence measures comprises selecting the location estimate having the highest respective confidence measure as the location of the mobile station (column 26, lines 25-35, wherein maximum likelihood corresponds to the "highest confidence measure").

With respect to claim 17, Gordon discloses the method of claim 15, wherein the step of determining the location based on the plurality of location estimates and their respective confidence measures comprises weighing the plurality location estimates based on their respective confidence measures and obtaining a

weighted average as the location of the mobile (column 25, lines 53-60).

With respect to claim 18, Gordon discloses the method of 15, wherein the confidence measures comprises one or more of the group consisting of a pdf (probability distribution function) the Mahalanobis distance (column 16, lines 9-18), and a distortion measure.

With respect to claim 19, Gordon discloses the method of claim 15, wherein the step of collecting network propagation data further comprises modifying the network propagation data (column 18, lines 17-24, wherein modifying corresponds to correcting and information about signal corresponds to propagation data).

With respect to claim 20, Gordon teaches the method of claim 15, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further comprises modifying said calibration data prior to the comparison (column 18, lines 28-30, wherein differentials of measurements are utilized in contrast to the actual signal strength).

With respect to claim 21, Gordon discloses the method of claim 20, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further comprises modifying said calibration data prior to the comparison (column 18, lines 28-30, wherein differentials of measurements are utilized in contrast to the actual signal strength).

NOTICE RE PATENT OWNER'S CORRESPONDENCE ADDRESS

Effective May 16, 2007, 37 CFR 1.33(c) has been revised to provide that: The Patent owner's correspondence address for all communications in an ex parte reexamination or an **inter partes** reexamination is designated as the correspondence address of the patent.

Revisions and Technical Corrections Affecting Requirements for Ex Parte and Inter Partes Reexamination, 72 FR 18892 (April, 16, 2007) (Final Rule)

The correspondence address for any pending reexamination proceeding not having the same correspondence address as that of the patent is, by way of this revision to 37 CFR 1.33(c), automatically changed to that of the patent file as of the effective date.

This change is effective for any reexamination proceeding which is pending before the Office as of May 16, 2007, including the present reexamination proceeding, and to any reexamination proceeding which is filed after that date.

Parties are to take this change into account when filing papers, and direct communications accordingly.

In the event the patent owner's correspondence address listed in the papers (record) for the present proceeding is different from the correspondence address of the patent, it is strongly encouraged that the patent owner affirmatively file a Notification of Change of Correspondence Address in the reexamination proceeding and/or the patent (depending on which address patent owner desires), to conform the address of the proceeding with that of the patent and to clarify the record as to which address should be used for correspondence.

Telephone Numbers for reexamination inquiries:

Reexamination	(571) 272-7703
Central Reexam Unit (CRU)	(571) 272-7705
Reexamination Facisimile Transmission No.	(571) 273-9900

Conclusion

Extensions of time under 37 CFR 1.136(a) will not be permitted in these proceedings because the provisions of 37 CFR 1.136 apply only to "an applicant" and not to parties in a reexamination proceeding. Additionally, 35 U.S.C. 305 requires that reexamination proceedings "will be conducted with special dispatch" (37 CFR 1.550(a)). Extension of time in reexamination proceedings are provided for in 37 CFR 1.550(c). After the filing of a request for reexamination by a third party requester, any document

filed by either the patent owner of the third party requester must be served on the other party (or parties where two or more third-party-requester proceedings are merged) in the reexamination proceeding in the manner provided in 37 CFR 1.248. See 37 CFR 1.550(f).

The patent owner is reminded of the continued responsibility under 37 CFR 1.565(a) to apprise the Office of any litigation activity, or other prior or concurrent proceeding, throughout the course of this reexamination proceeding. The third party requester is also reminded of the ability to similarly apprise the Office of any such activity or proceeding throughout the course of this reexamination proceeding. See MPEP § 2207, 2282 and 2286.

All correspondence relating to this *ex parte* reexamination proceeding should be directed:

By EFS-Web: Registered Users may submit correspondence via EFS-Web, at https://efs.uspto.gov/efile/myportal/efs-registered.

By Mail to: Mail Stop *Ex Parte* Reexam
Central Reexamination Unit
Commissioner for Patents
United States Patent & Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

By FAX to: (571) 273-9900
Central Reexamination Unit

By hand: Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

EFS-Web offers the benefit of quick submission to the particular area of the Office that needs to act on the correspondence. Also, EFS-Web submissions are “soft-scanned” (i.e., electronically uploaded) directly into the official file for the reexamination proceeding, which offers parties the opportunity to review the content of their submission after the "soft scanning" process is complete.

Any inquiry concerning this communication should be directed to the Central Reexamination Unit at telephone number 571-272-7705.

/ANGELA M LIE/
Primary Examiner, Art Unit 3992

/Luke S. Wassum/
Primary Examiner, Art Unit 3992

/Sudhanshu C Pathak/
Supervisory Patent Examiner, Art Unit 3992

Office Action in Ex Parte Reexamination	Control No. 90/012,694	Patent Under Reexamination 7,561,104 B2 E	
	Examiner ANGELA M. LIE	Art Unit 3992	AIA (First Inventor to File) Status No

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

a. ☒ Responsive to the communication(s) filed on *8/20/2013* .
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

b. ☒ This action is made FINAL.

c. ☐ A statement under 37 CFR 1.530 has not been received from the patent owner.

A shortened statutory period for response to this action is set to expire *2* month(s) from the mailing date of this letter. Failure to respond within the period for response will result in termination of the proceeding and issuance of an *ex parte* reexamination certificate in accordance with this action. 37 CFR 1.550(d). **EXTENSIONS OF TIME ARE GOVERNED BY 37 CFR 1.550(c).** If the period for response specified above is less than thirty (30) days, a response within the statutory minimum of thirty (30) days will be considered timely.

Part I THE FOLLOWING ATTACHMENT(S) ARE PART OF THIS ACTION:

1. ☐ Notice of References Cited by Examiner, PTO-892.
2. ☐ Information Disclosure Statement, PTO/SB/08.
3. ☐ Interview Summary, PTO-474.
4. ☐ _____.

Part II SUMMARY OF ACTION

1a. ☒ Claims *1-21* are subject to reexamination.
1b. ☐ Claims _____ are not subject to reexamination.
2. ☐ Claims _____ have been canceled in the present reexamination proceeding.
3. ☒ Claims *12-14* are patentable and/or confirmed.
4. ☒ Claims *1-11 and 15-21* are rejected.
5. ☐ Claims _____ are objected to.
6. ☐ The drawings, filed on _____ are acceptable.
7. ☐ The proposed drawing correction, filed on _____ has been (7a) ☐ approved (7b) ☐ disapproved.
8. ☐ Acknowledgment is made of the priority claim under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the certified copies have
   1 ☐ been received.
   2 ☐ not been received.
   3 ☐ been filed in Application No. _____ .
   4 ☐ been filed in reexamination Control No. _____.
   5 ☐ been received by the International Bureau in PCT application No. _____.
   * See the attached detailed Office action for a list of the certified copies not received.
9. ☐ Since the proceeding appears to be in condition for issuance of an *ex parte* reexamination certificate 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.
10. ☐ Other: _____

cc: Requester (if third party requester)

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	90012694	7,561,104 B2 ET AL.
	Examiner	Art Unit
	ANGELA M LIE	3992

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
review of patented file's prosecution history	12/10/2012	AL

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

	/ANGELA M LIE/ Primary Examiner, Art Unit 3992

Reexamination	Application/Control No.	Applicant(s)/Patent Under Reexamination
	90012694	7,561,104 B2 ET AL.
	Certificate Date	Certificate Number

Requester Correspondence Address:	☐ Patent Owner	☒ Third Party

Kaplan, Breyer, Schwarz & Ottesen, LLP
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Holmdel, NJ 07733

LITIGATION REVIEW ☒	/A.M.L/ (examiner initials)	12/12/2012 (date)
Case Name		Director Initials
none		

COPENDING OFFICE PROCEEDINGS	
TYPE OF PROCEEDING	NUMBER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of: Martin Alles, et al.

Control No.: 90/012,694 Patent No: 7,561,104

Confirmation No: 6575 Art Unit: 3992

Filed: 24 September 2012 Examiner: Angela M. Lie

Title: METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE UNIT

REQUEST FOR RECONSIDERATION

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

Sir:

In response to the Office Action mailed on 20 June 2013, Applicant submits the following arguments.

REMARKS

I. INTRODUCTION

Claims 1-21 of U.S. Patent No. 7,561,104 (" '104") are subject to reexamination and have proposed rejections.

II. PROPOSED REJECTIONS BASED ON BENES

Benes discloses a method in which the mobile station using information associated with sectors of a base station, determines a signal difference ("SD"), then normalizes that information and compares the signal difference with an antenna gain difference associated with the sectors in order to autonomously determine its location with respect to the base station. Specifically, Benes, using the information, generates effective radiated power ("ERP") metrics for first downlink signals associated with a first antenna in the first sector and generates ERP metrics for second downlink signals associated with a second antenna in the second sector. Benes determines the peak for the first downlink signal ERP ("peak ERP") and determines the peak for the second downlink signal ERP. The difference between the peaks is defined as the signal difference (SD). Benes then calibrates the ERPs of the signals such that the peaks are both 0 dB. Figure 9 shows the calibrated first and second downlink signals ERPs of Figure 8. The angle of arrival ("AoA") of the first signal is estimated as the angle at which the signal difference (SD) between the first and second signals equals the antenna gain difference ("AGD"). In Figure 8 the signal difference (SD) is shown as 10 dB and in Figure 9 the AGD between 904 and 902 at 240 degrees is shown as approximately 10 db. Thus, the AoA of 904 is estimated as 240.

A. Proposed rejections under 35 U.S.C. §102

The Office's proposed rejection of Claims 1, 3, and 11 under 35 U.S.C. §102(b) as being anticipated by Benes is improper.

Benes fails to provide each of the features recited in Claims 1, 3, and 11 and thus these claims are not anticipated[1].

1 "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." Verdegaal Bros. v. Union Oil Co. of California, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987).

Claim 1, recites:

> A method for determining a location of a mobile station, comprising:
>
> providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;
>
> collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;
>
> determining which of said first and second signal characteristics has a greater magnitude;
>
> modifying said observed network measurement data using the greater magnitude signal characteristic; and
>
> comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Claim 1 requires three types of data: (i) previously-gathered calibration data, (ii) observed network measurement data, and (iii) modified network measurement data. Among other issues regarding the deficiency of the proposed rejection, the latter two types of data are entirely missing from the Benes reference.

"Observed network measurement data" is discussed in the current specification as representing a network characteristic observed (measured) by a mobile station at a particular region.

> Observed network measurement data may be collected (operation 201). The observed data would typically be the same or similar to the data in a network measurement report (NMR). The network measurement data represents at least one network characteristic observed by the mobile station operating at a particular location within a region. 104 Col 9, ll. 41-47
>
> Network measurement data may be then observed and measured typically by a mobile station or any other wireless device (operation 703). *Id* Col. 18, ll. 58-60.

> Network measurement data from transmitters may be observed and collected including a signal characteristic from each of the transmitters (operation 903). *Id.* Col. 11, ll. 23-25

As recited in the claims and consistent with the specification, it is the observed network measurement data that is modified to become the "modified network measurement data."

In the proposed rejection, the Office cites Benes [0028] and states the information about antennas' radiation patterns and signals' strength correspond to the claimed calibration data. This information ("the information') as noted in Benes may be automatically provided by the base station or the mobile station may request "the information" from the base station.

> ...A mobile station within the communication cell may automatically receive information associated with the plurality of sectors from the base station. **The information** associated with the plurality of sectors may include, but is not limited to, an antenna pattern, a boresight, a downtilt, and a signal strength value associated with each one of the plurality of antennas. The mobile station may receive **the information** associated with the plurality of sectors via a pilot signal strength measurement message or a measurement report message. Alternatively, the mobile station may request for **the information** associated with the plurality of sectors from the base station. Benes [0011] (emphasis added)

> ...In response to the request, the mobile station 160 at step 1020 may receive information associated with the plurality of sectors. In particular, **the information** associated with the plurality of sectors may include, but is not limited to, antenna patterns, boresights, downtilts, and signal strength values associated with the plurality of antennas. Alternatively, the mobile station 160 may automatically receive **the information** associated with the plurality of sectors from the base station (i.e., without a request).*Id* [0028] (emphasis added)

It is "the information" (antenna patterns as shown in Figures 4-7 and specifically the antenna patterns in sectors 202 and 204 shown in Figures 8 and 9) received from the base station that the mobile station may use to determine the AoA.

> ...Based on the antenna patterns, the mobile station 160 may autonomously determine an angle of arrival (AOA) estimation by comparing ERPs between the antennas of at least two sectors in a communication cell. *Id.* [0026]

The ERPs are determined from "the information":

> Upon receiving the information associated with the plurality of sectors, the mobile station 160 may determine a power parameter associated with each of the plurality of antennas. For example, the mobile station 160 may determine an effective radiated power (ERP) associated with each of a first sector 202 and a second sector 204 based on their respective signal strength values. *Id.* [0021]

The signal difference (SD) in Benes is determined from "the information":

> ...In particular, a downlink signal 802 from the antenna associated with the first sector 202 has a boresight of 160 degree. azimuth (i.e., degrees from north) and an effective radiated power (ERP) of -80 dB, a downlink signal 804 from the antenna associated with the second sector 204 has a boresight of 230 degree. azimuth and an ERP of -70 dB, and a downlink signal 806 from the antenna associated with the third sector 206 has a boresight of 100 degree. and an ERP of -110 dB. As noted above, persons of ordinary skill in the art will readily appreciate that the ERPs may be compensated for gain differences of the antennas and losses from cables and connectors coupled to the antennas. Based on the ERPs, the mobile station 160 may calculate a signal difference (SD) between the peaks of the downlink signals 802, 804 associated with the antennas corresponding to the first and second sectors 202, 204. For example, the mobile station 160 may determine a signal difference of 10 dB between the first sector 202 and the second sector 204. *Id.* [0026]

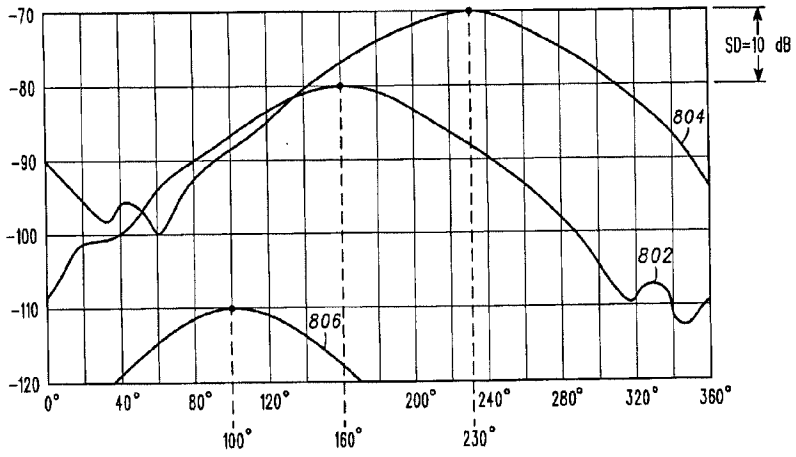

FIG. 8

The signal difference, as shown in Figure 8, is taken as the difference from the Peak ERPs of 804 and 802:

> ...Based on the ERPs, the mobile station 160 may calculate a signal difference (e.g., a change in dB) between the first and second downlink signals. That is, the mobile station 160 may compare the peak ERPs of the first and second downlink signals. *Id.* [0029]

The antenna gain difference (AGD) is also determined from "the information":

> Based on the information associated with the plurality of sectors, the mobile station 160 at step 1030 may determine an antenna gain difference. *Id.* [0029]

Specifically, the antenna gain difference (AGD) is determined from the calibration of the ERP peaks (normalized downlink signals 902 and 904) as shown in Figure 9:

> To determine an antenna gain difference (AGD) for comparison with the signal difference, the mobile station 160 may normalize the downlink signals 802, 804 from the antennas associated with the first and second sectors 202, 204 (shown as 902 and 904, respectively, in FIG. 9). For example, the peak ERPs of the normalized downlink signals 902, 904 may be calibrated to 0 dB. *Id.* [0027]

All the metrics used by the Office in applying Benes to the current claims are taken solely from "the information" provided by the base station. As a result, Benes fails to provide teachings for the claimed "observed network measurement data" and the "modified network measurement data," which, as noted previously, are measured at the mobile station.

Along with Benes' failure to disclose the observed network measurement data, Benes also fails to disclose modifying the observed network measurements and, further still, modifying the observed network measured data with the signal of greater magnitude.

The Office, in applying Benes to the modifying limitation, cites [0027] and states "wherein normalization corresponds to the step of modification and Figure 9 wherein signals are adjusted using the greater magnitude." However, the normalization disclosed in [0027] of Benes is without regards to the magnitude of the signal with the greater ERP.

Benes recites:

> To determine an antenna gain difference (AGD) for comparison with the signal difference, the mobile station 160 may normalize the downlink signals 802, 804 from the antennas associated with

> the first and second sectors 202, 204 (shown as 902 and 904, respectively, in FIG. 9). For example, the peak ERPs of the normalized downlink signals 902, 904 may be calibrated to 0 dB. Benes [0027]

Figure 9 below shows both 904 (the greater peak ERP) and 902(the smaller peak ERP) were simply normalized to a nominal 0 dB, 804 (of Figure 8) was offset by 70 dB and 802 (Figure 8) was offset by 80 dB, to arrive at 904 and 902 respectively.

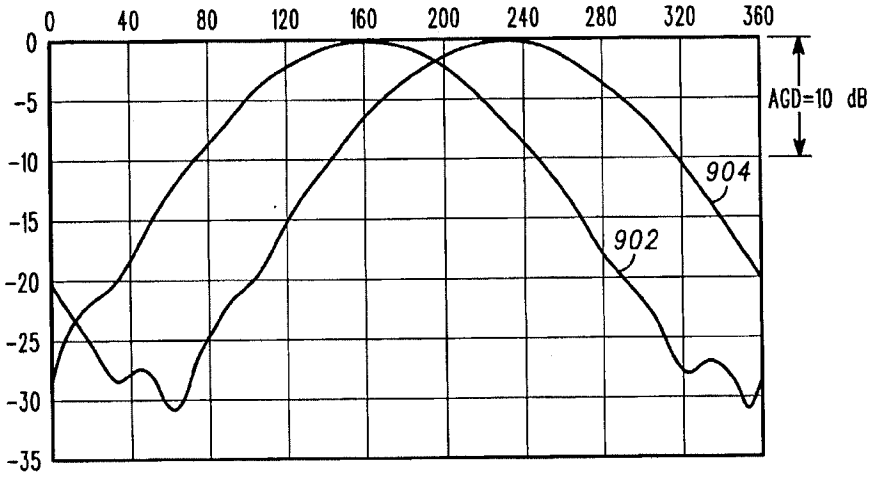

FIG. 9

The modification (normalization) of Benes that the Office relies upon fails for two reasons. First, the modification is not on the observed network measurement data as required in the claims but rather on the data that the Office used for the claimed calibration data, as demonstrated above. Secondly, the ERPs calculated from the information are not modified "using the greater magnitude signal characteristic." Both ERP peaks are simply calibrated to 0 dB, as shown above. Thus there is no disclosure for the limitation of "modifying said observed network measurement data using the greater magnitude signal characteristic."

Claims 3 and 11 depend from Claim 1 and thus are not anticipated by Benes for at least the same reasons as elaborated above and irrespective of the additional features recited therein. Nonetheless, several of the additional distinctions between Benes and the dependent claims are addressed below.

Claim 3 recites the further limitations of "wherein said observed network measurement data includes data collected at the mobile station."

The Office argues that Benes discloses this limitation because the "mobile station received information associated with the plurality of sectors from a base station" and cites [0028] as a basis.

However [0028] is discussing "the information" received from the base station and not the observed network measurement data that is measured and collected at the mobile station.

Claim 11 recites the further limitations of "the observed network measurement data includes received signal strength of said transmitters as said mobile station."

The Office argues that the "mobile station may receive information about signal strength from multiple transmitters (i.e. antennas). The information is based on the location of the mobile station with respect to the transmitters" and cites [0011] as a basis.

First, the Office's assertion that the information is based on the location of the mobile station with respect to the transmitter is not supported by the referenced citation, nor is it relevant to the disposition of the limitation. Secondly, the claim specifically recites "received signal strength [at] said mobile station." Received signal strength has a particular meaning to one skilled in the art and it is the strength of the signal as received, as opposed to the signal strength as transmitted[2].

The signal strength reference in [0011] is "a signal strength value associated with each one of the plurality of antennas" and this value is provided by the base station and reflects the nominal transmission power of the respective antenna (a physical property of the antenna). The information received from the base station upon which the Office relies cannot be considered as the received signal strength at the mobile station under any reasonable interpretation[3].

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2 "[T]he ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, i.e., as of the effective filing date of the patent application." Phillips v. AWH Corp., 415 F.3d 1303, 1313, 75 USPQ2d 1321, 1326 (Fed. Cir. 2005) (en banc); Sunrace Roots Enter. Co. v. SRAM Corp., 336 F.3d 1298, 1302, 67 USPQ2d 1438, 1441 (Fed. Cir. 2003); Brookhill-Wilk 1, LLC v. Intuitive Surgical, Inc., 334 F.3d 1294, 1298 67 USPQ2d 1132, 1136 (Fed. Cir. 2003

3 During examination, the claims must be interpreted as broadly as their terms reasonably allow. In re American Academy of Science Tech Center, 367 F.3d 1359, 1369, 70 USPQ2d 1827, 1834 (Fed. Cir. 2004) (The USPTO uses a different standard for construing claims than that used by district courts; during examination the USPTO must give claims their broadest reasonable interpretation in light of the specification.).This means that the words of the claim must be given their plain meaning unless the plain meaning is inconsistent with the specification. In re Zletz, 893 F.2d 319, 321, 13 USPQ2d 1320, 1322 (Fed. Cir.

Benes does not meet each and every limitation within Claims 1, 3 and 11 and therefore cannot anticipate these claims.

B. Proposed rejections under 35 U.S.C. §103

The Office's proposed rejections of Claims 2, 4-7, and 9-11 under 35 U.S.C. §103(a) as being obvious over Benes in view of Gordon are improper.

To establish a *prima facie* case of obviousness, the Office is required to present "some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness."[4] Towards that end, the Office's rational to modify Benes with Gordon is for the purposes of (i) accounting for real-world wireless network coverage regions [in determining location]; (ii) to consider outdoor location of the mobile station [in determining location]; (iii) to consider indoor locations of the mobile [in determining location]; (iv) to use a readily-available signal characteristic for determining the location of the mobile station; and (v) to use a readily-available source of a signal from which to measure signal strength [in determining the location of the mobile station].

However, one skilled in the art would recognize the disclosure of Benes is inoperative to determine the location of a mobile station, as supported in the accompanying §1.132 affidavit. Therefore, one skilled in the art would not be motivated to look at Benes for the purpose of locating a mobile and certainly would understand that the modifications proposed by the Office would not render Benes operable and thus there would be no reasonable expectation of success[5]. Absent such a motivation, a *prima facie* case of obviousness cannot be maintained. For at least this reason the proposed rejections of Claims 2, 4-7, and 9-11 as being obvious over Benes in view of Gordon cannot be maintained.

Claims 2, 4-7, and 9-11 all depend from Claim 1 and the Office depends upon Benes to provide the limitations of Claim 1 (the Office states "Benes teaches all the limitations disclosed in Claim 1"). However, Gordon does not obviate the deficiencies of Benes with respect to Claim 1 as explained above and thus the proposed combination

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1989) (discussed below); Chef America, Inc. v. Lamb-Weston, Inc., 358 F.3d 1371, 1372, 69 USPQ2d 1857 (Fed. Cir. 2004)

4 "'[R]ejections 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 ___, 82 USPQ2d at 1396.

5 Where there is a reason to modify or combine the prior art to achieve the claimed invention, the claims may be rejected as prima facie obvious provided there is also a reasonable expectation of success. In re Merck & Co., Inc., 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986)

fails to disclose each and every limitation. For at least this reason, a *prima facie* case of obviousness over Benes in view of Gordon cannot be maintained and the proposed rejection is improper. Irrespective of the deficiencies of Benes in view of Gordon addressed above, each one of which on its own sufficiently overcomes the Office's proposed rejection, several additional distinctions between Benes in view of Gordon and the dependent claims are addressed below.

Claim 2, recites *inter alia*:

> wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

The Office, while acknowledging that Benes does not disclose the above limitation, suggests that Gordon teaches that the previously gathered calibration data is for one or more non-uniform grid points within said region and cites Col. 9, ll. 9-13 as a basis.

The cited portion of Gordon recites:

> With these considerations in mind, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that partition geographic region 220 into any number of locations of any size, shape, and arrangement. Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use embodiments of the present invention in which the **locations are identical in size and shape.** Gordon Col. 9, 11, 9-16. (emphasis added)

There is nothing in Gordon, much less the cited portion, regarding the use of non-uniform grid points as recited in the claim. There must be either an express or inherent disclosure and clearly there is no express disclosure. There is also no rational, expressed, or existing reason why a non-uniform grid is necessarily present, thus there is also no inherent[6] disclosure. To the contrary, the passage, as highlighted above, suggests quite the opposite in that the locations are uniform (identical in size and shape). Therefore at least for this reason, the proposed rejection of Claim 2 is improper.

---

6 "To establish inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.' " In re Robertson, 169 F.3d 743, 745, 49 USPQ2d 1949, 1950-51 (Fed. Cir. 1999)

Claim 5 recites *inter alia*:

> said observed network measurement data is collected at a mobile station located within a structure.

The Office relies upon Gordon to provide a disclosure for this limitation stating "locations such as 'four-story building' or 'two-story building' correspond to a location within a structure" and citing Col. 9, ll. 17-41. However these passages in Gordon are with respect to calibration data, which the Office acknowledges in the rejection ("It would have been obvious…to modify Benes's method and include **calibration data** gathered at a predetermined points located within a structure" (emphasis added)). Claim 5 requires the collection of **observed network measurement data, not calibration data** within a structure. Furthermore, Claim 5, which depends from Claim 4, requires the collection of calibration data outdoors and observed network measurement data indoors, a combination that is absent in both Benes and Gordon.

Therefore the proposed rejection of Claim 5 as being obvious over Benes and Gordon is improper.

Claims 9 and 10 respectively, recite *inter alia*:

> wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station" and "wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

Thus, the claims require the signal characteristic be the signal strength of **a control channel.** The Office relies upon Gordon to meet this limitation. The Office cites Col. 8, ll. 56-59, stating:

> Wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitter (radio stations A and B)

Gordon in the cited passage recites:

> If a given wireless terminal with a broken antenna and at an unknown location receives Radio Station A at -47 dBm and Radio Station B at -61 dBm, then it registers Radio Station A as 14 dBm stronger than Radio Station B. Gordon, Col. 8, ll. 56-59.

Both the rational provided by the Office and the cited portion of Gordon are void of any disclosure of control channel or signal strength of the control channel. Thus a *prima facie* case of obviousness has not been established.

The Office's proposed rejection of Claims 8-10 and 12-14 under 35 U.S.C. §103(a) as being obvious over Benes in view of Gordon and further in view of Spain is improper.

The Office's rational to modify Benes and Gordon with Spain is for the purpose of determining location of the mobile device. However, as discussed above, one skilled in the art would recognize the disclosure of Benes is inoperative to determine the location of a mobile station. Therefore, one skilled in the art would not be motivated to look at Benes for the purpose of locating a mobile and certainly would understand that the modifications proposed by the Office from Spain would not render Benes operable. Therefore, in addition to having no reasonable expectation of success, a motivation to combine is absent. Absent such a motivation, a *prima facie* case of obviousness cannot be maintained.

For at least this reason the proposed rejections of Claims 8-10 and 12-14 as being obvious over Benes in view of Gordon and further in view of Spain cannot be maintained.

Claims 8-10 and 12-14 all depend from Claim 1 and the Office depends upon Benes to provide the limitations of Claim 1 (the Office states "Benes teaches all the limitations disclosed in Claim 1"). However, Gordon and Spain do not obviate the deficiencies of Benes with respect to Claim 1 as explained above and thus the proposed combination fails to disclose each and every limitation. Therefore for at least this reason, a *prima facie* case of obviousness over Benes in view of Gordon and further in view of Spain cannot be maintained and the proposed rejection is improper. Irrespective of the deficiencies of Benes in view of Gordon and further in view of Spain addressed above, at least one of the several distinctions between Benes, Gordon, and Spain and the dependent claims is further addressed below.

Claim 12 recites *inter alia*:

> The method of Claim 1 wherein said observed network measurement data includes a data set comprising:
>
> [P1, P2..., Pn, TA]
>
> where:
>
> P1 represents the signal strength of said first transmitter as measured at said mobile station,
>
> P2 represents a signal strength of said second transmitter as measured at said mobile station wherein P2 > P1,
>
> Pn represents a signal strength of a nth transmitter as measured at said mobile station wherein P2 > Pn, and

TA represents a timing advance parameter;

and wherein said modified network measurement data includes a data set comprising:

[P2-P1, 0, P2-Pn, TA]

where:

P2-P1 represents a difference between P2 and P1,

0 represents a difference between P2 and P2, and

P2-Pn represents a difference between P2 and Pn.

The Office acknowledges that Benes does not disclosure the features of Claim 12 and relies upon both Gordon and Spain to provide the disclosure.

The Office incorrectly asserts that Gordon teaches a data set comprising signal strength differentials which are used to modify measurement data and cites Col 18, ll. 17-25. However, while Gordon "computes the differentials, in those cases that are appropriate, of the measurements to correct the situational errors in the measurements received" the differentials are not used to modify the measurement data.

The Office incorrectly asserts that Gordon teaches the observed network measurement data "TA representing a timing advance parameter" and cites Col. 17, ll. 26-28 and Col. 16, ll. 9-18. The cited portions of Gordon however relate respectively to the round trip time through the base station, and a ΔT that is the time between successive measurements; neither of which are a timing advance parameter. (the terms TA and Timing Advance are not found in Gordon, nor is a discussion of a timing advance parameter[7])

The Office acknowledges that Benes and Gordon do not explicitly teach:

[P1, P2..., Pn, TA]

where:

P1 represents the signal strength of said first transmitter as measured at said mobile station,

P2 represents a signal strength of said second transmitter as measured at said mobile station wherein P2 > P1,

7 Timing advance corresponds to the length of time a signal takes to reach the base station from a mobile phone and is used to avoid interference in a TDMA system.

Pn represents a signal strength of a nth transmitter as measured at said mobile station wherein P2 > Pn, and

TA represents a timing advance parameter;

and wherein said modified network measurement data includes a data set comprising:

[P2-P1, 0, P2-Pn, TA]

where:

P2-P1 represents a difference between P2 and P1,

0 represents a difference between P2 and P2, and

P2-Pn represents a difference between P2 and Pn.

The Office relies upon Spain for a disclosure. However, as noted by the Office, "Spain only teaches using signal measurements to calculate signal differential." However, doing so does not result in measurement modification. In other words, the received data is used in calculation of differentials and the actual measurements remain the same" *see* NFOA Page 17.

In addition, Spain fails to disclose a modified network measurement data set as claimed. In particular, the Office cites Table 4 of Spain for the disclosure of [P2-P1, 0, P2-Pn, TA]. Table 4 is reproduced below:

TABLE 4

Signal-strength Differentials for
Signal 1 = –98, Signal 2 = –64, and Signal 3 = –43

k	ΔR_k	$R_k - R_1$
2	34	–64 – (–98)
3	47	–51 – (–98)

Table 4 shows [R1-R1, R2-R1 and Rn-R1] or otherwise arranged, and substituting P for R results in (P2-P1, P1-P1 and Pn-P1). However, unlike Claim 12, the operator modifying each of the measurements is P1 rather than P2, and the claim requires the modifier to be greater in magnitude than all the other signals. P1 of Spain, unlike P2 of Claim 12, is not greater than P2 or Pn.

Furthermore, Benes does not modify observed network measurement data, nor use differentials of observed network measurement data, and thus the modification proposed would not improve Benes, and thus there is no proper motivation.

III. PROPOSED REJECTIONS BASED ON GORDON

A. Proposed rejections under 35 U.S.C. §103

The Office incorrectly rejected Claims 1-11 under 35 U.S.C. §103(a) as being obvious over Gordon in view of Krumm.

Claim 1 recites *inter alia*:

> modifying said observed network measurement data using the greater magnitude signal characteristic;
>
> comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

The Office, citing Col. 18, lines 17-25, states that Gordon's "correcting situational errors in the measurements is considered data modification" and that the "correction is based on differentials which are essentially the difference between signals" meets the modifying limitation. The Office further states "the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part is based on the strongest signal."

The Office also suggests that Gordon discloses the comparing limitation citing Column 16, lines 9-18 and stating "the expected values" are those stored in the database and "measurements" are the data received from transmitters."

However, the Office is incorrect regarding the teachings of Gordon.

Gordon describes a method of using non-GPS techniques for generating location-specific assistance data. The assistance data is used to acquire GPS signals to estimate the mobile device's location. In the portions of Gordon relied upon by the Office, Gordon describes correcting for situational error. Situational errors (broken antennae, low battery, inside a car) are addressed by Gordon by computing differentials.

> In accordance with process 1103, location server 214 computes the differentials, in those cases that are appropriate, of the measurements to correct the situational errors in the measurements received in process 1001. Many factors, including the condition of wireless terminal 201's antenna, the state of its battery, and whether or not the terminal is inside a vehicle can introduce situational measurement errors. This is particularly true for

> measurements of pathloss and signal strength. Gordon Col. 18, ll. 18-25

Gordon explicitly explains that in order to account for these situational errors, pattern matching with the measurements are not undertaken, but rather pair-wise differentials of the measurements are matched with pair-wise differentials of the expected values:

> The illustrative embodiment ameliorates the effects of these factors by pattern matching not the measurements themselves...to the expected values for those trails, but by pattern matching the pair-wise differentials of those measurements to the pair-wise differentials of the expected values for those traits. *Id* Col. 18, ll. 26-34

The correction relied upon by the Office is not of the observed measurement data, but of the situation. The observed measurement data is not changed or modified, but rather a difference is computed. Thus, the Office's rational "the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part is based on the strongest signal" is incorrect. Simply stated, **the differential does not modify any data.**

The Office's suggestion that the "measurements" (data received from transmitters) are compared with the "expected values" meets the comparing limitation is insufficient. First, the claim requires the modified network measurement data to be compared and, as noted above, the data received from the transmitters is not modified. Secondly, Gordon expressly states for situational errors the network measurements are not compared to expected values. *See Id.*

Gordon provides an illustrative example, where the observed measurements from radio A and radio B are neither modified nor compared with the expected values, but rather the differential between radio A and radio B (without respect to which has the greater magnitude) is compared with the difference between the expected values of radio A and radio B:

> A simple example involving signal strengths illustrates this approach. A first radio station, Radio Station A, can be received at -56 dBm at Location 1, -42 dBm at Location 2, -63 dBm at Location 3, and -61 dBm at Location 4, and a second radio station, Radio Station B, can be received at -63 dBm at Location 1, -56 dBm at Location 2, -65 dBm at Location 3, and -52 dBm at Location 4. This information is summarized in the table below and forms the basis for a map or database that correlates location to signal strength. Col. 18, ll. 36-44

TABLE 3

Illustrative Location-Trait Database (Differential Reception)

	Radio Station A	Radio Station B	Difference
Location 1	-56 dBm	-63 dBm	-7 dB
Location 2	-42 dBm	-56 dBm	-14 dB
Location 3	-63 dBm	-65 dBm	-2 dB
Location 4	-61 dBm	-52 dBm	9 dB

> If a given wireless terminal with a broken antenna and at an unknown location receives Radio Station A at -47 dBm and Radio Station B at -61 dBm, then it registers Radio Station A as 14 dBm stronger than Radio Station B. This suggests that the wireless terminal is more likely to be at Location 2 than it is at Location 1, 3, or 4. If the measured signal strengths themselves were pattern matched into Location-Trait Database 313, the resulting probability distribution for the location of wireless terminal 201 might not be as accurate. Col. 18, ll. 56-64

Gordon, in much the same manner as the Office recognized in Spain, determines a difference between observed network measurement data but does not modify the first and second signal characteristics that make up the observed network measurement data. Additionally, neither the observed network measurement data nor the computed difference is compared with the collected calibration data as required by the claim.

Claim 1 further recites:

> determining which of said first and second signal characteristics has a greater magnitude;

The Office suggests that Krumm cures any deficiency in Gordon regarding this limitation, stating "it would have been obvious to one of ordinary skill....to modify Gordon invention and determine and utilize the signal with strongest magnitude, as taught by Krum, for the purpose of generating the most accurate result." However, in Gordon, the differential between the signals is used to pattern match, and thus whether the greater magnitude signal in the pair-wise differential is subtracted from the smaller signal, or the smaller signal is subtracted from the larger magnitude signal is irrelevant and would have no effect on the accuracy of the results. Therefore, there is no correlation between the modification and the motivation, thus a *prima facie* case of obviousness has not been made.

Claims 2-11 depend from Claim 1 and thus are not obvious over Gordon in view of Krumm for at least the same reasons as elaborated above, irrespective of the additional features recited. Nonetheless, several of the additional distinctions between Gordon in view of Krumm and the dependent claims are addressed.

Claim 2 recites *inter alia*:

> wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

As discussed with respect to the proposed rejection of Claim 2 over Benes in view of Gordon (see above), Gordon does not expressly or inherently disclose the use of non-uniform grid points as recited in the claims. Therefore at least for this reason, the proposed rejection of Claim 2 is improper.

Claim 8 recites *inter alia*:

> wherein the modifying of said calibration data uses a difference between said first or second signal characteristics.

The Office cites Col. 18, ll. 17-25 and states that Gordon teaches "differentials are used to correct the error in measurements and differential is a difference between two signals."

Irrespective that the measurements described in that portion of Gordon are not modified, as discussed previously, the differential in measurements that Gordon is describing is not related to the calibration data (expected values) as required in the claims but relates to a differential in observed network measurement data. Therefore the proposed rejection is improper.

Claims 9 and 10 respectively, recite *inter alia*:

> wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station" and "wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

The claims require that the signal characteristic be the signal strength of **a control channel.** The Office relies upon Gordon to meet this limitation. The Office, citing Col. 8, ll. 56-59, states:

> Wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitter (radio stations A and B)

As discussed regarding the proposed rejection of Claims 9 and 10 with respect to Benes in view of Gordon, both the rationale provided by the Office and the cited portion of Gordon are void of any disclosure of control channel or signal strength of the control channel. Thus a *prima facie* case of obviousness has not been established.

The Office's proposed rejection of Claims 8-10 and 12-14 under 35 U.S.C. §103(a) as being obvious over Gordon in view of Krumm and further in view of Spain are improper.

Claims 8-10 and 12-14 all depend from Claim 1 and the Office depends upon Gordon and Krumm to provide the limitations of Claim 1. However, Spain does not obviate the deficiencies of Gordon in view of Krumm with respect to Claim 1, as explained above, and thus the proposed combination fails to disclose each and every limitation. Therefore for at least this reason, a *prima facie* case of obviousness over Gordon in view of Krumm and further in view of Spain cannot be maintained and the proposed rejection is improper.

Irrespective of the deficiencies of Gordon in view of Krumm and further in view of Spain addressed above, at least one of the several distinctions between Gordon, Krumm, and Spain and the dependent claims is addressed below.

The Office acknowledges that Gordon in view of Krumm does not disclose the features of Claim 12 and relies upon Spain to provide the disclosure.

The Office incorrectly asserts that Gordon teaches a data set comprising signal strength differentials which are used to modify measurement data and cites to Col 18, ll. 17-25. However, as discussed previously, the differentials are not used to modify the measurement data.

Gordon also does not teach that the observed network measurement data includes "TA representing a timing advance parameter." As discussed previously, the round trip time and the ΔT are not timing advance parameters.

Spain fails to disclose a modified network measurement data set as claimed as described earlier with respect to the proposed rejection of Claim 12 with Benes, Gordon, and Spain. Therefore a *prima facie* case of obviousness has not been established.

B. Proposed rejections under 35 U.S.C. 102(a)

The proposed rejection of Claims 15-21 under 35 U.S.C. 102(a) as being anticipated by Gordon is improper.

Claim 15 recites *inter alia*:

> determining a confidence measure for each of the plurality of location estimates;
>
> determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.

The Claim requires the determination of a confidence measure and determining the location of the mobile station at least based on the confidence measure. Gordon does not disclose a confidence measure.

The Office's argument equates "confidence measure" of the claims with "probabilities of location" of Gordon. However, the confidence measure of a location as used in the specification and as known in the art is not the same as a probability location being the actual location of a mobile station as described in Gordon.

The '104 patent states:

> A confidence measure may also be used to represent the accuracy of a mobile station's estimated location. Col 7, ll. 65-67.

Gordon does not discuss confidence measure, Gordon however describes the probability as the likelihood that a mobile station will be in a location. Gordon recites:

> The term "staying probability" is defined as an estimate of the probability P.sub.S(b, T, N, W) that wireless terminal W in location b at calendrical time T will still be in location b at time T+.DELTA.t, given environmental conditions, N. The term "moving probability" is defined as an estimate of the probability P.sub.M(b, T, N, W, c) that wireless terminal W in location b at calendrical time T will be in adjacent location c at time T+.DELTA.t, given environmental conditions, N. Col. 3, ll. 52-60

While confidence measure and probability may be related, they are not the same and the Office has only presented conclusory statements of their equality. A disclosure of a probability is not a disclosure of a confidence measure for the purposes of an anticipation rejection.

Claims 16-21 depend from Claim 15 and thus each require a confidence measure which is absent from Gordon. Therefore, for at least the same reason articulated with respect to Claim 15, the proposed rejections of Claims 16-21 are also improper.

CONCLUSION

Applicant has demonstrated that the anticipation and obviousness rejections proposed by the Office fail to meet the statutory requirements and thus should not be maintained. Benes, Gordon, Spain, and Krum alone or in combination have not been demonstrated to disclose each and every limitation recited in the claims. The claims are allowable and a reexamination certificate should be issued accordingly.

If the Examiner believes that any additional changes would place the application in better condition for allowance, the Examiner is invited to contact the undersigned attorney at the telephone number listed below.

Respectfully submitted,

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Dated: 20 August 2013

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of: Martin Alles, et al.

Confirmation No.: 6575

Control No.: 90/012,694 Art Unit: 3992

Filed: 24 September 2012 Examiner: Angela M. Lie

Title: METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE UNIT

DECLARATION UNDER 37 CFR § 1.132

1. I, _Dr. Saul A. Torrico_____ declare as follows:

2. I am a Principal Scientist____ at Andrew Corporation.

3. I have a PhD in the field of Electrophysics.

4. I have read and I understand the Published Application of Benes. "Benes" (U.S. Publication 2004/0203539), attached as Exhibit A.

5. I am one of ordinary skill in the art of location of mobile devices which is most pertinent to the disclosure of Benes.

6. As one skilled in the art, I read Benes to determine both the antenna gain difference ("AGD") and the signal difference ("SD") from the information provided from the base station regarding the antenna radiation patterns in the sectors served by the base station.

7. In my understanding of Benes, the information received by the mobile station from the base station is not determinative of a mobile station's actual location as the information is generic to all mobile devices in the sectors served by the base station.

8. I also reviewed the example provided by Benes including Figures 8 and 9. The explicit disclosure of Benes reveals that, using the information provided by the base station, each

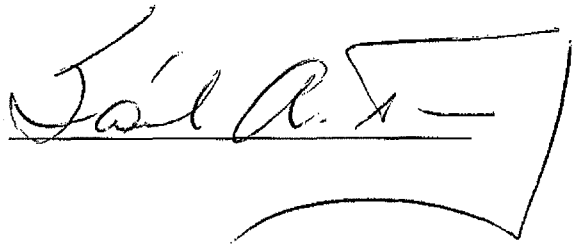
mobile would determine its location as 240° from the antenna serving sector 204, irrespective of the mobile's actual location.

9. As one skilled in the art, I would not look to the teachings of Benes for the purpose of devising, improving, or modifying a method to determine a mobile device's location.

10. 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 Title 18, United States Code, Section 1001, and that such willful false statements may jeopardize the validity of the above-identified application or any patent issuing thereon.

Respectfully submitted,

DATE: 8/19/2013



Certificate of Service

I hereby certify that on 20 August 2013, I caused to be mailed, by First Class Mail, a copy of the Request for Reconsideration and the Declaration Under 37 CFR §1.132 in the Reexamination of U.S. Patent 7,561,104, Reexamination Control Number 90/012,694, as submitted to the United States Patent and Trademark Office, to the Third Party Requestor:

Kenneth Ottensen
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On 20 August 2013

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Electronic Acknowledgement Receipt

EFS ID:	16637808
Application Number:	90012694
International Application Number:	
Confirmation Number:	6575
Title of Invention:	Method to modify calibration data used to locate a mobile unit
First Named Inventor/Applicant Name:	7,561,104 B2
Customer Number:	79172
Filer:	Mark Charles Comtois/laureen ponder
Filer Authorized By:	Mark Charles Comtois
Attorney Docket Number:	466-333us1
Receipt Date:	20-AUG-2013
Filing Date:	24-SEP-2012
Time Stamp:	16:39:16
Application Type:	Reexam (Patent Owner)

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		AND01082REReqDeccert.pdf	2459247 1a543475ad86575c015fe5f26467d0e13e295611	yes	24

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	21
	Oath or Declaration filed	22	23
	Reexam Certificate of Service	24	24

Warnings:	
Information:	
Total Files Size (in bytes):	2459247

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.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
90/012,694	09/24/2012	7,561,104 B2	466-333us1	6575

79172 7590 06/20/2013

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EXAMINER	
LIE, ANGELA M	
ART UNIT	PAPER NUMBER
3992	
MAIL DATE	DELIVERY MODE
06/20/2013	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.

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EX PARTE REEXAMINATION COMMUNICATION TRANSMITTAL FORM

REEXAMINATION CONTROL NO. *90/012,694*.

PATENT NO. *7,561,104 B2 E*.

ART UNIT *3992*.

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above identified *ex parte* reexamination proceeding (37 CFR 1.550(f)).

Where this copy is supplied after the reply by requester, 37 CFR 1.535, or the time for filing a reply has passed, no submission on behalf of the *ex parte* reexamination requester will be acknowledged or considered (37 CFR 1.550(g)).

Office Action in Ex Parte Reexamination	Control No. 90/012,694	Patent Under Reexamination 7,561,104 B2 E
	Examiner ANGELA M. LIE	Art Unit 3992

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

a☒ Responsive to the communication(s) filed on *06 February 2013* . b☐ This action is made FINAL.
c☐ A statement under 37 CFR 1.530 has not been received from the patent owner.

A shortened statutory period for response to this action is set to expire _____ month(s) from the mailing date of this letter. Failure to respond within the period for response will result in termination of the proceeding and issuance of an *ex parte* reexamination certificate in accordance with this action. 37 CFR 1.550(d). **EXTENSIONS OF TIME ARE GOVERNED BY 37 CFR 1.550(c).** If the period for response specified above is less than thirty (30) days, a response within the statutory minimum of thirty (30) days will be considered timely.

Part I THE FOLLOWING ATTACHMENT(S) ARE PART OF THIS ACTION:

1. ☐ Notice of References Cited by Examiner, PTO-892.
2. ☐ Information Disclosure Statement, PTO/SB/08.
3. ☐ Interview Summary, PTO-474.
4. ☐ _____.

Part II SUMMARY OF ACTION

1a. ☒ Claims *1-21* are subject to reexamination.
1b. ☐ Claims _____ are not subject to reexamination.
2. ☐ Claims _____ have been canceled in the present reexamination proceeding.
3. ☐ Claims _____ are patentable and/or confirmed.
4. ☒ Claims *1-21* are rejected.
5. ☐ Claims _____ are objected to.
6. ☐ The drawings, filed on _____ are acceptable.
7. ☐ The proposed drawing correction, filed on _____ has been (7a)☐ approved (7b)☐ disapproved.
8. ☐ Acknowledgment is made of the priority claim under 35 U.S.C. § 119(a)-(d) or (f).
   a)☐ All b)☐ Some* c)☐ None of the certified copies have
   1☐ been received.
   2☐ not been received.
   3☐ been filed in Application No. _____ .
   4☐ been filed in reexamination Control No. _____.
   5☐ been received by the International Bureau in PCT application No. _____.
   * See the attached detailed Office action for a list of the certified copies not received.
9. ☐ Since the proceeding appears to be in condition for issuance of an *ex parte* reexamination certificate 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.
10. ☐ Other: _____

cc: Requester (if third party requester)

DETAILED ACTION

This action is directed to claims 1-21 for which reexamination has been requested and substantial new question of patentability has been determined to exist. The considered claims are 1-21 in US Patent No. 7,561,104 to Alles et al. (hereinafter referred to as '104 patent). **Claims 1-21 are rejected.**

Table of Contents

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The References

(1) Benes et al; U.S. Patent Publication No. 2004/0203539; Date Filed: December 11, 2002; Date Published: October 14, 2004 (Benes, hereinafter).

(2) Spain; US Patent No. 7,460,505; Date Filed: February 4, 2003; Date Published: December 2, 2008.

(3) Gordon et al; US Patent No. 7,433,695; Date Filed: May 22, 2006; Date Published: October 7, 2008 (Gordon, hereinafter).

(4) Krumm et al; US Patent No. 7,250,907; Date Filed: June 30, 2003; Date Published: July 31, 2007 (Krumm, hereinafter).

Response to Patent Owner Statement

The Patent Owner's statement dated 2/6/2013 and the Third Party Requester's Reply to the Patent Owner's statement dated 3/8/2013 have been considered.

In regards to the Patent Owner's Statement, 37 C.F.R. § 1.530 (in part) states:

(c) Any statement filed by the patent owner shall clearly point out why the subject matter as claimed is not anticipated or rendered obvious by the prior art patents or printed publications, either alone or in any reasonable combinations. Where the reexamination request was filed by a third party requester, any statement filed by the patent owner must be served upon the *ex parte* reexamination requester in accordance with § 1.248.

Furthermore, MPEP 2249 (in part) states:

If reexamination is ordered, the decision will set a period of not less than 2 months within which period the patent owner may file a statement and any narrowing amendments to the patent claims. If necessary, an extension of time beyond the 2 months may be requested under 37 CFR 1.550(c) by the patent owner. Such request is decided by the Technology Center (TC) or Central Reexamination Unit (CRU) Director. Any statement filed must clearly point out why the patent claims are believed to be **patentable**, considering the cited prior art patents or printed publications alone or in any reasonable combination.

.....

In the event the decision is made to reexamine, 35 U.S.C. 304 provides that the owner will have a period, not less than 2 months, to file a statement **directed to the issue of patentability**. (Emphasis added)

Therefore, consistent with the MPEP (see above), only the issues, in the Patent Owner statement, related to the patentability of the claims under reexamination have been considered.

The Patent Owner submitted that the Requester did not "provide a proposed rejections and basis for combining the cited references and a statement why the claims under reexamination would been obvious over each of the proposed reference combinations" (Page 3 of the Patent Owner Statement dated 2/6/2013).

In response to the Patent Owners argument pertaining to the patentability of the claims the Requester has proposed plurality of rejections and as it is indicated in the request, all the independent claims have been mapped to the portions of cited references. The rejections of the dependent claims include at least one reference which teaches limitation(s) not taught by the primary reference and the motivation for combining the references is also cited by the Requester (Third Party Requester's Reply to the Patent Owner's statement dated 3/8/2013).

Furthermore, the Rejections proposed by the Office under obviousness provide explicit basis for combining the cited references (see below).

Statutes

Claim Rejections - 35 USC § 102

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.

(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.

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claim Rejections - 35 USC § 103

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.

Proposed Rejections

A. Benes (U.S. Patent Publication No. 2004/0203539)

1. The Requester proposed rejection of claims 1, 3 and 11 under 35 U.S.C. 102(b) as being anticipated by Benes.

(See Request, Pages 5-7)

With respect to claim 1, Benes discloses a method for determining a location of a mobile station (paragraphs [0019] and [0020], wherein location of a mobile station may be determined autonomously), comprising: providing a database of previously-gathered calibration data for a

predetermined region in a wireless network (paragraph [0028], wherein information about antennas' radiation patterns and signals' strength correspond to the claimed calibration data), wherein said network includes a first transmitter and a second transmitter (Figure 10, wherein there is a plurality of antennas and each antenna corresponds to a transmitter as it supports communication services); collecting observed network measurement data including a first signal characteristic from said first transmitter (paragraph [0026] and [0029], wherein "downlink signals" are received from the respective antennas and compared such that signal difference may be calculated) and a second signal characteristic from said second transmitter (paragraph [0026], wherein downlink signal is received from plurality of antennas); determining which of said first and second signal characteristics has a greater magnitude (paragraphs [0026] and [0027], wherein the greater ERP signal peak is determined); modifying said observed network measurement data using the greater magnitude signal characteristic (paragraph [0027], wherein normalization corresponds to the step of modification and Figure 9, wherein signals are adjusted using the greater magnitude); and comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station (paragraph [0027], wherein antenna gain difference is compared (i.e. matched to) with the signal difference (see paragraph [0012], which explains how the signal difference is obtained)).

With respect to claim 3, Benes teaches the method of claim 1 wherein said observed network measurement data includes data collected at the mobile station (paragraph [0028], wherein mobile station receives information associated with plurality of sectors from a base station).

With respect to claim 11, Benes teaches the method of claim 1, wherein the observed network measurement data includes received signal strength of said transmitters as said mobile station (paragraph [0011], wherein mobile station may receive information about signal strength from multiple transmitters (i.e. antennas). The information is based on the location of the mobile station with respect to transmitters).

2. The Requester proposed rejection of claims 2, 4-7 and 9-11 under 35 U.S.C. 103(a) as being obvious over Benes in view of Gordon.

With respect to claim 2, Benes teaches all the limitations disclosed in claim 1, however he does not explicitly teach the method wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region. On the other hand Gordon teaches the method wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region (column 9, lines 9-13). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify

Benes's method and utilize the partitions of various sizes, shapes, and arrangements taught by Gordon, in order to account for real-world wireless network coverage regions.

With respect to claim 4, Benes does not explicitly teach the method of claim 1 wherein said previously-gathered calibration data includes calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point is not located within a structure. On the other hand, Gordon teaches the method of claim 1 wherein said previously-gathered calibration data includes calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point is not located within a structure (column 9, lines 17-41, wherein features such as fountain or park are not located within a structure. In other words the region may be partitioned into plurality of locations and certain points may be outside the structure in question). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's method and include calibration data gathered at a predetermined points not located within a structure, as taught by Gordon, in order to consider outdoor locations of the mobile station.

With respect to claim 5, Benes does not explicitly teach that observed network measurement data is collected at a mobile station location within structure. On the other hand, Gordon teaches the method of claim 4 wherein said observed

network measurement data is collected at a mobile station located within a structure (column 9, lines 17-41, wherein locations such as “four-story building" or "two-story building" correspond to location within a structure). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes’s method and include calibration data gathered at a predetermined points located within a structure, as taught by Gordon, in order to consider indoor locations of the mobile station.

With respect to claim 6, furthermore Benes does not explicitly teach first signal characteristic being signal strength, however Gordon teaches first signal characteristic being signal strength (column 16, lines 49-64, wherein the signal strength of all the signals is received). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Bene’s method with Gordon’s teaching about first signal characteristic being signal strength, in order to use a readily-available signal characteristic for determining the location of the mobile station.

With respect to claim 7, furthermore Benes does not explicitly teach the second signal characteristic being signal strength, however Gordon teaches the second signal characteristic being signal strength (column 16, lines 49-64, wherein signal strength is received from signals originated from all the transmitters, therefore this characteristic is measured for first and second signals). It would have been obvious to one of ordinary skill in the art at the time the

invention was made to modify Bene's method with Gordon's teaching about the second signal characteristic being signal strength, in order to use a readily-available signal characteristic for determining the location of the mobile station.

With respect to claim 9, furthermore if one would conclude that Benes does not teach first signal characteristic being signal strength of a control channel transmitted by said first transmitter and received by said mobile station, then Gordon explicitly teaches the first signal characteristic being signal strength of a control channel transmitted by said first transmitter and received by said mobile station (column 18, lines 56-59, wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitters (radio stations A and B)). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's method with Gordon's teaching about utilizing signal strength as a control signal, in order to use readily-available source of a signal of which to measure signal strength.

With respect to claim 10, furthermore if one would conclude that Benes does not teach the second signal characteristic being signal strength of a control channel transmitted by said second transmitter and received by said mobile station, then Gordon explicitly teaches the second signal characteristic being signal strength of a control

channel transmitted by said second transmitter and received by said mobile station (column 18, lines 56-59, wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitters (radio stations A and B)). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's method with Gordon's teaching about utilizing signal strength as a control signal, in order to use readily-available source of a signal of which to measure signal strength.

With respect to claim 11, if for some reason, one would conclude that Benes does not explicitly teach the method of claim 1, wherein the observed network measurement data includes received signal strength of said transmitters as said mobile station, then Gordon cures this deficiency by explicitly teaching receiving signal strength of all the signals received by wireless terminal (column 16, lines 49-64). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's signal processing means by including signal strength of the transmitter, as taught by Gordon, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

3. The Requester proposed rejection of claims 8-10 and 12-14 under 35 U.S.C. 103(a) as being obvious over Benes in view of Gordon and further in view of Spain.

With respect to claim 8, if for some reason, one would conclude that Benes does not teach the method of claim 7 wherein the modifying of said

calibration data uses a difference between said first or second signal characteristics, Spain cures this deficiency by explicitly teaching modifying calibration data using a difference between first and second signals (column 10, lines 51-60, wherein differential is calculated by subtracting one signal from another (i.e. S_K and S_1)). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's teaching with Spain disclosure about modifying calibration data because Benes teaches using differential for the purpose of error correction and specifically explains how the differentials are calculated.

With respect to claim 9, if for some reason, one would conclude that Benes does not teach the method of claim 7 wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station, Spain cures this deficiency by explicitly teaching receiving measurements of signal strength from each from each base station, wherein the signal from each base station is the control signal (column 7, lines 44-50). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's signal processing means and to use signal characteristics such as signal strength as taught by Spain, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

With respect to claim 10, if for some reason, one would conclude that Benes does not teach the method of claim 9 wherein said second signal characteristic is signal strength of a control channel

transmitted by said second transmitter and received by said mobile station, Spain cures this deficiency by explicitly teaching receiving measurements of signal strength from each from each base station, wherein the signal from each base station is the control signal (column 7, lines 44-50). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's signal processing means and to use signal characteristics such as signal strength, as taught by Spain, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

With respect to claim 12, Gordon further teaches the method of claim 1 wherein said observed network measurement data includes a data set comprising signal strength differentials which are used to modify measurement data (column 18, lines 17-25) and TA representing a timing advance parameter (column 17, lines 26-28 and column 16, lines 9-18), however Benes and Gordon do not explicitly teach: [P.sub.1, P.sub.2 . . . , P.sub.n, TA] where: P.sub.1 represents the signal strength of said first transmitter as measured at said mobile station, P.sub.2 represents a signal strength of said second transmitter as measured at said mobile station wherein P.sub.2>P.sub.1 P.sub.n, represents a signal strength of a n.sup.th transmitter as measured at said mobile station wherein P.sub.2>P.sub.n,; and wherein said modified network measurement data includes a data set comprising: [P.sub.2-P.sub.1, 0, P.sub.2-P.sub.n, TA] where: P.sub.2-P.sub.1 represents a

difference between P.sub.2 and P.sub.1, 0 represents a difference between P.sub.2 and P.sub.2, and P.sub.2-P.sub.n represents a difference between P.sub.2 and P.sub.n. On the other hand, Spain teaches: [P.sub.1, P.sub.2 . . . , P.sub.n, TA] where: P.sub.1 represents the signal strength of said first transmitter as measured at said mobile station (column 3, lines 60-65, wherein first signal strength is received by wireless terminal (i.e. mobile station) from “Radio Station B" (i.e. first transmitter)), P.sub.2 represents a signal strength of said second transmitter as measured at said mobile station wherein P.sub.2>P.sub.1 (column 3, lines 60-65, wherein first signal strength is received by wireless terminal (i.e. mobile station) from “Radio Station A" (i.e. first transmitter)) P.sub.n, represents a signal strength of a n.sup.th transmitter as measured at said mobile station wherein P.sub.2>P.sub.n,

Table 3 from column 9:

TABLE 3

Signal-Strength Database

Location	Signal-Strength Tuple: Strength of Signal 1	Strength of Signal 2	Strength of Signal 3
x_1, y_1	−115	−115	−115
x_2, y_1	−115	−115	−111
...	...	...	...
X_7, y_7	−45	−51	−49
X_8, y_7	−46	−52	−55
X_9, y_7	−50	−49	−62
...	...	...	...
X_{16}, y_{13}	−115	−96	−115
X_{17}, y_{13}	−115	−105	−115

, wherein signal 3 corresponds to signal n and signal 2 is stronger than signals 1 and 3); and wherein said network measurement data includes a data set comprising: [P.sub.2-P.sub.1, 0, P.sub.2-P.sub.n, TA] where: P.sub.2-P.sub.1 represents a difference between P.sub.2 and P.sub.1, 0 represents a difference between P.sub.2 and P.sub.2, and P.sub.2-P.sub.n represents a difference between P.sub.2 and P.sub.n (wherein table 4, in column 12, illustrates the multiple differentials R2-R1, R3-R1 and R1-R1 would be equal to 0). It would have been obvious to one of ordinary skill in the art at the time the invention was made to further improve Benes's modified method and use multiple differentials to correct

measurements, as taught by Spain, in order to more accurately determine location of a mobile station (i.e. wireless device).

With respect to claim 13, furthermore if one would conclude that Benes does not explicitly teach the method of claim 12 wherein said first transmitter is a serving transmitter for said mobile station and said second and third transmitters are neighboring transmitters, then Gordon heels this deficiency by teaching the method of claim 12 wherein said first transmitter is a serving transmitter for said mobile station and said second and third transmitters are neighboring transmitters (column 17, lines 32-36, wherein "base stations" correspond to transmitters). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's method with Gordon's teaching about configuration of the transmitters, in order to reflect what a mobile station that is compliant with an air-interface standard being capable of reporting.

With respect to claim 14, furthermore if one would conclude that Benes does not explicitly teach the method of claim 12 wherein said third transmitter is not a member of said wireless network, then Gordon heels this deficiency by teaching the third transmitter not being a member of said wireless network (column 16, lines 53-54 and 63-64, wherein signal strength is received for all the signals originated from all the transmitters and as explained in column 16, lines 56-58 and column 4, line 6, transmitters such as "commercial

television, commercial radio, ground base aviation, navigation etc, are not considered "wireless telecommunication system"). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Benes's and exclude third transmitter from the wireless network, as taught by Gordon, in order to have varied signal sources to measure in a wireless network.

B. Spain in view of Krumm

1. The Requester proposed rejection of claims 1-14 under 35 U.S.C. 103(a) as being obvious over Spain in view of Krumm (See Request, Pages 7-8). After detailed consideration, the Examiner concluded that Spain in view of Krumm by itself or in combination, fail to teach all the limitation disclosed in claim 1. More specifically, Spain and Krumm fail to teach following limitation:

> "modifying said observed network measurement data using the greater magnitude signal characteristic".

Spain teaches a system and method for estimating location of wireless terminals through pattern matching of signal-strength differentials. There is no mention about modifying the observed network measurement data using greater magnitude signal characteristic. On contrary, Spain only teaches using signal measurements to calculate signal differential. However doing that, does not result in measurement modification. In other words, the received data is used in calculation of differentials and the actual measurements remain the same.

With respect to claims 2-14, *Spain in view of Krumm also fails to teach the content of those claims, by the virtue of their dependency on claim 1.*

C. Gordon in view of Krumm

1. The Requester proposed rejection of claims 1-11 under 35 U.S.C. 103(a) as being obvious over Gordon in view of Krumm (See Request, Pages 8-11).

With respect to claim 1, Gordon teaches a method for determining a location of a mobile station (Abstract), comprising: providing a database of previously-gathered calibration data for a

predetermined region in a wireless network (Table 3 in column 18, lines 45-55 and lines 61-64), wherein said network includes a first transmitter and a second transmitter (as illustrated in Figure 3, in column 18, lines 45-55, there are at least two transmitters (i.e. "Radio Station A" and "Radio Station B")); collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter (column 16, lines 63-65); determining which of said first and second signal characteristics has a greater magnitude (column 18, lines 56-61); modifying said observed network measurement data using the greater magnitude signal characteristic (column 18, lines 17-25, , wherein correcting situational errors in the measurements is considered data modification. Note that correction is based on differentials which are essentially the difference between signals. Furthermore, the strongest signal (see column 18, lines 56-61) is used in calculations and since this differential is used to modify data, inherently the modification, at least in part, is based on the strongest signal); and comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station (column 16, lines 9-18, wherein the "expected values" are those stored in the database and "measurements" are data received from transmitters).

If one would determine that Grodon does not teach the step of: determining which of said first and second signal characteristics has a

greater magnitude, Krumm cures this deficiency by teaching a system and method for determining the location of portable devices wherein it is determined which of the first and second signal characteristics has a greater magnitude (column 22, lines 65-66).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Gordon invention and determine and utilize the signal with strongest magnitude, as taught by Krumm, for the purpose of generating the most accurate results.

With respect to claim 2, Gordon teaches the method wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region (column 9, lines 9-13).

With respect to claim 3, Gordon teaches the method of claim 1 wherein said observed network measurement data includes data collected at the mobile station (column 2, lines 38-40, wherein measurement of a first characteristic of a signal is processed by the wireless terminal (i.e. mobile station), and wherein in order to process information, it has to be first received).

With respect to claim 4, Gordon teaches the method of claim 1 wherein said previously-gathered calibration data includes

calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point is not located within a structure (column 9, lines 17-41, wherein features such as fountain or park are not located within a structure. In other words the region may be partitioned into plurality of locations and certain points may be outside the structure in question).

With respect to claim 5, Gordon teaches the method of claim 4 wherein said observed network measurement data is collected at a mobile station located within a structure (column 9, lines 17-41, wherein locations such as “four-story building" or "two-story building" correspond to location within a structure).

With respect to claim 6, Gordon teaches the method of claim 4 wherein said first signal characteristic is signal strength (column 16, lines 49-64, wherein the signal strength of all the signals is received).

With respect to claim 7, Gordon teaches the method of claim 6 wherein said second signal characteristic is signal strength (column 16, lines 49-64, wherein signal strength is received from signals originated from all the transmitters, therefore this characteristic is measured for first and second signals).

With respect to claim 8, Gordon teaches the method of claim 7 wherein the modifying of said calibration data uses a difference between said first or second signal characteristics (Column 18, lines 17-25, wherein differentials are used to correct the error in measurements and differential is a difference between two signals as explained in column 18, lines 61).

With respect to claim 9, Gordon teaches the method of claim 7 wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station (column 18, lines 56-59, wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitters (radio stations A and B)).

With respect to claim 10, Gordon teaches the method of claim 9 wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station (column 18, lines 56-59, wherein wireless terminal (i.e. mobile station) receives first and second signals from first and second transmitters (radio stations A and B)).

With respect to claim 11, Gordon teaches the method of claim 1, wherein the observed network measurement data includes received signal strength of said transmitters as said mobile station

(column 16, lines 49-51, wherein location server receives measurements associated with wireless terminal (i.e. mobile station) including the signal strength of all the signals received by wireless terminal (column 16, lines 63-64)).

2. The Requester proposed rejection of claims 8-10 and 12-14 under 35 U.S.C. 103(a) as being obvious over Gordon in view of Krumm and further in view of Spain.

With respect to claim 8, if for some reason, one would conclude that Gordon does not teach the method of claim 7 wherein the modifying of said calibration data uses a difference between said first or second signal characteristics, Spain cures this deficiency by explicitly teaching modifying calibration data using a difference between first and second signals (column 10, lines 51-60, wherein differential is calculated by subtracting one signal from another (i.e. S_K and S_1)). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Gordon's teaching with Spain disclosure about modifying calibration data because Gordon teaches pattern matching the pair-wise differentials of signal-strength measurements (i.e., modified measurements) with pair-wise differentials of expected signal-strength values.

With respect to claim 9, if for some reason, one would conclude that Gordon does not teach the method of claim 7 wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station, Spain cures this deficiency by explicitly teaching receiving

measurements of signal strength from each from each base station, wherein the signal from each base station is the control signal (column 7, lines 44-50). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Gordon's signal processing means and to use signal characteristics such as signal strength as taught by Spain, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

With respect to claim 10, if for some reason, one would conclude that Gordon does not teach the method of claim 9 wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station, Spain cures this deficiency by explicitly teaching receiving measurements of signal strength from each from each base station, wherein the signal from each base station is the control signal (column 7, lines 44-50). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Gordon's signal processing means and to use signal characteristics such as signal strength as taught by Spain, because signal strength is one of the most critical features in establishing the distance between an antenna (i.e. transmitter) and receiver.

With respect to claim 12, Gordon teaches the method of claim 1 wherein said observed network measurement data includes a data set comprising signal strength differentials which are used to modify measurement data (column 18, lines 17-25) and TA representing a timing advance parameter (column 17, lines 26-28 and column 16, lines 9-18), however Gordon does not explicitly teach: [P.sub.1, P.sub.2 . . .

, P.sub.n, TA] where: P.sub.1 represents the signal strength of said first transmitter as measured at said mobile station, P.sub.2 represents a signal strength of said second transmitter as measured at said mobile station wherein P.sub.2>P.sub.1 P.sub.n, represents a signal strength of a n.sup.th transmitter as measured at said mobile station wherein P.sub.2>P.sub.n,; and wherein said modified network measurement data includes a data set comprising: [P.sub.2-P.sub.1, 0, P.sub.2-P.sub.n, TA] where: P.sub.2-P.sub.1 represents a difference between P.sub.2 and P.sub.1, 0 represents a difference between P.sub.2 and P.sub.2, and P.sub.2-P.sub.n represents a difference between P.sub.2 and P.sub.n. On the other hand, Spain teaches: [P.sub.1, P.sub.2 . . . , P.sub.n, TA] where: P.sub.1 represents the signal strength of said first transmitter as measured at said mobile station (column 3, lines 60-65, wherein first signal strength is received by wireless terminal (i.e. mobile station) from “Radio Station B" (i.e. first transmitter)), P.sub.2 represents a signal strength of said second transmitter as measured at said mobile station wherein P.sub.2>P.sub.1 (column 3, lines 60-65, wherein first signal strength is received by wireless terminal (i.e. mobile station) from “Radio Station A" (i.e. first transmitter)) P.sub.n, represents a signal strength of a n.sup.th transmitter as measured at said mobile station wherein P.sub.2>P.sub.n,

Table 3 from column 9:

TABLE 3

	Signal-Strength Database		
	Signal-Strength Tuple		
Location	Strength of Signal 1	Strength of Signal 2	Strength of Signal 3
x_1, y_1	−115	−115	−115
x_2, y_1	−115	−115	−111
. . .	. . .	. . .	. . .
X_7, y_7	−45	−51	−49
X_8, y_7	−46	−52	−55
X_9, y_7	−50	−49	−62
. . .	. . .	. . .	. . .
X_{16}, y_{13}	−115	−96	−115
X_{17}, y_{13}	−115	−105	−115

, wherein signal 3 corresponds to signal n and signal 2 is stronger than signals 1 and 3); and wherein said network measurement data includes a data set comprising: [P.sub.2-P.sub.1, 0, P.sub.2-P.sub.n, TA] where: P.sub.2-P.sub.1 represents a difference between P.sub.2 and P.sub.1, 0 represents a difference between P.sub.2 and P.sub.2, and P.sub.2-P.sub.n represents a difference between P.sub.2 and P.sub.n (wherein table 4, in column 12, illustrates the multiple differentials R2-R1, R3-R1 and R1-R1 would be equal to 0). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Gordon's method and use multiple differentials to correct measurements, as

taught by Spain, in order to more accurately determine location of a mobile station (i.e. wireless device).

With respect to claim 13, Gordon teaches the method of claim 12 wherein said first transmitter is a serving transmitter for said mobile station and said second and third transmitters are neighboring transmitters (column 17, lines 32-36, wherein "base stations" correspond to transmitters).

With respect to claim 14, Gordon teaches the method of claim 12 wherein said third transmitter is not a member of said wireless network (column 16, lines 53-54 and 63-64, wherein signal strength is received for all the signals originated from all the transmitters and as explained in column 16, lines 56-58 and column 4, line 6, transmitters such as "commercial television, commercial radio, ground base aviation, navigation etc, are not considered "wireless telecommunication system").

D. Gordon

1. The Requester proposed rejection of claims 15-21 under 35 U.S.C. 102(a) as being anticipated by Gordon (See Request, Pages 18-22).

With respect to claim 15, Gordon discloses a method for determining a location of a mobile station (Abstract), comprising: providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network (column 6, lines 45-49,

wherein data has to be previously gathered to form a database); collecting network measurement data (column 16, lines 49-51 and 63-64, wherein measurement data corresponds to data about signal strength); comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station (column 16, lines 9-18, wherein "database calibration" corresponds to "expected values") determining a confidence measure for each of the plurality of location estimates (column 22, lines 4-7, wherein "confidence measure" corresponds to "probabilities of locations"); determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures (column 26, lines 25-35, wherein Li refers to each probability distribution corresponding to each possible location, generated earlier (see column 25, lines 53-55)).

With respect to claim 16, Gordon discloses the method of claim 15, wherein the step of determining the location based on the plurality of location estimates and the respective confidence measures comprises selecting the location estimate having the highest respective confidence measure as the location of the mobile station (column 26, lines 25-35, wherein maximum likelihood corresponds to the "highest confidence measure").

With respect to claim 17, Gordon discloses the method of claim 15, wherein the step of determining the location based on the plurality of location estimates and their respective confidence measures comprises weighing the plurality location estimates based on their respective confidence measures and obtaining a weighted average as the location of the mobile (column 25, lines 53-60).

With respect to claim 18, Gordon discloses the method of 15, wherein the confidence measures comprises one or more of the group consisting of a pdf (probability distribution function) the Mahalanobis distance (column 16, lines 9-18), and a distortion measure.

With respect to claim 19, Gordon discloses the method of claim 15, wherein the step of collecting network propagation data further comprises modifying the network propagation data (column 18, lines 17-24, wherein modifying corresponds to correcting and information about signal corresponds to propagation data).

With respect to claim 20, Gordon teaches the method of claim 15, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further

comprises modifying said calibration data prior to the comparison (column 18, lines 28-30, wherein differentials of measurements are utilized in contrast to the actual signal strength).

With respect to claim 21, Gordon discloses the method of claim 20, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further comprises modifying said calibration data prior to the comparison (column 18, lines 28-30, wherein differentials of measurements are utilized in contrast to the actual signal strength).

NOTICE RE PATENT OWNER'S CORRESPONDENCE ADDRESS

Effective May 16, 2007, 37 CFR 1.33(c) has been revised to provide that: The Patent owner's correspondence address for all communications in an ex parte reexamination or an **inter partes** reexamination is designated as the correspondence address of the patent.

Revisions and Technical Corrections Affecting Requirements for Ex Parte and Inter Partes Reexamination, 72 FR 18892 (April, 16, 2007) (Final Rule)

The correspondence address for any pending reexamination proceeding not having the same correspondence address as that of the patent is, by way of this revision to 37 CFR 1.33(c), automatically changed to that of the patent file as of the effective date.

This change is effective for any reexamination proceeding which is pending before the Office as of May 16, 2007, including the present reexamination proceeding, and to any reexamination proceeding which is filed after that date.

Parties are to take this change into account when filing papers, and direct communications accordingly.

In the event the patent owner's correspondence address listed in the papers (record) for the present proceeding is different from the correspondence address of the patent, it is strongly encouraged that the patent owner affirmatively file a Notification of Change of Correspondence Address in the reexamination proceeding and/or the patent (depending on which address patent owner desires), to conform the address of the proceeding with that of the patent and to clarify the record as to which address should be used for correspondence.

Telephone Numbers for reexamination inquiries:

Reexamination	(571) 272-7703
Central Reexam Unit (CRU)	(571) 272-7705
Reexamination Facisimile Transmission No.	(571) 273-9900

Conclusion

Extensions of time under 37 CFR 1.136(a) will not be permitted in these proceedings because the provisions of 37 CFR 1.136 apply only to "an applicant" and not to parties in a reexamination proceeding. Additionally, 35 U.S.C. 305 requires that

reexamination proceedings "will be conducted with special dispatch" (37 CFR 1.550(a)). Extension of time in reexamination proceedings are provided for in 37 CFR 1.550(c). After the filing of a request for reexamination by a third party requester, any document filed by either the patent owner of the third party requester must be served on the other party (or parties where two or more third-party-requester proceedings are merged) in the reexamination proceeding in the manner provided in 37 CFR 1.248. See 37 CFR 1.550(f).

The patent owner is reminded of the continued responsibility under 37 CFR 1.565(a) to apprise the Office of any litigation activity, or other prior or concurrent proceeding, throughout the course of this reexamination proceeding. The third party requester is also reminded of the ability to similarly apprise the Office of any such activity or proceeding throughout the course of this reexamination proceeding. See MPEP § 2207, 2282 and 2286.

All correspondence relating to this *ex parte* reexamination proceeding should be directed:

By EFS-Web: Registered Users may submit correspondence via EFS-Web, at https://efs.uspto.gov/efile/myportal/efs-registered.

By Mail to: Mail Stop *Ex Parte* Reexam
Central Reexamination Unit
Commissioner for Patents
United States Patent & Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

By FAX to: (571) 273-9900
Central Reexamination Unit

By hand: Customer Service Window

Randolph Building
401 Dulany Street
Alexandria, VA 22314

EFS-Web offers the benefit of quick submission to the particular area of the Office that needs to act on the correspondence. Also, EFS-Web submissions are “soft-scanned” (i.e., electronically uploaded) directly into the official file for the reexamination proceeding, which offers parties the opportunity to review the content of their submission after the "soft scanning" process is complete.

Any inquiry concerning this communication should be directed to the Central Reexamination Unit at telephone number 571-272-7705.

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/Sudhanshu C Pathak/
Supervisory Patent Examiner, Art Unit 3992

Reexamination	Application/Control No. 90012694	Applicant(s)/Patent Under Reexamination 7,561,104 B2 ET AL.
	Certificate Date	Certificate Number

Requester Correspondence Address:	☐ Patent Owner	☒ Third Party

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LITIGATION REVIEW ☒	/A.M.L/ (examiner initials)	12/12/2012 (date)
Case Name		Director Initials
none		/SP/ for IY

COPENDING OFFICE PROCEEDINGS	
TYPE OF PROCEEDING	NUMBER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Ex Parte Reexamination of:

US Patent No.:	7,561,104
First Inventor:	Martin Alles
Issued:	07/14/2009
Title:	Method to modify calibration data used to locate a mobile unit
Reexam Control No.:	90/012,694
Art Unit:	3992
Examiner:	Angela M. Lie

REPLY BY THIRD PARTY REQUESTER PURSUANT TO 37 C.F.R. § 1.535

Pursuant to 37 C.F.R. § 1.535, this *Reply by Third Party Requester* (hereinafter "*Reply*") constitutes a reply to the patent owner's statement (hereinafter "*Statement*") under 37 C.F.R. § 1.530 concerning the above-referenced Reexamination. The date of service of the patent owner's statement was February 6, 2013. Therefore, this *Reply* has been timely filed by the Third Party Requester (hereinafter "Requester") within the two-month period after the date of service. Accompanying this Reply is a certification that a copy of the Reply has been served on the patent owner.

In regard to the *Statement*, according to 37 C.F.R. § 1.530(c) "Any statement filed by the patent owner shall clearly point out why the subject matter as claimed is not anticipated or rendered obvious by the prior art patents or printed publications, either alone or in any reasonable combinations." Requester points out that the *Statement* fails to include the aforementioned required information.

The foregoing deficiency of the *Statement* notwithstanding, Requester has carefully considered the points that were raised by the patent owner. Without commenting on the merits of the points raised, and as the *Reply* need not be limited to issues raised in the *Statement*, the Requester takes this opportunity to enhance the format and content of the Reexamination Request (i.e., "Request").

As the enhancements affect multiple pages of the Request, for the Office's convenience the current *Reply* includes all of the sections from the original Reexamination Request (except as specified below) and now provides a Table of Contents and Claim Charts. The current *Reply* does not include the previously-submitted Exhibits A-F (i.e., the

'104 Patent, the cited prior art references, and PTO/SB/08 filed in the original Request), and there are no new citations.

Respectfully,

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Ex Parte Reexamination of:

US Patent No.:	7,561,104
First Inventor:	Martin Alles
Issued:	07/14/2009
Title:	Method to modify calibration data used to locate a mobile unit
Reexam Control No.:	90/012,694
Art Unit:	3992
Examiner:	Angela M. Lie

REQUEST FOR EX PARTE REEXAMINATION UNDER 37 C.F.R. § 1.510(b)

Ex Parte Reexamination is requested under 35 U.S.C. § 302 and 37 C.F.R. § 1.510 of U.S. Patent No. 7,561,104 (hereinafter, the "'104 Patent"), issued July 14, 2009 to Alles et al. from an application filed February 5, 2008. The '104 Patent is assigned to CommScope, Inc. of North Carolina.

Pursuant to 37 C.F.R. § 1.510, this Request for Reexamination includes:

- a statement pointing out each new question of patentability based on prior patents and printed publications;
- an identification of every claim for which reexamination is requested, and a detailed explanation of the pertinence and manner of applying the cited prior art to every claim for which reexamination is requested;
- the appropriate fee of $17,750 under 37 C.F.R. § 1.20(c)(1);
- a copy of the entire '104 Patent including the front face and specification/claims in double column format, attached as Exhibit A; and
- a copy of each of the cited prior art patents and printed publications, attached as Exhibits B-E, including a listing thereof in an Information Disclosure Statement with Form PTO/SB/08, attached as Exhibit F.

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a. Claim 1 is unpatentable under 35 U.S.C. 102(b) as being anticipated by Benes. ..... - 12 -

b. Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm. ..... - 14 -

c. Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm. ..... - 16 -

2. CLAIM 2 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART. ..... - 19 -

a. Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1a)* ..... - 19 -

b. Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1b)* ..... - 19 -

c. Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm. *(following from the Claim 1 rejection proposed in Section 1c)* ..... - 19 -

3. CLAIM 3 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART. ..... - 19 -

a. Claim 3 is unpatentable under 35 U.S.C. 102(b) as being anticipated by Benes. *(following from the Claim 1 rejection proposed in Section 1a)* ..... - 20 -

b. Claim 3 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm. *(following from the Claim 1 rejection proposed in Section 1b)* ..... - 20 -

c. Claim 3 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm. *(following from the Claim 1 rejection proposed in Section 1c)* ..... - 20 -

4. CLAIM 4 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART. ..... - 20 -

a. Claim 4 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1a)* ..... - 20 -

b. Claim 4 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1b)* ..... - 20 -
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b. Claim 5 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 4 rejection proposed in Section 4b)* ..... - 21 -
c. Claim 5 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm. *(following from the Claim 4 rejection proposed in Section 4c)* ..... - 21 -
6. CLAIM 6 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART. ..... - 22 -
a. Claim 6 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon. *(following from the Claim 4 rejection proposed in Section 4a)* ..... - 22 -
b. Claim 6 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 4 rejection proposed in Section 4b)* ..... - 22 -
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b. Claim 7 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 6 rejection proposed in Section 6b)* ..... - 23 -
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8. CLAIM 8 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART. ..... - 23 -
a. Claim 8 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon, and further in view of Spain. *(following from the Claim 7 rejection proposed in Section 7a)* ..... - 23 -

b. Claim 8 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 7 rejection proposed in Section 7b)* ..... - 23 -
c. Claim 8 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm, and further in view of Spain. *(following from the Claim 7 rejection proposed in Section 7c)* ..... - 24 -
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b. Claim 9 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 7 rejection proposed in Section 7b)* ..... - 24 -
c. Claim 9 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm, and further in view of Spain. *(following from the Claim 7 rejection proposed in Section 7c)* ..... - 24 -
10. CLAIM 10 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART. ..... **- 25 -**
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b. Claim 10 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 9 rejection proposed in Section 9b)* ..... - 25 -
c. Claim 10 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm, and further in view of Spain. *(following from the Claim 9 rejection proposed in Section 9c)* ..... - 25 -
11. CLAIM 11 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART. ..... **- 26 -**
a. Claim 11 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1a)* ..... - 26 -
b. Claim 11 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1b)* ..... - 26 -
c. Claim 11 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm. *(following from the Claim 1 rejection proposed in Section 1c)* ..... - 26 -
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a. Claim 12 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Spain, and further in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1a)* ..... - 27 -

b. Claim 12 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1b)* ..... - 27 -
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b. Claim 13 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 12 rejection proposed in Section 12b)* ..... - 28 -
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A. IDENTIFICATION OF CLAIMS FOR WHICH REEXAMINATION IS REQUESTED

In accordance with 37 CFR 1.510, reexamination of claims 1-21 of U.S. Patent 7,561,104 is requested, in view of the following references:

Benes, U.S. Pre-Grant Publication 2004/0203539

Spain, U.S. Patent 7,460,505

Gordon, U.S. Patent 7,433,695

Krumm, U.S. Patent 7,250,907

Requestor submits that Benes alone anticipates independent claim 1, while either Spain in combination with Krumm or Gordon in combination with Krumm renders claim 1 obvious. Requestor submits that dependent claims 2-14 are rendered obvious by combinations of the references listed above. Requestor submits that Gordon by itself anticipates independent claim 15 and dependent claims 16-18. Requestor submits that dependent claims 19-21 are rendered obvious by Gordon in combination with Spain.

B. CITATION OF PRIOR ART

A copy of every document relied upon or referred to herein is annexed hereto, in accordance with 37 CFR 1.510(b)(3). These prior art documents include:

1. U.S. Pre-Grant Publication 2004/0203539 to Benes et al., "Method and mobile station for autonomously determining an angle of arrival (AOA) estimation," filed December 11, 2002;
2. U.S. Patent 7,460,505 to Spain, "Location estimation of wireless terminals through pattern matching of signal-strength differentials," filed February 4, 2003;
3. U.S. Patent 7,433,695 to Gordon et al., "Computationally-efficient estimation of the location of a wireless terminal based on pattern matching," filed May 22, 2006 and (i) is a continuation-in-part of application serial no. 11/194,151 filed Aug. 1, 2005 which is a continuation of serial no. 10/299,398 filed Nov. 18, 2002 now U.S. Pat. No. 6,944,465, and (ii) claims benefit of application serial no. 60/757,066 filed Jan. 6, 2006; and
4. U.S. Patent 7,250,907 to Krumm et al., "System and methods for determining the location dynamics of a portable computing device," filed June 30, 2003.

C. STATEMENT POINTING OUT EACH SUBSTANTIAL NEW QUESTION OF PATENTABILITY

The prior art documents, listed in the previous section, are new, previously uncited prior art references against the claims of the '104 Patent. Since these prior art documents render claims 1-21 of the '104 Patent unpatentable for the reasons discussed below, these documents raise substantial new questions of patentability, in accordance with 37 CFR 1.510(b)(1).

CLAIMS FOR WHICH REEXAMINATION IS REQUESTED

Reexamination is requested for claims 1-21 of the '104 Patent. Claims 1 and 15 are the only independent claims. All of the other claims are dependent claims that add additional claim limitations. The following table sets forth the references relied upon in this Request for Reexamination.

Reexam. Claim Number	References Applied Against the Reexamination Claim
1. Independent	• Benes • Spain, in view of Krumm • Gordon, in view of Krumm
2.	• Benes, in view of Gordon • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm
3.	• Benes • Spain, in view of Krumm • Gordon, in view of Krumm
4.	• Benes, in view of Gordon • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm
5.	• Benes, in combination with Gordon • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm
6.	• Benes, in combination with Gordon • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm

Reexam. Claim Number	References Applied Against the Reexamination Claim
7.	• Benes, in view of Gordon • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm
8.	• Benes, in view of Gordon and Spain • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm and Spain
9.	• Benes, in view of Gordon and Spain • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm and Spain
10.	• Benes, in view of Gordon and Spain • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm and Spain
11.	• Benes, in view of Gordon • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm
12.	• Benes, in view of Spain and Gordon • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm and Spain
13.	• Benes, in view of Spain and Gordon • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm and Spain
14.	• Benes, in view of Spain and Gordon • Spain, in view of Krumm and Gordon • Gordon, in view of Krumm and Spain
15. Independent	• Gordon
16.	• Gordon
17.	• Gordon
18.	• Gordon
19.	• Gordon • Gordon in view of Spain
20.	• Gordon • Gordon in view of Spain

Reexam. Claim Number	References Applied Against the Reexamination Claim
21.	• Gordon • Gordon in view of Spain

D. DETAILED EXPLANATION UNDER 37 C.F.R. § 1.510(b)(2)

The following sections include statements pointing out each substantial new question of patentability based on cited patents and printed publications, and a detailed explanation of the pertinency and manner of applying the patents and printed publications of every one of claims 1-21 of the '104 Patent, in accordance with 37 CFR 1.510(b)(2).

1. CLAIM 1 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Detailed reasons for these assertions of unpatentability are described in detail below and summarized in charts attached as Appendix A.

a. Claim 1 is unpatentable under 35 U.S.C. 102(b) as being anticipated by Benes.

The reasons why claim 1 of the '104 Patent is anticipated by Benes are described below feature-by-feature.

A method for determining a location of a mobile station, comprising:

Benes discloses a method for "determining an angle of arrival (AOA) estimation" (see Abstract), which is a method for determining a location of a mobile station.

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

In the '104 Patent, "calibration data" refers to data such as signal strength. ('104 Patent, col. 1, lines 21-24) Modified network measurement data "may be compared with the database of calibration data to determine the location of a mobile station." ('104 Patent, col. 2, lines 20-22)

Benes teaches "mobile station **160** at step **1020** may receive [(i.e., 'be provided with')] information [(i.e., the 'previously-gathered calibration data')] associated with [a] plurality of sectors [(i.e., the 'predetermined region')]. In particular, the information associated with the plurality of sectors may include, but is limited to, antenna patterns,

boresights, downtilts, and signal strength values associated with the plurality of antennas." (Para. [0028], lines 21-26)

The "plurality of sectors" are within "wireless telecommunication system **100** [(i.e., the 'wireless network')]" (Para. [0017], lines 1-2), which comprises a plurality of base stations" (Para. [0017], line 6), which "includes the radio equipment (transceivers, antennas, amplifiers, etc.) [(i.e., the 'first transmitter', the 'second transmitter')] needed to service each communication cell in the system." (Para. [0016], lines 2-4)

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

Benes teaches "mobile station **160** calculating an effective radiated power (ERP) of a first downlink signal [(i.e., the 'first signal characteristic')] and a second downlink signal [(i.e., the 'second signal characteristic')], the first downlink signal being associated with a first antenna [(i.e., 'from the first transmitter')] and the second downlink signal being associated with a second antenna [(i.e., 'from the second transmitter')]." (Para. [0029], lines 4-8)

determining which of said first and second signal characteristics has a greater magnitude;

Benes teaches mobile station **160** utilizing "the stronger downlink signal [(i.e., the 'greater magnitude')] of the first and second downlink signals." (Para. [0030], lines 5-6) In a specific example, Benes teaches "mobile station **160** may determine [(i.e., 'determining')] that the downlink signal **804** from the antenna associated with the second sector **204** is stronger than the downlink signal **802** from the antenna associated with the first sector **202**."

modifying said observed network measurement data using the greater magnitude signal characteristic; and

Benes teaches "To determine an antenna gain difference (AGD) for comparison with the signal difference, mobile station **160** may normalize [(i.e., 'modify')] the downlink signals **802**, **804** [(i.e., 'observed network measurement data')] from the antennas associated with the first and second sectors **202**, **204** (shown as [normalized downlink signals] **902** and **904**, respectively, in FIG. 9)" (Para. [0027]) Normalized downlink signal **904**, which is a modified signal because it is normalized, corresponds to stronger

downlink signal **804** [(i.e., the 'greater magnitude signal characteristic')], as indicated in the previous sentence.

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Continuing with the example used in the foregoing limitation, Benes teaches "Accordingly, the mobile station **160** may determine where along the normalized downlink signal **904** [(i.e., the 'modified network measurement data')] from the antenna associated with the second sector **204** the antenna gain difference [(i.e., 'calibration data')] matches the signal difference calculated above." (Para. [0027], lines 19-23, emphasis added) As discussed in the foregoing limitation, the antenna gain difference was determined "for comparison [(i.e., 'comparing')] with the signal difference."

In regard to using the foregoing comparison to determine the location of the mobile station, Benes prefaces the discussion of the foregoing comparison by teaching "mobile station **160** may determine an angle of arrival (AOA) estimation by comparing ERPs between antennas of at least two sectors." (Para. [0026], lines 1-4) AOA estimation is a method of location determination. The ERPs were determined "based on their respective signal strength values," (Para. [0021], line 7), wherein the "respective signal strength values," are part of the calibration data already discussed in the first limitation of the current claim.

b. Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm.

The reasons why claim 1 of the '104 Patent is unpatentable over Spain in view of Krumm are described below feature-by-feature.

A method for determining a location of a mobile station, comprising:

Spain discloses "Location estimation of wireless terminals through pattern matching of signal-strength differentials." (see Title of Invention)

Krumm discloses a "location system for locating […] a wireless device." (see Abstract)

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

In the '104 Patent, "calibration data" refers to data such as signal strength. ('104 Patent, col. 1, lines 21-24) Modified network measurement data "may be compared with

the database of calibration data to determine the location of a mobile station." ('104 Patent, col. 2, lines 20-22)

Spain teaches "At operation **401**, signal-strength database **302** is populated with data [(i.e., 'calibration data')] that associates each location within geographic region **200** [(i.e., 'predetermined region')] with a tuple of signal-strength measurements for that location." (col. 6, lines 30-33). The illustrative embodiment taught in Spain comprises "base stations **202-1**, **202-2**, and **202-3** [(i.e., 'first transmitter', 'second transmitter')]" (col. 4, lines 58-59) and "provides wireless telecommunications service [(i.e., 'wireless network')] to most of geographic region **200**." (col. 4, lines 60-61).

In regard to the actual "gathering" of the data in the database taught in Spain, "the tuple of three signal-strength measurements for each location are determined through […] empirical signal-strength measurements." (col. 7, lines 63-67) The data in the database must have been "previously" gathered before it can appear in the database, owing to causality.

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

Spain teaches "At task **1103**, location system **212** receives [(i.e., 'collects')] a report [(i.e., 'observed network measurement data')] from wireless terminal **201** on the signals that it was directed to monitor in task **602**." (col. 9, lines 50-52) Spain also teaches "A first signal [(i.e., 'first signal characteristic')] is transmitted by a first transmitter [and a] second signal [(i.e., 'second characteristic')] is transmitted by a second transmitter." (col. 14, lines 45-48)

determining which of said first and second signal characteristics has a greater magnitude;

Krumm teaches "sensing [(i.e., 'determining')] the wireless transmitter with the strongest signal [(i.e., 'greater magnitude')]." (col. 22, lines 65-66)

modifying said observed network measurement data using the greater magnitude signal characteristic; and

Spain teaches "At task **1202**, location system **212** computes the signal-strength differentials […]. In particular, for n reported signals [(i.e., 'observed network measurement data')], n-1 signal-strength differentials are computed [(i.e., 'modified')] where: $\Delta S_k = S_k - S_1$ for k=2, 3, … n, wherein ΔS_k is the kth signal-strength of Signal k, and

S_1 [(i.e., 'greater magnitude signal characteristic')] is the reported signal-strength of Signal 1." (col. 10, lines 51-60) Spain teaches this, recognizing the measurement bias problem associated with not knowing "whether the terminal is inside a vehicle." (col. 3, lines 31-32)

A skilled artisan starting from Spain would have been motivated to utilize the strongest signal sensed in Krumm [(i.e., 'the greater magnitude signal characteristic')], as "Signal 1" in the difference calculation in Spain. This would be done in order to have a reference signal with which to address the problem with measurement biases (e.g., measurements inside a vehicle, etc.) identified above. These biases are similar to those identified in the '104 Patent (e.g., measurements indoors).

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Spain teaches "At task **1203**, location system **212** computes the signal-strength differential" based on the locations "in signal-strength database **302**." (Col. 11, lines 3-18). Spain goes on to teach "At task **1204**, location system **212** compares the signal-strength differences [(i.e., 'modified network measurement data')] computed in task **1202**, ΔS_2 through ΔS_{m-n}, to the signal-strength differentials in task **1203**. (col. 11, lines 23-25) This is all done within the framework of task **403** in Spain, at which "location system **212** estimates the location of wireless terminal **201** [(i.e., 'determines the location of the mobile station')] based on: (i) the tuple of signal-strength measurements received in operation **402**, and (ii) the tuples of signal-strength measurements within signal-strength database **302** [(i.e., 'database of calibration data')]."

c. Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm.

The reasons why claim 1 of the '104 Patent is unpatentable over Gordon in view of Krumm are described below feature-by-feature.

A method for determining a location of a mobile station, comprising:

Gordon discloses "Computationally-efficient estimation of the location of a wireless terminal based on pattern matching." (see Title of Invention)

Krumm discloses a "location system for locating […] a wireless device." (see Abstract)

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

In the '104 Patent, "calibration data" refers to data such as signal strength, round trip time, time difference of arrival (TDOA). ('104 Patent, col. 1, lines 21-24) Modified network measurement data "may be compared with the database of calibration data to determine the location of a mobile station." ('104 Patent, col. 2, lines 20-22)

Gordon teaches "Location-Trait Database **313** [(i.e., 'provided data of previously-gathered calibration data')] is built [which is] a database that maps each of a plurality of locations [(i.e., 'predetermined region in a wireless network')] to one or more expected traits associated with a wireless terminal at that location." (col. 6, lines 45-49) For example, one such expected trait is "the expected received signal strength of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is in the location, from all transmitters [(i.e., 'first transmitter', 'second transmitter')]." (col. 10, lines 4-6) For example, "all transmitters" can refer to "base stations **202-1**, **202-2**, and **202-3**" (col. 9, lines 61-62) As part of building the database, Gordon also teaches "geographic region **220** is partitioned into B(T,N) locations." (col. 7, lines 16-17) The illustrative embodiment taught in Gordon, "provides wireless telecommunications service to all of geographic region **220**." (col. 4, lines 12-14)

In regard to the actual "gathering" of the data in the database taught in Gordon, "In accordance with process **901**, a drive-test regimen is developed" (col. 15, lines 55-56) and "In accordance with process **902**, the drive-test regimen is implemented." (col. 15, lines 61-62). The data in the database must have been "previously" gathered before it can appear in the database, owing to causality.

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

Gordon teaches "In accordance with process **1101**, location server **214** receives [(i.e., 'collects')] Y non-empty sets of measurements of the traits […] associated with wireless terminal **201**," (col. 16, lines 49-51) including "the received signal strength of all of the signals [(i.e., 'first signal characteristic', 'second signal characteristic')] received by wireless terminal **201**, from all transmitters [(i.e., 'first transmitter', 'second transmitter')]." (col. 16, lines 63-64; emphasis added)

determining which of said first and second signal characteristics has a greater magnitude;

Krumm teaches "sensing [(i.e., 'determining')] the wireless transmitter with the strongest signal [(i.e., 'greater magnitude')]." (col. 22, lines 65-66)

modifying said observed network measurement data using the greater magnitude signal characteristic; and

Gordon teaches "In accordance with process **1103**, location server **214** computes the differentials […] of the measurements [(i.e., 'modifies said observed network measurement data')] to correct the situational errors in the measurements received in process **1001**. Many factors, including […] whether or not the terminal is inside a vehicle can introduce situational measurement errors. This is particularly true for measurements of […] signal strength." (col. 18, lines 17-24)

A skilled artisan starting from Gordon would have been motivated to utilize the strongest signal sensed in Krumm [(i.e., 'the greater magnitude signal characteristic')], in order to have a reference signal with which to compute the differentials of the measurements in Gordon. This is because Gordon is addressing a problem with situational measurement errors (e.g., measurements inside a vehicle, etc.). These situational errors are similar to those identified in the '104 Patent (e.g., measurements indoors), which uses the stronger signal (i.e., "greater magnitude") to address errors associated with indoor measurements.

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Gordon teaches generating "In accordance with process **1001**, Y probability distributions for the location of wireless terminal **201** […] for each of instants H_1 through H_Y in the temporal interval ΔT […], based on comparing the measurements of traits associated with wireless terminal **201** [(i.e., 'network measurement data')] at each of instants H_1 through H_Y to expected values for those traits [(i.e., 'database of calibration data')] at those times. Each of the Y probability distributions provides a first estimate of the probability [(i.e., 'location of the mobile station')] that wireless terminal **201** is in each location at each of instants H_1 through H_Y." (col. 16, lines 9-18)

Gordon also teaches the "illustrative embodiment ameliorates the effects of [the aforementioned factors] by pattern matching not the measurements themselves […] to the expected values for those traits, but by pattern matching the pair-wise differentials of those

measurements [(i.e., 'modified network measurement data')] to the pair-wise differentials of the expected values for those traits [(i.e., 'database of calibration data')]." (col. 18, lines 25-30)

2. CLAIM 2 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 2 of the '104 Patent depends from Claim 1 and adds:

wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

a. Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1a)*

b. Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1b)*

c. Claim 2 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm. *(following from the Claim 1 rejection proposed in Section 1c)*

Gordon further teaches "It will be clear to those skilled in the art, after reading this disclosure, how to make and use [...] embodiments of the present invention that partition geographic region 220 into any number of locations of any size, shape, and arrangement." (Col. 9, lines 9-13). Furthermore, Figures 6a through 6n and the accompanying text in Columns 7 and 8 describe non-uniform "locations."

When starting from any of the other references – namely i) Benes or ii) Spain in combination with Krumm – a skilled artisan starting from any of those references would have been motivated to utilize the partitions of various sizes, shapes, and arrangements taught in Gordon, in order to account for real-world wireless network coverage regions.

3. CLAIM 3 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 3 of the '104 Patent depends from Claim 1 and adds:

wherein said observed network measurement data includes data collected at the mobile station.

a. **Claim 3 is unpatentable under 35 U.S.C. 102(b) as being anticipated by Benes.** *(following from the Claim 1 rejection proposed in Section 1a)*

b. **Claim 3 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm.** *(following from the Claim 1 rejection proposed in Section 1b)*

c. **Claim 3 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm.** *(following from the Claim 1 rejection proposed in Section 1c)*

As discussed above and with respect to Claim 1, each of Benes, Spain, and Gordon teaches that it is the mobile station that measures downlink signals that are transmitted by two or more base station transmitters, for the purpose of determining at least the signal strengths of those signals.

4. CLAIM 4 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 4 of the '104 Patent depends from Claim 1 and adds:

wherein said previously-gathered calibration data includes calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point is not located within a structure.

a. **Claim 4 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon.** *(following from the Claim 1 rejection proposed in Section 1a)*

b. **Claim 4 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon.** *(following from the Claim 1 rejection proposed in Section 1b)*

c. **Claim 4 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm.** *(following from the Claim 1 rejection proposed in Section 1c)*

Gordon further teaches various features within geographic region **220** that are partitioned into various locations for the purpose of building Location-Trait Database **313**. (Col. 9, lines 17-41). Such features include "water fountain **601** [and] park **602**," which are depicted as being not located within a structure. (Col. 9, lines 18-19, Fig. 6a)

When starting from any of the other references – namely i) Benes or ii) Spain in combination with Krumm – a skilled artisan would have been motivated to utilize the predetermined points that are not in structures, as taught in Gordon, in order to consider possible outdoor locations of the mobile station.

5. CLAIM 5 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 5 of the '104 Patent depends from Claim 4 and adds:

wherein said observed network measurement data is collected at a mobile station located within a structure.

a. Claim 5 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon. *(following from the Claim 4 rejection proposed in Section 4a)*

b. Claim 5 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 4 rejection proposed in Section 4b)*

c. Claim 5 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm. *(following from the Claim 4 rejection proposed in Section 4c)*

Gordon further teaches various features within geographic region **220** that are partitioned into various locations. (Col. 9, lines 17-41). Such features include structures such as "four-story building **603** [and] two-story building **604**," (Col. 9, lines 18-19, Fig. 6a) which are locations from which a mobile station can report signal-strength measurements, in order to determine the mobile station's position.

When starting from any of the other references – namely i) Benes or ii) Spain in combination with Krumm – a skilled artisan would have been motivated to utilize the observed network measurement data that is collected at a mobile station located within a

structure, as taught in Gordon, in order to consider possible indoor locations of the mobile station.

6. CLAIM 6 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 6 of the '104 Patent depends from Claim 4 and adds:

wherein said first signal characteristic is signal strength.

a. Claim 6 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon. *(following from the Claim 4 rejection proposed in Section 4a)*

b. Claim 6 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 4 rejection proposed in Section 4b)*

c. Claim 6 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm. *(following from the Claim 4 rejection proposed in Section 4c)*

Gordon further teaches "In accordance with process **1101**, location server **214** receives Y non-empty sets of measurements of the traits […] associated with wireless terminal **201**," (col. 16, lines 49-51) including "the received signal strength of all of the signals received by wireless terminal **201**, from all transmitters." (col. 16, lines 63-64; emphasis added)

When starting from any of the other references – namely i) Benes or ii) Spain in combination with Krumm – a skilled artisan would have been motivated to utilize signal strength, as taught in Gordon, in order to use a readily-available signal characteristic for determining the location of the mobile station.

7. CLAIM 7 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 7 of the '104 Patent depends from Claim 6 and adds:

wherein said second signal characteristic is signal strength.

a. **Claim 7 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon.** *(following from the Claim 6 rejection proposed in Section 6a)*

b. **Claim 7 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon.** *(following from the Claim 6 rejection proposed in Section 6b)*

c. **Claim 7 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm.** *(following from the Claim 6 rejection proposed in Section 6c)*

Gordon further teaches "In accordance with process **1101**, location server **214** receives Y non-empty sets of measurements of the traits […] associated with wireless terminal **201**," (col. 16, lines 49-51) including "the received signal strength of all of the signals received by wireless terminal **201**, from all transmitters." (col. 16, lines 63-64; emphasis added)

When starting from any of the other references – namely i) Benes or ii) Spain in combination with Krumm – a skilled artisan would have been motivated to utilize signal strength, as taught in Gordon, in order to use a readily-available signal characteristic for determining the location of the mobile station.

8. CLAIM 8 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 8 of the '104 Patent depends from Claim 7 and adds:

wherein the modifying of said calibration data uses a difference between said first or [*sic*] second signal characteristics.

a. **Claim 8 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon, and further in view of Spain.** *(following from the Claim 7 rejection proposed in Section 7a)*

b. **Claim 8 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon.** *(following from the Claim 7 rejection proposed in Section 7b)*

c. Claim 8 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm, and further in view of Spain. *(following from the Claim 7 rejection proposed in Section 7c)*

Spain further teaches "At task **1202**, location system **212** computes the signal-strength differentials for those reported values that are not the maximum signal strength. In particular, for n reported signals […], n-1 signal-strength differentials are computed where: $\Delta S_k = S_k - S_1$ for k=2, 3, … n, wherein ΔS_k is the kth signal-strength of Signal k, and S_1 is the reported signal-strength of Signal 1." (Col. 10, lines 51-60; emphasis added)

When starting from any of the other combinations of references – namely i) Benes in combination with Gordon or ii) Gordon in combination with Krumm – a skilled artisan would have been motivated to also modify the calibration data (i.e., computing signal-strength differentials of expected values), as taught in Spain, because Gordon teaches pattern matching the pair-wise differentials of signal-strength measurements (i.e., modified measurements) with pair-wise differentials of expected signal-strength values.

9. CLAIM 9 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 9 of the '104 Patent depends from Claim 7 and adds:

wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station.

a. Claim 9 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon, and further in view of Spain. *(following from the Claim 7 rejection proposed in Section 7a)*

b. Claim 9 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 7 rejection proposed in Section 7b)*

c. Claim 9 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm, and further in view of Spain. *(following from the Claim 7 rejection proposed in Section 7c)*

Spain further teaches "At task **502**, the signal-strength measurements for a signal from each base station are determined at each location in geographic region. In accordance with the illustrative embodiment, the signal used from each base station is the control

channel because […] wireless terminal **201** can distinguish it from every other control channel." (Col. 7, lines 44-50; emphasis added)

When starting from any of the other references – namely i) Benes in combination with Gordon or ii) Gordon in combination with Krumm – a skilled artisan would have been motivated to use the signal strength of a control channel, as taught in Spain, in order to use a readily-available source of a signal of which to measure signal strength.

10. CLAIM 10 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 10 of the '104 Patent depends from Claim 9 and adds:

wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

a. Claim 10 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon, and further in view of Spain. *(following from the Claim 9 rejection proposed in Section 9a)*

b. Claim 10 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 9 rejection proposed in Section 9b)*

c. Claim 10 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm, and further in view of Spain. *(following from the Claim 9 rejection proposed in Section 9c)*

Spain further teaches "At task **502**, the signal-strength measurements for a signal from each base station are determined at each location in geographic region. In accordance with the illustrative embodiment, the signal used from each base station is the control channel because […] wireless terminal **201** can distinguish it from every other control channel." (Col. 7, lines 44-50; emphasis added)

When starting from any of the other references – namely i) Benes in combination with Gordon or ii) Gordon in combination with Krumm – a skilled artisan would have been motivated to use the signal strength of a control channel, as taught in Spain, in order to use a readily-available source of a signal of which to measure signal strength.

11. CLAIM 11 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 11 of the '104 Patent depends from Claim 1 and adds:

wherein the observed network measurement data includes received signal strength of said transmitters as [*sic*] said mobile station.

a. Claim 11 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1a)*

b. Claim 11 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 1 rejection proposed in Section 1b)*

c. Claim 11 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm. *(following from the Claim 1 rejection proposed in Section 1c)*

Gordon further teaches "In accordance with process **1101**, location server **214** receives Y non-empty sets of measurements of the traits […] associated with wireless terminal **201**," (col. 16, lines 49-51) including "the received signal strength of all of the signals received by wireless terminal **201**." (col. 16, lines 63-64; emphasis added)

When starting from any of the other references – namely i) Benes or ii) Spain in combination with Krumm – a skilled artisan would have been motivated to utilize signal strength as measured at the mobile station, as taught in Gordon, in order to use a readily-available signal characteristic for determining the location of the mobile station, from a readily-accessible measurement point.

12. CLAIM 12 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 12 of the '104 Patent depends from Claim 1 and adds:

wherein said observed network measurement data includes a data set comprising: [P_1, P_2 . . . , P_n, TA] where: P_1 represents the signal strength of said first transmitter as measured at said mobile station, P_2 represents a signal strength of said second transmitter as measured at said mobile station wherein $P_2 > P_1$ P_n, represents a signal strength of a n^{th} transmitter as measured at said

mobile station wherein $P_2 > P_n$, and TA represents a timing advance parameter; and wherein said modified network measurement data includes a data set comprising: [P_2- P_1, 0, P_2- P_n, TA] where: P_2- P_1 represents a difference between P_2 and P_1, 0 represents a difference between P_2 and P_2, and P_2- P_n represents a difference between P_2 and P_n.

a. **Claim 12 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Spain, and further in view of Gordon.** *(following from the Claim 1 rejection proposed in Section 1a)*

b. **Claim 12 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon.** *(following from the Claim 1 rejection proposed in Section 1b)*

c. **Claim 12 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm, and further in view of Spain.** *(following from the Claim 1 rejection proposed in Section 1c)*

In regard to signal strengths in the measurement data set, Spain further teaches "location system **212** computes two (2) signal-strength differentials for the first report in which R_1=Signal 1=-98, R_2=Signal 2=-64 and R_3[=]Signal 3=-43. In particular, ΔR_2 and ΔR_3 are computed as depicted in Table 4." (col. 12, lines 18-21) Table 4 in Spain discloses an R_2-R_1 value of "-64-(-98)", and an R_3-R_1 value of "-51-(-98)". It is implicit that a value in the data set for R_1-R_1 would be 0. The fact that the '104 Patent, in essence, uses R_2 in the subtraction to generate all differential values and Spain features illustrating the concept of generating differential values by using R_1, is arbitrary.

Meanwhile, in regard to a timing advance parameter in the measurement data set, Gordon further teaches that each set of measurements comprises "the round-trip time of all of the signals transmitted and received by wireless terminal **201** through base stations **202-1**, **202-2**, and **202-3**." (col. 17, lines 26-28)

When starting from Benes, a skilled artisan would be motivated to incorporate the data set parameters in Spain and Gordon, in order to reflect what a mobile station that is compliant with an air-interface standard is already capable of reporting.

13. CLAIM 13 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 13 of the '104 Patent depends from Claim 12 and adds:

wherein said first transmitter is a serving transmitter for said mobile station and said second and third transmitters are neighboring transmitters.

a. Claim 13 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Spain, and further in view of Gordon. *(following from the Claim 12 rejection proposed in Section 12a)*

b. Claim 13 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 12 rejection proposed in Section 12b)*

c. Claim 13 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm, and further in view of Spain. *(following from the Claim 12 rejection proposed in Section 12c)*

Gordon further teaches that each set of measurements comprises "[(1)] the identity of the base stations that provide telecommunications service to wireless terminal **201**; and [(2)] the identities of the neighboring base stations that can provide telecommunications service to wireless terminal **201**." (col. 17, lines 32-36) These identities in each set of measurements correspond to (1) a serving transmitter and (2) neighboring transmitters, respectively.

When starting from any of the other references – namely i) Benes or ii) Spain in combination with Krumm – a skilled artisan would be motivated to utilize serving and neighboring transmitters in Gordon, in order to have sufficient and available signal sources to measure in a wireless network.

14. CLAIM 14 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 14 of the '104 Patent depends from Claim 12 and adds:

wherein said third transmitter is not a member of said wireless network.

a. Claim 14 is unpatentable under 35 U.S.C. 103 as being obvious over Benes in view of Spain, and further in view of Gordon. *(following from the Claim 12 rejection proposed in Section 12a)*

b. Claim 14 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm, and further in view of Gordon. *(following from the Claim 12 rejection proposed in Section 12b)*

c. Claim 14 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm, and further in view of Spain. *(following from the Claim 12 rejection proposed in Section 12c)*

Gordon further teaches that "each set of measurements comprises […] the received signal strength of all of the signals received by wireless terminal **201** from all transmitters," (Col. 16, lines 53-54 and 63-64) wherein the term "all transmitters" is previously defined to include, for example "commercial television, commercial radio, ground-based aviation, navigation, etc." (Col. 16, lines 56-58), which are not part of "wireless telecommunication system **200**" (Col 4., line 6)

When starting from any of the other references – namely i) Benes or ii) Spain in combination with Krumm – a skilled artisan would be motivated to external transmitters in Gordon, in order to have varied signal sources to measure in a wireless network.

15. CLAIM 15 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Detailed reasons for these assertions of unpatentability are described in detail below and summarized in charts attached as Appendix B.

a. Claim 15 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Gordon.

The reasons why claim 15 of the '104 Patent is anticipated by Gordon are described below feature-by-feature.

A method for determining a location of a mobile station, comprising:

Gordon discloses "Computationally-efficient estimation of the location of a wireless terminal based on pattern matching." (see Title of Invention)

providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network;

In the '104 Patent, "calibration data" refers to data such as signal strength, round trip time, time difference of arrival (TDOA). ('104 Patent, col. 1, lines 21-24) Modified network measurement data "may be compared with the database of calibration data to determine the location of a mobile station." ('104 Patent, col. 2, lines 20-22)

Gordon teaches "In accordance with process **401**, Location-Trait Database **313** [(i.e., 'provided data of previously-gathered calibration data')] is built [which is] a database that maps each of a plurality of locations [(i.e., 'predetermined region in a wireless network')] to one or more expected traits associated with a wireless terminal at that location." (col. 6, lines 45-49) For example, one such expected trait is "the expected received signal strength of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is in the location, from all transmitters [(i.e., 'first transmitter', 'second transmitter')]." (col. 10, lines 4-6) As part of building the database, Gordon also teaches "geographic region **220** is partitioned into B(T,N) locations." (col. 7, lines 16-17) The illustrative embodiment taught in Gordon, "provides wireless telecommunications service to all of geographic region **220**." (col. 4, lines 12-14)

In regard to the actual "gathering" of the data in the database taught in Gordon, "In accordance with process **901**, a drive-test regimen is developed" (col. 15, lines 55-56) and "In accordance with process **902**, the drive-test regimen is implemented." (col. 15, lines 61-62). The data in the database must have been "previously" gathered before it can appear in the database, owing to causality.

Within the context of building the database, Gordon also teaches "a map of geographic region **220**," (col. 9, line 18) which comprises outdoor features such as "water fountain **601**, park **602**, four-story building **603**, two-story building **604**, various streets, sidewalks, and other features that are partitioned into 28 locations." (col. 9, lines 19-22)

collecting network measurement data;

Gordon teaches "In accordance with process **1101**, location server **214** receives [(i.e., 'collects')] Y non-empty sets of measurements of the traits […] associated with wireless terminal **201**." (col. 16, lines 49-51) For example, such sets of measurements can include, but are not limited to, "the received signal strengths of all of the signals [(i.e., 'first signal characteristic', 'second signal characteristic')] received by wireless terminal **201** from all transmitters [(i.e., 'first transmitter', 'second transmitter')]." (col., 16, lines 63-64)

comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate [*sic*] of the mobile station;

Gordon teaches generating "In accordance with process **1001**, Y probability distributions for the location of wireless terminal **201** […] for each of instants H_1 through H_Y in the temporal interval ΔT […], based on comparing the measurements of traits associated

with wireless terminal **201** [(i.e., 'network measurement data')] at each of instants H_1 through H_Y to expected values for those traits [(i.e., 'database of calibration data')] at those times. Each of the Y probability distributions provides a first estimate of the probability [(i.e., 'location of the mobile station')] that wireless terminal **201** is in each location at each of instants H_1 through H_Y." (col. 16, lines 9-18)

determining a confidence measure for each of the plurality of location estimates; [and]

Gordon teaches in "accordance with process **1123**, the un-normalized probabilities of the location [(i.e., 'confidence measures')] of wireless terminal **201** at each location [(i.e., 'for each of the plurality of location estimates')] are generated [(i.e., 'determined')] based on the Euclidean norm generated in process **1122**." (col. 22, lines 4-7) Furthermore, "At process **1124**, the probabilities generated in process **1123** are normalized […], wherein $NP(b,H_i)$ represents the normalized probability that wireless terminal **201** is in Location b." (col. 22, lines 28-37) A probability, or a probability distribution, of a location is an example of a confidence measure of a location.

determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.

Gordon teaches "In accordance with process **1305**, location server **214** generates an estimate of the location of wireless terminal **201** [(i.e., 'determines the location of the mobile station')] at one or more instances J_i based on the maximum likelihood function of L_i [(i.e., 'the respective confidence measures')] [and] then provides the estimate of the location of wireless terminal **201** generated in process **1305**." (col. 26, lines 25-35) L_i refers to each probability distribution (i.e., 'each respective confidence measure') corresponding to each possible location (i.e., 'the plurality of location estimates'), generated earlier. (col. 25, lines 53-55)

16. CLAIM 16 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 16 of the '104 Patent depends from Claim 15 and adds:

wherein the step of determining the location based on the plurality of location estimates and the respective confidence measures comprises selecting the location estimate having the highest respective confidence measure as the location of the mobile station.

a. Claim 16 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Gordon.

As discussed above and with respect to Claim 15, Gordon teaches using the maximum likelihood function of the probability distribution corresponding to each possible location. This is consistent with selecting the location estimate having the highest respective confidence measure.

17. CLAIM 17 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 17 of the '104 Patent depends from Claim 15 and adds:

wherein the step of determining the location based on the plurality of location estimates and their respective confidence measures comprises weighing [*sic*] the plurality [of] location estimates based on their respective confidence measures and obtaining a weighted average as the location of the mobile.

a. Claim 17 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Gordon.

As discussed above and with respect to Claim 15, Gordon teaches using the maximum likelihood function of the probability distribution corresponding to each possible location. This is not inconsistent with weighting the plurality of location estimates based on their respective confidence measures. Moreover, Gordon also teaches "an estimate might be generated from probability distribution L_i, using another function or method." (col. 26, lines 31-32)

18. CLAIM 18 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 18 of the '104 Patent depends from Claim 15 and adds:

wherein the confidence measures comprises one or more of the group consisting of a pdf [,] the Mahalanobis distance, and a distortion measure.

a. Claim 18 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Gordon.

Gordon teaches a pdf (probability distribution function): "In accordance with process **1001**, Y probability distributions for the location of wireless terminal **201** are

generated for each of instants H_1 through H_Y in the temporal interval ΔT […]. Each of the Y probability distributions provides a first estimate of the probability that wireless terminal **201** is in each location at each of instants H_1 through H_Y." (col. 16, lines 9-18)

19. CLAIM 19 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 19 of the '104 Patent depends from Claim 15 and adds:

wherein the step of collecting network propagation [*sic*] data further comprises modifying the network propagation [*sic*] data.

a. Claim 19 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Gordon.

Gordon teaches "In accordance with process **1103**, location server **214** computes the differentials […] of the measurements to correct the situational errors in the measurements received in process **1001**. Many factors, including […] whether or not the terminal is inside a vehicle can introduce situational measurement errors. This is particularly true for measurements of […] signal strength." (col. 18, lines 17-24)

b. Claim 19 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Spain.

Spain teaches "At task 1202, location system 212 computes the signal-strength differentials for those reported values […]. In particular, for n reported signals […], n-1 signal-strength differentials are computed where: $\Delta S_k = S_k - S_1$ for k=2, 3, … n, wherein ΔS_k is the kth signal-strength of Signal k, and S_1 is the reported signal-strength of Signal 1." (Col. 10, lines 51-60)

A skilled artisan starting from Gordon would have been motivated to also modify the network measurement data (i.e., computing signal-strength differentials of reported values), as taught in Spain, because Gordon teaches pattern matching the pair-wise differentials of measurements (i.e., modified measurements) with pair-wise differentials of expected values.

20. CLAIM 20 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 20 of the '104 Patent depends from Claim 15 and adds:

wherein the step of comparing said network propagation [*sic*] data with said database of calibration data to thereby determine a plurality of location estimate [*sic*] of the mobile station, further comprises modifying said calibration data prior to the comparison.

a. Claim 20 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Gordon.

Gordon teaches "pattern matching the pair-wise differentials of those measurements to the pair-wise differentials of the expected values for those traits," (Col. 18, lines 28-30) in contrast to the straight expected values stored in Location-Trait Database **313** (discussed above in regard to Claim 15).

b. Claim 20 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Spain.

As discussed above and with respect to Claim 1, Spain teaches "At task **1203**, location system **212** computes the signal-strength differential" based on the locations "in signal-strength database **302**." (Col. 11, lines 3-18). This occurs before what Spain then teaches: "At task **1204**, location system **212** compares the signal-strength differences computed in task **1202**, ΔS_2 through ΔS_{m-n}, to the signal-strength differentials in task **1203**. (Col. 11, lines 23-25)

A skilled artisan starting from Gordon would have been motivated to compute the signal-strength differential based on the locations in signal-strength database 302, prior to computing the signal-strength differentials with the expected signal-strength differentials, because Gordon teaches pattern matching the pair-wise differentials of measurements with pair-wise differentials of expected values, wherein the straight values (i.e., not differential values) of expected values had been stored in the database.

21. CLAIM 21 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 21 of the '104 Patent depends from Claim 20 and adds:

wherein the step of comparing said network propagation [*sic*] data with said database of calibration data to thereby determine a plurality of location estimate [*sic*] of the mobile station, further comprises modifying said calibration data prior to the comparison.

a. Claim 21 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Gordon.

b. Claim 21 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Spain.

Claim 21 is identical to Claim 20 except for depending from Claim 20. Accordingly, the arguments presented above for Claim 20 are applicable here as well.

E. SPECIFICATION OF THE ORIGINAL PATENT

Attached as Exhibit A is the entire specification (including claims) and drawings of the '104 Patent as required by 37 CFR 1.510(b)(4).

F. NOTIFICATION OF CONCURRENT PROCEEDING

There is no concurrent proceeding at this time.

G. CONCLUSION

For the above reasons and in view of the prior-art references discussed above, it is submitted that reexamination of claims 1-21 of the '104 Patent is appropriate.

Respectfully,

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Appendix A

1) Summarized application of Benes to Independent Claim 1:

Claim 1	Benes
1. A method for determining a location of a mobile station, comprising:	"determining an angle of arrival (AOA) estimation" (see Abstract)
providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;	"mobile station **160** at step **1020** may receive information associated with [a] plurality of sectors. In particular, the information associated with the plurality of sectors may include, but is limited to, antenna patterns, boresights, downtilts, and signal strength values associated with the plurality of antennas." (Para. [0028], lines 21-26) The "plurality of sectors" are within "wireless telecommunication system **100**" (Para. [0017], lines 1-2), which comprises a plurality of base stations" (Para. [0017], line 6), which "includes the radio equipment (transceivers, antennas, amplifiers, etc.) needed to service each communication cell in the system." (Para. [0016], lines 2-4)
collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;	"mobile station **160** calculating an effective radiated power (ERP) of a first downlink signal and a second downlink signal, the first downlink signal being associated with a first antenna and the second downlink signal being associated with a second antenna." (Para. [0029], lines 4-8) (pg. 26, col. 3)
determining which of said first and second signal characteristics has a greater magnitude;	"the stronger downlink signal of the first and second downlink signals." (Para. [0030], lines 5-6) "mobile station **160** may determine that the downlink signal **804** from the antenna associated with the second sector **204** is stronger than the downlink signal **802** from the antenna associated with the first sector **202**."
modifying said observed network measurement data using the greater magnitude signal characteristic; and	"To determine an antenna gain difference (AGD) for comparison with the signal difference, mobile station **160** may normalize the downlink signals **802**, **804** from the antennas associated with the first and second sectors **202**, **204** (shown as [normalized downlink signals] **902** and **904**, respectively, in FIG. 9)" (Para. [0027])

Claim 1	Benes
comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.	"Accordingly, the mobile station **160** may determine where along the normalized downlink signal **904** from the antenna associated with the second sector **204** the antenna gain difference matches the signal difference calculated above." (Para. [0027])

2) Summarized Application of Spain and Krumm to Independent Claim 1:

Claim 1	Spain	Krumm
1. A method for determining a location of a mobile station, comprising:	"Location estimation of wireless terminals through pattern matching of signal-strength differentials." (see Title of Invention)	"location system for locating [...] a wireless device." (see Abstract)
providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;	"At operation **401**, signal-strength database **302** is populated with data that associates each location within geographic region **200** with a tuple of signal-strength measurements for that location." (col. 6, lines 30-33). The illustrative embodiment taught in Spain comprises "base stations **202-1**, **202-2**, and **202-3**" (col. 4, lines 58-59) and "provides wireless telecommunications service to most of geographic region **200**." (col. 4, lines 60-61). "the tuple of three signal-strength measurements for each location are determined through [...] empirical signal-strength measurements." (col. 7, lines 63-67)	
collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;	"At task **1103**, location system **212** receives [...] a report from wireless terminal **201** on the signals that it was directed to monitor in task **602**." (col. 9, lines 50-52) "A first signal is transmitted by a first transmitter [and a] second signal is transmitted by a second transmitter." (col. 14, lines 45-48)	
determining which of said first and second signal characteristics has a greater magnitude;		"sensing the wireless transmitter with the strongest signal." (col. 22, lines 65-66)

Claim 1	Spain	Krumm
modifying said observed network measurement data using the greater magnitude signal characteristic; and	"At task **1202**, location system **212** computes the signal-strength differentials […]. In particular, for n reported signals […], n-1 signal-strength differentials are computed where: $\Delta S_k = S_k - S_1$ for k=2, 3, … n, wherein ΔS_k is the kth signal-strength of Signal k, and S_1 is the reported signal-strength of Signal 1." (col. 10, lines 51-60) Spain teaches this, recognizing the measurement bias problem associated with not knowing "whether the terminal is inside a vehicle." (col. 3, lines 31-32)	
comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.	"At task **1203**, location system **212** computes the signal-strength differential" based on the locations "in signal-strength database **302**." (Col. 11, lines 3-18). "At task **1204**, location system **212** compares the signal-strength differences computed in task **1202**, ΔS_2 through ΔS_{m-n}, to the signal-strength differentials in task **1203**. (col. 11, lines 23-25) This is all done within the framework of task **403** in Spain, at which "location system **212** estimates the location of wireless terminal **201** based on: (i) the tuple of signal-strength measurements received in operation **402**, and (ii) the tuples of signal-strength measurements within signal-strength database **302**."	

3) Summarized Application of Gordon and Krumm to Independent Claim 1:

Claim 1	Gordon	Krumm
1. A method for determining a location of a mobile station, comprising:	"Computationally-efficient estimation of the location of a wireless terminal based on pattern matching." (see Title of Invention)	"location system for locating [...] a wireless device." (see Abstract)
providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;	"Location-Trait Database **313** is built [which is] a database that maps each of a plurality of locations to one or more expected traits associated with a wireless terminal at that location." (col. 6, lines 45-49) For example, "all transmitters" can refer to "base stations **202-1**, **202-2**, and **202-3**" (col. 9, lines 61-62) "geographic region **220** is partitioned into B(T,N) locations." (col. 7, lines 16-17) "In accordance with process **901**, a drive-test regimen is developed" (col. 15, lines 55-56) and "In accordance with process **902**, the drive-test regimen is implemented." (col. 15, lines 61-62).	
collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;	"In accordance with process **1101**, location server **214** receives Y non-empty sets of measurements of the traits [...] associated with wireless terminal **201**," (col. 16, lines 49-51) including "the received signal strength of all of the signals received by wireless terminal **201**, from all transmitters." (col. 16, lines 63-64)	
determining which of said first and second signal characteristics has a greater magnitude;		"sensing the wireless transmitter with the strongest signal." (col. 22, lines 65-66)

Claim 1	Gordon	Krumm
modifying said observed network measurement data using the greater magnitude signal characteristic; and	"In accordance with process **1103**, location server **214** computes the differentials […] of the measurements to correct the situational errors in the measurements received in process **1001**. Many factors, including […] whether or not the terminal is inside a vehicle can introduce situational measurement errors. This is particularly true for measurements of […] signal strength." (col. 18, lines 17-24)	
comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.	"In accordance with process **1001**, Y probability distributions for the location of wireless terminal **201** […] for each of instants H_1 through H_Y in the temporal interval ΔT […], based on comparing the measurements of traits associated with wireless terminal **201** at each of instants H_1 through H_Y to expected values for those traits at those times. Each of the Y probability distributions provides a first estimate of the probability that wireless terminal **201** is in each location at each of instants H_1 through H_Y." (col. 16, lines 9-18) "illustrative embodiment ameliorates the effects of [the aforementioned factors] by pattern matching not the measurements themselves […] to the expected values for those traits, but by pattern matching the pair-wise differentials of those measurements to the pair-wise differentials of the expected values for those traits." (col. 18, 25-30)	

Appendix B

1) Summarized Application of Gordon to Independent Claim 15:

Claim 15	Gordon
15. A method for determining a location of a mobile station, comprising:	"Computationally-efficient estimation of the location of a wireless terminal based on pattern matching." (see Title of Invention)
providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network;	"Location-Trait Database **313** is built [which is] a database that maps each of a plurality of locations to one or more expected traits associated with a wireless terminal at that location." (col. 6, lines 45-49) For example, "geographic region **220** is partitioned into B(T,N) locations." (col. 7, lines 16-17) "In accordance with process **901**, a drive-test regimen is developed" (col. 15, lines 55-56) and "In accordance with process **902**, the drive-test regimen is implemented." (col. 15, lines 61-62). "a map of geographic region **220**," (col. 9, line 18) which comprises outdoor features such as "water fountain **601**, park **602**, four-story building **603**, two-story building **604**, various streets, sidewalks, and other features that are partitioned into 28 locations." (col. 9, lines 19-22)
collecting network measurement data;	"In accordance with process **1101**, location server **214** receives Y non-empty sets of measurements of the traits […] associated with wireless terminal **201**," (col. 16, lines 49-51) including "the received signal strength of all of the signals received by wireless terminal **201**, from all transmitters." (col. 16, lines 63-64)
comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate [*sic*] of the mobile station;	"In accordance with process **1001**, Y probability distributions for the location of wireless terminal **201** […] for each of instants H_1 through H_Y in the temporal interval ΔT […], based on comparing the measurements of traits associated with wireless terminal **201** at each of instants H_1 through H_Y to expected values for those traits at those times. Each of the Y probability distributions provides a first estimate of the probability that wireless terminal **201** is in each location at each of instants H_1 through H_Y." (col. 16, lines 9-18)

Claim 15	Gordon
determining a confidence measure for each of the plurality of location estimates;	"In accordance with process **1123**, the un-normalized probabilities of the location of wireless terminal **201** at each location are generated based on the Euclidean norm generated in process **1122**." (col. 22, lines 4-7) Furthermore, "At process **1124**, the probabilities generated in process **1123** are normalized [...], wherein $NP(b,H_i)$ represents the normalized probability that wireless terminal **201** is in Location b. (col. 22, lines 28-37)
determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.	"In accordance with process **1305**, location server **214** generates an estimate of the location of wireless terminal **201** at one or more instances J_i based on the maximum likelihood function of L_i [and] then provides the estimate of the location of wireless terminal **201** generated in process **1305**." (col. 26, lines 25-35)

CERTIFICATE OF SERVICE

In accordance with 37 CFR 1.535 and 1.248, I hereby certify that I mailed by certified mail, return-receipt-requested a copy of the Reply by Third Party Requester (i.e., "Reply") for *Ex Parte* Reexamination of U.S. Patent 7,561,104 (Reexamination Control Number 90/012,694) and its attachments and all documents submitted to the USPTO related to the Reply, to the patent owner c/o the attorney of record at:

Patrick D. McPherson
Duane Morris LLP
Suite 1000
505 9th Street, N.W.
Washington, DC 20004-2166

on March 8, 2013

/Kenneth Ottesen/
Kenneth Ottesen
Kaplan, Breyer, Schwarz & Ottesen, LLP
Reg. No. 54353
732-578-0103 x222

Kaplan, Breyer, Schwarz & Ottesen, LLP
Suite 250
100 Commons Way
Holmdel, NJ 07733
United States of America

Electronic Acknowledgement Receipt

EFS ID:	15163248
Application Number:	90012694
International Application Number:	
Confirmation Number:	6575
Title of Invention:	Method to modify calibration data used to locate a mobile unit
First Named Inventor/Applicant Name:	7,561,104 B2
Customer Number:	79172
Filer:	Wayne Scott Breyer/Joanne Murphy
Filer Authorized By:	Wayne Scott Breyer
Attorney Docket Number:	466-333us1
Receipt Date:	08-MAR-2013
Filing Date:	24-SEP-2012
Time Stamp:	19:50:55
Application Type:	Reexam (Third Party)

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	Reexam Timely Requester's Reply to an Owner's Statement	requester_reply_466-333us1.pdf	255283 37659cc4ed3364851e8f042a059f7fabd5bf4408	no	44

Warnings:	
Information:	

Total Files Size (in bytes):	255283

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.

ATTORNEY DOCKET NO. AND01 082 RE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Ex Parte Reexamination of U.S. Patent No. 7,561,104 to Martin Alles, et al.

Reexamination Serial No. 90/012,694

Application Serial No.: 12/026,333 Art Unit: 3992

Filed: February 5, 2008 Examiner: Angela M. Lie

Title: METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE DEVICE

PATENT OWNER'S STATEMENT

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

Sir:

In response to the Order Granting a Request for Ex Parte Reexamination dated December 12, 2012, Applicant submits the following:

Applicant's **Remarks** begin on sheet 2 of this paper.

REMARKS

Without addressing the merits of the Decision or the allegations that any of the references cited by the third party requester (the "Requester") raise a substantial new question of patentability affecting claims 1-21 of U.S. Patent No. 7,561,104 to Alles, Applicant submits that the "Request for *Ex Parte* Reexamination Under 37 C.F.R. § 1.510(b)" served on September 24, 2012 (the "Request") is procedurally improper.

The Request does not comply with the filing requirements of *ex parte* reexamination proceedings under 37 C.F.R. § 1.510(b). As the Office is aware, a request for *ex parte* reexamination must meet all of the applicable statutory and regulatory requirements before a filing date is accorded to the request. *See* MPEP §§ 2227(B)(1) and 2217(1). *See also Clarification of Filing Date Requirements for Ex Parte and Inter Partes Reexamination Proceedings*, 71 Fed. Reg. 44219 (Aug. 4, 2006), 1309 Off. Gaz. Pat. Office 216 (Aug. 29, 2006) (Final Rule). Under 37 C.F.R. § 1.510(b), each proposed reference and combination of references must be separately discussed and proposed combinations of reference must not be lumped together in the alternative. This regulation thus requires that there be an explanation of the pertinency and manner of applying the cited prior art to every claim for which reexamination is requested. In the instant case, the Requester lumped together proposed rejections and combinations of references of at least Claims 2-14 throughout the Request, particularly on pages 11-18 of the Request.

As one of many examples, on page 11 regarding Claim 3, the Request states "This claim limitation is anticipated by any of Benes, Spain, and Gordon." However, no explanation is given as to how Claim 3 is anticipated by any of these references other

than a blanket statement – without citations – that "each of these references teaches that it is the mobile station that measures downlink signals that are transmitted by two or more base station transmitters, for the purpose of determining at least the signal strengths of those signals." Indeed, the Request does not even allege that Claim 1, from which Claim 3 depends, is anticipated by either Spain or Gordon.

As another example, on page 17 regarding Claim 13, the Request states "This claim is anticipated by Gordon, in combination with other references identified for Claim 12." Claim 13 depends directly from Claim 12 and ultimately from Claim 1. Neither Claim 1 nor Claim 12 is alleged to be anticipated by Gordon.

As yet a further example, the Request is rife with alternative combinations of references and even alternative compounded combinations of references between a claim and its dependent claim(s). Each of these alternative combinations are impermissibly lumped together and therefore lack the required separate discussion, pertinency, and manner of applying the cited prior art to every claim for which reexamination is requested as required by 37 C.F.R. § 1.510(b).

As delineated in MPEP § 2617 (providing examples of inappropriate and appropriate language in a Request), the Requester must provide a proposed rejection(s) and basis for combining the cited references and a statement why the claim(s) under reexamination would been obvious over each of the proposed reference combinations, rather than lumping such combinations together as provided by the Requester on, for example, pages 11-18 with regard to at least Claims 2-14.

If the Requester were allowed to omit a proper explanation of how such documents cited in the Request were applied to the patent claims, an undue burden would be placed on the Office and/or Patentee to address each document without an explanation of the relevance to the patent claims. As such, the Requester's omission is prohibited by regulation.

Applicant respectfully requests the Office issue a Notice to the Requester regarding the Requester's failure to comply with *ex parte* reexamination filing requirements.

Should any additional fees be necessary in connection with the filing of this Response, or if a petition for extension of time is required for timely acceptance of the same, such a petition is made and the Office is authorized to charge such fees to **Deposit Account No. 04-1679**.

Respectfully submitted,

/Mark C. Comtois/

Mark C. Comtois
Reg. No. 46,285
Ryan T. Hardee
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Telephone: (202) 776-7800
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Dated: February 6, 2013

Certificate of Service

In accordance with 37 C.F.R. §§ 1.530(c) and 1.248, I hereby certify that I mailed by certified mail, return-receipt-requested, a copy of the Patent Owner's Statement to the Requester at:

Kenneth Ottesen
Kaplan, Breyer, Schwarz & Ottesen, LLP
Suite 250
100 Commons Way
Holmdel, NJ 07733

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

February 6, 2013

Electronic Acknowledgement Receipt

EFS ID:	14890384
Application Number:	90012694
International Application Number:	
Confirmation Number:	6575
Title of Invention:	Method to modify calibration data used to locate a mobile unit
First Named Inventor/Applicant Name:	7,561,104 B2
Customer Number:	79172
Filer:	Patrick Dennis McPherson/Josh Staples
Filer Authorized By:	Patrick Dennis McPherson
Attorney Docket Number:	466-333us1
Receipt Date:	06-FEB-2013
Filing Date:	24-SEP-2012
Time Stamp:	14:29:44
Application Type:	Reexam (Patent Owner)

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	and01082restatement.pdf	338311 78b8d126d6da0f3a04c19241167f7cc54a69b686	no	5

Warnings:	
Information:	

Total Files Size (in bytes):	338311

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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.

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.
90/012,694	09/24/2012	7,561,104 B2	466-333us1	6575

79172 7590 12/12/2012

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

EXAMINER	
LIE, ANGELA M	
ART UNIT	**PAPER NUMBER**
3992	

MAIL DATE	DELIVERY MODE
12/12/2012	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.

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

DO NOT USE IN PALM PRINTER

(THIRD PARTY REQUESTER'S CORRESPONDENCE ADDRESS)

Kaplan, Breyer, Schwarz & Ottesen, LLP
Suite 250
100 Commons Way
Holmdel, NJ 07733

EX PARTE REEXAMINATION COMMUNICATION TRANSMITTAL FORM

REEXAMINATION CONTROL NO. *90/012,694*.

PATENT NO. *7,561,104 B2 E*.

ART UNIT *3992*.

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above identified *ex parte* reexamination proceeding (37 CFR 1.550(f)).

Where this copy is supplied after the reply by requester, 37 CFR 1.535, or the time for filing a reply has passed, no submission on behalf of the *ex parte* reexamination requester will be acknowledged or considered (37 CFR 1.550(g)).

Order Granting / Denying Request For Ex Parte Reexamination	Control No.	Patent Under Reexamination
	90/012,694	7,561,104 B2 E
	Examiner	Art Unit
	ANGELA M. LIE	3992

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

The request for *ex parte* reexamination filed *24 September 2012* has been considered and a determination has been made. An identification of the claims, the references relied upon, and the rationale supporting the determination are attached.

Attachments: a)☐ PTO-892, b)☒ PTO/SB/08, c)☐ Other: _____

1. ☒ The request for *ex parte* reexamination is GRANTED.

RESPONSE TIMES ARE SET AS FOLLOWS:

For Patent Owner's Statement (Optional): TWO MONTHS from the mailing date of this communication (37 CFR 1.530 (b)). **EXTENSIONS OF TIME ARE GOVERNED BY 37 CFR 1.550(c).**

For Requester's Reply (optional): TWO MONTHS from the **date of service** of any timely filed Patent Owner's Statement (37 CFR 1.535). **NO EXTENSION OF THIS TIME PERIOD IS PERMITTED.** If Patent Owner does not file a timely statement under 37 CFR 1.530(b), then no reply by requester is permitted.

2. ☐ The request for *ex parte* reexamination is DENIED.

This decision is not appealable (35 U.S.C. 303(c)). Requester may seek review by petition to the Commissioner under 37 CFR 1.181 within ONE MONTH from the mailing date of this communication (37 CFR 1.515(c)). **EXTENSION OF TIME TO FILE SUCH A PETITION UNDER 37 CFR 1.181 ARE AVAILABLE ONLY BY PETITION TO SUSPEND OR WAIVE THE REGULATIONS UNDER 37 CFR 1.183.**

In due course, a refund under 37 CFR 1.26 (c) will be made to requester:

a) ☐ by Treasury check or,

b) ☐ by credit to Deposit Account No. _____, or

c) ☐ by credit to a credit card account, unless otherwise notified (35 U.S.C. 303(c)).

/ANGELA M LIE/ Primary Examiner, Art Unit 3992		

cc:Requester (if third party requester)

Reexamination

Claims 1-21 are pending in the Request for Reexamination dated September 24th, 2012 (See PTO-1465).

DECISION ON REQUEST FOR REEXAMINATION

A substantial new question of patentability affecting claims 1-21 (See PTO-1465) of US Patent 7,561,104 to Alles et al. (the '104 patent, hereafter) is raised by the request for ex parte reexamination.

Table of Contents

The References **1**

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Conclusion **11**

The References

(1) Benes et al; U.S. Patent Publication No. 2004/0203539; Date Filed: December 11, 2002; Date Published: October 14, 2004 (Benes, hereinafter).

(2) Spain; US Patent No. 7,460,505; Date Filed: February 4, 2003; Date Published: December 2, 2008.

(3) Gordon et al; US Patent No. 7,433,695; Date Filed: May 22, 2006; Date Published: October 7, 2008 (Gordon, hereinafter).

(4) Krumm et al; US Patent No. 7,250,907; Date Filed: June 30, 2003; Date Published: July 31, 2007 (Krumm, hereinafter).

Prosecution History

The Application for Patent with serial number 12/026,333 now patent 7,561,104, has been filed on February 5th, 2008. On February 25th, 2009, the Examiner rejected claims 1-40 and 55-66 under 35 U.S.C 102(b) as being anticipated by Krumm et al (US 2005/0093745), Stilp (US 2002/0172223) and Schantz et al (Patent No. 7,298,314). Claims 41-54 and 67-73 have been allowed. Then on April 2nd 2009 the Patent Owner filled remarks along with amended set of claims. Specifically, the Patent Owner canceled previously rejected claims 1-40 and 55-66, leaving only allowed claims. Accordingly, on May 29th, 2009, the Examiner issued notice of allowance, indicating that following limitations, which are underlined below, rendered claims allowable:

Claims 1:

A method for determining a location of a mobile station, comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter; collecting observed network measurement data including a first signal characteristic from said first

transmitter and a second signal characteristic from said second transmitter; **determining which of said first and second signal characteristics has a greater magnitude; modifying said observed network measurement data using the greater magnitude signal characteristic**; and comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Claim 15:

A method for determining a location of a mobile station, comprising: providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network; collecting network measurement data; comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station **determining a confidence measure for each of the plurality of location estimates; determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures**.

Furthermore claims 41-54 have been renumbered to claims 1-14 and formerly claims 67-73 are recorded in the patent '104 as claims 15-21.

Substantial New Question of Patentability

A. The Request indicates that the Requester believes Benes raises a substantial new question of patentability as to claim 1.

(See Request Pages 5-7)

With respect to the independent claim 1, Benes raises a substantial new question of patentability because Benes teaches the following new, non-cumulative technical feature that may raise a substantial new question of patentability:

"A method for determining a location of a mobile station, comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter; collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter; ***determining which of said first and second signal characteristics has a greater magnitude (1); modifying said observed network measurement data using the greater magnitude signal characteristic (2);*** *and comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station".*

Benes reference discloses the above features which may raise substantial new question of patentability. The limitation 1 is taught in paragraph [0030], wherein in order to determine an angle of arrival (AOA) which is bearing on the stronger downlink signal, the signal has to be first determined. The limitation 2 is taught in paragraph [0027], wherein normalization of the signal based on the signal with greater magnitude corresponds to the step of modification.

Therefore, a reasonable examiner would find Benes teachings to be important in determining the patentability of claim 1 of the '104 patent. The teachings of Benes discussed herein are not cumulative to any written discussion on the record of the teachings of the prior art, were not previously considered nor addressed during a prior examination, and the same question was not the subject of a final holding of invalidity in the Federal Courts.

With respect to claims 2-14, those claims also raise substantial new question, by the virtue of their dependency on claim 1.

B. The Request indicates that the Requester believes Spain in view of Krumm raises a substantial new question of patentability as to claim 1.

(See Request Pages 7-8)

With respect to the independent claim 1, Spain in view of Krumm raises a substantial new question of patentability because Spain in view of Krumm teaches the following new, non-cumulative technical feature that may raise a substantial new question of patentability:

"A method for determining a location of a mobile station, comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter; collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter; ***determining which of said first and second signal characteristics has a greater magnitude (1); modifying said observed network measurement data using the greater magnitude signal characteristic (2);*** *and comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station".*

Spain in view of Krumm teaches the above features which may raise substantial new question of patentability. The limitation 1 is taught by Krumm in column 22, lines 65-66, column 10, lines 43-54 and column 11, lines 35-40 and Spain in column 3, lines 1-10, wherein Table 1 illustrates plurality of signals and their corresponding strengths at different locations, i.e. the signals' strengths are determined. The limitation 2 is taught by Spain in column 11, line 60 to column 12, line 67, wherein the probability (i.e. observed network measurement) is a function of the signal strength data, and it changes (i.e. is modified) as the magnitude of signal varies. Specifically, the greater

magnitude signal characteristic associated with a particular location, the greater probability that the wireless device is located at that spot.

Therefore, a reasonable examiner would find teaching of Spain in view of Krumm to be important in determining the patentability of claim 1 of the '104 patent. The teachings of Spain in view of Krumm discussed herein are not cumulative to any written discussion on the record of the teachings of the prior art, were not previously considered nor addressed during a prior examination, and the same question was not the subject of a final holding of invalidity in the Federal Courts.

With respect to claims 2-14, those claims also raise substantial new question, by the virtue of their dependency on claim 1.

C. The Request indicates that the Requester believes Gordon in view of Krumm raises a substantial new question of patentability as to claim 1.

(See Request Pages 8-11)

With respect to the independent claim 1, Gordon in view of Krumm raises a substantial new question of patentability because Gordon in view of Krumm teaches the following new, non-cumulative technical feature that may raise a substantial new question of patentability:

"A method for determining a location of a mobile station, comprising: providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a

second transmitter; collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter; ***determining which of said first and second signal characteristics has a greater magnitude (1); modifying said observed network measurement data using the greater magnitude signal characteristic (2);*** *and comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station".*

Gordon in view of Krumm teaches the above features which may raise substantial new question of patentability. The limitation 1 is taught by Krumm in column 22, lines 65-66, column 10, lines 43-54 and column 11, lines 35-40. The limitation 2 is taught by Gordon in column 18, lines 17-24, wherein corrected "situational measurement error" corresponds to modified network measurement.

Therefore, a reasonable examiner would find teaching of Gordon in view of Krumm to be important in determining the patentability of claim 1 of the '104 patent. The teachings of Gordon in view of Krumm discussed herein are not cumulative to any written discussion on the record of the teachings of the prior art, were not previously considered nor addressed during a prior examination, and the same question was not the subject of a final holding of invalidity in the Federal Courts.

With respect to claims 2-14, those claims also raise substantial new question, by the virtue of their dependency on claim 1.

D. The Request indicates that the Requester believes Gordon raises a substantial new question of patentability as to claim 15.

(See Request Pages 18-20)

With respect to the independent claim 15, Gordon raises a substantial new question of patentability because Gordon teaches the following new, non-cumulative technical feature that may raise a substantial new question of patentability:

"A method for determining a location of a mobile station, comprising: providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network; collecting network measurement data; comparing said network measurement data with said database of calibration data to thereby **determine a plurality of location estimate of the mobile station determining a confidence measure for each of the plurality of location estimates (1); determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures (2)**."

Gordon teaches the above features which may raise substantial new question of patentability. The limitation 1 is taught by Gordon in column 19, lines 16-43, wherein each location has its corresponding probability (i.e. confidence measure). The limitation

2 is taught by Gordon in column 25, line 53 to column 26, line 43, wherein maximum likelihood is calculated based on distribution of probabilities obtained for the plurality of possible locations.

Therefore, a reasonable examiner would find teaching of Gordon to be important in determining the patentability of claim 15 of the '104 patent. The teachings of Gordon discussed herein are not cumulative to any written discussion on the record of the teachings of the prior art, were not previously considered nor addressed during a prior examination, and the same question was not the subject of a final holding of invalidity in the Federal Courts.

With respect to claims 16-21, those claims also raise substantial new question, by the virtue of their dependency on claim 15.

NOTICE RE PATENT OWNER'S CORRESPONDENCE ADDRESS

Effective May 16, 2007, 37 CFR 1.33(c) has been revised to provide that: The Patent owner's correspondence address for all communications in an ex parte reexamination or an **inter partes** reexamination is designated as the correspondence address of the patent.

Revisions and Technical Corrections Affecting Requirements for Ex Parte and Inter Partes Reexamination, 72 FR 18892 (April, 16, 2007) (Final Rule)

The correspondence address for any pending reexamination proceeding not having the same correspondence address as that of the patent is, by way of this revision to 37 CFR 1.33(c), automatically changed to that of the patent file as of the effective date.

This change is effective for any reexamination proceeding which is pending before the Office as of May 16, 2007, including the present reexamination proceeding, and to any reexamination proceeding which is filed after that date.

Parties are to take this change into account when filing papers, and direct communications accordingly.

In the event the patent owner's correspondence address listed in the papers (record) for the present proceeding is different from the correspondence address of the patent, it is strongly encouraged that the patent owner affirmatively file a Notification of Change of Correspondence Address in the reexamination proceeding and/or the patent (depending on which address patent owner desires), to conform the address of the proceeding with that of the patent and to clarify the record as to which address should be used for correspondence.

Telephone Numbers for reexamination inquiries:

Reexamination	(571) 272-7703
Central Reexam Unit (CRU)	(571) 272-7705
Reexamination Facisimile Transmission No.	(571) 273-9900

Conclusion

Extensions of time under 37 CFR 1.136(a) will not be permitted in these proceedings because the provisions of 37 CFR 1.136 apply only to "an applicant" and not to parties in a reexamination proceeding. Additionally, 35 U.S.C. 305 requires that reexamination proceedings "will be conducted with special dispatch" (37 CFR 1.550(a)).

Extension of time in reexamination proceedings are provided for in 37 CFR 1.550(c). After the filing of a request for reexamination by a third party requester, any document filed by either the patent owner of the third party requester must be served on the other party (or parties where two or more third-party-requester proceedings are merged) in the reexamination proceeding in the manner provided in 37 CFR 1.248. See 37 CFR 1.550(f).

The patent owner is reminded of the continued responsibility under 37 CFR 1.565(a) to apprise the Office of any litigation activity, or other prior or concurrent proceeding, throughout the course of this reexamination proceeding. The third party requester is also reminded of the ability to similarly apprise the Office of any such activity or proceeding throughout the course of this reexamination proceeding. See MPEP § 2207, 2282 and 2286.

All correspondence relating to this *ex parte* reexamination proceeding should be directed:

By EFS-Web: Registered Users may submit correspondence via EFS-Web, at https://efs.uspto.gov/efile/myportal/efs-registered.

By Mail to: Mail Stop *Ex Parte* Reexam
Central Reexamination Unit
Commissioner for Patents
United States Patent & Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

By FAX to: (571) 273-9900
Central Reexamination Unit

By hand: Customer Service Window
Randolph Building
401 Dulany Street

Alexandria, VA 22314

EFS-Web offers the benefit of quick submission to the particular area of the Office that needs to act on the correspondence. Also, EFS-Web submissions are "soft-scanned" (i.e., electronically uploaded) directly into the official file for the reexamination proceeding, which offers parties the opportunity to review the content of their submission after the "soft scanning" process is complete.

Any inquiry concerning this communication should be directed to the Central Reexamination Unit at telephone number 571-272-7705.

/ANGELA M LIE/

Primary Examiner, Art Unit 3992

/Luke S. Wassum/
Primary Examiner, Art Unit 3992

/Sudhanshu C Pathak/
Supervisory Patent Examiner, Art Unit 3992

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	12026333
Filing Date	2008-02-05
First Named Inventor	Martin Alles
Art Unit	~~3662~~ 3992
Examiner Name	PHAN, DAO LINDA
Attorney Docket Number	466-333US1

U.S.PATENTS Remove

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
/A.L./	1	7460505	B2	2008-12-02	Spain	
/A.L./	2	7433695	B2	2008-10-07	Gordon et al.	
/A.L./	3	7250907	B2	2007-07-31	Krumm et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

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
/A.L./	1	20040203539	A1	2004-10-14	Benes et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

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							☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	12026333
	Filing Date	2008-02-05
	First Named Inventor	Martin Alles
	Art Unit	3662
	Examiner Name	PHAN, DAO LINDA
	Attorney Docket Number	466-333US1

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

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	/Angela Lie/	Date Considered	12/12/2012

*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	12026333
	Filing Date	2008-02-05
	First Named Inventor	Martin Alles
	Art Unit	3662
	Examiner Name	PHAN, DAO LINDA
	Attorney Docket Number	466-333US1

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.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

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	/Jason Paul DeMont/	Date (YYYY-MM-DD)	2012-09-24
Name/Print	Jason Paul DeMont	Registration Number	35793

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.**

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 the Freedom of Information Act requires disclosure of these record s.

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 inspections 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.

Reexamination	Application/Control No.	Applicant(s)/Patent Under Reexamination
	90012694	7,561,104 B2 ET AL.
	Certificate Date	Certificate Number

Requester Correspondence Address:	☐ Patent Owner	☒ Third Party

Kaplan, Breyer, Schwarz & Ottesen, LLP
Suite 250
100 Commons Way
Holmdel, NJ 07733

LITIGATION REVIEW ☒	/A.M.L/ (examiner initials)	12/12/2012 (date)
Case Name		Director Initials
none		/SP/ for IY

COPENDING OFFICE PROCEEDINGS	
TYPE OF PROCEEDING	NUMBER

	/ANGELA M LIE/ Primary Examiner.Art Unit 3992

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	90012694	7,561,104 B2 ET AL.
	Examiner	Art Unit
	ANGELA M LIE	3992

SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
review of patented file's prosecution history	12/10/2012	AL

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

	/ANGELA M LIE/ Primary Examiner.Art Unit 3992

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.
90/012,694	09/24/2012	7,561,104 B2	466-333us1	6575

79172 7590 11/16/2012

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

EXAMINER	
LIE, ANGELA M	
ART UNIT	**PAPER NUMBER**
3992	

MAIL DATE	DELIVERY MODE
11/16/2012	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.

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patents and Trademark Office
P.O.Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

THIRD PARTY REQUESTER'S CORRESPONDENCE ADDRESS
KENNETH OTTESEN
KAPLAN, BREYER, SCHWARZ & OTTESEN LLP
100 COMMONS WAY, SUITE 250
HOLMDEL, NJ 07733

Date:
MAILED

NOV 15 2012

CENTRAL REEXAMINATION UNIT

EX PARTE REEXAMINATION COMMUNICATION TRANSMITTAL FORM

REEXAMINATION CONTROL NO. : 90012694
PATENT NO. : 7561104
ART UNIT : 3993

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above identified ex parte reexamination proceeding (37 CFR 1.550(f)).

Where this copy is supplied after the reply by requester, 37 CFR 1.535, or the time for filing a reply has passed, no submission on behalf of the ex parte reexamination requester will be acknowledged or considered (37 CFR 1.550(g)).

Ex Parte Reexamination Interview Summary – Pilot Program for Waiver of Patent Owner's Statement	Control No. 90/012,694	Patent For Which Reexamination is Requested 7,561,104
	Examiner	Art Unit 3992

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

All participants (USPTO official and patent owner):

(1) Karen Ward, CRU (3)

(2) Mark Comtois, 46285 (4)

Date of Telephonic Interview: September 27, 2012.

The USPTO official requested waiver of the patent owner's statement pursuant to the pilot program for waiver of patent owner's statement in *ex parte* reexamination proceedings.*

☐ The patent owner **agreed** to waive its right to file a patent owner's statement under 35 U.S.C. 304 in the event reexamination is ordered for the above-identified patent.

☐ The patent owner **did not agree** to waive its right to file a patent owner's statement under 35 U.S.C. 304 at this time.

The patent owner is not required to file a written statement of this telephone communication under 37 CFR 1.560(b) or otherwise. However, any disagreement as to this interview summary must be brought to the immediate attention of the USPTO, and no later than one month from the mailing date of this interview summary. Extensions of time are governed by 37 CFR 1.550(c).

*For more information regarding this pilot program, see *Pilot Program for Waiver of Patent Owner's Statement in Ex Parte Reexamination Proceedings*, 75 *Fed. Reg.* 47269 (August 5, 2010), available on the USPTO Web site at http://www.uspto.gov/patents/law/notices/2010.jsp.

☒ USPTO personnel were unable to reach the patent owner.

The patent owner may contact the USPTO personnel at the telephone number provided below if the patent owner decides to waive the right to file a patent owner's statement under 35 U.S.C. 304.

/Karen Ward/ 571-272-7932
Signature and telephone number of the USPTO official who contacted or attempted to contact the patent owner.

cc: Requester (if third party requester)

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

REEXAM CONTROL NUMBER	FILING OR 371 (c) DATE	PATENT NUMBER
90/012,694	09/24/2012	7561104

CONFIRMATION NO. 6575

REEXAM ASSIGNMENT NOTICE

79172
Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

OC000000057105990

Date Mailed: 10/16/2012

NOTICE OF ASSIGNMENT OF REEXAMINATION REQUEST

The above-identified request for reexamination has been assigned to Art Unit 3993. All future correspondence to the proceeding should be identified by the control number listed above and directed to the assigned Art Unit.

A copy of this Notice is being sent to the latest attorney or agent of record in the patent file or to all owners of record. (See 37 CFR 1.33(c)). If the addressee is not, or does not represent, the current owner, he or she is required to forward all communications regarding this proceeding to the current owner(s). An attorney or agent receiving this communication who does not represent the current owner(s) may wish to seek to withdraw pursuant to 37 CFR 1.36 in order to avoid receiving future communications. If the address of the current owner(s) is unknown, this communication should be returned within the request to withdraw pursuant to Section 1.36.

cc: Third Party Requester(if any)
KENNETH OTTESEN
KAPLAN, BREYER, SCHWARZ & OTTESEN, LLP
100 COMMONS WAY, SUITE 250
HOLMDEL, NJ 07733

/jawhitfield/

Legal Instruments Examiner
Central Reexamination Unit 571-272-7705; FAX No. 571-273-9900

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
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REEXAM CONTROL NUMBER	FILING OR 371 (c) DATE	PATENT NUMBER
90/012,694	09/24/2012	7561104

CONFIRMATION NO. 6575

REEXAMINATION REQUEST NOTICE

KENNETH OTTESEN
KAPLAN, BREYER, SCHWARZ & OTTESEN, LLP
100 COMMONS WAY, SUITE 250
HOLMDEL, NJ 07733

OC000000057105989

Date Mailed: 10/16/2012

NOTICE OF REEXAMINATION REQUEST FILING DATE

(Third Party Requester)

Requester is hereby notified that the filing date of the request for reexamination is 09/24/2012, the date that the filing requirements of 37 CFR § 1.510 were received.

A decision on the request for reexamination will be mailed within three months from the filing date of the request for reexamination. (See 37 CFR 1.515(a)).

A copy of the Notice is being sent to the person identified by the requester as the patent owner. Further patent owner correspondence will be the latest attorney or agent of record in the patent file. (See 37 CFR 1.33). Any paper filed should include a reference to the present request for reexamination (by Reexamination Control Number).

cc: Patent Owner
79172
Duane Morris LLP
505 9th Street, N.W.
Suite 1000
Washington, DC 20004

/jawhitfield/

Legal Instruments Examiner
Central Reexamination Unit 571-272-7705; FAX No. 571-273-9900

Patent Assignment Abstract of Title

Total Assignments: 5

Application #: 12026333 **Filing Dt:** 02/05/2008 **Patent #:** 7561104 **Issue Dt:** 07/14/2009
PCT #: NONE **Publication #:** US20080186234 **Pub Dt:** 08/07/2008
Inventors: Martin Alles, John Carlson, George Maher, Selcuk Mazlum
Title: METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE UNIT

Assignment: 1

Reel/Frame: 020785 / 0060 **Received:** 04/10/2008 **Recorded:** 04/10/2008 **Mailed:** 04/10/2008 **Pages:** 5
Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).
Assignors: ALLES, MARTIN **Exec Dt:** 04/01/2008
CARLSON, JOHN **Exec Dt:** 04/04/2008
MAHER, GEORGE **Exec Dt:** 03/31/2008
MAZLUM, SELCUK **Exec Dt:** 03/31/2008
Assignee: COMMSCOPE, INC. OF NORTH CAROLINA
1100 COMMSCOPE PLACE SE
HICKORY, NORTH CAROLINA 28602
Correspondent: DUANE MORRIS LLP
505 9TH STREET
SUITE 1000
WASHINGTON, DC 20004-2166

Assignment: 2

Reel/Frame: 020884 / 0365 **Received:** 05/01/2008 **Recorded:** 05/01/2008 **Mailed:** 05/01/2008 **Pages:** 10
Conveyance: PATENT SECURITY AGREEMENT SUPPLEMENT
Assignors: COMMSCOPE, INC. OF NORTH CAROLINA **Exec Dt:** 04/25/2008
ANDREW CORPORATION **Exec Dt:** 04/25/2008
Assignee: BANK OF AMERICA, N.A.
2001 CLAYTON ROAD
BUILDING B
CONCORD, CALIFORNIA 94520
Correspondent: CORPORATION SERVICE COMPANY
1133 AVENUE OF THE AMERICAS
SUITE 3100
NEW YORK, NY 10036

Assignment: 3

Reel/Frame: 026039 / 0005 **Received:** 02/03/2011 **Recorded:** 02/03/2011 **Mailed:** 04/03/2011 **Pages:** 134
Conveyance: PATENT RELEASE
Assignor: BANK OF AMERICA, N.A., AS ADMINISTRATIVE AGENT **Exec Dt:** 01/14/2011
Assignees: COMMSCOPE, INC. OF NORTH CAROLINA
1100 COMMSCOPE PLACE SE
HICKORY, NORTH CAROLINA USA 28602
ALLEN TELECOM LLC
1100 COMMSCOPE PLACE SE
A DELAWARE LIMITED LIABILITY COMPANY
HICKORY, NORTH CAROLINA 28602
ANDREW LLC (F/K/A ANDREW CORPORATION)
1100 COMMSCOPE PLACE SE
DELAWARE LIMITED LIABLITY COMPANY
HICKORY, NORTH CAROLINA 28602
Correspondent: CORPORATION SERVICE COMPANY
1090 VERMONT AVENUE
SUITE 430
WASHINGTON, DC 20005

Assignment: 4

Reel/Frame: 026272 / 0543 **Received:** 05/04/2011 **Recorded:** 05/04/2011 **Mailed:** 05/17/2011 **Pages:** 72

Conveyance: SECURITY AGREEMENT

Assignors: ALLEN TELECOM LLC, A DELAWARE LLC — **Exec Dt:** 01/14/2011

ANDREW LLC, A DELAWARE LLC — **Exec Dt:** 01/14/2011

COMMSCOPE, INC OF NORTH CAROLINA, A NORTH CAROLINA CORPORATION — **Exec Dt:** 01/14/2011

Assignee: JPMORGAN CHASE BANK, N.A., AS COLLATERAL AGENT
2700 PARK AVENUE
NEW YORK, NEW YORK 10017

Correspondent: CORPORATION SERVICE CO.-J PATERSON
1090 VERMONT AVENUE
SUITE 430
WASHINGTON, DC 20005

Assignment: 5

Reel/Frame: 026276 / 0363 **Received:** 05/04/2011 **Recorded:** 05/03/2011 **Mailed:** 05/17/2011 **Pages:** 71

Conveyance: SECURITY AGREEMENT

Assignors: ALLEN TELECOM LLC, A DELAWARE LLC — **Exec Dt:** 01/14/2011

ANDREW LLC, A DELAWARE LLC — **Exec Dt:** 01/14/2011

COMMSCOPE, INC. OF NORTH CAROLINA, A NORTH CAROLINA CORPORATION — **Exec Dt:** 01/14/2011

Assignee: JPMORGAN CHASE BANK, N.A., AS COLLATERAL AGENT
2700 PARK AVENUE
NEW YORK, NEW YORK USA 10017

Correspondent: CORPORATION SERVICE CO.-J. PATERSON
1090 VERMONT AVENUE
SUITE 430
WASHINGTON, DC 20005

Search Results as of: 10/12/2012 03:38 PM

If you have any comments or questions concerning the data displayed, contact PRD / Assignments at 571-272-3350. v.2.2.1
Web interface last modified: Jan 26, 2012

Litigation Search Report CRU 3999

Reexam Control No. 90/012,694

To: Examiner **Art Unit: 3999** **Date: 10/11/12** **Case Serial Number: 90/012,694**	**From: Karen L. Ward** **Location: CRU 3999** **MDW 7C76** **Phone: (571) 272-7932** **Karen.Ward@uspto.gov**

Search Notes

Litigation was not found involving U.S. Patent No. 7,561,104.

1) I performed a KeyCite Search in Westlaw, which retrieves all history on the patent including any litigation.

2) I performed a search on the patent in Lexis CourtLink for any open dockets or closed cases.

3) I performed a search in Lexis in the Federal Courts and Administrative Materials databases for any cases found.

4) I performed a search in Lexis in the IP Journal and Periodicals database for any articles on the patent.

5) I performed a search in Lexis in the news databases for any articles about the patent or any articles about litigation on this patent.

Westlaw.

Date of Printing: Oct 11, 2012

KEYCITE

C US PAT 7561104 METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE UNIT, Assignee: Andrew LLC (Jul 14, 2009)

History

Direct History

=> 1 **METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE UNIT,** US.PAT 7561104, 2009 WL 2024233 (U.S. PTO Utility Jul 14, 2009)

Patent Family

2 MOBILE STATION LOCATION DETERMINING METHOD, INVOLVES MODIFYING OBSERVED NETWORK MEASUREMENT DATA, AND COMPARING MODIFIED NETWORK MEASUREMENT DATA WITH DATABASE OF CALIBRATION DATA TO DETERMINE LOCATION OF MOBILE STATION, Derwent World Patents Legal 2008-J68346

Assignments

3 Action: SECURITY AGREEMENT Number of Pages: 072, (DATE RECORDED: May 04, 2011)

4 Action: SECURITY AGREEMENT Number of Pages: 071, (DATE RECORDED: May 03, 2011)

5 Action: PATENT RELEASE Number of Pages: 134, (DATE RECORDED: Feb 03, 2011)

6 Action: PATENT SECURITY AGREEMENT SUPPLEMENT Number of Pages: 010, (DATE RECORDED: May 01, 2008)

7 Action: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS). Number of Pages: 005, (DATE RECORDED: Apr 10, 2008)

Prior Art (Coverage Begins 1976)

C 8 NEAR FIELD ELECTROMAGNETIC POSITIONING SYSTEM AND METHOD, US PAT 7298314Assignee: Q-Track Corporation, (U.S. PTO Utility 2007)

C 9 SYSTEM AND METHOD FOR GEOLOCATING A WIRELESS MOBILE UNIT FROM A SINGLE BASE STATION USING REPEATABLE AMBIGUOUS MEASUREMENTS, US PAT 6871077Assignee: Grayson Wireless, (U.S. PTO Utility 2005)

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LexisNexis· *CourtLink*·

Patent Search 7561104 10/11/2012

No cases found.

Return to Search

(Charges for search still apply)

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Terms: **7561104** (Suggest Terms for My Search)

026333 (12) 7561104 July 14, 2009

UNITED STATES PATENT AND TRADEMARK OFFICE GRANTED PATENT

7561104

Get Drawing Sheet 1 of 10
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Link to Claims Section

July 14, 2009

Method to modify calibration data used to locate a mobile unit

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ENGLISH-ABST:

A method of modifying calibration data used to geo-locate a mobile station located in an indoor environment is disclosed. When a mobile station is located indoors, the signal strength of signals received and/or transmitted by the mobile station have the tendency to be lower than the strength of the signals received by a mobile station located outdoors. As a result of these lower signal strengths, geo-location efforts which rely on signal strengths may result in unsatisfactory location accuracy. Modifying pre-existing calibration data obtained outdoors may provide a way to simulate indoor calibration data characteristics.

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[0001]The present application is related to provisional application No. 60/899,379 entitled Mobile Location Using Network Measurement Reports filed on Feb. 5, 2007, which is hereby incorporated by reference in its entirety.

SUMMARY:

BACKGROUND

[0002]The use of wireless communication devices such as telephones, pagers, personal digital assistants, laptop computers, etc., hereinafter referred to collectively as "mobile appliances" or

"mobiles stations" has become prevalent in today's society. In recent years, at the urging of public safety groups, there has been increased interest in technology which can determine the geographic position or "geo-locate" a mobile station in certain circumstances.

[0003]Estimating the location or "geo-locating" a mobile station may require one or more types of calibration data associated with the mobile station (e.g., signal strength, round trip time, time difference of arrival (TDOA), etc.). Calibration data is typically collected in an outdoor environment. The primary reason for collecting calibration data outdoors is the greater ease of performing automated calibration collection procedures or, in some instances, manual collection procedures along roads. It is more time-consuming to perform calibration procedures indoors due to the required access to buildings and the inability to utilize automated collection procedures designed for outdoor environments.

[0004]When a wireless device is located indoors, the signal strengths of signals received from the serving and/or neighboring base stations tend to be lower than the strength of the signals received by a wireless device located outdoors. As a result of these lower signal strengths, performing comparisons between the received signal strengths of the indoor wireless device and signal strength data stored in a calibration database may result in a poor estimated location accuracy. Modifying the calibration data obtained outdoors may provide a way to simulate indoor calibration data characteristics. Calibration data collected in areas located adjacent to indoor facilities may be altered to increase the accuracy of location estimates of a mobile station located indoors.

[0005]One embodiment of the present subject matter is a method for determining a location of a mobile station. The method includes providing a database of previously-gathered calibration data for a predetermined region in a wireless network and collecting observed network measurement data. The method also includes modifying the observed network measurements and then comparing the modified data with the database of calibration data to determine the location of the mobile station.

[0006]Another embodiment of the present subject matter is a system for determining a location of a mobile station. The system includes a database of previously-gathered calibration data for a region in a wireless network and circuitry such as a wireless receiver for collecting observed network measurement data. The system includes circuitry, such as a processor, for modifying the observed network measurement data; and circuitry, such as a processor, for comparing the modified data with the calibration data in the database to determine the location of the mobile station.

[0007]Yet another embodiment of the present subject matter is a method for determining a location of a mobile station. The method includes providing a database of previously-gathered calibration data for a region in a wireless network which includes a serving transmitter. The method collects observed network measurement data including a first network characteristic from said serving transmitter and modifies the observed network measurement data using said first characteristic. The method compares the modified network measurement data with the database of calibration data to thereby determine the location of the mobile station.

[0008]Still yet another embodiment of the present subject matter is a method for determining a location of a mobile station. The method includes providing a database of previously-gathered calibration data for a region in a wireless network including a first transmitter and a second transmitter. The method also includes collecting observed network measurement data including a first and second signal characteristic from the first and second transmitters respectively and determining which of the first and second signal characteristics has a greater magnitude. The observed network measurement data may be modified using the greater magnitude signal characteristic, and the modified network measurement data may be compared with the database of calibration data to determine the location of the mobile station.

[0009]A further embodiment of the present subject matter is a method for determining a

location of a mobile station. The method includes providing a database of previously-gathered calibration data for a region in a wireless network and collecting observed network measurement data from a plurality of transmitters which includes a signal characteristic from each one of said plural transmitters. The method also includes determining an average value for the signal characteristics and modifying the observed network measurement data using the average value. The method may then compare the modified network measurement data with the database of calibration data to determine the location of the mobile station.

[0010]Still a further embodiment of the present subject matter recognizes that it may be desirable to locate a mobile station by obtaining at least one network measurement report representing at least one first signal characteristic of the mobile station's serving base station, and at least one second and third signal characteristics of neighboring base stations. The method may also compute the difference between the at least one first signal characteristic of the mobile station's serving base station and the at least one second signal characteristic of at least one of the neighboring base stations to determine a first solution and determine which neighboring base station has the highest signal power level at a particular location. The difference between the highest signal power and the power levels of the serving base station and the remaining neighboring base stations may be computed to determine a second solution. It may also be determined which neighboring base station has the lowest signal power level at the particular location. The method may also comprise computing an average signal power level intermediary to the difference between the highest signal power level and the lowest signal power level to determine a third solution and determining which of the three solutions is a most optimal solution based on at least one comparison of the three solutions. At least one signal characteristic of the network measurement report may be adjusted based on the most optimal solution and the modified network measurement report may be utilized to locate a mobile station.

[0011]Another embodiment of the present subject matter is a method for determining a location of a mobile station. The method includes providing a database of previously-gathered outdoor calibration data for a region in a wireless network, collecting network measurement data, and comparing the network measurement data with the database of calibration data to thereby determine several location estimates of the mobile station. The method may also include determining a confidence measure for each of the plurality of location estimates and determining the location of the mobile station based on the plurality of location estimates and their respective confidence measures.

[0012]These and other advantages of the disclosed subject matter over the prior art will be readily apparent to one skilled in the art to which the disclosure pertains from a perusal of the claims, the appended drawings, and the following detailed description of the preferred embodiments.

DRWDESC:

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]FIG. 1 illustrates a wireless communications networking environment.

[0014]FIG. 2 illustrates a flow diagram of an exemplary inventive concept.

[0015]FIG. 3 illustrates a flow diagram of another exemplary inventive concept.

[0016]FIG. 4 illustrates a flow diagram of yet another exemplary inventive concept.

[0017]FIG. 5 illustrates a flow diagram of still another exemplary inventive concept.

[0018]FIG. 6 illustrates a flow diagram of still yet another exemplary inventive concept.

[0019]FIG. 7 illustrates a flow diagram of an embodiment of the subject matter.

[0020]FIG. 8 illustrates a flow diagram of another embodiment of the subject matter.

[0021]FIG. 9 illustrates a flow diagram of another embodiment of the subject matter.

[0022]FIG. 10 illustrates a flow diagram of another embodiment of the subject matter.

DETDESC:

DETAILED DESCRIPTION

[0023]Calibration data samples obtained outdoors may be used to simulate indoor calibration data to locate a mobile station (MS) in an indoor facility. A method of utilizing calibration data samples to represent indoor and/or outdoor wireless networking environments is described herein.

[0024]Reliably locating a mobile station located indoors, even when the calibration data has been obtained in an outdoor environment, may simplify a calibration collection procedure. Calibration data obtained outdoors may be modified and substituted for indoor calibration data. In addition network measurement data may be modified for comparison with the outdoor calibration data.

[0025]In general, a non-uniform grid point (NUG) may represent the signal characteristics and/or calibration data over a given region. As illustrated in FIG. 1, a set of NUGs (NUG**1**, NUG**2** and NUG**3**) are shown as being a part of a larger geographical region (R), which includes various wireless networking components (e.g., (MS **11** and BS **20**—NUG**1**), (MSs **12**-**15**—NUG**2**) and (MSs **16**-**18** and BS **30**—NUG**3**)). The NUGs represent an area of collected calibration data, which may be stored in a database for easy retrieval during a calibration data comparison operation between the NUG and a received network measurement report (NMR).

[0026]Calibration data may be obtained from data collection devices during field test operations, and/or from MSs or other communication devices within the general area of the NUG. Cross-NUG communications may occur between MSs and/or BSs located within communication range of one or more of the NUGs. For example, BS **10** may be located outside the region (R) and may communicate with one or more devices located in the various NUGs **1**-**3**. The different NUGs **1**-**3** may be separately defined by a variety of parameters. For example, geographical areas (e.g., mountains, buildings, roads) may be a factor in deciding the boundaries of a NUG. Additionally, varying concentrations of MSs may be another factor that separates one NUG from another.

[0027]Network measurement reports (NMRs) may be used to represent network characteristics at particular locations within a given region (R). Any point located within a NUG may have corresponding signal strength levels that represent the signal power of the serving and/or neighboring cell (NC) BSs. An exemplary NMR may be represented by example_data_vector= [P**1**, P**2**, P**3**, TA**1**]. Referring to FIG. 1, the power level signals (P**1**-P**3**) may represent the power levels of the three BSs **10**, **20** and **30**, as measured at a particular location. The timing advance parameter TA**1** (or equivalent parameter) may be used to represent timing information of signals transmitted between the MS and one or more BSs.

[0028]The value of the timing advance (TA) parameter corresponds to the length of time a signal from a MS takes to reach a particular BS. A MS may be configured to transmit data signals at specific timeslot intervals depending on the type of wireless communication protocol

employed (e.g., TDMA, GSM, 3GPP etc.). Using the speed of light (c=3*10^8 m/s) as a reference velocity for the radio waves, the TA parameter may be increased or decreased depending on the distance between the MS and the BS. The TA parameter may be periodically adjusted as the distance from the MS to the BS changes. Of course, a NMR may contain any number and type of parameters, and may be used to estimate the location of a MS.

[0029]For example, NMR(s) may be transmitted from the MS or from other wireless communication components to position determining equipment (PDE) **50**, which processes the received NMR information and may attempt to locate the position of the MS. NMR(s) may be periodically generated by MSs or other communication devices to calibrate the NUG. The NUG may also be based entirely on information received from NMR(s) generated by MSs located in the NUG.

[0030]The received Network Measurement data (NM data) may be compared to predetermined calibration data representing one or more NUGs to estimate the location of a MS. In a case where NM data is compared against a NUG, like parameters may be compared to estimate if the target MS **18** is within the NUG. Similarly, NUG parameters may be computed in response to a comparison operation, and then compared to the NM data. Each NUG may have a series of parameters and/or functions characterizing one or more particular locations in the NUG. Given a received set of one or more NMR(s) obtained from some unknown location, an estimate of that unknown location may be calculated using the characterization of the NUG or uniform grid (UG) over that region.

[0031]It may be desirable to use the original unmodified NM data directly without modification when locating a mobile station. Assuming the MS is located in an indoor facility, the data contained in the NMR(s) may be a function of calibration data collected outdoors. In some cases, the unmodified outdoor calibration data used to represent the indoor facility may provide an accurate representation of the location of the target MS **18** (e.g., low distortion structures, open-faced facilities, etc.).

[0032]Referring to FIG. 1, the NM data may be sent from the target MS **18** to the BS **10**, where the PDE **50** processes the NMR and performs one or more comparison operations between the NM data and the calibration data of the NUG(s). Once the comparison operation is complete, the location of the target MS **18** may be estimated. A direct comparison of the original NM data may be made against the corresponding NUG(s) characteristics. Alternatively, the NM data may not be modified even if NUG(s) are utilized to estimate the location of the mobile station.

[0033]NM data may also be modified to adjust the power levels received from the serving and/or neighboring cell (NC) base stations. For example, differences in parameters between the serving cell and the NC may be calculated and the quantities used to modify the original NM data.

[0034]If an original NMR received at the PDE **50** had the form NMR**1**=[P**1**, P**2**, P**3**, TA**1**], where P**1** is the serving BS power at a particular location, P**2** is a first NC power, P**3** is a second NC power, and TA**1** is the timing advance parameter, the modified NMR may be represented by: NMR_modified=[0, P**1**-P**2**, P**1**-P**3**, TA**1**]. The resulting data vector may be used to calculate new relative power levels of the NC BSs by subtracting or adding the NMR_modified parameters from the original NMR**1** parameters. In this example, the power of the serving BS may be used as a basis to obtain relative power level modification parameters to modify the NC power level parameters of NMR(s).

[0035]The calculated modified parameters (NMR_modified=[0, P**1**-P**2**, P**1**-P**3**, TA**1**]) may also be used to simulate an indoor facility by modifying NMR(s) received from an indoor location. Alternatively, the modified parameters may be used to conduct other calculations to obtain a desired set of modified results. For example, the modified NMR may be compared to one or more of the NUG(s) to provide an estimated location of a MS. Of course, the serving BS power

level is not a required parameter to be used as a basis to obtain relative power level modification parameters, and many other parameters may be used to modify the NM data to simulate an indoor facility.

[0036]To further illustrate modification of the NMR, consider a particular implementation where the variable RxLevServing_WD represents the received signal strength of the serving base station's control channel measured by the wireless device at an unknown location. Let RxLevNeigh_i_WD represent the received signal strength of the $i^{(th)}$neighbor's control channel, RxLevServing_DB represent the average received signal strength of the serving station's control channel, stored in a database of the PDE **50** during the calibration process, and RxLevNeigh_i_DB represent the average received signal strength of the $i^{(th)}$neighbor's control channel stored in the database during a calibration process (i=1 to N, where N is the number of neighbor cells reported).

[0037]A comparison operation may be conducted between the received signal strengths of the NC-BSs relative to the serving BS's received signal strength. For example, a comparison may include computing the difference between the parameters of the serving base station and the $i^{(th)}$neighbor's parameters (i.e., (RxLevServing_WD−RxLevNeigh_i_WD) and (RxLevServing_DB−RxLevNeigh_i_DB)). Once the differences are calculated, the magnitudes of the differences may be compared to a predetermined threshold value used to distinguish between an acceptable difference value requiring no modification to the NM data and a non-acceptable difference value invoking further modification efforts.

[0038]NM data may be modified by an amount relative to the signal strength of a NC-BS. In this example, the NC-BS having the highest signal power may be used as a basis to modify the values of the NM data. The differences between the NC having the highest cell power and the cell powers of the remaining NC-BSs may be calculated and the quantities thereof used to modify the original NM data.

[0039]An exemplary NMR may have the form NMR=[**P1**, **P2**, **P3**, **P4**, **TA1**], where **P1** is the serving BS signal power, **P2** is a NC having the highest signal power at the intended location of the NMR, **P3** and **P4** are different NC signal powers, and **TA1** is a timing advance parameter. In this example, **P2** has the highest signal power level and may be used as the basis for modifying the parameters of the NMR. The modified NMR may then be represented by NMR_modified**2**= [**P2**-**P1**, 0, **P2**-**P3**, **P2**-**P4**, **TA1**]. The resulting data vector NMR_modified**2** may be used to calculate new power levels of the NC base stations by subtracting or adding the NMR_modified**2** parameters to the original NMR parameters.

[0040]The modified NMR may be compared to one or more of the NUG(s). In the previous examples, the power of the serving BS and the NC with the highest signal power level were used to obtain the relative power modification quantities. The signal power level of the serving BS and/or the NC having the highest signal power may be used solely to modify the NMR, and may not be included in comparison operations against the NUG(s). If the serving BS power level parameter and/or the NC having the highest signal power level parameter are excluded from the comparison to the NUG(s), the first and/or additional terms of the NMR may be ignored during the comparison operation. Of course, any other parameter may be utilized and the example above including power level should not limit the scope of the claims appended herewith.

[0041]To further illustrate modification of the NMR, consider a particular implementation where the variable RxLevNeigh_h_WD represents the received signal strength of a neighboring BS's control channel (neighbor A) having the highest signal level, as measured by the wireless device. RxLevNeigh_h_WD may be listed first in a measurement report list containing signal strengths sorted in descending order (h=1). Let RxLevNeigh_i_WD represent the received signal strength of the $i^{(th)}$neighbor's control channel measured (neighbor i, where i≠h), as by the wireless device, and RxLevNeigh_h_DB represent the received signal strength of the

neighbor (neighbor A) with the highest received signal strength, as measured by the wireless device, and which may be stored in the PDE **50** database during a calibration process. RxLevNeigh_i_DB may be used to represent the received signal strength of the $i^{(th)}$neighboring BS's control channel (neighbor i, where i≠h, and i=1 to N, and where N is the number of neighbors reported). RxLevNeigh_i_DB may be stored in the PDE **50** database during a calibration process.

[0042]In this example, correlation may be conducted over the received signal strengths of the NC-BSs relative to the NC-BS having the highest received signal strength, as observed by the wireless device. A comparison may include computing the difference between the parameters of the serving BS and the $i^{(th)}$neighbor's parameters (i.e. (RxLevNeigh_h_WD−RxLevNeigh_i_WD) and (RxLevNeigh_h_DB−RxLevNeigh_i_DB)). Comparisons may also be conducted for any one, combination of or all of the measured parameters of the NC-BSs.

[0043]NM data may be modified to adjust the power levels received from the serving and/or neighboring cell (NC) base stations by an amount relative to the average signal strength of one or more NC base stations. Each signal power or parameter component of the NMR may also be modified by an average signal power or parameter level based on one or more of the measured NC signal power levels. The average received signal power level may be calculated a number of different ways, for example, the average of the two highest signal powers, the three highest powers, the average of all (N) signal powers, or an intermediary number between one or more of the measured NC signal power components. Modifying the original NMR components may include subtracting or adding to the existing NMR power components by an amount based on the calculated average, or other various known functions.

[0044]To further illustrate modification of the NMR, consider a particular implementation where RxLevNeigh_avg_WD represents the average received signal strength based upon a number of control channel signal powers of neighboring BSs, as measured by the wireless device at an unknown location to be estimated. Let RxLevNeigh_i_WD represent the received signal strength of the $i^{(th)}$neighbor's control channel signal power, and RxLevNeigh_avg_DB represent the average received signal strength of data stored during calibration, and computed based on the neighboring BSs, as measured by the wireless device and used in computing the average received signal strength. The same neighboring BSs may be used to represent the average received signal strength of the signal power levels received by the wireless device and for the average received signal strength of calibration data stored in the PDE **50** database. Let RxLevNeigh_i_DB represent the received signal strength of the $i^{(th)}$neighbor's control channel stored in the PDE **50** database during the calibration process (i=1 to N, where N is the number of neighbors reported).

[0045]In this example, a comparison may be conducted over the received signal strengths of the neighboring BSs relative to the average received signal strength computed for all neighboring BSs observed by the wireless device (i.e., compare between (RxLevNeigh_avg_WD−RxLevNeigh_i_WD)) and for all neighbors previously measured by the wireless device (i.e., compare between (RxLevNeigh_avg_DB−RxLevNeigh$_{(-)}$ i_DB)). The average signal power level observed over all the neighbor signal power levels may be realized in absolute powers (mW) or in relative powers (dBm).

[0046]Any combination of the above NMR modification procedures may be performed to increase the accuracy of mobile station location estimates. Further, any number of or type of parameters may be utilized in any of the aforementioned procedures and the exemplary parameters of power level, signal strength, etc. should not limit the scope of the claims appended wherewith. Certain factors impacting the modification procedure selection process may include the specific type of cellular technology, the geographical terrain and/or environmental conditions, etc. Further, the present subject matter acknowledges that some NMR modification procedures may be best suited for outdoor location estimation, while others

are better suited for indoor location estimation, and some even may be best for mixed (indoor & outdoor) location estimation.

[0047]For example, if the serving BS for a mobile station is known to be in an area where there are no buildings or obstructions then it may be prudent to leave the NM data unmodified or select the NMR modification procedure where the serving base station is used as the basis to calculate NMR modifications. Further, if the serving cell is in a geographical area with known large obstructions (e.g., buildings, mountains etc.) then it may be prudent to use the NMR modification procedure that selects the NC base station having the highest signal power as the basis to calculate NMR modifications. Additionally, if the serving cell is in an area containing both outdoor and indoor facilities, then it may be best to use the average of more than one NC signal power value as the basis to modify the NMR(s).

[0048]Regardless of the type of modification algorithm selected to modify the NM data, a margin of error may still be present when attempting to determine the precise location of a mobile station. Determining the amount of location error may be useful when estimating the likelihood of accurately locating a mobile station. A confidence measure may also be used to represent the accuracy of a mobile station's estimated location.

[0049]The value of a confidence measure may vary depending on the estimated accuracy of the location estimated. If estimated locations derived from mapping NM data to a given location, whether using a NUG or other form of a data source for comparison purposes, agree under any or all combinations, the respective confidence measure "C" may be considered high. A confidence measure may also be represented as a function that increases as the quantity of measured data correctly matches data associated with a final estimated location. An exemplary confidence measure or function may be represented as a fraction of all locations that are similar to the final estimated location, however, such an example should not limit the scope of the claims appended herewith.

[0050]After one or more of the data modification procedures have been calculated, respective confidence measures may be calculated to represent the likely accuracy of the modification procedures. Confidence measures may then be compared and the best one selected to represent the appropriate modification procedure to implement.

[0051]Certain estimated locations may be assigned weights by using a confidence measure as a weight to represent the probability of locating a mobile station at a given location. For example, confidence measures may be based on one or more calculated parameters, including, but not limited to: a probability density function (PDF), a joint PDF, Mahalanobis distance, distortion measure, ordered number parameter, timing advance (TA) parameter, mobile orientation etc. The calculated parameters may be derived from the NUG calibration data stored in the PDE **50** database. The parameters may be pre-stored in memory or may be calculated during a NMR to NUG comparison operation.

[0052]Probability density functions may be calculated based on an individual NC base station power level, or a set of multiple NC base station power levels. The calculated probability density function may be compared to the set of available NUGs (i.e., NUGS **1**-**3** of FIG. 1) to determine a probability that the NM data matches a particular NUG location. A joint probability may also be calculated over a set of probabilities to further estimate the location of the mobile station. The results of the calculated PDF may be used in a number of estimation techniques to locate the mobile station.

[0053]Distortion measures may be determined at a particular location may be included in a NMR and used in a comparison operation to measure the difference in distortion between NUG data and NM data. The distortion measures may be used to estimate a location of a mobile station based on the results of the comparison.

[0054]A Mahalanobis distance may be an exemplary distortion measure and may utilized to

assist in identifying and analyzing different patterns in a wireless communications environment. The Mahalanobis distance may also be useful in determining similarities between an unknown sample data set and a known data set.

[0055]Ordering number lists may also be used to organize parameters for comparison purposes. An ordering number list may be a list or table of data parameters organized in a particular order. The power levels may be listed in descending order and compared to similar parameters associated with a NUG(s). A threshold power level may be used to represent an acceptable amount of deviation between a comparison of power levels obtained from a NMR(s) and/or a NUG(s). If one or more power levels in the NMR(s) and the NUG(s) fall within an acceptable range of one another, the location of a mobile station may be measured with a corresponding degree of accuracy.

[0056]Each generated NMR may be used to provide an individual estimate of the mobile station's location. The PDE **50** may receive a number of NMRs over a period of time, a corresponding number of location estimates may be generated based on the number of NMRs received. These estimates may be combined in a statistical algorithm and may provide a more accurate location estimate than the individual NMRs.

[0057]Given a particular NMR or set of NMR(s) containing data collected outdoors, a selection procedure may be conducted to select the most appropriate modification procedure to use when modifying the NM data. Once one or more of the above described NMR modification procedures have been calculated, (e.g., non-modification, serving cell power level, highest NC power level, average(s) of the NC power levels, etc.) one or more of these calculations may be selected as an optimal solution to be used to modify the NMR.

[0058]One way to determine the optimal solution that should be used to modify the NMR is to calculate a confidence measure for each of the calculated modification procedures. Once the confidence measures have been calculated, the optimal solution may be selected as the modification procedure with the highest confidence measure. Alternatively, a location estimate may be made by weighting the individual solutions by the applicable confidence measure and combining the results into a single NMR solution.

[0059]Combining multiple NMR(s) may generate a location estimate with increased accuracy. When comparing NM data to a NUG, the grid point data that most closely matches the NM data may become the estimated location of the mobile station. In an alternative arrangement, interpolation may be used for determining a location that falls between two grid points to provide an even more accurate location estimate. Applying probabilistic weights, hypotheses and deriving confidence measures may increase the accuracy of the location estimates. Utilizing exemplary probabilistic measures, the estimated location of a mobile station may be determined within a particular degree of certainty. A similar approach may also be applied to select the appropriate NMR modification procedure to accommodate for varying conditions and other operational variables (e.g., different air standards, varying environmental circumstances, etc.).

[0060]FIG. 2 illustrates a flow diagram **200** of a method to locate a mobile station. Observed network measurement data may be collected (operation **201**). The observed data would typically be the same or similar to the data in a network measurement report (NMR). The network measurement data represents at least one network characteristic observed by the mobile station operating at a particular location within a region. The NM data may be compared to calibration database data, where the calibration database data represents calibration data measured within the geographical area of the region (operation **202**). The location of the mobile station may be estimated based on the comparison of the modified network measurement data and the calibration database data (operation **203**).

[0061]FIG. 3 illustrates a flow diagram **300** of a method to locate a mobile station in an indoor environment. Calibration data samples are collected in an outdoor environment (operation

301). At least one attenuation variable may be applied to the calibration data sample to simulate an indoor environment (operation **302**). The modified network measurement data sample may be applied to a mobile station location algorithm (operation **303**). The mobile station may be then located in the indoor environment based on the mobile station location algorithm implementing the at least one modified calibration sample (operation **304**).

[0062]FIG. 4 illustrates a flow diagram **400** of a method to locate a mobile station. NM data may be obtained to represent at least one network characteristic of the mobile station's serving base station and at least one second network characteristic of at least one of the mobile station's neighboring base stations (operation **401**). The difference between the at least one first signal characteristic and the at least one second signal characteristic may be computed (operation **402**). At least one signal characteristic of the NM data may be adjusted based on the computed difference (operation **403**). The mobile station may be then located based on the modified network measurement data (operation **404**).

[0063]FIG. 5 illustrates a flow diagram **500** of a method to locate a mobile station. NM data may be obtained (operation **501**), which represents at least one first network characteristic of the mobile station's serving base station, and at least one second and third network characteristic of the mobile station's at least two neighboring base stations. It may be then determined which base station has the highest signal power at a particular location (operation **502**). The difference between the highest signal power at the particular location and the power levels at the particular location of the serving base station and the remaining neighboring base stations may be determined (operation **503**). At least one signal characteristic of the NM data may be adjusted based on the computed differences (operation **504**). The mobile station may then be located based on the modified NMR (operation **505**).

[0064]FIG. 6 illustrates a flow diagram **600** of a method to locate a mobile station. A NMR may be obtained (operation **601**), which represents at least one first signal characteristic of the mobile station's serving base station, and at least one second and third signal characteristics of the mobile station's at least two respective neighboring base stations. A difference may be computed between the at least one first signal characteristic of the mobile station's serving base station and the at least one second signal characteristic of at least one of the mobile station's neighboring base stations to determine a first solution (operation **602**). It may then be determined which base station has the highest signal power level at a particular location (operation **603**). The difference between the highest signal power and the power levels of the serving base station and the remaining neighboring base stations may be determined as a second solution (operation **604**). The neighboring base station having the lowest signal power level at the particular location may be determined (operation **605**). An average signal power level intermediary to the difference between the highest signal power level and the lowest signal power level may be determined as a third solution (operation **606**). It may then be determined which solution is a most optimal solution by comparing the three solutions (operation **607**). The signal characteristic of the NM data may then be adjusted based on the most optimal solution (operation **608**). The mobile station may then be located based on the adjusted NM data (operation **609**).

[0065]FIG. 7 illustrates an embodiment of the present subject matter. The method includes providing a database of previously-gathered calibration data for a predetermined region in a wireless network (operation **701**). The database may be a collection of data from uniform or non-uniform grids that contain network measurements with associated location estimates. Network measurement data may be then observed and measured typically by a mobile station or any other wireless device (operation **703**). The network measurement data may include received base station power and timing advance, as well as other network characteristics observable by a mobile station. The observed network measurement data may then be modified (operation **705**). This modification may include applying an attenuation function to some or all of the network measurement data or converting absolute values into relative values. The modification may be performed by a processor, microprocessor or ASICS. The modified network measurement data may then be compared to the calibration database in order to determine the

location of the mobile station (operation **707**). The comparison may be performed by a processor, microprocessor or ASICS.

[0066]FIG. 8 is another illustration of an embodiment of the present subject matter. A database of previously-gathered calibration data for a predetermined region in a wireless network may be provided (operation **801**). Observed network measurement data may be collected which includes a first signal characteristic from the mobile's serving transmitter (operation **803**). The observed network measurement data may be modified as a function of the first signal characteristic (operation **805**), for example the first signal characteristic may be received power and the modification may be a function of the relative value with respect to the received power. The modified network measurement data may be compared with the database of calibration data to determine the location of the mobile station (operation **807**)

[0067]FIG. 9 is an illustration of an embodiment of the present subject matter for determining a location of a mobile station. A database of calibration data for a region may be provided (**901**). Network measurement data from transmitters may be observed and collected including a signal characteristic from each of the transmitters (operation **903**). An average value for the signal characteristic among the transmitters may be determined (operation **905**). The average for the signal characteristic may be a weighted average. The observed network measurement data may be modified using the determined average value (operation **907**) and the modified network measurement data may be compared with the database of calibration data to determine the location of the mobile station (operation **909**)

[0068]FIG. 10 is an illustration of an embodiment of the present subject matter for determining a location of a mobile station. A database of previously-gathered outdoor calibration data for a predetermined region in a wireless network may be provided (operation **1001**). Network measurement data may be observed and collected (operation **1003**). The network measurement data may be compared with the database of calibration data to thereby determine a plurality of location estimates for the mobile station (operation **1005**). The location estimates may be derived using modified, unmodified, limited signal characteristics, several signal characteristics, etc. For each location estimate, a confidence measure may be determined (operation **1007**). A location may be determined based on the plurality of location estimates and their respective confidence measures (**1009**). For example, the location may be determined based on a weighted average, where the weights are directly proportional to the confidence measures.

[0069]The embodiments described above may be used in communication devices, such as, a base station, having varying configurations that include, but are not limited to: predetermined calibration data collected over varying terrain, different base station configurations, varying cellular communication protocols, etc.

[0070]While preferred embodiments of the present invention have been described, it is to be understood that the embodiments described are illustrative only and the scope of the invention is to be defined solely by the appended claims when accorded a full range of equivalents, many variations and modifications naturally occurring to those skilled in the art from a perusal hereof.

ENGLISH-CLAIMS:
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What is claimed is:

1. A method for determining a location of a mobile station, comprising:

- -

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

- -

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

- -

determining which of said first and second signal characteristics has a greater magnitude;

- -

modifying said observed network measurement data using the greater magnitude signal characteristic; and

- -

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

2. The method of claim 1 wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

3. The method of claim 1 wherein said observed network measurement data includes data collected at the mobile station.

4. The method of claim 1 wherein said previously-gathered calibration data includes calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point is not located within a structure.

5. The method of claim 4 wherein said observed network measurement data is collected at a mobile station located within a structure.

6. The method of claim 4 wherein said first signal characteristic is signal strength.

7. The method of claim 6 wherein said second signal characteristic is signal strength.

8. The method of claim 7 wherein the modifying of said calibration data uses a difference between said first or second signal characteristics.

9. The method of claim 7 wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station.

10. The method of claim 9 wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

11. The method of claim 1, wherein the observed network measurement data includes received signal strength of said transmitters as said mobile station.

12. The method of claim 1 wherein said observed network measurement data includes a data set comprising:

- -

$[P_{(1)}, P_{(2)} \ldots, P_{(n)}, TA]$

- -

where:

- -

$P_{(1)}$ represents the signal strength of said first transmitter as measured at said mobile station,

- -

$P_{(2)}$ represents a signal strength of said second transmitter as measured at said mobile station wherein $P_{(2)}>P_{(1)}$

- -

$P_{(n)}$, represents a signal strength of a $n^{(th)}$ transmitter as measured at said mobile station wherein $P_{(2>P)(n)}$, and

- -

TA represents a timing advance parameter;

- -

and wherein said modified network measurement data includes a data set comprising:

  - -

    [$P_{(2)}$−$P_{(1)}$, 0, $P_{(2)}$−$P_{(n)}$, TA]

- -

where:

- -

$P_{(2)}$−$P_{(1)}$ represents a difference between $P_{(2)}$ and $P_{(1)}$,

- -

0 represents a difference between $P_{(2)}$ and $P_{(2)}$, and

- -

$P_{(2)}$−$P_{(n)}$ represents a difference between $P_{(2)}$ and $P_{(n)}$.

13. The method of claim 12 wherein said first transmitter is a serving transmitter for said mobile station and said second and third transmitters are neighboring transmitters.

14. The method of claim 12 wherein said third transmitter is not a member of said wireless network.

15. A method for determining a location of a mobile station, comprising:

- -

providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network;

- -

collecting network measurement data;

- -

  comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station

- -

  determining a confidence measure for each of the plurality of location estimates;

- -

  determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.

16. The method of claim 15, wherein the step of determining the location based on the plurality of location estimates and the respective confidence measures comprises selecting the location estimate having the highest respective confidence measure as the location of the mobile station.

17. The method of claim 15, wherein the step of determining the location based on the plurality of location estimates and their respective confidence measures comprises weighing the plurality location estimates based on their respective confidence measures and obtaining a weighted average as the location of the mobile.

18. The method of **15**, wherein the confidence measures comprises one or more of the group consisting of a pdf the Mahalanobis distance, and a distortion measure.

19. The method of claim 15, wherein the step of collecting network propagation data further comprises modifying the network propagation data.

20. The method of claim 15, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further comprises modifying said calibration data prior to the comparison.

21. The method of claim 20, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further comprises modifying said calibration data prior to the comparison.

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Patent No. 7,561,104 Issued on July 14, Assigned to Andrew for Calibration Data Modification Method (Virginia Inventors) US Fed News July 17, 2009 Friday 11:54 AM EST

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HEADLINE: Patent No. **7,561,104** Issued on July 14, Assigned to Andrew for Calibration Data Modification Method (Virginia Inventors)

DATELINE: ALEXANDRIA, Va.

BODY:

ALEXANDRIA, Va., July 17 -- Martin Alles of Vienna, Va., John Carlson of Dulles, Va., George Maher of Herndon, Va., and Selcuk Mazlum of Leesburg, Va., have developed a method of modifying calibration data used to geo-locate a mobile station located in an indoor environment. The inventors were issued U.S. Patent No. **7,561,104** on July 14.

The patent has been assigned to Andrew LLC, Hickory, N.C. According to the abstract released by the U.S. Patent & Trademark Office: "A method of modifying calibration data used to geo-locate a mobile station located in an indoor environment is disclosed. When a mobile station is located indoors, the signal strength of signals received and/or transmitted by the mobile station have the tendency to be lower than the strength of the signals received by a mobile station located outdoors." The original application was filed on Feb. 5, 2008.For more information about US Fed News contract awards please contact: Sarabjit Jagirdar, US Fed News, Email:- htsyndication@hindustantimes.com

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(Not for submission under 37 CFR 1.99)

Application Number	12026333
Filing Date	2008-02-05
First Named Inventor	Martin Alles
Art Unit	3662
Examiner Name	PHAN, DAO LINDA
Attorney Docket Number	466-333US1

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	First Named Inventor	Martin Alles
	Art Unit	3662
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Signature	/Jason Paul DeMont/	Date (YYYY-MM-DD)	2012-09-24
Name/Print	Jason Paul DeMont	Registration Number	35793

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In re Ex Parte Reexamination of:

US Patent No.: 7,561,104

First Inventor: Martin Alles

Issued: 07/14/2009

Title: Method to modify calibration data used to locate a mobile unit

Mail Stop *Ex Parte* Reexam
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

REQUEST FOR EX PARTE REEXAMINATION UNDER 37 C.F.R. § 1.510(b)

Ex Parte Reexamination is requested under 35 U.S.C. § 302 and 37 C.F.R. § 1.510 of U.S. Patent No. 7,561,104 (hereinafter, the "'104 Patent"), issued July 14, 2009 to Alles et al. from an application filed February 5, 2008. The '104 Patent is assigned to CommScope, Inc. of North Carolina.

Pursuant to 37 C.F.R. § 1.510, this Request for Reexamination includes:

- a statement pointing out each new question of patentability based on prior patents and printed publications;
- an identification of every claim for which reexamination is requested, and a detailed explanation of the pertinence and manner of applying the cited prior art to every claim for which reexamination is requested;
- the appropriate fee of $17,750 under 37 C.F.R. § 1.20(c)(1);
- a copy of the entire '104 Patent including the front face and specification/claims in double column format, attached as Exhibit A; and
- a copy of each of the cited prior art patents and printed publications, attached as Exhibits B-E, including a listing thereof in an Information Disclosure Statement with Form PTO/SB/08, attached as Exhibit F.

I. IDENTIFICATION OF CLAIMS FOR WHICH REEXAMINATION IS REQUESTED

In accordance with 37 CFR 1.510, reexamination of claims 1-21 of U.S. Patent 7,561,104 is requested, in view of the following references:

Benes, U.S. Pre-Grant Publication 2004/0203539

Spain, U.S. Patent 7,460,505

Gordon, U.S. Patent 7,433,695

Krumm, U.S. Patent 7,250,907

Requestor submits that Benes alone anticipates independent claim 1, while either Spain in combination with Krumm or Gordon in combination with Krumm renders claim 1 obvious. Requestor submits that dependent claims 2-14 are rendered obvious by combinations of the references listed above. Requestor submits that Gordon by itself anticipates independent claim 15 and dependent claims 16-18. Requestor submits that dependent claims 19-21 are rendered obvious by Gordon in combination with Spain.

II. CITATION OF PRIOR ART

A copy of every document relied upon or referred to herein is annexed hereto, in accordance with 37 CFR 1.510(b)(3). These prior art documents include:

1. U.S. Pre-Grant Publication 2004/0203539 to Benes et al., "Method and mobile station for autonomously determining an angle of arrival (AOA) estimation," filed December 11, 2002;
2. U.S. Patent 7,460,505 to Spain, "Location estimation of wireless terminals through pattern matching of signal-strength differentials," filed February 4, 2003;
3. U.S. Patent 7,433,695 to Gordon et al., "Computationally-efficient estimation of the location of a wireless terminal based on pattern matching," filed May 22, 2006 and (i) is a continuation-in-part of application serial no. 11/194,151 filed Aug. 1, 2005 which is a continuation of serial no. 10/299,398 filed Nov. 18, 2002 now U.S. Pat. No. 6,944,465, and (ii) claims benefit of application serial no. 60/757,066 filed Jan. 6, 2006; and
4. U.S. Patent 7,250,907 to Krumm et al., "System and methods for determining the location dynamics of a portable computing device," filed June 30, 2003.

III. STATEMENT POINTING OUT EACH SUBSTANTIAL NEW QUESTION OF PATENTABILITY

The prior art documents, listed in the previous section, are new, previously uncited prior art references against the claims of the '104 Patent. Since these prior art documents render claims 1-21 of the '104 Patent unpatentable for the reasons discussed below, these documents raise substantial new questions of patentability, in accordance with 37 CFR 1.510(b)(1).

A. CLAIMS FOR WHICH REEXAMINATION IS REQUESTED

Reexamination is requested for claims 1-21 of the '104 Patent. Claims 1 and 15 are the only independent claims. All of the other claims are dependent claims that add additional claim limitations. The following table sets forth the references relied upon in this Request for Reexamination.

Reexam. Claim Number	References Applied Against the Reexamination Claim
1. Independent	• Benes • Spain, in combination with Krumm • Gordon, in combination with Krumm
2.	• Benes, in combination with Gordon • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm
3.	• Benes • Spain, in combination with Krumm • Gordon, in combination with Krumm
4.	• Benes, in combination with Gordon • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm
5.	• Benes, in combination with Gordon • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm
6.	• Benes, in combination with Gordon • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm

Reexam. Claim Number	References Applied Against the Reexamination Claim
7.	• Benes, in combination with Gordon • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm
8.	• Benes, in combination with Gordon and Spain • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm and Spain
9.	• Benes, in combination with Gordon and Spain • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm and Spain
10.	• Benes, in combination with Gordon and Spain • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm and Spain
11.	• Benes, in combination with Gordon • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm
12.	• Benes, in combination with Gordon and Spain • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm and Spain
13.	• Benes, in combination with Gordon and Spain • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm and Spain
14.	• Benes, in combination with Gordon and Spain • Spain, in combination with Krumm and Gordon • Gordon, in combination with Krumm and Spain
15. Independent	• Gordon
16.	• Gordon
17.	• Gordon
18.	• Gordon
19.	• Gordon, either alone or in combination with Spain
20.	• Gordon, either alone or in combination with Spain
21.	• Gordon, either alone or in combination with Spain

B. DETAILED EXPLANATION UNDER 37 C.F.R. § 1.510(b)(2)

The following sections include statements pointing out each substantial new question of patentability based on cited patents and printed publications, and a detailed explanation of the pertinency and manner of applying the patents and printed publications of every one of claims 1-21 of the '104 Patent, in accordance with 37 CFR 1.510(b)(2).

1. CLAIM 1 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Detailed reasons for these assertions of unpatentability are described in detail below and summarized in charts attached as Appendix A.

a. Claim 1 is unpatentable under 35 U.S.C. 102(b) as being anticipated by Benes

The reasons why claim 1 of the '104 Patent is anticipated by Benes are described below feature-by-feature.

A method for determining a location of a mobile station, comprising:

Benes discloses a method for "determining an angle of arrival (AOA) estimation" (see Abstract), which is a method for determining a location of a mobile station.

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

In the '104 claim, "calibration data" refers to data such as signal strength. ('104 Patent, col. 1, lines 21-24) Modified network measurement data is compared with the calibration data, in some embodiments, to determine the location of a mobile station.

Benes teaches "mobile station **160** at step **1020** may receive information associated with [a] plurality of sectors. In particular, the information associated with the plurality of sectors may include, but is limited to, antenna patterns, boresights, downtilts, and signal strength values associated with the plurality of antennas." (Para. [0028], lines 21-26) The "plurality of sectors" are within "wireless telecommunication system **100**" (Para. [0017], lines 1-2), which comprises a plurality of base stations" (Para. [0017], line 6), which "includes the radio equipment (transceivers, antennas, amplifiers, etc.) needed to service each communication cell in the system." (Para. [0016], lines 2-4)

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

Benes teaches "mobile station **160** calculating an effective radiated power (ERP) of a first downlink signal and a second downlink signal, the first downlink signal being associated with a first antenna and the second downlink signal being associated with a second antenna." (Para. [0029], lines 4-8)

determining which of said first and second signal characteristics has a greater magnitude;

Benes teaches mobile station **160** utilizing "the stronger downlink signal of the first and second downlink signals." (Para. [0030], lines 5-6) In a specific example, Benes teaches "mobile station **160** may determine that the downlink signal **804** from the antenna associated with the second sector **204** is stronger than the downlink signal **802** from the antenna associated with the first sector **202**.

modifying said observed network measurement data using the greater magnitude signal characteristic; and

Benes teaches "[t]o determine an antenna gain difference (AGD) for comparison with the signal difference, mobile station **160** may normalize the downlink signals **802**, **804** from the antennas associated with the first and second sectors **202**, **204** (shown as [normalized downlink signals] **902** and **904**, respectively, in FIG. 9)" (Para. [0027], lines Normalized downlink signal **904**, which is a modified signal because it is normalized, corresponds to stronger downlink signal **804**, as indicated in the previous sentence.

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Continuing with the example used in the foregoing limitation, Benes teaches "[a]ccordingly, the mobile station **160** may determine where along the normalized downlink signal **904** from the antenna associated with the second sector **204** the antenna gain difference matches the signal difference calculated above." (Para. [0027], lines 19-23, emphasis added) As discussed in the foregoing limitation, the antenna gain difference was determined "for comparison with the signal difference."

In regard to using the foregoing comparison to determine the location of the mobile station, Benes prefaces the discussion of the foregoing comparison by teaching "mobile station **160** may determine an angle of arrival (AOA) estimation by comparing ERPs between antennas of at least two sectors." (Para. [0026], lines 1-4) AOA estimation is a method of location determination. The ERPs were determined "based on their respective signal strength values," (Para. [0021], line 7), wherein the "respective signal strength

values," are part of the calibration data already discussed in the first limitation of the current claim.

b. Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Spain in view of Krumm

The reasons why claim 1 of the '104 Patent is unpatentable over Spain in view of Krumm are described below feature-by-feature.

A method for determining a location of a mobile station, comprising:

Spain discloses "Location estimation of wireless terminals through pattern matching of signal-strength differentials." (see Title of Invention)

Krumm discloses a "location system for locating [...] a wireless device." (see Abstract)

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

In the '104 claim, "calibration data" refers to data such as signal strength. ('104 Patent, col. 1, lines 21-24) Modified network measurement data is compared with the calibration data, in some embodiments, to determine the location of a mobile station.

Spain teaches "[a]t operation 401, signal-strength database 302 is populated with data that associates each location within geographic region 200 with a tuple of signal-strength measurements for that location." (col. 6, lines 30-33). The illustrative embodiment taught in Spain comprises "base stations **202-1**, **202-2**, and **202-3**" (col. 4, lines 58-59) and "provides wireless telecommunications service to most of geographic region **200**." (col. 4, lines 60-61).

In regard to the actual "gathering" of the data in the database taught in Spain, "the tuple of three signal-strength measurements for each location are determined through [...] empirical signal-strength measurements." (col. 7, lines 63-67) The data in the database must have been "previously" gathered before it can appear in the database, owing to causality.

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

Spain teaches "[a]t task **1103**, location system **212** receives [...] a report from wireless terminal **201** on the signals that it was directed to monitor in task **602**." (col. 9,

lines 50-52) Spain also teaches "[a] first signal is transmitted by a first transmitter [and a] second signal is transmitted by a second transmitter." (col. 14, lines 45-48)

determining which of said first and second signal characteristics has a greater magnitude;

Krumm teaches "sensing the wireless transmitter with the strongest signal." (col. 22, lines 65-66)

modifying said observed network measurement data using the greater magnitude signal characteristic; and

Spain teaches "[a]t task 1202, location system 212 computes the signal-strength differentials [...]. In particular, for n reported signals [...], n-1 signal-strength differentials are computed where: $\Delta S_k = S_k - S_1$ for k=2, 3, ... n, wherein ΔS_k is the kth signal-strength of Signal k, and S_1 is the reported signal-strength of Signal 1." (col. 10, lines 51-60) Spain teaches this, recognizing the measurement bias problem associated with not knowing "whether the terminal is inside a vehicle." (col. 3, lines 31-32)

A skilled artisan starting from Spain would have been motivated to utilize the strongest signal sensed in Krumm, as "Signal 1" in the difference calculation in Spain, in order to have a reference signal with which to address the problem with measurement biases (e.g., measurements inside a vehicle, etc.) identified above. These biases are similar to those identified in the '104 Patent (e.g., measurements indoors). Furthermore, Signal 1 as used in Spain does not prevent the use of the strongest of the reported signal strengths.

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Spain teaches "[a]t task **1203**, location system **212** computes the signal-strength differential" based on the locations "in signal-strength database **302**." (Col. 11, lines 3-18). Spain goes on to teach "[a]t task **1204**, location system **212** compares the signal-strength differences computed in task **1202**, ΔS_2 through ΔS_{m-n}, to the signal-strength differentials in task **1203**. (col. 11, lines 23-25) This is all done within the framework of task **403** in Spain, at which "location system **212** estimates the location of wireless terminal **201** based on: (i) the tuple of signal-strength measurements received in operation **402**, and (ii) the tuples of signal-strength measurements within signal-strength database **302**.

c. Claim 1 is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Krumm

The reasons why claim 1 of the '104 Patent is unpatentable over Gordon in view of Krumm are described below feature-by-feature.

A method for determining a location of a mobile station, comprising:

Gordon discloses "Computationally-efficient estimation of the location of a wireless terminal based on pattern matching." (see Title of Invention)

Krumm discloses a "location system for locating [...] a wireless device." (see Abstract)

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

In the '104 claim, "calibration data" refers to data such as signal strength, round trip time, time difference of arrival (TDOA). ('104 Patent, col. 1, lines 21-24) Modified network measurement data is compared with the calibration data, in some embodiments, to determine the location of a mobile station.

Gordon teaches "Location-Trait Database **313** is built [which is] a database that maps each of a plurality of locations to one or more expected traits associated with a wireless terminal at that location." (col. 6, lines 45-49) For example, one such expected trait is "the expected received signal strength of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is in the location, from all transmitters." (col. 10, lines 4-6) For example, "all transmitters" can refer to "base stations **202-1**, **202-2**, and **202-3**" (col. 9, lines 61-62) As part of building the database, Gordon also teaches "geographic region **220** is partitioned into B(T,N) locations." (col. 7, lines 16-17) The illustrative embodiment taught in Gordon, "provides wireless telecommunications service to all of geographic region **220**." (col. 4, lines 12-14)

In regard to the actual "gathering" of the data in the database taught in Gordon, "[i]n accordance with process **901**, a drive-test regimen is developed" (col. 15, lines 55-56) and "[i]n accordance with process **902**, the drive-test regimen is implemented." (col. 15, lines 61-62). The data in the database must have been "previously" gathered before it can appear in the database, owing to causality.

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

Gordon teaches "[i]n accordance with process **1101**, location server **214** receives & non-empty sets of measurements of the traits [...] associated with wireless terminal **201**," (col. 16, lines 49-51) including "the received signal strength of all of the signals received by wireless terminal **201**, from all transmitters." (col. 16, lines 63-64; emphasis added)

determining which of said first and second signal characteristics has a greater magnitude;

Krumm teaches "sensing the wireless transmitter with the strongest signal." (col. 22, lines 65-66)

modifying said observed network measurement data using the greater magnitude signal characteristic; and

Gordon teaches "[i]n accordance with process **1103**, location server **214** computes the differentials [...] of the measurements to correct the situational errors in the measurements received in process **1001**. Many factors, including [...] whether or not the terminal is inside a vehicle can introduce situational measurement errors. This is particularly true for measurements of [...] signal strength." (col. 18, lines 17-24)

A skilled artisan starting from Gordon would have been motivated to utilize the strongest signal sensed in Krumm, in order to have a reference signal with which to compute the differentials of the measurements in Gordon, because Gordon is addressing a problem with situational measurement errors (e.g., measurements inside a vehicle, etc.). These situational errors are similar to those identified in the '104 Patent (e.g., measurements indoors), which uses the stronger signal (i.e., "greater magnitude") to address errors associated with indoor measurements.

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

Gordon teaches generating "[i]n accordance with process **1001**, Y probability distributions for the location of wireless terminal **201** [...] for each of instants H_1 through H_Y in the temporal interval ΔT [...], based on comparing the measurements of traits associated with wireless terminal **201** at each of instants H_1 through H_Y to expected values for those traits at those times. Each of the Y probability distributions provides a first estimate of the probability that wireless terminal **201** is in each location at each of instants H_1 through H_Y." (col. 16, lines 9-18)

Gordon also teaches the "illustrative embodiment ameliorates the effects of [the aforementioned factors] by pattern matching not the measurements themselves [...] to the

expected values for those traits, but by pattern matching the pair-wise differentials of those measurements to the pair-wise differentials of the expected values for those traits." (col. 18, 25-30)

2. CLAIM 2 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 2 of the '104 Patent depends from Claim 1 and adds:

wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

a. This claim is unpatentable over Gordon, in combination with other references identified for Claim 1.

Gordon teaches "[i]t will be clear to those skilled in the art, after reading this disclosure, how to make and use [...] embodiments of the present invention that partition geographic region 220 into any number of locations of any size, shape, and arrangement." (Col. 9, lines 9-13). Furthermore, Figures 6a through 6n and the accompanying text in Columns 7 and 8 describe non-uniform "locations."

Furthermore, when used in conjunction with the other references, namely i) Benes or ii) Spain in combination with Krumm, a skilled artisan starting from any of those references would have been motivated to utilize the partitions of various sizes, shapes, and arrangements taught in Gordon, in order to account for real-world wireless network coverage regions.

3. CLAIM 3 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 3 of the '104 Patent depends from Claim 1 and adds:

wherein said observed network measurement data includes data collected at the mobile station.

a. This claim limitation is anticipated by any of Benes, Spain, and Gordon.

As discussed above and with respect to Claim 1, each of these references teaches that it is the mobile station that measures downlink signals that are transmitted by two or more base station transmitters, for the purpose of determining at least the signal strengths of those signals.

4. CLAIM 4 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 4 of the '104 Patent depends from Claim 1 and adds:

wherein said previously-gathered calibration data includes calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point is not located within a structure.

a. This claim is unpatentable over Gordon, in combination with other references identified for Claim 1.

Gordon teaches various features within geographic region **220** that are partitioned into various locations for the purpose of building Location-Trait Database **313**. (Col. 9, lines 17-41). Such features include "water fountain **601** [and] park **602**," which are depicted as being not located within a structure. (Col. 9, lines 18-19, Fig. 6a)

Alternatively, when starting from any of the other references, namely i) Benes or ii) Spain in combination with Krumm, a skilled artisan would have been motivated to utilize the predetermined points that are not in structures, as taught in Gordon, in order to consider possible outdoor locations of the mobile station.

5. CLAIM 5 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 5 of the '104 Patent depends from Claim 4 and adds:

wherein said observed network measurement data is collected at a mobile station located within a structure.

a. This claim is unpatentable over Gordon, in combination with other references identified for Claim 4.

Gordon teaches various features within geographic region **220** that are partitioned into various locations. (Col. 9, lines 17-41). Such features include structures such as "four-story building **603** [and] two-story building **604**," (Col. 9, lines 18-19, Fig. 6a) which are locations from which a mobile station can report signal-strength measurements, in order to determine the mobile station's position.

Alternatively, when starting from any of the other references, namely i) Benes or ii) Spain in combination with Krumm, a skilled artisan would have been motivated to utilize the observed network measurement data that is collected at a mobile station located within

a structure, as taught in Gordon, in order to consider possible indoor locations of the mobile station.

6. CLAIM 6 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 6 of the '104 Patent depends from Claim 4 and adds:

wherein said first signal characteristic is signal strength.

a. This claim is unpatentable over Gordon, in combination with other references identified for Claim 4.

Gordon teaches "[i]n accordance with process **1101**, location server **214** receives & non-empty sets of measurements of the traits [...] associated with wireless terminal **201**," (col. 16, lines 49-51) including "the received signal strength of all of the signals received by wireless terminal **201**, from all transmitters." (col. 16, lines 63-64; emphasis added)

Alternatively, when starting from any of the other references, namely i) Benes or ii) Spain in combination with Krumm, a skilled artisan would have been motivated to utilize signal strength, as taught in Gordon, in order to use a readily-available signal characteristic for determining the location of the mobile station.

7. CLAIM 7 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 7 of the '104 Patent depends from Claim 6 and adds:

wherein said second signal characteristic is signal strength.

a. This claim is unpatentable over Gordon, in combination with other references identified for Claim 6.

Gordon teaches "[i]n accordance with process **1101**, location server **214** receives & non-empty sets of measurements of the traits [...] associated with wireless terminal **201**," (col. 16, lines 49-51) including "the received signal strength of all of the signals received by wireless terminal **201**, from all transmitters." (col. 16, lines 63-64; emphasis added)

Alternatively, when starting from any of the other references, namely i) Benes or ii) Spain in combination with Krumm, a skilled artisan would have been motivated to utilize signal strength, as taught in Gordon, in order to use a readily-available signal characteristic for determining the location of the mobile station.

8. CLAIM 8 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 8 of the '104 Patent depends from Claim 7 and adds:

wherein the modifying of said calibration data uses a difference between said first or [*sic*] second signal characteristics.

a. This claim is unpatentable over Spain, in combination with other references identified for Claim 7.

Spain teaches "[a]t task **1202**, location system **212** computes the signal-strength differentials for those reported values that are not the maximum signal strength. In particular, for n reported signals [...], n-1 signal-strength differentials are computed where: $\Delta S_k = S_k - S_1$ for k=2, 3, ... n, wherein ΔS_k is the kth signal-strength of Signal k, and S_1 is the reported signal-strength of Signal 1." (Col. 10, lines 51-60; emphasis added)

When starting from any of the previously-identified combinations of references, namely i) Benes and Gordon or ii) Spain, Krumm and Gordon, or iii) Gordon and Krumm, a skilled artisan would have been motivated to also modify the calibration data (i.e., computing signal-strength differentials of expected values), as taught in Spain, because Gordon teaches pattern matching the pair-wise differentials of signal-strength measurements (i.e., modified measurements) with pair-wise differentials of expected signal-strength values.

9. CLAIM 9 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 9 of the '104 Patent depends from Claim 7 and adds:

wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station.

a. This claim is unpatentable over Spain, in combination with other references identified for Claim 7.

Spain teaches "[a]t task **502**, the signal-strength measurements for a signal from each base station are determined at each location in geographic region. In accordance with the illustrative embodiment, the signal used from each base station is the control channel because [...] wireless terminal **201** can distinguish it from every other control channel." (Col. 7, lines 44-50; emphasis added)

When starting from any of the previously-identified combinations of references, namely i) Benes and Gordon or ii) Spain, Krumm and Gordon, or iii) Gordon and Krumm, a skilled artisan would have been motivated to use the signal strength of a control channel, as taught in Spain, in order to use a readily-available source of a signal of which to measure signal strength.

10. CLAIM 10 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 10 of the '104 Patent depends from Claim 9 and adds:

wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

a. This claim is unpatentable over Spain, in combination with other references identified for Claim 9.

Spain teaches "[a]t task **502**, the signal-strength measurements for a signal from each base station are determined at each location in geographic region. In accordance with the illustrative embodiment, the signal used from each base station is the control channel because [...] wireless terminal **201** can distinguish it from every other control channel." (Col. 7, lines 44-50; emphasis added)

When starting from any of the previously-identified combinations of references, namely i) Benes and Gordon or ii) Spain, Krumm and Gordon, or iii) Gordon and Krumm, a skilled artisan would have been motivated to use the signal strength of a control channel, as taught in Spain, in order to use a readily-available source of a signal of which to measure signal strength.

11. CLAIM 11 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 11 of the '104 Patent depends from Claim 1 and adds:

wherein the observed network measurement data includes received signal strength of said transmitters as [*sic*] said mobile station.

a. This claim is unpatentable over Gordon, in combination with other references identified for Claim 1.

Gordon teaches "[i]n accordance with process **1101**, location server **214** receives & non-empty sets of measurements of the traits [...] associated with wireless terminal **201**,"

(col. 16, lines 49-51) including "the received signal strength of all of the signals received by wireless terminal **201**." (col. 16, lines 63-64; emphasis added)

Alternatively, when starting from any of the other references, namely i) Benes or ii) Spain in combination with Krumm, a skilled artisan would have been motivated to utilize signal strength as measured at the mobile station, as taught in Gordon, in order to use a readily-available signal characteristic for determining the location of the mobile station, from a readily-accessible measurement point.

12. CLAIM 12 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 12 of the '104 Patent depends from Claim 1 and adds:

wherein said observed network measurement data includes a data set comprising: [P_1, P_2 . . . , P_n, TA] where: P_1 represents the signal strength of said first transmitter as measured at said mobile station, P_2 represents a signal strength of said second transmitter as measured at said mobile station wherein $P_2 > P_1$ P_n, represents a signal strength of a n^{th} transmitter as measured at said mobile station wherein $P_2 > P_n$, and TA represents a timing advance parameter; and wherein said modified network measurement data includes a data set comprising: [$P_2 - P_1$, 0, $P_2 - P_n$, TA] where: $P_2 - P_1$ represents a difference between P_2 and P_1, 0 represents a difference between P_2 and P_2, and $P_2 - P_n$ represents a difference between P_2 and P_n.

a. This claim is unpatentable over the combination of Spain and Gordon, in combination with other references identified for Claim 1.

In regard to signal strengths in the measurement data set, Spain teaches "location system **212** computes two (2) signal-strength differentials for the first report in which R_1=Signal 1=-98, R_2=Signal 2=-64 and R_3[=]Signal 3=-43. In particular, ΔR_2 and ΔR_3 are computed as depicted in Table 4." (col. 12, lines 18-21) Table 4 in Spain discloses an R_2-R_1 value of "-64-(-98)", and an R_3-R_1 value of "-51-(-98)". It is implicit that a value in the data set for R_1-R_1 would be 0. The fact that the '104 Patent, in essence, uses R_2 in the subtraction to generate all differential values and Spain features illustrating the concept of generating differential values by using R_1, is arbitrary.

In regard to a timing advance parameter in the measurement data set, Gordon teaches that each set of measurements comprises "the round-trip time of all of the signals

transmitted and received by wireless terminal **201** through base stations **202-1**, **202-2**, and **202-3**." (col. 17, lines 26-28)

When starting from any of the previously-identified combinations of references, namely i) Benes or ii) Spain and Krumm, or iii) Gordon and Krumm, a skilled artisan would be motivated to incorporate the data set parameters in Spain and Gordon, in order to reflect what a mobile station that is compliant with an air-interface standard is already capable of reporting.

13. CLAIM 13 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 13 of the '104 Patent depends from Claim 12 and adds:

wherein said first transmitter is a serving transmitter for said mobile station and said second and third transmitters are neighboring transmitters.

a. This claim is anticipated by Gordon, in combination with other references identified for Claim 12.

Gordon teaches that each set of measurements comprises "[(1)] the identity of the base stations that provide telecommunications service to wireless terminal **201**; and [(2)] the identities of the neighboring base stations that can provide telecommunications service to wireless terminal **201**." (col. 17, lines 32-36) These identities in each set of measurements correspond to (1) a serving transmitter and (2) neighboring transmitters, respectively.

When starting from any of the previously-identified combinations of references, namely i) Benes and Spain, or ii) Spain and Krumm, or iii) Gordon and Krumm and Spain, a skilled artisan would be motivated to utilize serving and neighboring transmitters in Gordon, in order to have sufficient and available signal sources to measure in a wireless network.

14. CLAIM 14 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 14 of the '104 Patent depends from Claim 12 and adds:

wherein said third transmitter is not a member of said wireless network.

a. This claim is anticipated by Gordon, in combination with other references identified for Claim 12.

Gordon teaches that "each set of measurements comprises [...] the received signal strength of all of the signals received by wireless terminal **201** from all transmitters," (Col. 16, lines 53-54 and 63-64) wherein the term "all transmitters" is previously defined to include, for example "commercial television, commercial radio, ground-based aviation, navigation, etc." (Col. 16, lines 56-58), which are not part of "wireless telecommunication system **200**" (Col 4., line 6)

When starting from any of the previously-identified combinations of references, namely i) Benes and Spain, or ii) Spain and Krumm, or iii) Gordon and Krumm and Spain, a skilled artisan would be motivated to external transmitters in Gordon, in order to have varied signal sources to measure in a wireless network.

15. CLAIM 15 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Detailed reasons for these assertions of unpatentability are described in detail below and summarized in charts attached as Appendix A.

a. Claim 15 is unpatentable under 35 U.S.C. 102(a) as being anticipated by Gordon

The reasons why claim 15 of the '104 Patent is anticipated by Gordon are described below feature-by-feature.

A method for determining a location of a mobile station, comprising:

Gordon discloses "Computationally-efficient estimation of the location of a wireless terminal based on pattern matching." (see Title of Invention)

providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network;

In the '104 claim, "calibration data" refers to data such as signal strength, round trip time, time difference of arrival (TDOA). ('104 Patent, col. 1, lines 21-24) Modified network measurement data is compared with the calibration data, in some embodiments, to determine the location of a mobile station.

Gordon teaches "[i]n accordance, with process **401**, Location-Trait Database **313** is built [which is] a database that maps each of a plurality of locations to one or more expected traits associated with a wireless terminal at that location." (col. 6, lines 45-49) For example, one such expected trait is "the expected received signal strength of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is in the location,

from all transmitters." (col. 10, lines 4-6) As part of building the database, Gordon also teaches "geographic region **220** is partitioned into B(T,N) locations." (col. 7, lines 16-17) The illustrative embodiment taught in Gordon, "provides wireless telecommunications service to all of geographic region **220**." (col. 4, lines 12-14)

In regard to the actual "gathering" of the data in the database taught in Gordon, "[i]n accordance with process **901**, a drive-test regimen is developed" (col. 15, lines 55-56) and "[i]n accordance with process **902**, the drive-test regimen is implemented." (col. 15, lines 61-62). The data in the database must have been "previously" gathered before it can appear in the database, owing to causality.

Within the context of building the database, Gordon also teaches "a map of geographic region **220**," (col. 9, line 18) which comprises outdoor features such as "water fountain **601**, park **602**, four-story building **603**, two-story building **604**, various streets, sidewalks, and other features that are partitioned into 28 locations." (col. 9, lines 19-22)

collecting network measurement data;

Gordon teaches "[i]n accordance with process **1101**, location server **214** receives & non-empty sets of measurements of the traits [...] associated with wireless terminal **201**." (col. 16, lines 49-51) For example, such sets of measurements can include, but are not limited to, "the received signal strengths of all of the signals received by wireless terminal **201** from all transmitters." (col., 16, lines 63-64)

comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate [*sic*] of the mobile station;

Gordon teaches generating "[i]n accordance with process **1001**, Y probability distributions for the location of wireless terminal **201** [...] for each of instants H_1 through H_Y in the temporal interval ΔT [...], based on comparing the measurements of traits associated with wireless terminal **201** at each of instants H_1 through H_Y to expected values for those traits at those times. Each of the Y probability distributions provides a first estimate of the probability that wireless terminal **201** is in each location at each of instants H_1 through H_Y." (col. 16, lines 9-18)

determining a confidence measure for each of the plurality of location estimates; and

Gordon teaches in "accordance with process **1123**, the un-normalized probabilities of the location of wireless terminal **201** at each location are generated based on the

Euclidean norm generated in process **1122**." (col. 22, lines 4-7) Furthermore, "[a]t process **1124**, the probabilities generated in process **1123** are normalized [...], wherein $NP(b,H_i)$ represents the normalized probability that wireless terminal **201** is in Location b. (col. 22, lines 28-37) A probability, or a probability distribution, of a location is an example of a confidence measure of a location.

determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.

Gordon teaches "[i]n accordance with process **1305**, location server **214** generates an estimate of the location of wireless terminal **201** at one or more instances J_i based on the maximum likelihood function of L_i [and] then provides the estimate of the location of wireless terminal **201** generated in process **1305**." (col. 26, lines 25-35) L_i refers to each probability distribution corresponding to each possible location, generated earlier. (col. 25, lines 53-55)

16. CLAIM 16 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 16 of the '104 Patent depends from Claim 15 and adds:

wherein the step of determining the location based on the plurality of location estimates and the respective confidence measures comprises selecting the location estimate having the highest respective confidence measure as the location of the mobile station.

a. This claim is anticipated by Gordon.

As discussed above and with respect to Claim 15, Gordon teaches using the maximum likelihood function of the probability distribution corresponding to each possible location. This is consistent with selecting the location estimate having the highest respective confidence measure.

17. CLAIM 17 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 17 of the '104 Patent depends from Claim 15 and adds:

wherein the step of determining the location based on the plurality of location estimates and their respective confidence measures comprises weighing [*sic*] the plurality [of] location estimates based on their respective

confidence measures and obtaining a weighted average as the location of the mobile.

a. This claim is anticipated by Gordon.

As discussed above and with respect to Claim 15, Gordon teaches using the maximum likelihood function of the probability distribution corresponding to each possible location. This is not inconsistent with weighting the plurality of location estimates based on their respective confidence measures. Moreover, Gordon also teaches "an estimate might be generated from probability distribution L_i, using another function or method." (col. 26, lines 31-32)

18. CLAIM 18 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 18 of the '104 Patent depends from Claim 15 and adds:

wherein the confidence measures comprises one or more of the group consisting of a pdf the Mahalanobis distance, and a distortion measure.

a. This claim is anticipated by Gordon.

Gordon teaches a pdf (probability distribution function): "In accordance with process **1001**, Y probability distributions for the location of wireless terminal **201** are generated for each of instants H_1 through H_Y in the temporal interval ΔT [...]. Each of the Y probability distributions provides a first estimate of the probability that wireless terminal **201** is in each location at each of instants H_1 through H_Y." (col. 16, lines 9-18)

19. CLAIM 19 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 19 of the '104 Patent depends from Claim 15 and adds:

wherein the step of collecting network propagation [*sic*] data further comprises modifying the network propagation [*sic*] data.

a. This claim is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Spain.

Spain teaches "[a]t task 1202, location system 212 computes the signal-strength differentials for those reported values [...]. In particular, for n reported signals [...], n-1 signal-strength differentials are computed where: $\Delta S_k = S_k - S_1$ for k=2, 3, ... n, wherein

ΔS_k is the kth signal-strength of Signal k, and S_1 is the reported signal-strength of Signal 1." (Col. 10, lines 51-60)

A skilled artisan starting from Gordon would have been motivated to also modify the network measurement data (i.e., computing signal-strength differentials of reported values), as taught in Spain, because Gordon teaches pattern matching the pair-wise differentials of measurements (i.e., modified measurements) with pair-wise differentials of expected values.

b. This claim is anticipated by Gordon.

Gordon teaches "[i]n accordance with process **1103**, location server **214** computes the differentials [...] of the measurements to correct the situational errors in the measurements received in process **1001**. Many factors, including [...] whether or not the terminal is inside a vehicle can introduce situational measurement errors. This is particularly true for measurements of [...] signal strength." (col. 18, lines 17-24)

20. CLAIM 20 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 20 of the '104 Patent depends from Claim 15 and adds:

wherein the step of comparing said network propagation [*sic*] data with said database of calibration data to thereby determine a plurality of location estimate [*sic*] of the mobile station, further comprises modifying said calibration data prior to the comparison.

a. This claim is anticipated by Gordon.

Gordon teaches "pattern matching the pair-wise differentials of those measurements to the pair-wise differentials of the expected values for those traits," (Col. 18, lines 28-30) in contrast to the straight expected values stored in Location-Trait Database **313** (discussed above in regard to Claim 15).

b. This claim is unpatentable under 35 U.S.C. 103 as being obvious over Gordon in view of Spain

As discussed above and with respect to Claim 1, Spain teaches "[a]t task **1203**, location system **212** computes the signal-strength differential" based on the locations "in signal-strength database **302**." (Col. 11, lines 3-18). This occurs before what Spain then teaches: "[a]t task **1204**, location system **212** compares the signal-strength differences

computed in task **1202**, ΔS_2 through ΔS_{m-n}, to the signal-strength differentials in task **1203**. (Col. 11, lines 23-25)

A skilled artisan starting from Gordon would have been motivated to compute the signal-strength differential based on the locations in signal-strength database 302, prior to computing the signal-strength differentials with the expected signal-strength differentials, because Gordon teaches pattern matching the pair-wise differentials of measurements with pair-wise differentials of expected values, wherein the straight values (i.e., not differential values) of expected values had been stored in the database.

21. CLAIM 21 IS ANTICIPATED AND/OR OBVIOUS OVER THE FOLLOWING PRIOR ART.

Claim 21 of the '104 Patent depends from Claim 20 and adds:

wherein the step of comparing said network propagation [*sic*] data with said database of calibration data to thereby determine a plurality of location estimate [*sic*] of the mobile station, further comprises modifying said calibration data prior to the comparison.

a. This claim is unpatentable based on the arguments presented for Claim 20.

Claim 21 is identical to Claim 20 except for depending from Claim 20. Therefore, please refer to the arguments presented above for Claim 20.

IV. SPECIFICATION OF THE ORIGINAL PATENT

Attached as Exhibit A is the entire specification (including claims) and drawings of the '104 Patent as required by 37 CFR 1.510(b)(4).

V. NOTIFICATION OF CONCURRENT PROCEEDING

There is no concurrent proceeding at this time.

VI CONCLUSION

For the above reasons and in view of the prior-art references discussed above, it is submitted that reexamination of claims 1-21 of the '104 Patent is appropriate.

Respectfully,

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CERTIFICATE OF SERVICE

In accordance with 37 CFR 1.510(b)(5), I hereby certify that I mailed by certified mail, return-receipt-requested a copy of the Third Party's Request for *Ex Parte* Reexamination of U.S. Patent 7,561,104 and its attachments and all documents submitted to the USPTO related to the Third Party Request for *Ex Parte* Reexamination to the patent owner c/o the attorney of record at:

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on September 24, 2012

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EXHIBIT A

US007561104B2

(12) **United States Patent**
Alles et al.

(10) **Patent No.: US 7,561,104 B2**
(45) **Date of Patent: Jul. 14, 2009**

(54) **METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE UNIT**

(75) Inventors: **Martin Alles**, Vienna, VA (US); **John Carlson**, Dulles, VA (US); **George Maher**, Herndon, VA (US); **Selcuk Mazlum**, Leesburg, VA (US)

(73) Assignee: **Andrew LLC**, Hickory, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **12/026,333**

(22) Filed: **Feb. 5, 2008**

(65) **Prior Publication Data**

US 2008/0186234 A1 Aug. 7, 2008

Related U.S. Application Data

(60) Provisional application No. 60/899,379, filed on Feb. 5, 2007.

(51) **Int. Cl.**
G01S 3/02 (2006.01)

(52) **U.S. Cl.** **342/451**; 342/457

(58) **Field of Classification Search** 342/357.01, 342/357.06, 451, 457, 463–465; 455/456.6, 455/457

See application file for complete search history.

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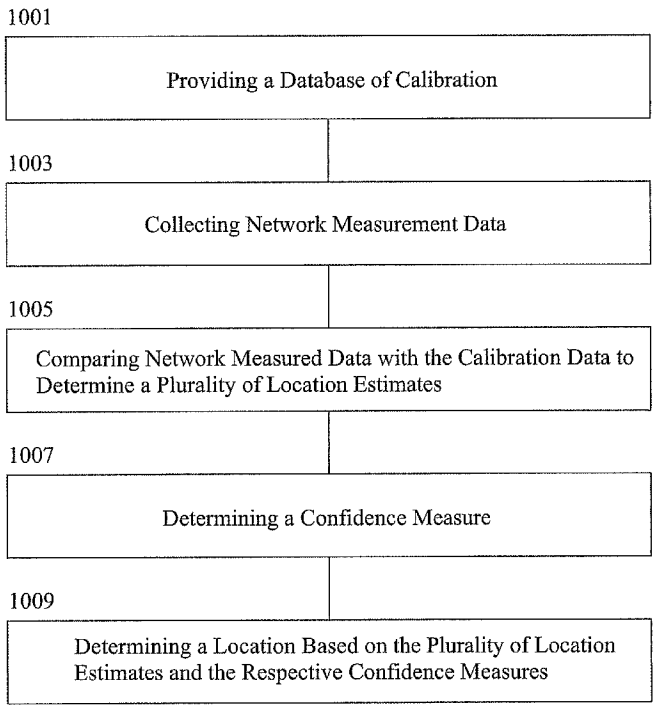
Primary Examiner—Dao L Phan
(74) *Attorney, Agent, or Firm*—Duane Morris LLP

(57) **ABSTRACT**

A method of modifying calibration data used to geo-locate a mobile station located in an indoor environment is disclosed. When a mobile station is located indoors, the signal strength of signals received and/or transmitted by the mobile station have the tendency to be lower than the strength of the signals received by a mobile station located outdoors. As a result of these lower signal strengths, geo-location efforts which rely on signal strengths may result in unsatisfactory location accuracy. Modifying pre-existing calibration data obtained outdoors may provide a way to simulate indoor calibration data characteristics.

21 Claims, 10 Drawing Sheets



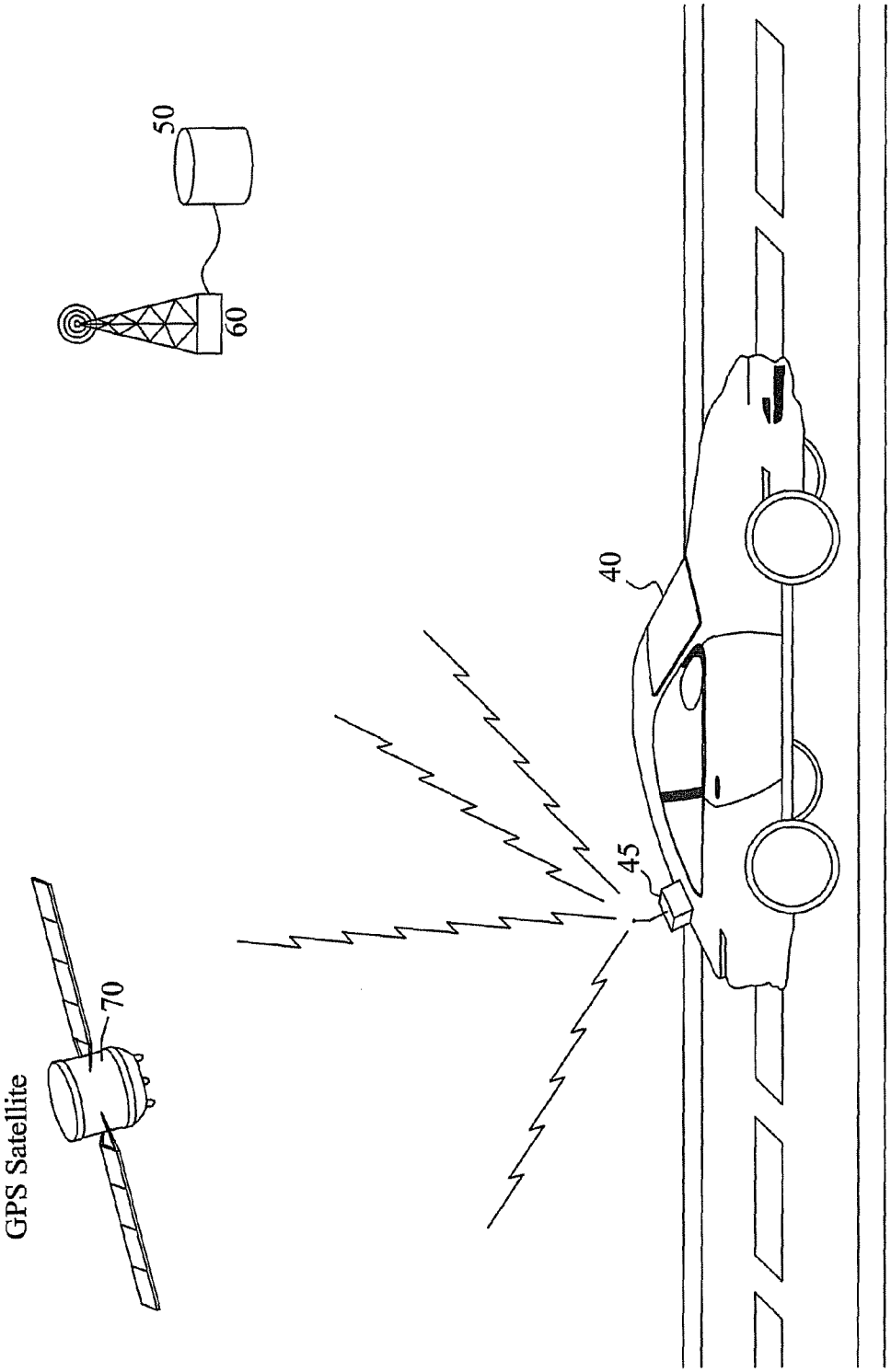


Figure 1

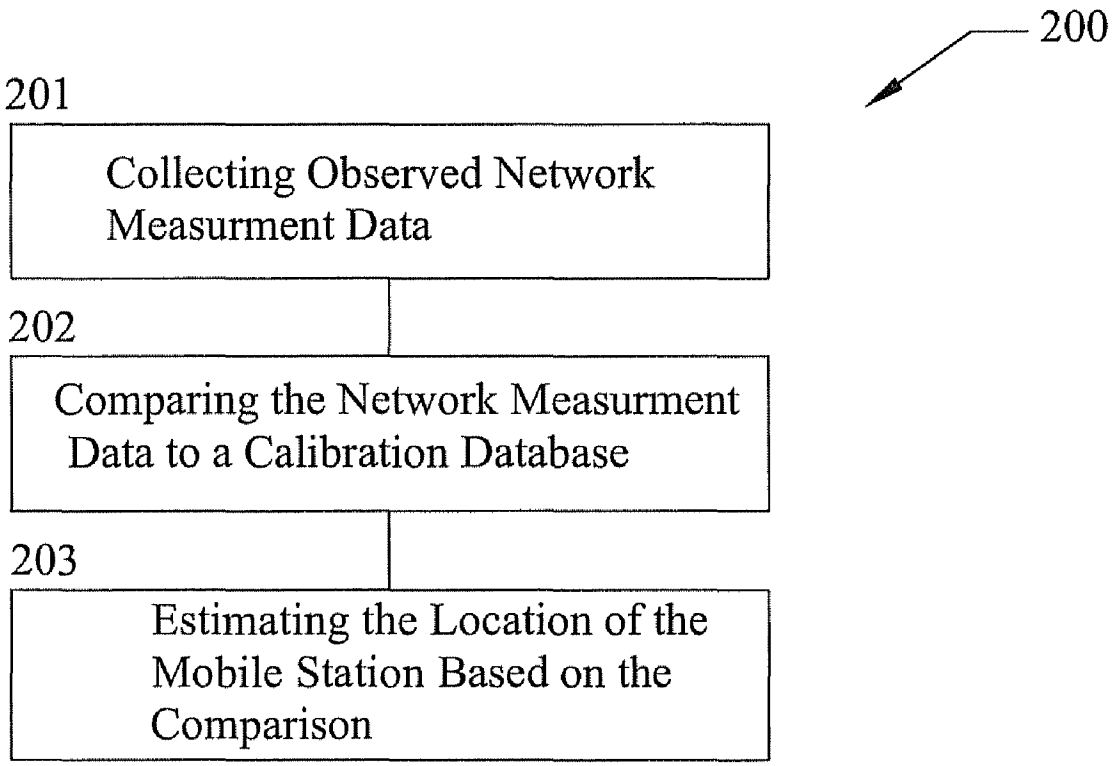

200
201
Collecting Observed Network Measurment Data
202
Comparing the Network Measurment Data to a Calibration Database
203
Estimating the Location of the Mobile Station Based on the Comparison

Figure 2

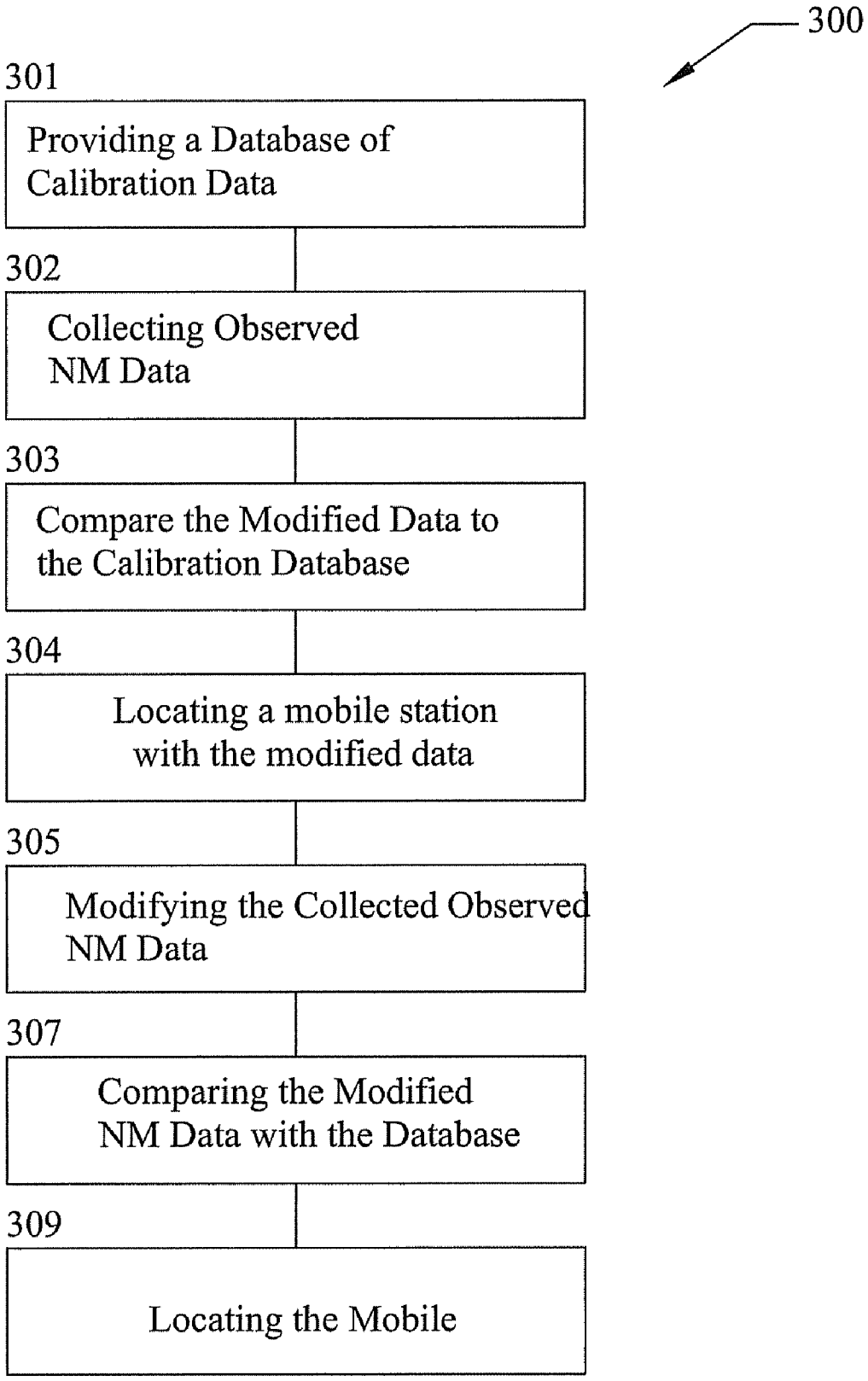

300
301
Providing a Database of Calibration Data
302
Collecting Observed NM Data
303
Compare the Modified Data to the Calibration Database
304
Locating a mobile station with the modified data
305
Modifying the Collected Observed NM Data
307
Comparing the Modified NM Data with the Database
309
Locating the Mobile

Figure 3

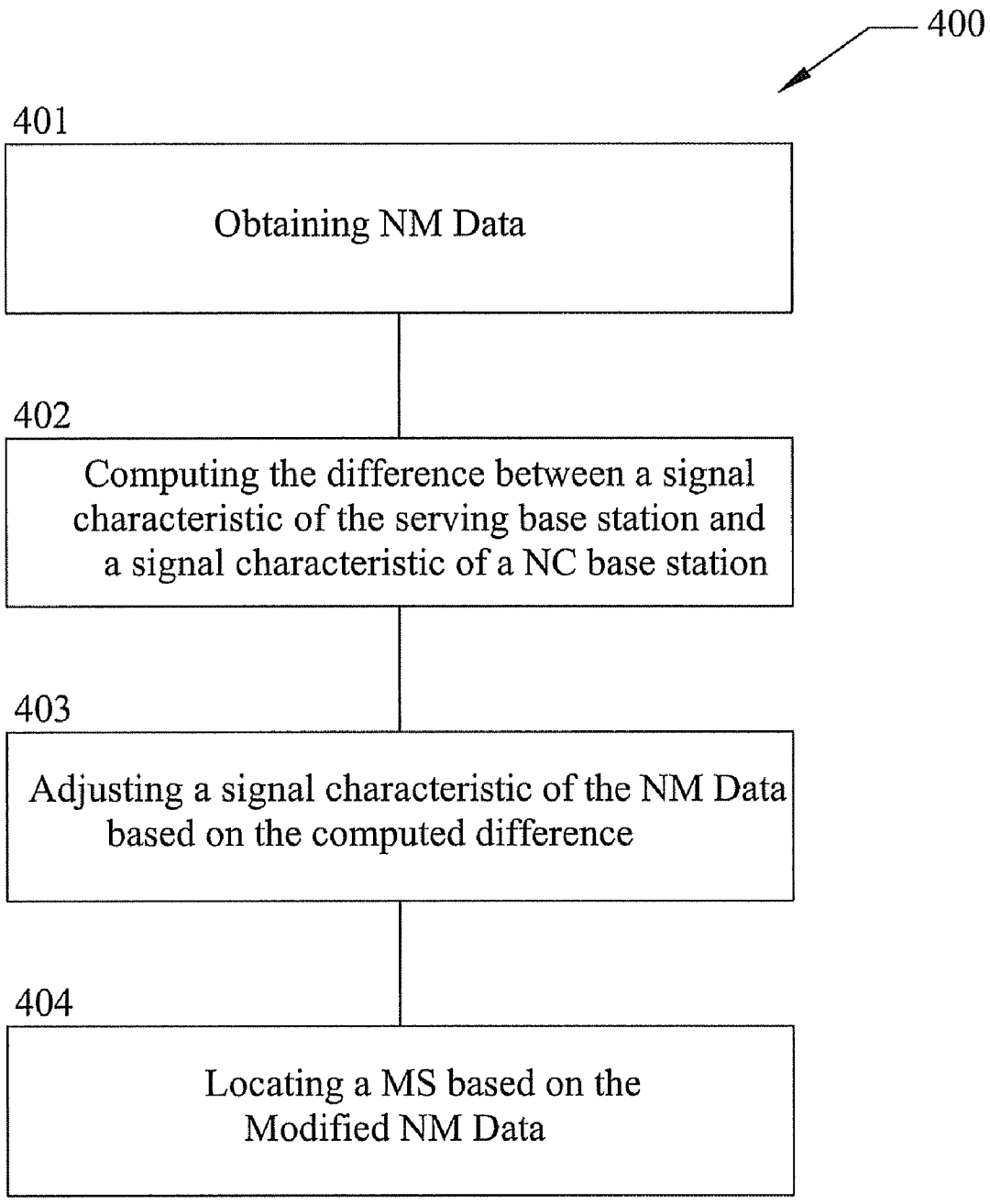

400
401
Obtaining NM Data
402
Computing the difference between a signal characteristic of the serving base station and a signal characteristic of a NC base station
403
Adjusting a signal characteristic of the NM Data based on the computed difference
404
Locating a MS based on the Modified NM Data

Figure 4

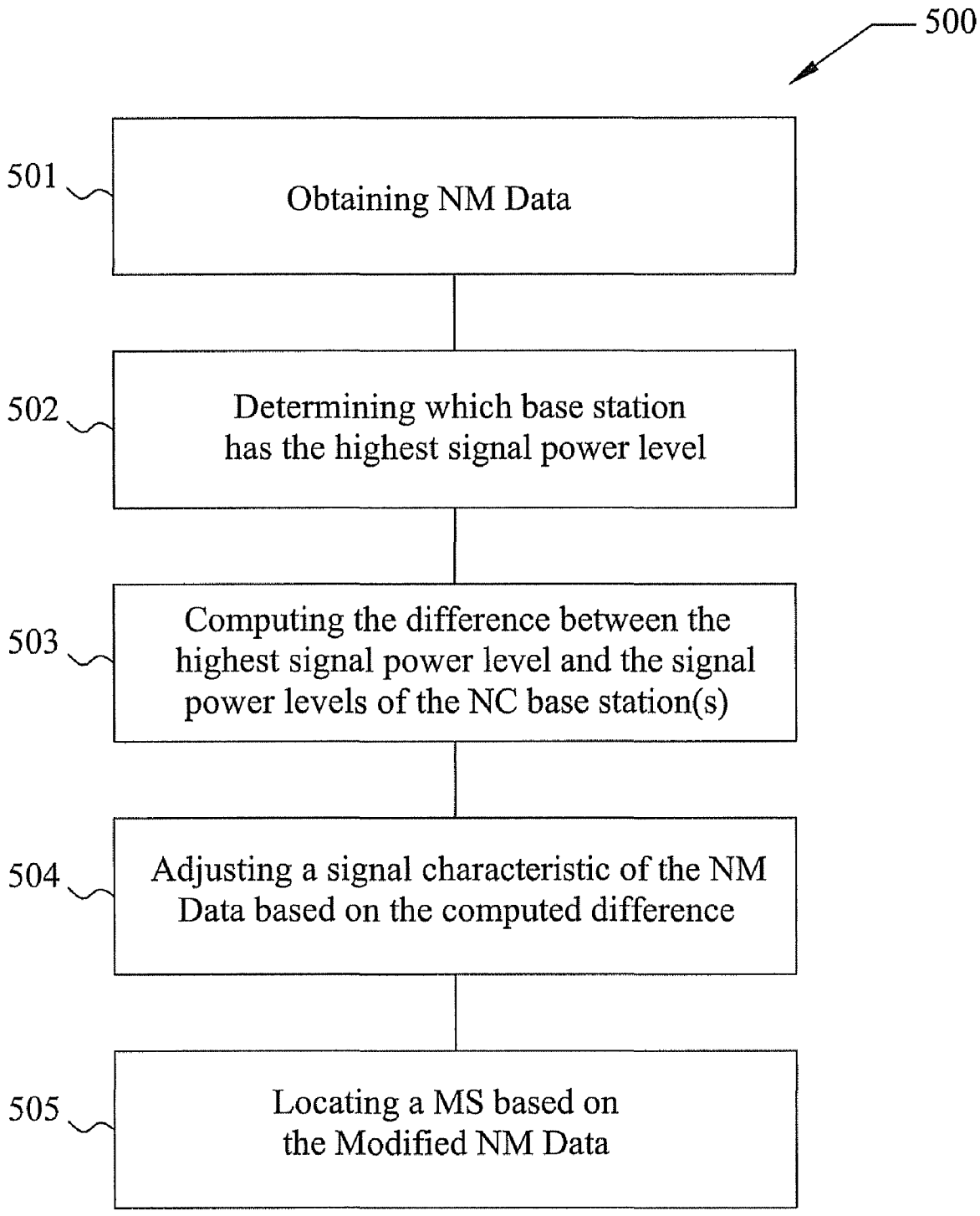

500
501
Obtaining NM Data
502
Determining which base station has the highest signal power level
503
Computing the difference between the highest signal power level and the signal power levels of the NC base station(s)
504
Adjusting a signal characteristic of the NM Data based on the computed difference
505
Locating a MS based on the Modified NM Data

Figure 5

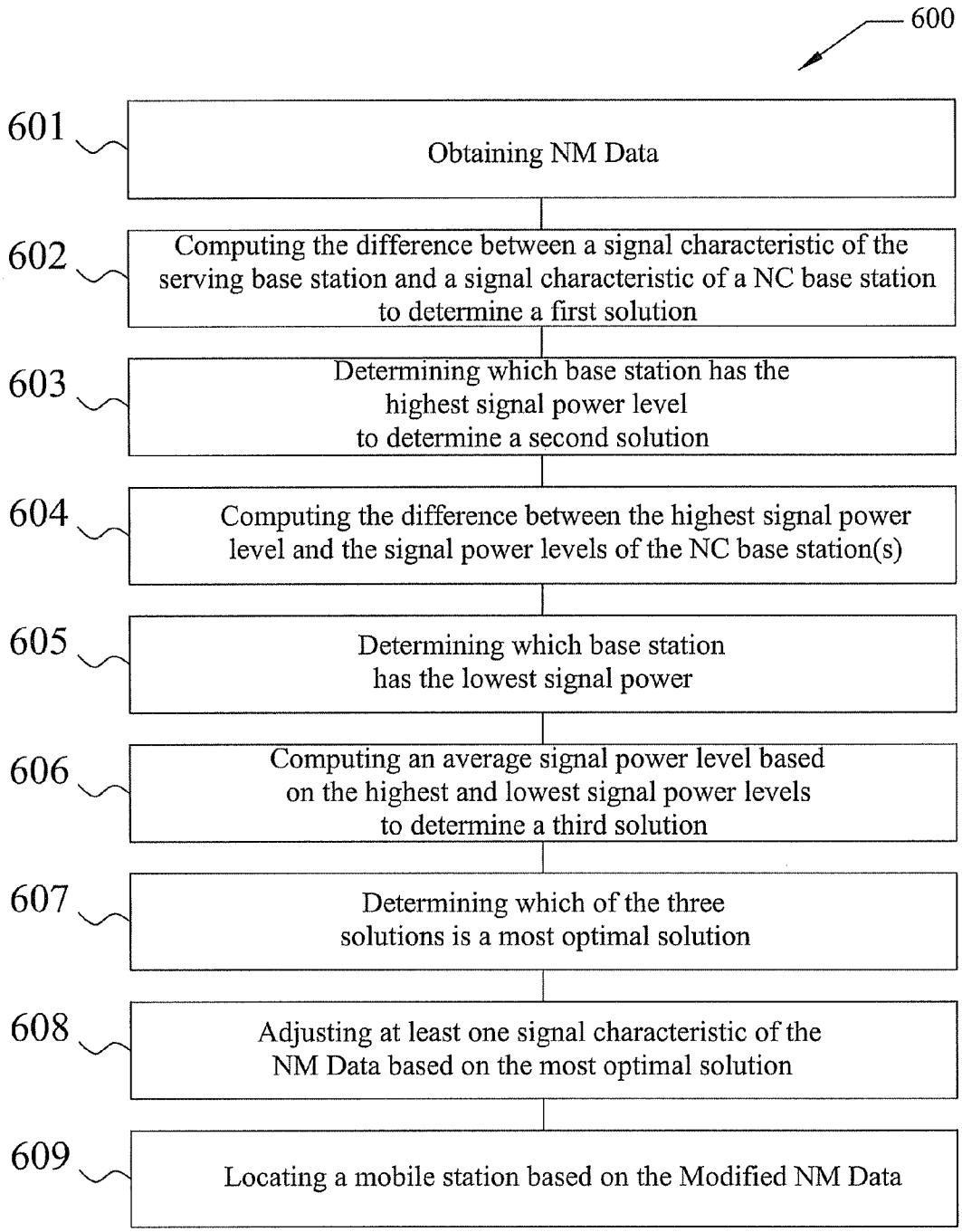

600
601
Obtaining NM Data
602
Computing the difference between a signal characteristic of the serving base station and a signal characteristic of a NC base station to determine a first solution
603
Determining which base station has the highest signal power level to determine a second solution
604
Computing the difference between the highest signal power level and the signal power levels of the NC base station(s)
605
Determining which base station has the lowest signal power
606
Computing an average signal power level based on the highest and lowest signal power levels to determine a third solution
607
Determining which of the three solutions is a most optimal solution
608
Adjusting at least one signal characteristic of the NM Data based on the most optimal solution
609
Locating a mobile station based on the Modified NM Data

Figure 6

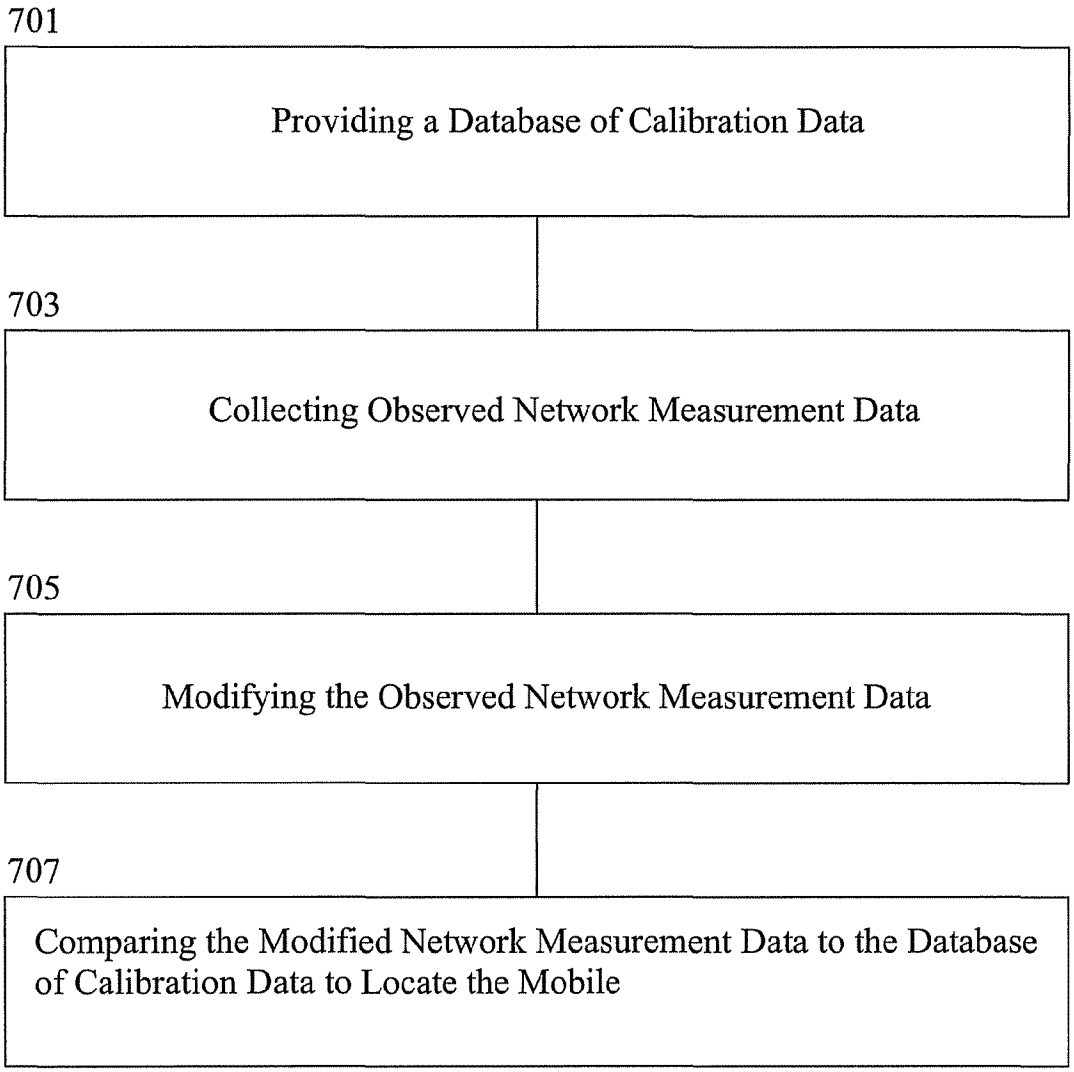

701
Providing a Database of Calibration Data
703
Collecting Observed Network Measurement Data
705
Modifying the Observed Network Measurement Data
707
Comparing the Modified Network Measurement Data to the Database of Calibration Data to Locate the Mobile

Figure 7

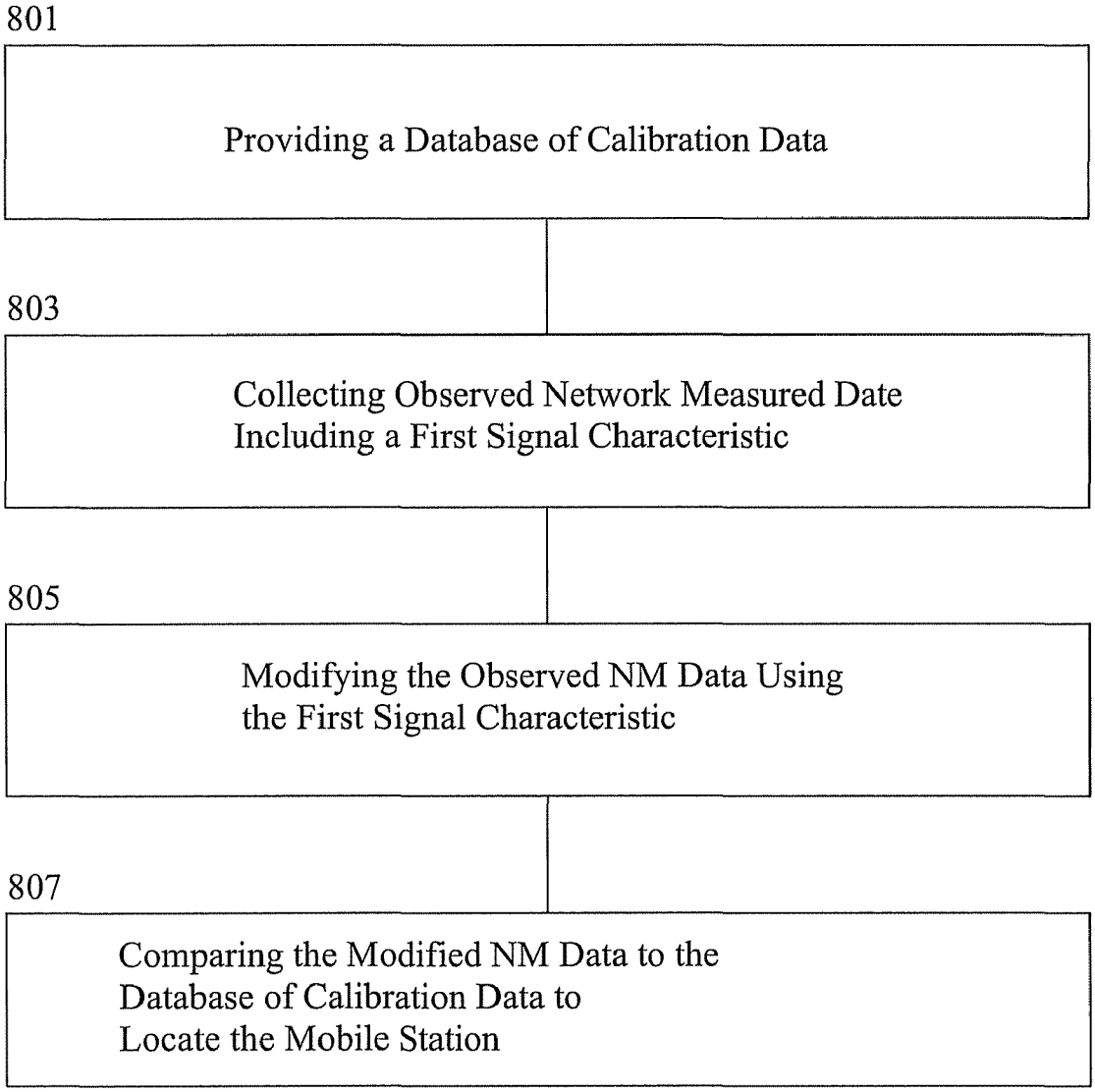

801
Providing a Database of Calibration Data
803
Collecting Observed Network Measured Date Including a First Signal Characteristic
805
Modifying the Observed NM Data Using the First Signal Characteristic
807
Comparing the Modified NM Data to the Database of Calibration Data to Locate the Mobile Station

Figure 8

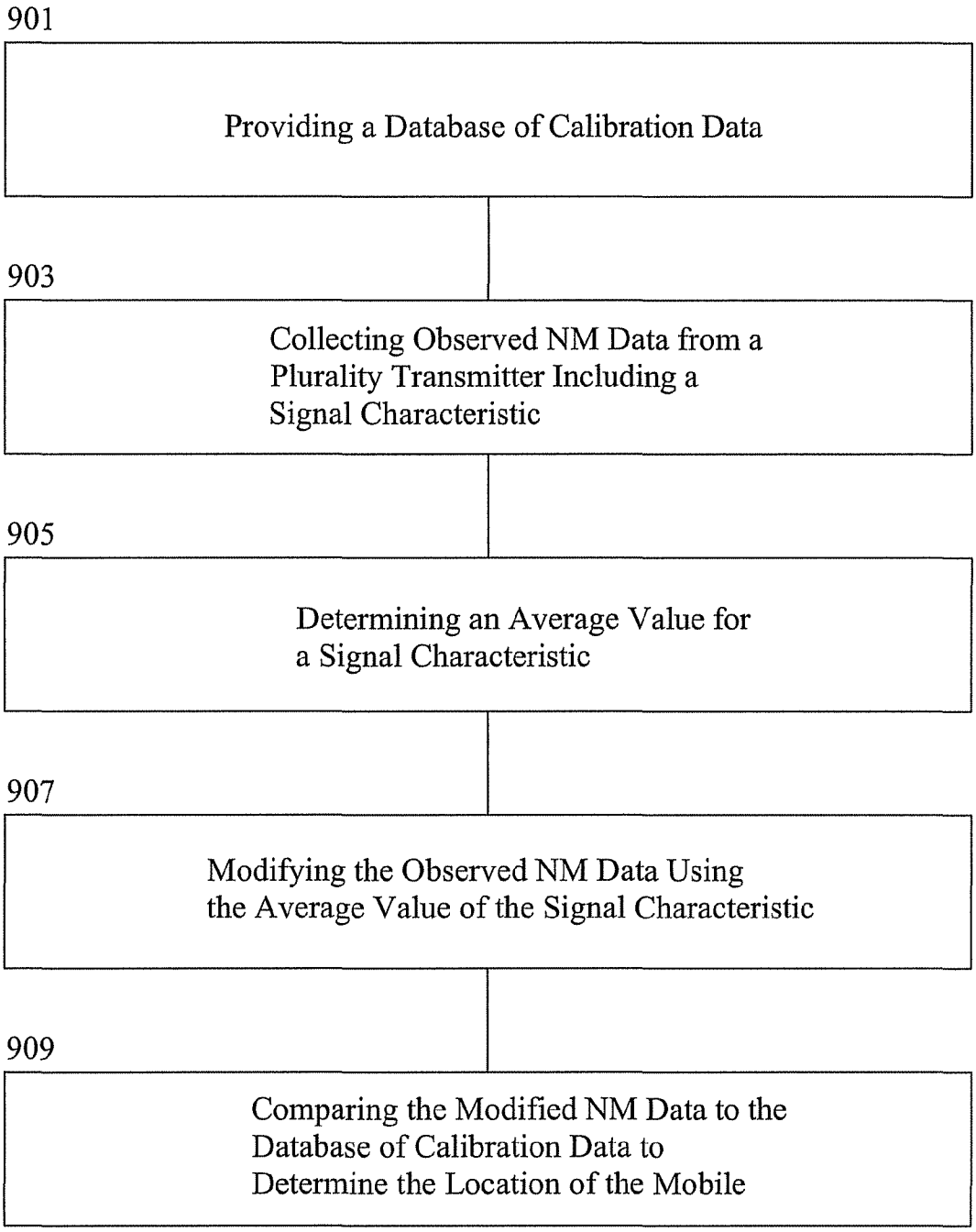

901
Providing a Database of Calibration Data
903
Collecting Observed NM Data from a Plurality Transmitter Including a Signal Characteristic
905
Determining an Average Value for a Signal Characteristic
907
Modifying the Observed NM Data Using the Average Value of the Signal Characteristic
909
Comparing the Modified NM Data to the Database of Calibration Data to Determine the Location of the Mobile

Figure 9

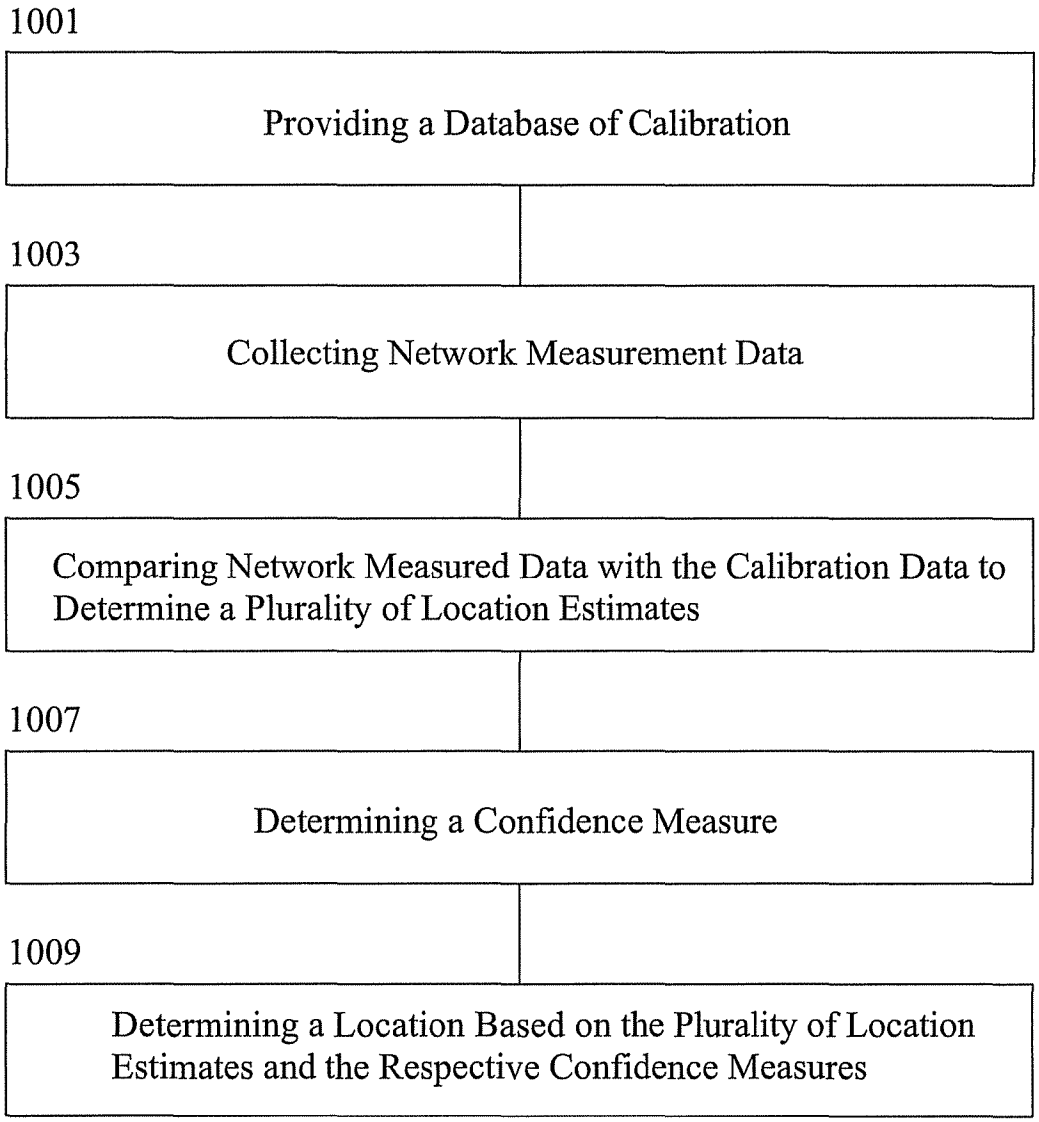

1001
Providing a Database of Calibration
1003
Collecting Network Measurement Data
1005
Comparing Network Measured Data with the Calibration Data to Determine a Plurality of Location Estimates
1007
Determining a Confidence Measure
1009
Determining a Location Based on the Plurality of Location Estimates and the Respective Confidence Measures

Figure 10

METHOD TO MODIFY CALIBRATION DATA USED TO LOCATE A MOBILE UNIT

CROSS REFERENCES

The present application is related to provisional application No. 60/899,379 entitled "Mobile Location Using Network Measurement Reports" filed on Feb. 5, 2007, which is hereby incorporated by reference in its entirety.

BACKGROUND

The use of wireless communication devices such as telephones, pagers, personal digital assistants, laptop computers, etc., hereinafter referred to collectively as "mobile appliances" or "mobiles stations" has become prevalent in today's society. In recent years, at the urging of public safety groups, there has been increased interest in technology which can determine the geographic position or "geo-locate" a mobile station in certain circumstances.

Estimating the location or "geo-locating" a mobile station may require one or more types of calibration data associated with the mobile station (e.g., signal strength, round trip time, time difference of arrival (TDOA), etc.). Calibration data is typically collected in an outdoor environment. The primary reason for collecting calibration data outdoors is the greater ease of performing automated calibration collection procedures or, in some instances, manual collection procedures along roads. It is more time-consuming to perform calibration procedures indoors due to the required access to buildings and the inability to utilize automated collection procedures designed for outdoor environments.

When a wireless device is located indoors, the signal strengths of signals received from the serving and/or neighboring base stations tend to be lower than the strength of the signals received by a wireless device located outdoors. As a result of these lower signal strengths, performing comparisons between the received signal strengths of the indoor wireless device and signal strength data stored in a calibration database may result in a poor estimated location accuracy. Modifying the calibration data obtained outdoors may provide a way to simulate indoor calibration data characteristics. Calibration data collected in areas located adjacent to indoor facilities may be altered to increase the accuracy of location estimates of a mobile station located indoors.

One embodiment of the present subject matter is a method for determining a location of a mobile station. The method includes providing a database of previously-gathered calibration data for a predetermined region in a wireless network and collecting observed network measurement data. The method also includes modifying the observed network measurements and then comparing the modified data with the database of calibration data to determine the location of the mobile station.

Another embodiment of the present subject matter is a system for determining a location of a mobile station. The system includes a database of previously-gathered calibration data for a region in a wireless network and circuitry such as a wireless receiver for collecting observed network measurement data. The system includes circuitry, such as a processor, for modifying the observed network measurement data; and circuitry, such as a processor, for comparing the modified data with the calibration data in the database to determine the location of the mobile station.

Yet another embodiment of the present subject matter is a method for determining a location of a mobile station. The method includes providing a database of previously-gathered calibration data for a region in a wireless network which includes a serving transmitter. The method collects observed network measurement data including a first network characteristic from said serving transmitter and modifies the observed network measurement data using said first characteristic. The method compares the modified network measurement data with the database of calibration data to thereby determine the location of the mobile station.

Still yet another embodiment of the present subject matter is a method for determining a location of a mobile station. The method includes providing a database of previously-gathered calibration data for a region in a wireless network including a first transmitter and a second transmitter. The method also includes collecting observed network measurement data including a first and second signal characteristic from the first and second transmitters respectively and determining which of the first and second signal characteristics has a greater magnitude. The observed network measurement data may be modified using the greater magnitude signal characteristic, and the modified network measurement data may be compared with the database of calibration data to determine the location of the mobile station.

A further embodiment of the present subject matter is a method for determining a location of a mobile station. The method includes providing a database of previously-gathered calibration data for a region in a wireless network and collecting observed network measurement data from a plurality of transmitters which includes a signal characteristic from each one of said plural transmitters. The method also includes determining an average value for the signal characteristics and modifying the observed network measurement data using the average value. The method may then compare the modified network measurement data with the database of calibration data to determine the location of the mobile station.

Still a further embodiment of the present subject matter recognizes that it may be desirable to locate a mobile station by obtaining at least one network measurement report representing at least one first signal characteristic of the mobile station's serving base station, and at least one second and third signal characteristics of neighboring base stations. The method may also compute the difference between the at least one first signal characteristic of the mobile station's serving base station and the at least one second signal characteristic of at least one of the neighboring base stations to determine a first solution and determine which neighboring base station has the highest signal power level at a particular location. The difference between the highest signal power and the power levels of the serving base station and the remaining neighboring base stations may be computed to determine a second solution. It may also be determined which neighboring base station has the lowest signal power level at the particular location. The method may also comprise computing an average signal power level intermediary to the difference between the highest signal power level and the lowest signal power level to determine a third solution and determining which of the three solutions is a most optimal solution based on at least one comparison of the three solutions. At least one signal characteristic of the network measurement report may be adjusted based on the most optimal solution and the modified network measurement report may be utilized to locate a mobile station.

Another embodiment of the present subject matter is a method for determining a location of a mobile station. The method includes providing a database of previously-gathered outdoor calibration data for a region in a wireless network, collecting network measurement data, and comparing the network measurement data with the database of calibration

data to thereby determine several location estimates of the mobile station. The method may also include determining a confidence measure for each of the plurality of location estimates and determining the location of the mobile station based on the plurality of location estimates and their respective confidence measures.

These and other advantages of the disclosed subject matter over the prior art will be readily apparent to one skilled in the art to which the disclosure pertains from a perusal of the claims, the appended drawings, and the following detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a wireless communications networking environment.

FIG. **2** illustrates a flow diagram of an exemplary inventive concept.

FIG. **3** illustrates a flow diagram of another exemplary inventive concept.

FIG. **4** illustrates a flow diagram of yet another exemplary inventive concept.

FIG. **5** illustrates a flow diagram of still another exemplary inventive concept.

FIG. **6** illustrates a flow diagram of still yet another exemplary inventive concept.

FIG. **7** illustrates a flow diagram of an embodiment of the subject matter.

FIG. **8** illustrates a flow diagram of another embodiment of the subject matter.

FIG. **9** illustrates a flow diagram of another embodiment of the subject matter.

FIG. **10** illustrates a flow diagram of another embodiment of the subject matter.

DETAILED DESCRIPTION

Calibration data samples obtained outdoors may be used to simulate indoor calibration data to locate a mobile station (MS) in an indoor facility. A method of utilizing calibration data samples to represent indoor and/or outdoor wireless networking environments is described herein.

Reliably locating a mobile station located indoors, even when the calibration data has been obtained in an outdoor environment, may simplify a calibration collection procedure. Calibration data obtained outdoors may be modified and substituted for indoor calibration data. In addition network measurement data may be modified for comparison with the outdoor calibration data.

In general, a non-uniform grid point (NUG) may represent the signal characteristics and/or calibration data over a given region. As illustrated in FIG. **1**, a set of NUGs (NUG**1**, NUG**2** and NUG**3**) are shown as being a part of a larger geographical region (R), which includes various wireless networking components (e.g., (MS **11** and BS **20**—NUG**1**), (MSs **12-15**—NUG**2**) and (MSs **16-18** and BS **30**—NUG**3**)). The NUGs represent an area of collected calibration data, which may be stored in a database for easy retrieval during a calibration data comparison operation between the NUG and a received network measurement report (NMR).

Calibration data may be obtained from data collection devices during field test operations, and/or from MSs or other communication devices within the general area of the NUG. Cross-NUG communications may occur between MSs and/or BSs located within communication range of one or more of the NUGs. For example, BS **10** may be located outside the region (R) and may communicate with one or more devices located in the various NUGs **1-3**. The different NUGs **1-3** may be separately defined by a variety of parameters. For example, geographical areas (e.g., mountains, buildings, roads) may be a factor in deciding the boundaries of a NUG. Additionally, varying concentrations of MSs may be another factor that separates one NUG from another.

Network measurement reports (NMRs) may be used to represent network characteristics at particular locations within a given region (R). Any point located within a NUG may have corresponding signal strength levels that represent the signal power of the serving and/or neighboring cell (NC) BSs. An exemplary NMR may be represented by example_data_vector=[P**1**, P**2**, P**3**, TA**1**]. Referring to FIG. **1**, the power level signals (P**1**-P**3**) may represent the power levels of the three BSs **10**, **20** and **30**, as measured at a particular location. The timing advance parameter TA**1** (or equivalent parameter) may be used to represent timing information of signals transmitted between the MS and one or more BSs.

The value of the timing advance (TA) parameter corresponds to the length of time a signal from a MS takes to reach a particular BS. A MS may be configured to transmit data signals at specific timeslot intervals depending on the type of wireless communication protocol employed (e.g., TDMA, GSM, 3GPP etc.). Using the speed of light (c=3*10^8 m/s) as a reference velocity for the radio waves, the TA parameter may be increased or decreased depending on the distance between the MS and the BS. The TA parameter may be periodically adjusted as the distance from the MS to the BS changes. Of course, a NMR may contain any number and type of parameters, and may be used to estimate the location of a MS.

For example, NMR(s) may be transmitted from the MS or from other wireless communication components to position determining equipment (PDE) **50**, which processes the received NMR information and may attempt to locate the position of the MS. NMR(s) may be periodically generated by MSs or other communication devices to calibrate the NUG. The NUG may also be based entirely on information received from NMR(s) generated by MSs located in the NUG.

The received Network Measurement data (NM data) may be compared to predetermined calibration data representing one or more NUGs to estimate the location of a MS. In a case where NM data is compared against a NUG, like parameters may be compared to estimate if the target MS **18** is within the NUG. Similarly, NUG parameters may be computed in response to a comparison operation, and then compared to the NM data. Each NUG may have a series of parameters and/or functions characterizing one or more particular locations in the NUG. Given a received set of one or more NMR(s) obtained from some unknown location, an estimate of that unknown location may be calculated using the characterization of the NUG or uniform grid (UG) over that region.

It may be desirable to use the original unmodified NM data directly without modification when locating a mobile station. Assuming the MS is located in an indoor facility, the data contained in the NMR(s) may be a function of calibration data collected outdoors. In some cases, the unmodified outdoor calibration data used to represent the indoor facility may provide an accurate representation of the location of the target MS **18** (e.g., low distortion structures, open-faced facilities, etc.).

Referring to FIG. **1**, the NM data may be sent from the target MS **18** to the BS **10**, where the PDE **50** processes the NMR and performs one or more comparison operations between the NM data and the calibration data of the NUG(s). Once the comparison operation is complete, the location of the target MS **18** may be estimated. A direct comparison of the

original NM data may be made against the corresponding NUG(s) characteristics. Alternatively, the NM data may not be modified even if NUG(s) are utilized to estimate the location of the mobile station.

NM data may also be modified to adjust the power levels received from the serving and/or neighboring cell (NC) base stations. For example, differences in parameters between the serving cell and the NC may be calculated and the quantities used to modify the original NM data.

If an original NMR received at the PDE **50** had the form NMR**1**=[P**1**, P**2**, P**3**, TA**1**], where P**1** is the serving BS power at a particular location, P**2** is a first NC power, P**3** is a second NC power, and TA**1** is the timing advance parameter, the modified NMR may be represented by: NMR_modified=[0, P**1**-P**2**, P**1**-P**3**, TA**1**]. The resulting data vector may be used to calculate new relative power levels of the NC BSs by subtracting or adding the NMR_modified parameters from the original NMR**1** parameters. In this example, the power of the serving BS may be used as a basis to obtain relative power level modification parameters to modify the NC power level parameters of NMR(s).

The calculated modified parameters (NMR_modified=[0, P**1**-P**2**, P**1**-P**3**, TA**1**]) may also be used to simulate an indoor facility by modifying NMR(s) received from an indoor location. Alternatively, the modified parameters may be used to conduct other calculations to obtain a desired set of modified results. For example, the modified NMR may be compared to one or more of the NUG(s) to provide an estimated location of a MS. Of course, the serving BS power level is not a required parameter to be used as a basis to obtain relative power level modification parameters, and many other parameters may be used to modify the NM data to simulate an indoor facility.

To further illustrate modification of the NMR, consider a particular implementation where the variable RxLevServing_WD represents the received signal strength of the serving base station's control channel measured by the wireless device at an unknown location. Let RxLevNeigh_i_WD represent the received signal strength of the i^{th} neighbor's control channel, RxLevServing_DB represent the average received signal strength of the serving station's control channel, stored in a database of the PDE **50** during the calibration process, and RxLevNeigh_i_DB represent the average received signal strength of the i^{th} neighbor's control channel stored in the database during a calibration process (i=1 to N, where N is the number of neighbor cells reported).

A comparison operation may be conducted between the received signal strengths of the NC-BSs relative to the serving BS's received signal strength. For example, a comparison may include computing the difference between the parameters of the serving base station and the i^{th} neighbor's parameters (i.e., (RxLevServing_WD−RxLevNeigh_i_WD) and (RxLevServing_DB−RxLevNeigh_i_DB)). Once the differences are calculated, the magnitudes of the differences may be compared to a predetermined threshold value used to distinguish between an acceptable difference value requiring no modification to the NM data and a non-acceptable difference value invoking further modification efforts.

NM data may be modified by an amount relative to the signal strength of a NC-BS. In this example, the NC-BS having the highest signal power may be used as a basis to modify the values of the NM data. The differences between the NC having the highest cell power and the cell powers of the remaining NC-BSs may be calculated and the quantities thereof used to modify the original NM data.

An exemplary NMR may have the form NMR=[P**1**, P**2**, P**3**, P**4**, TA**1**], where P**1** is the serving BS signal power, P**2** is a NC having the highest signal power at the intended location of the NMR, P**3** and P**4** are different NC signal powers, and TA**1** is a timing advance parameter. In this example, P**2** has the highest signal power level and may be used as the basis for modifying the parameters of the NMR. The modified NMR may then be represented by NMR_modified**2**=[P**2**-P**1**, 0, P**2**-P**3**, P**2**-P**4**, TA**1**]. The resulting data vector NMR_modified**2** may be used to calculate new power levels of the NC base stations by subtracting or adding the NMR_modified**2** parameters to the original NMR parameters.

The modified NMR may be compared to one or more of the NUG(s). In the previous examples, the power of the serving BS and the NC with the highest signal power level were used to obtain the relative power modification quantities. The signal power level of the serving BS and/or the NC having the highest signal power may be used solely to modify the NMR, and may not be included in comparison operations against the NUG(s). If the serving BS power level parameter and/or the NC having the highest signal power level parameter are excluded from the comparison to the NUG(s), the first and/or additional terms of the NMR may be ignored during the comparison operation. Of course, any other parameter may be utilized and the example above including power level should not limit the scope of the claims appended herewith.

To further illustrate modification of the NMR, consider a particular implementation where the variable RxLevNeigh_h_WD represents the received signal strength of a neighboring BS's control channel (neighbor A) having the highest signal level, as measured by the wireless device. RxLevNeigh_h_WD may be listed first in a measurement report list containing signal strengths sorted in descending order (h=1). Let RxLevNeigh_i_WD represent the received signal strength of the i^{th} neighbor's control channel measured (neighbor i, where i≠h), as by the wireless device, and RxLevNeigh_h_DB represent the received signal strength of the neighbor (neighbor A) with the highest received signal strength, as measured by the wireless device, and which may be stored in the PDE **50** database during a calibration process. RxLevNeigh_i_DB may be used to represent the received signal strength of the i^{th} neighboring BS's control channel (neighbor i, where i≠h, and i=1 to N, and where N is the number of neighbors reported). RxLevNeigh_i_DB may be stored in the PDE **50** database during a calibration process.

In this example, correlation may be conducted over the received signal strengths of the NC-BSs relative to the NC-BS having the highest received signal strength, as observed by the wireless device. A comparison may include computing the difference between the parameters of the serving BS and the i^{th} neighbor's parameters (i.e. (RxLevNeigh_h_WD−RxLevNeigh_i_WD) and (RxLevNeigh_h_DB−RxLevNeigh_i_DB)). Comparisons may also be conducted for any one, combination of or all of the measured parameters of the NC-BSs.

NM data may be modified to adjust the power levels received from the serving and/or neighboring cell (NC) base stations by an amount relative to the average signal strength of one or more NC base stations. Each signal power or parameter component of the NMR may also be modified by an average signal power or parameter level based on one or more of the measured NC signal power levels. The average received signal power level may be calculated a number of different ways, for example, the average of the two highest signal powers, the three highest powers, the average of all (N) signal powers, or an intermediary number between one or more of the measured NC signal power components. Modifying the original NMR components may include subtracting or adding to the existing NMR power components by an amount based on the calculated average, or other various known functions.

To further illustrate modification of the NMR, consider a particular implementation where RxLevNeigh_avg_WD represents the average received signal strength based upon a number of control channel signal powers of neighboring BSs, as measured by the wireless device at an unknown location to be estimated. Let RxLevNeigh_i_WD represent the received signal strength of the i^{th} neighbor's control channel signal power, and RxLevNeigh_avg_DB represent the average received signal strength of data stored during calibration, and computed based on the neighboring BSs, as measured by the wireless device and used in computing the average received signal strength. The same neighboring BSs may be used to represent the average received signal strength of the signal power levels received by the wireless device and for the average received signal strength of calibration data stored in the PDE **50** database. Let RxLevNeigh_i_DB represent the received signal strength of the i^{th} neighbor's control channel stored in the PDE **50** database during the calibration process (i=1 to N, where N is the number of neighbors reported).

In this example, a comparison may be conducted over the received signal strengths of the neighboring BSs relative to the average received signal strength computed for all neighboring BSs observed by the wireless device (i.e., compare between (RxLevNeigh_avg_WD−RxLevNeigh_i_WD)) and for all neighbors previously measured by the wireless device (i.e., compare between (RxLevNeigh_avg_DB−RxLevNeigh_i_DB)). The average signal power level observed over all the neighbor signal power levels may be realized in absolute powers (mW) or in relative powers (dBm).

Any combination of the above NMR modification procedures may be performed to increase the accuracy of mobile station location estimates. Further, any number of or type of parameters may be utilized in any of the aforementioned procedures and the exemplary parameters of power level, signal strength, etc. should not limit the scope of the claims appended wherewith. Certain factors impacting the modification procedure selection process may include the specific type of cellular technology, the geographical terrain and/or environmental conditions, etc. Further, the present subject matter acknowledges that some NMR modification procedures may be best suited for outdoor location estimation, while others are better suited for indoor location estimation, and some even may be best for mixed (indoor & outdoor) location estimation.

For example, if the serving BS for a mobile station is known to be in an area where there are no buildings or obstructions then it may be prudent to leave the NM data unmodified or select the NMR modification procedure where the serving base station is used as the basis to calculate NMR modifications. Further, if the serving cell is in a geographical area with known large obstructions (e.g., buildings, mountains etc.) then it may be prudent to use the NMR modification procedure that selects the NC base station having the highest signal power as the basis to calculate NMR modifications. Additionally, if the serving cell is in an area containing both outdoor and indoor facilities, then it may be best to use the average of more than one NC signal power value as the basis to modify the NMR(s).

Regardless of the type of modification algorithm selected to modify the NM data, a margin of error may still be present when attempting to determine the precise location of a mobile station. Determining the amount of location error may be useful when estimating the likelihood of accurately locating a mobile station. A confidence measure may also be used to represent the accuracy of a mobile station's estimated location.

The value of a confidence measure may vary depending on the estimated accuracy of the location estimated. If estimated locations derived from mapping NM data to a given location, whether using a NUG or other form of a data source for comparison purposes, agree under any or all combinations, the respective confidence measure "C" may be considered high. A confidence measure may also be represented as a function that increases as the quantity of measured data correctly matches data associated with a final estimated location. An exemplary confidence measure or function may be represented as a fraction of all locations that are similar to the final estimated location, however, such an example should not limit the scope of the claims appended herewith.

After one or more of the data modification procedures have been calculated, respective confidence measures may be calculated to represent the likely accuracy of the modification procedures. Confidence measures may then be compared and the best one selected to represent the appropriate modification procedure to implement.

Certain estimated locations may be assigned weights by using a confidence measure as a weight to represent the probability of locating a mobile station at a given location. For example, confidence measures may be based on one or more calculated parameters, including, but not limited to: a probability density function (PDF), a joint PDF, Mahalanobis distance, distortion measure, ordered number parameter, timing advance (TA) parameter, mobile orientation etc. The calculated parameters may be derived from the NUG calibration data stored in the PDE **50** database. The parameters may be pre-stored in memory or may be calculated during a NMR to NUG comparison operation.

Probability density functions may be calculated based on an individual NC base station power level, or a set of multiple NC base station power levels. The calculated probability density function may be compared to the set of available NUGs (i.e., NUGS **1-3** of FIG. **1**) to determine a probability that the NM data matches a particular NUG location. A joint probability may also be calculated over a set of probabilities to further estimate the location of the mobile station. The results of the calculated PDF may be used in a number of estimation techniques to locate the mobile station.

Distortion measures may be determined at a particular location may be included in a NMR and used in a comparison operation to measure the difference in distortion between NUG data and NM data. The distortion measures may be used to estimate a location of a mobile station based on the results of the comparison.

A Mahalanobis distance may be an exemplary distortion measure and may utilized to assist in identifying and analyzing different patterns in a wireless communications environment. The Mahalanobis distance may also be useful in determining similarities between an unknown sample data set and a known data set.

Ordering number lists may also be used to organize parameters for comparison purposes. An ordering number list may be a list or table of data parameters organized in a particular order. The power levels may be listed in descending order and compared to similar parameters associated with a NUG(s). A threshold power level may be used to represent an acceptable amount of deviation between a comparison of power levels obtained from a NMR(s) and/or a NUG(s). If one or more power levels in the NMR(s) and the NUG(s) fall within an acceptable range of one another, the location of a mobile station may be measured with a corresponding degree of accuracy.

Each generated NMR may be used to provide an individual estimate of the mobile station's location. The PDE **50** may

receive a number of NMRs over a period of time, a corresponding number of location estimates may be generated based on the number of NMRs received. These estimates may be combined in a statistical algorithm and may provide a more accurate location estimate than the individual NMRs.

Given a particular NMR or set of NMR(s) containing data collected outdoors, a selection procedure may be conducted to select the most appropriate modification procedure to use when modifying the NM data. Once one or more of the above described NMR modification procedures have been calculated, (e.g., non-modification, serving cell power level, highest NC power level, average(s) of the NC power levels, etc.) one or more of these calculations may be selected as an optimal solution to be used to modify the NMR.

One way to determine the optimal solution that should be used to modify the NMR is to calculate a confidence measure for each of the calculated modification procedures. Once the confidence measures have been calculated, the optimal solution may be selected as the modification procedure with the highest confidence measure. Alternatively, a location estimate may be made by weighting the individual solutions by the applicable confidence measure and combining the results into a single NMR solution.

Combining multiple NMR(s) may generate a location estimate with increased accuracy. When comparing NM data to a NUG, the grid point data that most closely matches the NM data may become the estimated location of the mobile station. In an alternative arrangement, interpolation may be used for determining a location that falls between two grid points to provide an even more accurate location estimate. Applying probabilistic weights, hypotheses and deriving confidence measures may increase the accuracy of the location estimates. Utilizing exemplary probabilistic measures, the estimated location of a mobile station may be determined within a particular degree of certainty. A similar approach may also be applied to select the appropriate NMR modification procedure to accommodate for varying conditions and other operational variables (e.g., different air standards, varying environmental circumstances, etc.).

FIG. **2** illustrates a flow diagram **200** of a method to locate a mobile station. Observed network measurement data may be collected (operation **201**). The observed data would typically be the same or similar to the data in a network measurement report (NMR). The network measurement data represents at least one network characteristic observed by the mobile station operating at a particular location within a region. The NM data may be compared to calibration database data, where the calibration database data represents calibration data measured within the geographical area of the region (operation **202**). The location of the mobile station may be estimated based on the comparison of the modified network measurement data and the calibration database data (operation **203**).

FIG. **3** illustrates a flow diagram **300** of a method to locate a mobile station in an indoor environment. Calibration data samples are collected in an outdoor environment (operation **301**). At least one attenuation variable may be applied to the calibration data sample to simulate an indoor environment (operation **302**). The modified network measurement data sample may be applied to a mobile station location algorithm (operation **303**). The mobile station may be then located in the indoor environment based on the mobile station location algorithm implementing the at least one modified calibration sample (operation **304**).

FIG. **4** illustrates a flow diagram **400** of a method to locate a mobile station. NM data may be obtained to represent at least one network characteristic of the mobile station's serving base station and at least one second network characteristic of at least one of the mobile station's neighboring base stations (operation **401**). The difference between the at least one first signal characteristic and the at least one second signal characteristic may be computed (operation **402**). At least one signal characteristic of the NM data may be adjusted based on the computed difference (operation **403**). The mobile station may be then located based on the modified network measurement data (operation **404**).

FIG. **5** illustrates a flow diagram **500** of a method to locate a mobile station. NM data may be obtained (operation **501**), which represents at least one first network characteristic of the mobile station's serving base station, and at least one second and third network characteristic of the mobile station's at least two neighboring base stations. It may be then determined which base station has the highest signal power at a particular location (operation **502**). The difference between the highest signal power at the particular location and the power levels at the particular location of the serving base station and the remaining neighboring base stations may be determined (operation **503**). At least one signal characteristic of the NM data may be adjusted based on the computed differences (operation **504**). The mobile station may then be located based on the modified NMR (operation **505**).

FIG. **6** illustrates a flow diagram **600** of a method to locate a mobile station. A NMR may be obtained (operation **601**), which represents at least one first signal characteristic of the mobile station's serving base station, and at least one second and third signal characteristics of the mobile station's at least two respective neighboring base stations. A difference may be computed between the at least one first signal characteristic of the mobile station's serving base station and the at least one second signal characteristic of at least one of the mobile station's neighboring base stations to determine a first solution (operation **602**). It may then be determined which base station has the highest signal power level at a particular location (operation **603**). The difference between the highest signal power and the power levels of the serving base station and the remaining neighboring base stations may be determined as a second solution (operation **604**). The neighboring base station having the lowest signal power level at the particular location may be determined (operation **605**). An average signal power level intermediary to the difference between the highest signal power level and the lowest signal power level may be determined as a third solution (operation **606**). It may then be determined which solution is a most optimal solution by comparing the three solutions (operation **607**). The signal characteristic of the NM data may then be adjusted based on the most optimal solution (operation **608**). The mobile station may then be located based on the adjusted NM data (operation **609**).

FIG. **7** illustrates an embodiment of the present subject matter. The method includes providing a database of previously-gathered calibration data for a predetermined region in a wireless network (operation **701**). The database may be a collection of data from uniform or non-uniform grids that contain network measurements with associated location estimates. Network measurement data may be then observed and measured typically by a mobile station or any other wireless device (operation **703**). The network measurement data may include received base station power and timing advance, as well as other network characteristics observable by a mobile station. The observed network measurement data may then be modified (operation **705**). This modification may include applying an attenuation function to some or all of the network measurement data or converting absolute values into relative values. The modification may be performed by a processor,

microprocessor or ASICS. The modified network measurement data may then be compared to the calibration database in order to determine the location of the mobile station (operation **707**). The comparison may be performed by a processor, microprocessor or ASICS.

FIG. **8** is another illustration of an embodiment of the present subject matter. A database of previously-gathered calibration data for a predetermined region in a wireless network may be provided (operation **801**). Observed network measurement data may be collected which includes a first signal characteristic from the mobile's serving transmitter (operation **803**). The observed network measurement data may be modified as a function of the first signal characteristic (operation **805**), for example the first signal characteristic may be received power and the modification may be a function of the relative value with respect to the received power. The modified network measurement data may be compared with the database of calibration data to determine the location of the mobile station (operation **807**)

FIG. **9** is an illustration of an embodiment of the present subject matter for determining a location of a mobile station. A database of calibration data for a region may be provided (**901**). Network measurement data from transmitters may be observed and collected including a signal characteristic from each of the transmitters (operation **903**). An average value for the signal characteristic among the transmitters may be determined (operation **905**). The average for the signal characteristic may be a weighted average. The observed network measurement data may be modified using the determined average value (operation **907**) and the modified network measurement data may be compared with the database of calibration data to determine the location of the mobile station (operation **909**)

FIG. **10** is an illustration of an embodiment of the present subject matter for determining a location of a mobile station. A database of previously-gathered outdoor calibration data for a predetermined region in a wireless network may be provided (operation **1001**). Network measurement data may be observed and collected (operation **1003**). The network measurement data may be compared with the database of calibration data to thereby determine a plurality of location estimates for the mobile station (operation **1005**). The location estimates may be derived using modified, unmodified, limited signal characteristics, several signal characteristics, etc. For each location estimate, a confidence measure may be determined (operation **1007**). A location may be determined based on the plurality of location estimates and their respective confidence measures (**1009**). For example, the location may be determined based on a weighted average, where the weights are directly proportional to the confidence measures.

The embodiments described above may be used in communication devices, such as, a base station, having varying configurations that include, but are not limited to: predetermined calibration data collected over varying terrain, different base station configurations, varying cellular communication protocols, etc.

While preferred embodiments of the present invention have been described, it is to be understood that the embodiments described are illustrative only and the scope of the invention is to be defined solely by the appended claims when accorded a full range of equivalents, many variations and modifications naturally occurring to those skilled in the art from a perusal hereof.

What is claimed is:

1. A method for determining a location of a mobile station, comprising:

providing a database of previously-gathered calibration data for a predetermined region in a wireless network, wherein said network includes a first transmitter and a second transmitter;

collecting observed network measurement data including a first signal characteristic from said first transmitter and a second signal characteristic from said second transmitter;

determining which of said first and second signal characteristics has a greater magnitude;

modifying said observed network measurement data using the greater magnitude signal characteristic; and

comparing said modified network measurement data with said database of calibration data to thereby determine the location of the mobile station.

2. The method of claim **1** wherein said database comprises previously-gathered calibration data for one or more non-uniform grid points within said region.

3. The method of claim **1** wherein said observed network measurement data includes data collected at the mobile station.

4. The method of claim **1** wherein said previously-gathered calibration data includes calibration data gathered at a predetermined calibration point within said region wherein said predetermined calibration point is not located within a structure.

5. The method of claim **4** wherein said observed network measurement data is collected at a mobile station located within a structure.

6. The method of claim **4** wherein said first signal characteristic is signal strength.

7. The method of claim **6** wherein said second signal characteristic is signal strength.

8. The method of claim **7** wherein the modifying of said calibration data uses a difference between said first or second signal characteristics.

9. The method of claim **7** wherein said first signal characteristic is signal strength of a control channel transmitted by said first transmitter and received by said mobile station.

10. The method of claim **9** wherein said second signal characteristic is signal strength of a control channel transmitted by said second transmitter and received by said mobile station.

11. The method of claim **1**, wherein the observed network measurement data includes received signal strength of said transmitters as said mobile station.

12. The method of claim **1** wherein said observed network measurement data includes a data set comprising:

$$[P_1, P_2 \ldots, P_n, TA]$$

where:

P_1 represents the signal strength of said first transmitter as measured at said mobile station,

P_2 represents a signal strength of said second transmitter as measured at said mobile station wherein $P_2 > P_1$

P_n, represents a signal strength of a n^{th} transmitter as measured at said mobile station wherein $P_{2>Pn}$, and

TA represents a timing advance parameter;

and wherein said modified network measurement data includes a data set comprising:

$$[P_2-P_1, 0, P_2-P_n, TA]$$

where:

P_2-P_1 represents a difference between P_2 and P_1,

0 represents a difference between P_2 and P_2, and

P_2-P_n represents a difference between P_2 and P_n.

13. The method of claim 12 wherein said first transmitter is a serving transmitter for said mobile station and said second and third transmitters are neighboring transmitters.

14. The method of claim 12 wherein said third transmitter is not a member of said wireless network.

15. A method for determining a location of a mobile station, comprising:

providing a database of previously-gathered outdoor calibration data for a predetermined region in a wireless network;

collecting network measurement data;

comparing said network measurement data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station

determining a confidence measure for each of the plurality of location estimates;

determining the location of the mobile station based on the plurality of location estimates and the respective confidence measures.

16. The method of claim 15, wherein the step of determining the location based on the plurality of location estimates and the respective confidence measures comprises selecting the location estimate having the highest respective confidence measure as the location of the mobile station.

17. The method of claim 15, wherein the step of determining the location based on the plurality of location estimates and their respective confidence measures comprises weighing the plurality location estimates based on their respective confidence measures and obtaining a weighted average as the location of the mobile.

18. The method of 15, wherein the confidence measures comprises one or more of the group consisting of a pdf the Mahalanobis distance, and a distortion measure.

19. The method of claim 15, wherein the step of collecting network propagation data further comprises modifying the network propagation data.

20. The method of claim 15, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further comprises modifying said calibration data prior to the comparison.

21. The method of claim 20, wherein the step of comparing said network propagation data with said database of calibration data to thereby determine a plurality of location estimate of the mobile station, further comprises modifying said calibration data prior to the comparison.

* * * * *

EXHIBIT B

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(54) **METHOD AND MOBILE STATION FOR AUTONOMOUSLY DETERMINING AN ANGLE OF ARRIVAL (AOA) ESTIMATION**

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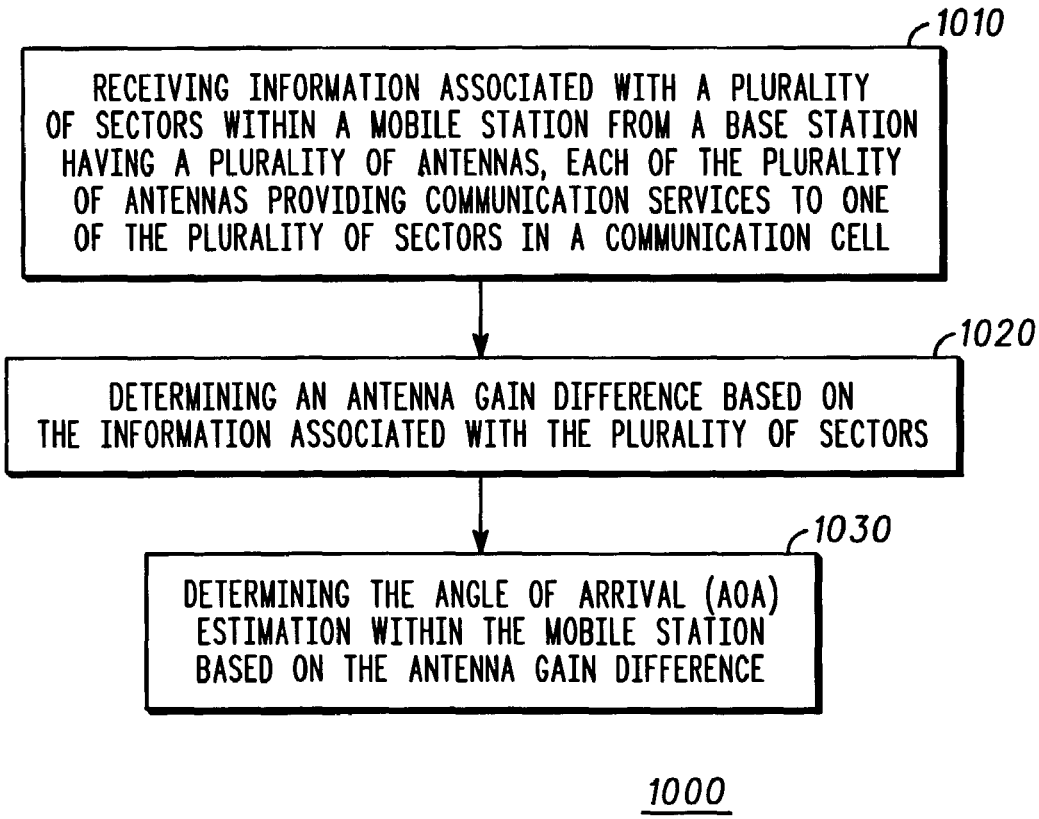
(57) **ABSTRACT**

A method (**900**) and a mobile station (**160**) for autonomously determining an angle of arrival (AOA) estimation are described herein. The mobile station (**160**) may receive information associated with a plurality of sectors (**200**) from a base station (**140**) having a plurality of antennas. Each of the plurality of antennas may provide communication service to one of the plurality of sectors (**200**). The information associated with the plurality of sectors (**200**) may be an antenna pattern, a boresight, a downtilt, and a signal strength value associated with each of the plurality of antennas. Based on the information associated with the plurality of sectors (**200**), the mobile station (**160**) may determine an antenna gain difference, which in turn, is used to determine the angle of arrival (AOA) estimation.



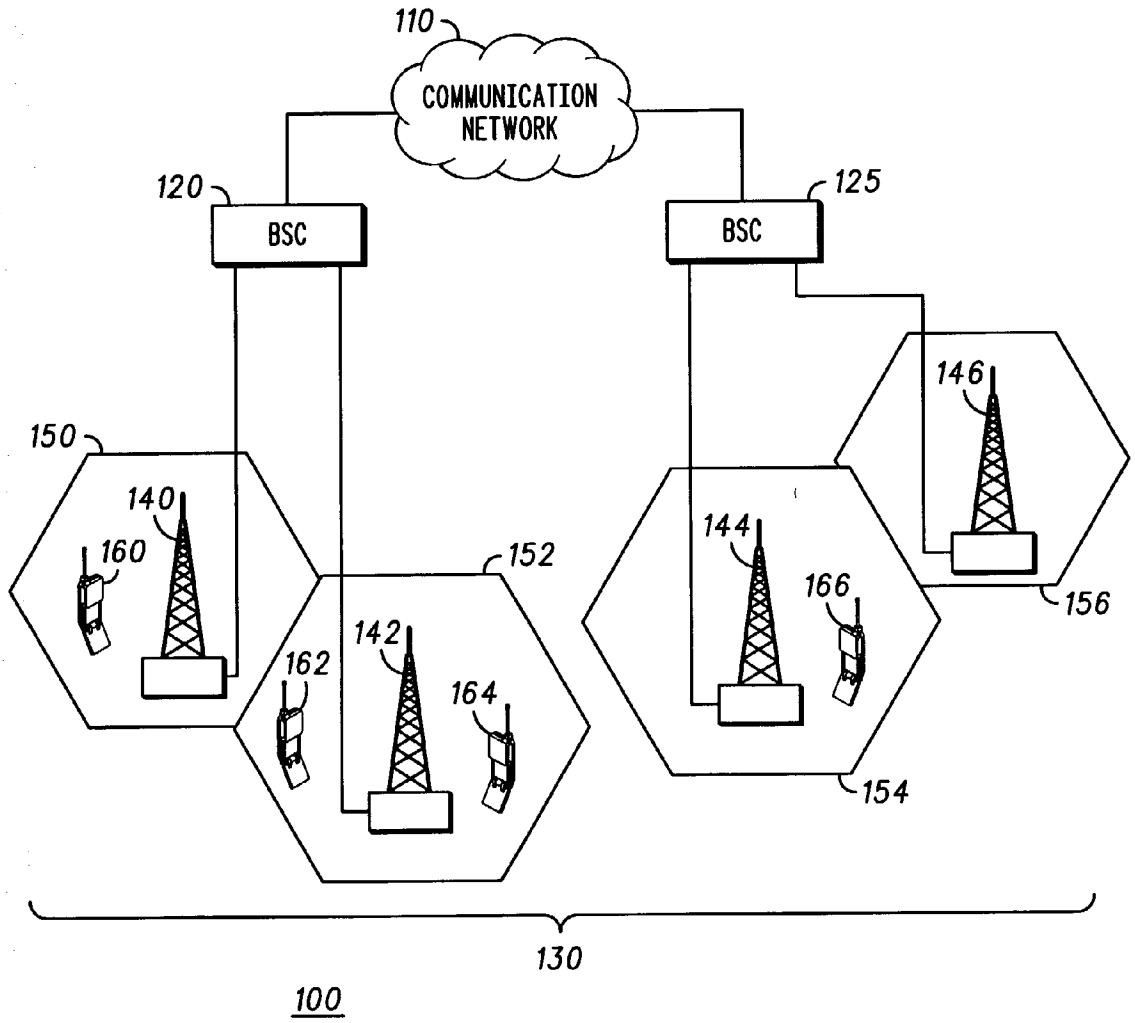

110
COMMUNICATION NETWORK
120
BSC
125
BSC
146
150
140
160
152
144
166
156
142
162
164
154
130
100

FIG. 1

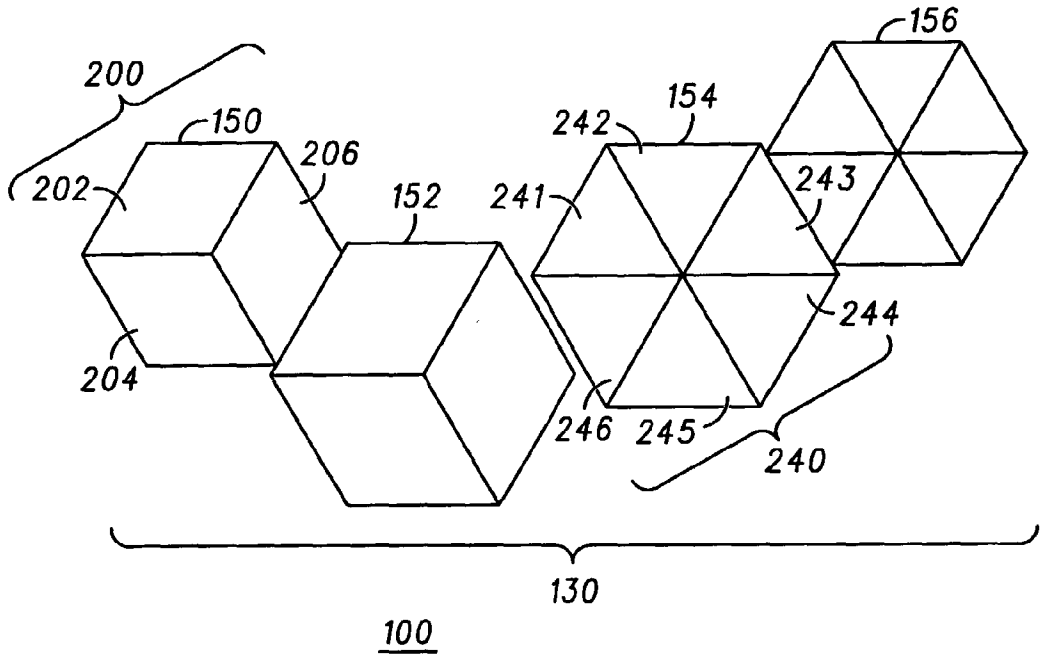

156
200
154
150
242
206
202
152
241
243
244
204
246
245
240
130
100

FIG. 2

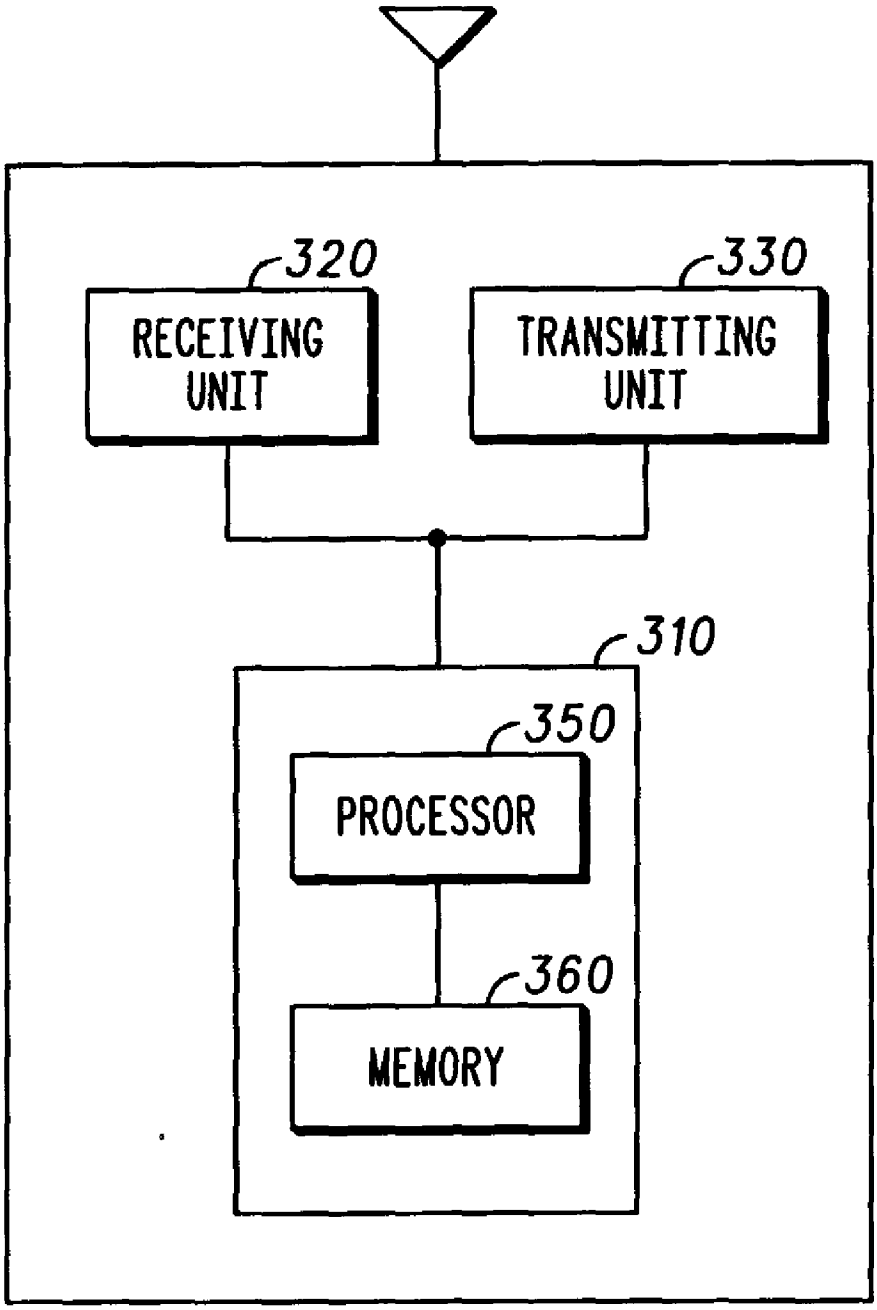

320
RECEIVING UNIT
330
TRANSMITTING UNIT
310
350
PROCESSOR
360
MEMORY
160

FIG. 3

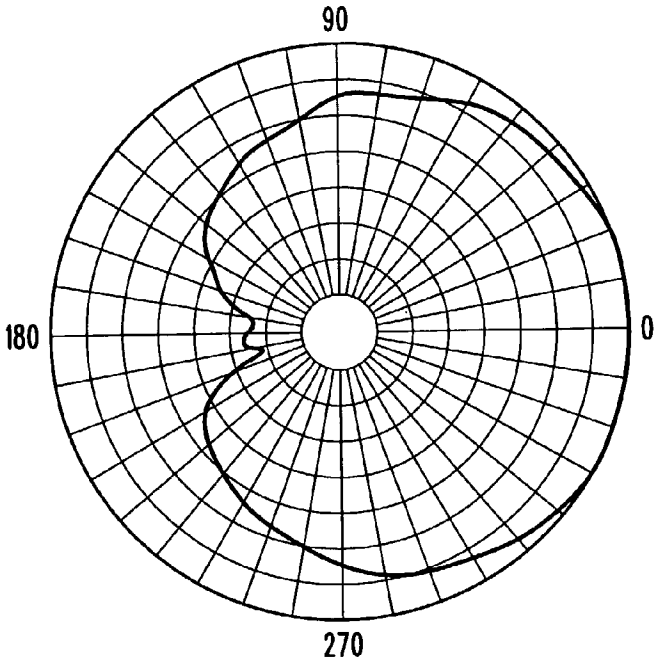


FIG. 4

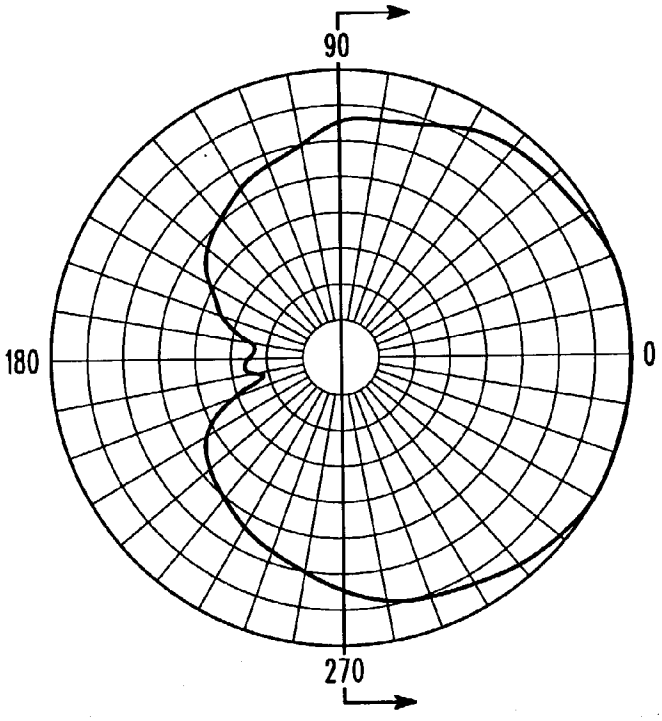


FIG. 5

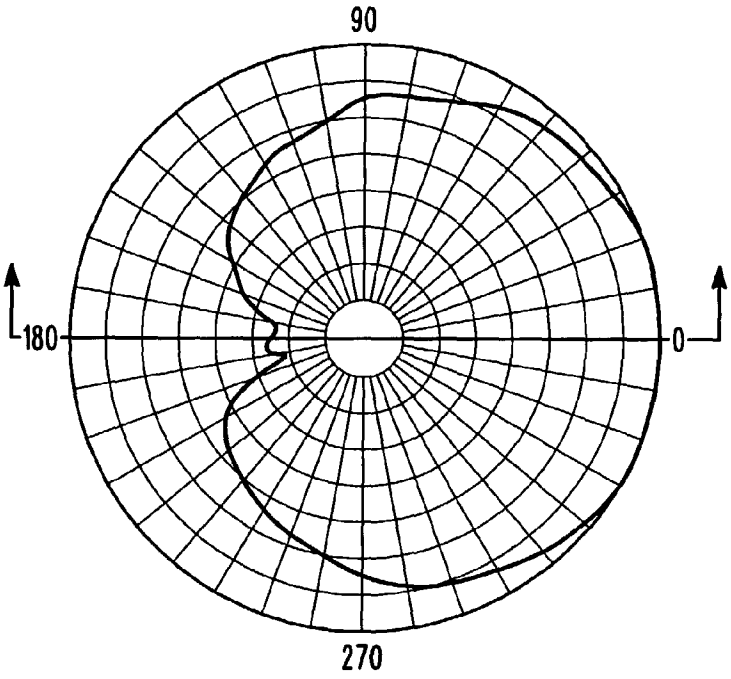


FIG. 6

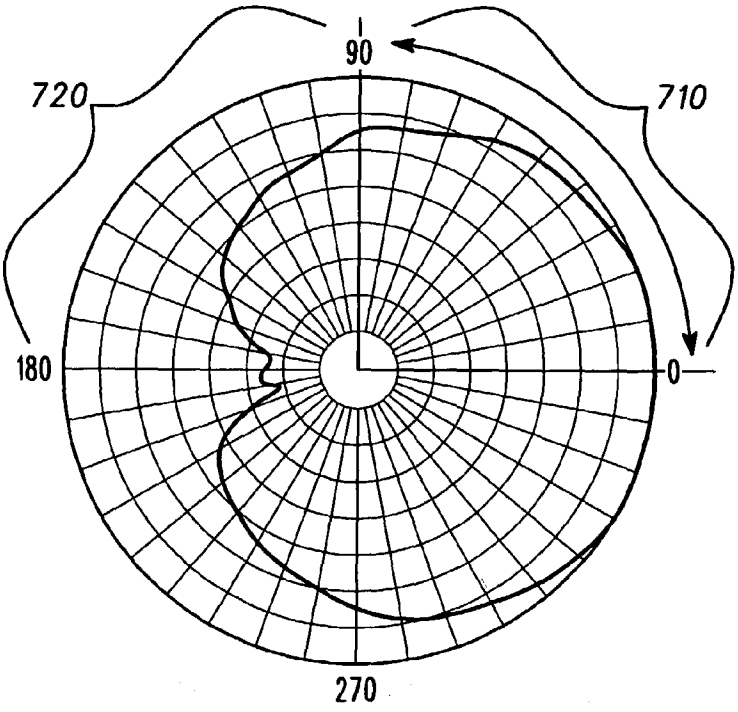


FIG. 7

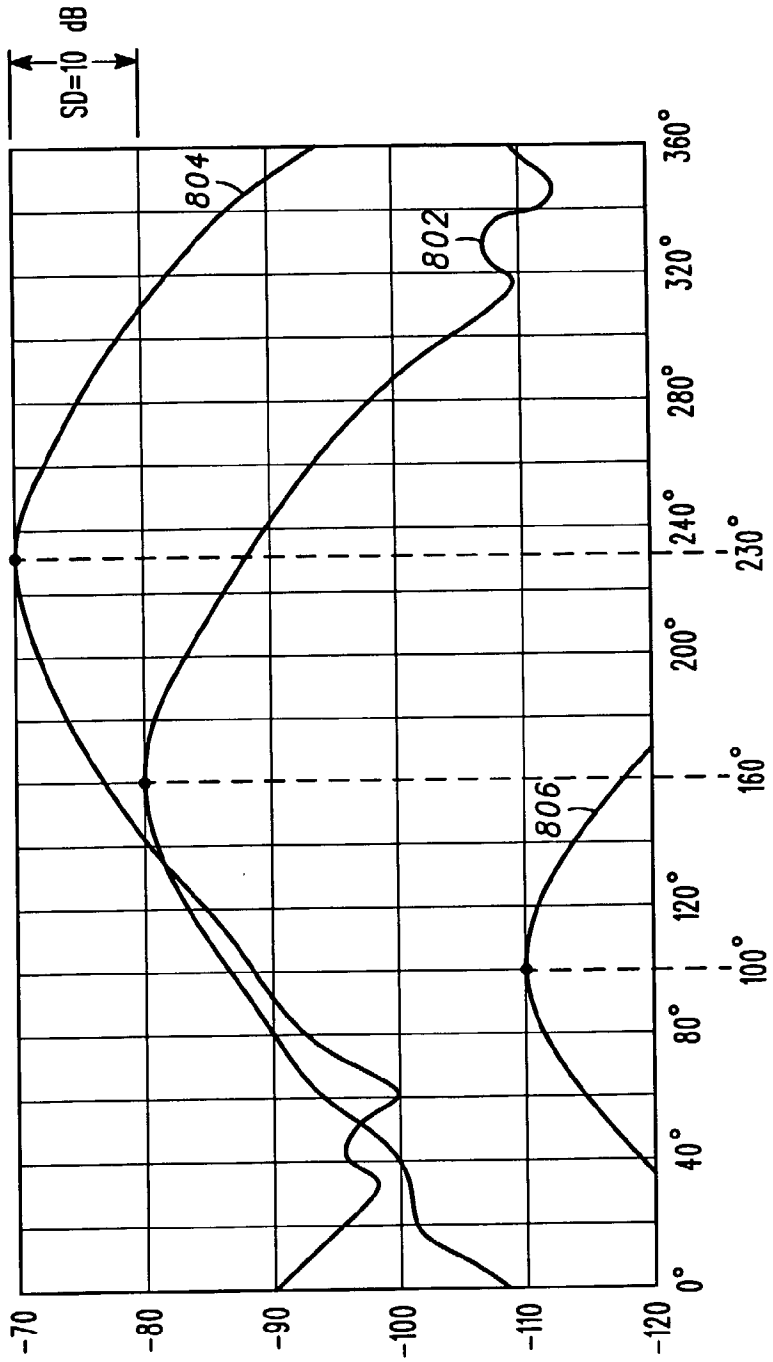

SD=10 dB
804
802
806
-70
-80
-90
-100
-110
-120
0°
40°
80°
100°
120°
160°
200°
230°
240°
280°
320°
360°

FIG. 8

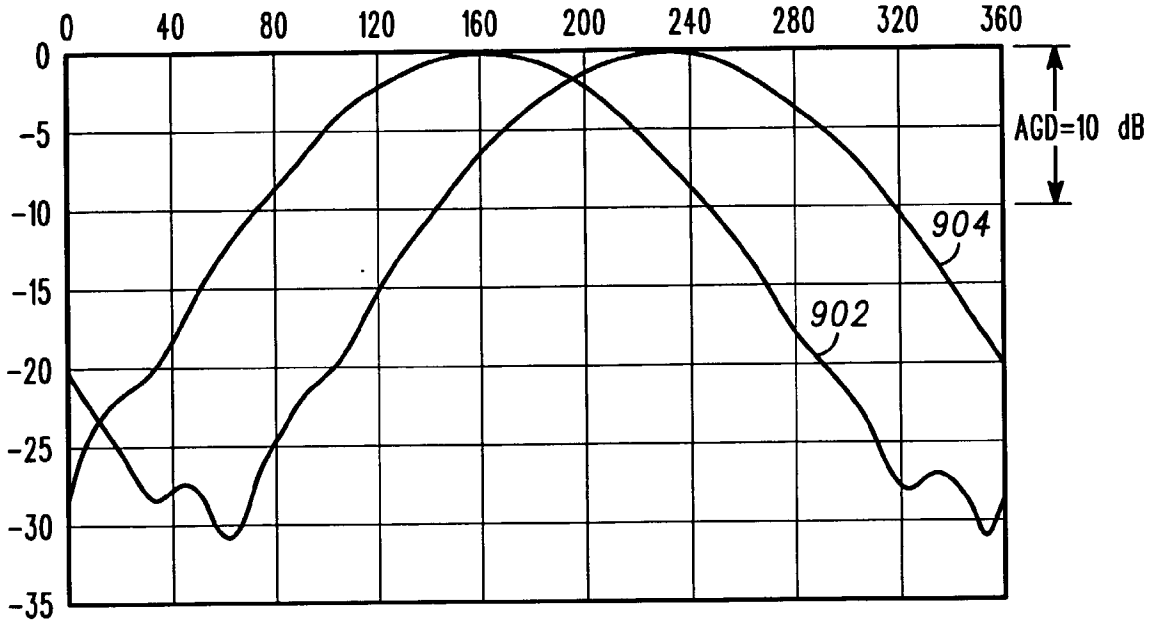

0
40
80
120
160
200
240
280
320
360
0
-5
-10
-15
-20
-25
-30
-35
AGD=10 dB
904
902

FIG. 9

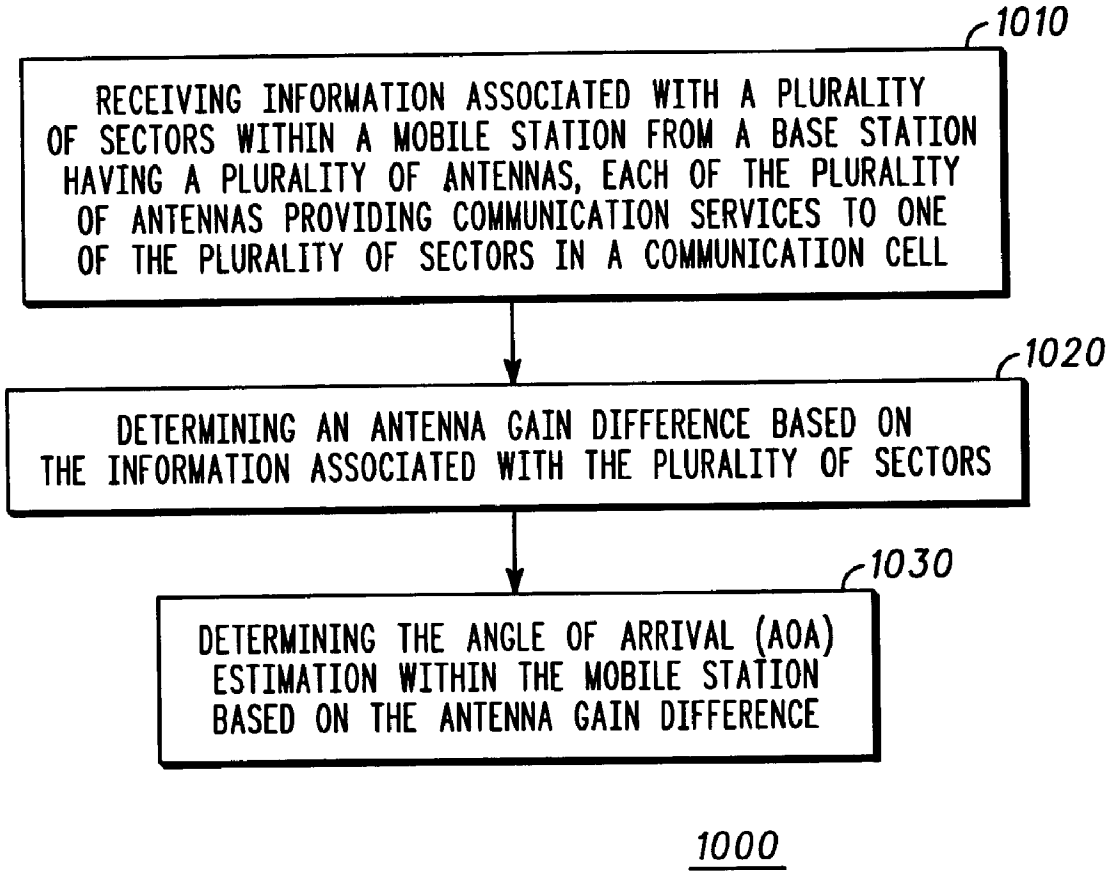

1010
RECEIVING INFORMATION ASSOCIATED WITH A PLURALITY OF SECTORS WITHIN A MOBILE STATION FROM A BASE STATION HAVING A PLURALITY OF ANTENNAS, EACH OF THE PLURALITY OF ANTENNAS PROVIDING COMMUNICATION SERVICES TO ONE OF THE PLURALITY OF SECTORS IN A COMMUNICATION CELL
1020
DETERMINING AN ANTENNA GAIN DIFFERENCE BASED ON THE INFORMATION ASSOCIATED WITH THE PLURALITY OF SECTORS
1030
DETERMINING THE ANGLE OF ARRIVAL (AOA) ESTIMATION WITHIN THE MOBILE STATION BASED ON THE ANTENNA GAIN DIFFERENCE
1000

FIG. 10

METHOD AND MOBILE STATION FOR AUTONOMOUSLY DETERMINING AN ANGLE OF ARRIVAL (AOA) ESTIMATION

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communication systems, and more particularly, to a method and a mobile station for autonomously determining an angle of arrival (AOA) estimation.

BACKGROUND

[0002] Many location-based services today such as emergency service, mobile yellow pages, and navigation assistance require knowledge of the location of a mobile station prior to providing service and/or information to the mobile station. Typically, the location-based services may query for the location information of the mobile station from a base station subsystem (BSS) or a radio access network (RAN), which in turn, may directly determine the location information from the mobile station via an uplink (i.e., from the mobile station to a base station) amplitude difference-based angle of arrival estimation (AD-AOA). In particular, the base station may take signal strength measurements on at least two directional antennas to determine the bearing (i.e., AOA) from the base station to the mobile station. The difference in signal strength may represent the difference in horizontal pattern gain between the two directional antennas. By comparing the two horizontal patterns, an AOA may be obtained. Because the base station (and/or the base station controller) performs the signal measurements and determines the location of the mobile station (i.e., latitude/longitude or x, y), the mobile station may not provide its location autonomously.

[0003] One aspect of designing a wireless communication system is to optimize resources available to the wireless communication system. In particular, one method of improving the availability of resources is to reduce the number of messages exchanged between a location service provider, a mobile station, and the BSS or the RAN. However, as noted above, the mobile station is dependent on the BSS to determine its location. Therefore, a need exists for a mobile station to determine autonomously its angle of arrival (AOA).

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] This disclosure will describe several embodiments to illustrate its broad teachings. Reference is also made to the attached drawings.

[0005] **FIG. 1** is a block diagram representation of a wireless communication system.

[0006] **FIG. 2** is a block diagram representation of communication cells.

[0007] **FIG. 3** is a block diagram representation of a mobile station.

[0008] **FIGS. 4, 5, 6** and **7** are polar plot representations of antenna patterns.

[0009] **FIGS. 8 and 9** are linear plot representations of antenna patterns.

[0010] **FIG. 10** is a flow diagram illustrating a method for autonomously determining an angle of arrival (AOA) estimation of a mobile station.

DETAILED DESCRIPTION

[0011] A method and a mobile station for autonomously determining an angle of arrival (AOA) estimation are described. In a wireless communication system, a communication cell may include a plurality of sectors. The communication cell may be serviced by a base station having a plurality of antennas. Each of the plurality of antennas may provide communication services to one of the plurality of the sectors within the communication cell. A mobile station within the communication cell may automatically receive information associated with the plurality of sectors from the base station. The information associated with the plurality of sectors may include, but is not limited to, an antenna pattern, a boresight, a downtilt, and a signal strength value associated with each one of the plurality of antennas. The mobile station may receive the information associated with the plurality of sectors via a pilot signal strength measurement message or a measurement report message. Alternatively, the mobile station may request for the information associated with the plurality of sectors from the base station.

[0012] Based on the information associated with the plurality of sectors, the mobile station may determine an antenna gain difference. For example, the mobile station may calculate an effective radiated power (ERP) of a first downlink signal and a second downlink signal. The first downlink signal may be associated with a first antenna, and the second downlink signal may be associated with a second antenna. Based on the ERPs, the mobile station may calculate a signal difference between the first and second downlink signals, and normalize the first and second downlink signals. That is, the mobile station may compare the peak ERPs of the first and second downlink signals to determine the signal difference. Then, the mobile station may calibrate the peak ERPs to a given power level such as 0 dB. The mobile station may compare the ERPs between the normalized first and second downlink signals to determine the antenna gain difference. Based on the antenna gain difference, the mobile station may determine an angle of arrival (AOA) estimation within the mobile station. The AOA estimation may be a bearing that corresponds to the antenna gain difference. In particular, the AOA estimation may be a bearing along the stronger downlink signal of the first and second signals where the antenna gain difference matches the signal difference (i.e., the antenna gain difference and the signal difference are equal). For example, the first downlink signal may have a greater peak ERP than the second downlink signal. As a result, the mobile station determines the AOA estimation along first downlink signal where the antenna gain difference is equal to the signal difference.

[0013] A communication system in accordance with the present disclosure is described in terms of several preferred embodiments, and particularly, in terms of a wireless communication system operating in accordance with at least one of several standards. These standards include analog, digital or dual-mode communication system protocols such as, but not limited to, the Advanced Mobile Phone System (AMPS), the Narrowband Advanced Mobile Phone System (NAMPS), the Global System for Mobile Communications (GSM), the IS-55 Time Division Multiple Access (TDMA)

digital cellular system, the IS-95 Code Division Multiple Access (CDMA) digital cellular system, the CDMA 2000 system, the Wideband CDMA (W-CDMA) system, the Personal Communications System (PCS), the Third Generation (3G) system, the Universal Mobile Telecommunications System (UMTS) and variations and evolutions of these protocols.

[0014] A wireless communication system is a complex network of systems and elements. Typical systems and elements include (1) a radio link to mobile stations (e.g., a cellular telephone or a subscriber equipment used to access the wireless communication system), which is usually provided by at least one and typically several base stations, (2) communication links between the base stations, (3) a controller, typically one or more base station controllers or centralized base station controllers (BSC/CBSC), to control communication between and to manage the operation and interaction of the base stations, (4) a switching system, typically including a mobile switching center (MSC), to perform call processing within the system, and (5) a link to the land line, i.e., the public switch telephone network (PSTN) or the integrated services digital network (ISDN).

[0015] A base station subsystem (BSS) or a radio access network (RAN), which typically includes one or more base station controllers and a plurality of base stations, provides all of the radio-related functions. The base station controller provides all the control functions and physical links between the switching system and the base stations. The base station controller is also a high-capacity switch that provides functions such as handover, cell configuration, and control of radio frequency (RF) power levels in the base stations.

[0016] The base station handles the radio interface to the mobile station. The base station includes the radio equipment (transceivers, antennas, amplifiers, etc.) needed to service each communication cell in the system. A group of base stations may be controlled by a base station controller. Thus, the base station controller operates in conjunction with the base station as part of the base station subsystem to provide the mobile station with real-time voice, data, and multimedia services (e.g., a call).

[0017] Referring to **FIG. 1**, a wireless communication system **100** includes a communication network **110**, and a plurality of base station controllers (BSC), generally shown as **120** and **125**, servicing a total service area **130**. As is known for such systems, each BSC **120** and **125** has associated therewith a plurality of base stations (BS), generally shown as **140**, **142**, **144**, and **146**, servicing communication cells, generally shown as **150**, **152**, **154**, and **156**, within the total service area **130**. The BSCs **120** and **125**, and base stations **140**, **142**, **144**, and **146** are specified and operate in accordance with the applicable standard or standards for providing wireless communication services to mobile stations (MS), generally shown as **160**, **162**, **164**, and **166**, operating in communication cells **150**, **152**, **154**, and **156**, and each of these elements are commercially available from Motorola, Inc. of Schaumburg, Ill.

[0018] Each communication cells **150**, **152**, **154**, and **156** may be divided into sectors to optimize communication resources. Referring to **FIG. 2**, for example, the communication cell **150** may be separated into three (3) sectors **200**, generally shown as **202**, **204**, and **206**. Each of the three sectors **200** may correspond to one or more directional antennas. Typically, the directional antennas are mounted on a base station (one shown as **140**) providing communication service to the communication cell **150**. Each of the directional antennas may be aligned to a boresight and a downtilt. The boresight of an antenna is the direction in which the antenna is pointed toward (i.e., the bearing of the antenna). The downtilt of an antenna is the angle deviated from the horizon (i.e., 0°) while being directed at the boresight. The directional antenna may only receive or transmit radio waves in or from a particular direction specified by the boresight because an antenna pattern of a directional antenna is not omnidirectional (i.e., any direction). In another example, the communication cell **154** may be separated into six (6) sectors **240**, generally shown as **241**, **242**, **243**, **244**, **245**, and **246**. Persons of ordinary skill in the art will readily appreciate that the communication cells **150**, **152**, **154** and **156** may be separated into other numbers of sectors.

[0019] Referring to **FIG. 3**, a mobile station (one shown as **160** in **FIG. 1**) adapted to determine autonomously its location is shown. The mobile station **160** generally includes a controller **310**, a receiving unit **320**, and a transmitting unit **330**. The controller **310** includes a processor **350** and a memory **360**. The processor **350** is operatively coupled to the memory **360**, which stores a program or a set of operating instructions for the processor **350**. The processor **350** executes the program or the set of operating instructions such that the mobile station **160** operates as described herein. The program of the set of operating instructions may be embodied in a computer-readable medium such as, but not limited to, paper, a programmable gate array, an application specific integrated circuit (ASIC), an erasable programmable read only memory (EPROM), a read only memory (ROM), a random access memory (RAM), a magnetic media, and an optical media. The receiving unit **320** and the transmitting unit **330** are operatively coupled to the controller **310**. Persons of ordinary skill in the art will readily appreciate that the receiving unit **320** and the transmitting unit **330** may be separate components as shown in **FIG. 3** or integrated into a single component (e.g., a transceiver unit).

[0020] A basic flow for autonomously determining location of the mobile station **160** shown in **FIG. 3** may start with the mobile station **160** requesting for information associated with the plurality of sectors **200**. As noted above, each of the plurality of the sectors **200** may correspond to an antenna. The information associated with the plurality of sectors may include, but is not limited to, an antenna pattern, a boresight, a downtilt and a signal strength value associated with each antenna corresponding to the plurality of sectors **200**.

[0021] Upon receiving the information associated with the plurality of sectors, the mobile station **160** may determine a power parameter associated with each of the plurality of antennas. For example, the mobile station **160** may determine an effective radiated power (ERP) associated with each of a first sector **202** and a second sector **204** based on their respective signal strength values. Persons of ordinary skill in the art will readily appreciate that the ERPs may be compensated for gain differences of the antennas and losses from cables and connectors coupled to the antennas.

[0022] Referring to **FIG. 4**, an antenna pattern **410** (i.e., physical property of an antenna) associated with an antenna

is shown. The antenna pattern **410** may indicate the variation of field intensity of an antenna as an angular function with respect to an axis, i.e., either a horizontal or vertical plane. In particular, the antenna pattern **410** may have a reference boresight (i.e., a direction in which the antenna may be pointed) of 0°. Although the embodiments disclosed herein are particularly well suited for use with horizontal patterns, persons of ordinary skill in the art will readily appreciate that the teachings of this disclosure are in no way limited to the horizontal patterns shown in **FIGS. 4, 5, 6** and **7**. On the contrary, persons of ordinary skill in the art will readily appreciate that the teachings of this disclosure can be employed with a vertical pattern of the antenna. Depending on the desired accuracy and/or the available storage capacity, the antenna pattern **310** may be entirely digitized and stored with the mobile station **160**.

[**0023**] To reduce data storage, only a portion of the pattern **410** may need to be digitized. For example, the pattern **410** may be digitized from 90° through 0° to 270° as shown in **FIG. 5** (i.e., "front" half of the pattern **410**). Typically in a multi-sector communication cell **150**, the base stations **140** may provide full azimuthal coverage from the "front" half of three (3) or more antennas. As a result, the entire antenna pattern **410** (i.e., 360°) of each antenna may not be needed.

[**0024**] Because a typical antenna pattern is symmetrical about the 0°/180° axis, a top portion of the antenna pattern **310** may need to be stored. Referring for **FIG. 6**, the antenna pattern **310** may be symmetrical about the 0°/180° axis. That is, the top portion **510** of the antenna pattern **310** may be a mirror image of the bottom portion **520** of the antenna pattern **310**. Thus, either the top portion **510** or the bottom portion **520** of the antenna pattern **310** may be used instead of storing both top and bottom portions **510, 520** of the antenna pattern **310**.

[**0025**] Data store may be further reduced by storing a quadrant of the antenna pattern **310**. Referring to **FIG. 7**, for example, the quadrant **610** of the antenna pattern **310** may be stored because the antenna pattern **310** may be symmetrical about the 0°/180° axis, and the entire antenna pattern **310** may not be necessary (i.e., the quadrant **620** may not be necessary).

[**0026**] Based on the antenna patterns, the mobile station **160** may autonomously determine an angle of arrival (AOA) estimation by comparing ERPs between the antennas of at least two sectors in a communication cell. To illustrate the concept of determining an AOA estimation, downlink signals from antennas associated with the first sector **202** and the second sector **204** are shown in **FIGS. 8 and 9** (i.e., **FIGS. 8 and 9** are linear plots whereas **FIGS. 4-7** are polar plots). In particular, a downlink signal **802** from the antenna associated with the first sector **202** has a boresight of 160° azimuth (i.e., degrees from north) and an effective radiated power (ERP) of −80 dB, a downlink signal **804** from the antenna associated with the second sector **204** has a boresight of 230° azimuth and an ERP of −70 dB, and a downlink signal **806** from the antenna associated with the third sector **206** has a boresight of 100° and an ERP of −110 dB. As noted above, persons of ordinary skill in the art will readily appreciate that the ERPs may be compensated for gain differences of the antennas and losses from cables and connectors coupled to the antennas. Based on the ERPs, the mobile station **160** may calculate a signal difference (SD) between the peaks of the downlink signals **802, 804** associated with the antennas corresponding to the first and second sectors **202, 204**. For example, the mobile station **160** may determine a signal difference of 10 dB between the first sector **202** and the second sector **204**. With stronger peak ERPs in the downlink signals **802, 804** from the antennas associated with the first and second sectors **202, 204**, downlink signals with weaker peak ERPs such as the downlink signal **806** from the antenna associated with the third sector **206** may not be necessary to determine the AOA estimation.

[**0027**] To determine an antenna gain difference (AGD) for comparison with the signal difference, the mobile station **160** may normalize the downlink signals **802, 804** from the antennas associated with the first and second sectors **202, 204** (shown as **902** and **904**, respectively, in **FIG. 9**). For example, the peak ERPs of the normalized downlink signals **902, 904** may be calibrated to 0 dB. Based on the antenna gain difference, the mobile station **160** may determine an angle of arrival (AOA) estimation. In particular, the mobile station **160** may determine a bearing along the stronger downlink signal where the antenna gain difference matches the signal difference (i.e., where the antenna gain difference is equal to the signal difference). Following the above example, the mobile station **160** may determine that the downlink signal **804** from the antenna associated with the second sector **204** is stronger than the downlink signal **802** from the antenna associated with the first sector **202** (i.e., a peak ERP of −70 dB is greater a peak ERP of −80 dB, respectively). Accordingly, the mobile station **160** may determine where along the normalized downlink signal **904** from the antenna associated with the second sector **204** the antenna gain difference matches the signal difference calculated above. As shown in **FIG. 9**, the antenna gain difference is 10 dB along the bearing of 240° azimuth on the normalized downlink signal **904** from the antenna associated with the second sector **204**. As a result, the bearing of the mobile station **160** is 240° azimuth.

[**0028**] One possible implementation of the computer program executed by the mobile station **160** (e.g., via the processor **350**) is illustrated in **FIG. 10**. Persons of ordinary skill in the art will appreciate that the computer program can be implemented in any of many different ways utilizing any of many different programming codes stored on any of many computer-readable mediums such as a volatile or nonvolatile memory or other mass storage device (e.g., a floppy disk, a compact disc (CD), and a digital versatile disc (DVD)). Thus, although a particular order of steps is illustrated in **FIG. 10**, persons of ordinary skill in the art will appreciate that these steps can be performed in other temporal sequences. Again, the flow chart **1000** is merely provided as an example of one way to program the mobile station **160** to determine autonomously its location. The flow chart **1000** begins at step **1010**, wherein the mobile station **160** may request for information associated with a plurality of sectors from a base station. The base station may include a plurality of antennas. Each of the plurality of antennas may provide communication services to one of the plurality of sectors. In response to the request, the mobile station **160** at step **1020** may receive information associated with the plurality of sectors. In particular, the information associated with the plurality of sectors may include, but is not limited to, antenna patterns, boresights, downtilts, and signal strength values associated with the plurality of antennas. Alterna-

tively, the mobile station **160** may automatically receive the information associated with the plurality of sectors from the base station (i.e., without a request).

[**0029**] Based on the information associated with the plurality of sectors, the mobile station **160** at step **1030** may determine an antenna gain difference. For example, the mobile station **160** may calculate an effective radiated power (ERP) of a first downlink signal and a second downlink signal, the first downlink signal being associated with a first antenna and the second downlink signal being associated with a second antenna. Based on the ERPs, the mobile station **160** may calculate a signal difference (e.g., a change in dB) between the first and second downlink signals. That is, the mobile station **160** may compare the peak ERPs of the first and second downlink signals. To determine the antenna gain difference, the mobile station **160** may normalize the first and second downlink signals and compare the ERPs between the normalized first and second downlink signals.

[**0030**] At step **1040**, the mobile station **160** may determine an angle of arrival (AOA) estimation based on the antenna gain difference between the ERPs of the first and second downlink signals. The AOA estimation may be a bearing on the stronger downlink signal of the first and second downlink signals where the antenna gain difference between the first and second downlink signals corresponds to the signal difference. That is, the stronger downlink signal is the signal with a greater peak ERP before being normalized with the other signal. In **FIG. 8**, for example, the signal **804** with a peak ERP of −70 dB (i.e., **204**) is stronger than the signal **802** with a peak ERP of −80 dB (i.e., **202**). As a result, the mobile station **160** may determine the AOA estimation along the normalized version of the signal **804** (shown as **904** in **FIG. 9**) where the antenna gain difference is equal to the signal difference.

[**0031**] Although the embodiments disclosed herein are particularly well suited for use with a cellular telephone, persons of ordinary skill in the art will readily appreciate that the teachings of this disclosure are in no way limited to cellular telephones. On the contrary, persons of ordinary skill in the art will readily appreciate that the teachings of this disclosure can be employed with any wireless communication device such as, but not limited to, a pager and a personal digital assistant (PDA).

[**0032**] Many changes and modifications to the embodiments described herein could be made. The scope of some changes is discussed above. The scope of others will become apparent from the appended claims.

What is claimed is:

1. In a wireless communication system, wherein a communication cell includes a plurality of sectors, a method for autonomously determining an angle of arrival (AOA) estimation of a mobile station, the method comprising:

receiving within the mobile station information associated with the plurality of sectors from a base station having a plurality of antennas, each of the plurality of antennas providing communication services to one of the plurality of sectors in the communication cell;

determining an antenna gain difference based on the information associated with the plurality of sectors; and

determining the angle of arrival (AOA) estimation within the mobile station based on the antenna gain difference.

2. The method of claim 1, wherein the step of receiving within the mobile station information associated with the plurality of sectors from a base station having a plurality of antennas comprises receiving one of an antenna pattern, a boresight, a downtilt, and a signal strength value associated with an antenna corresponding to one of the plurality of sectors.

3. The method of claim 1, wherein the step of receiving within the mobile station information associated with one of the plurality of sectors from a base station having a plurality of antennas comprises receiving information associated with one of the plurality of sectors within the mobile station via one of a pilot signal strength measurement message and a measurement report message.

4. The method of claim 1, wherein the step of determining an antenna gain difference based on the information associated with the plurality of sectors comprises:

calculating an effective radiated power (ERP) of each of a first downlink signal and a second downlink signal, the first downlink signal being associated with a first antenna and the second downlink signal being associated with a second antenna;

calculating a signal difference between the first and second downlink signals based on the ERPs;

normalizing the first and second downlink signals based on the ERPs; and

determining the antenna gain difference between the first and second downlink signals based on the normalized first and second downlink signals and the signal difference.

5. The method of claim 1, wherein the step of determining the angle of arrival (AOA) estimation within the mobile station based on the antenna gain difference comprises determining a bearing along a first downlink signal associated with a first antenna, the first downlink signal having a greater effective radiated power relative to a second downlink signal associated with a second antenna.

6. The method of claim 1, wherein the communication system is one of a code division multiple access (CDMA) based communication system and a time division multiple access (TDMA) based communication system.

7. In a wireless communication system, wherein a communication cell includes a plurality of sectors, and wherein a mobile station configured to autonomously determine an angle of arrival (AOA) estimation, the mobile station comprising:

a receiving unit configured to receive information associated with the plurality of sectors from a base station having a plurality of antennas, each of the plurality of antennas providing communication services to one of the plurality of sectors in the communication cell; and

a controller operatively coupled to the receiving unit, the controller having a memory and a processor operatively coupled to the memory,

the controller being programmed to the controller being programmed to determine an antenna gain difference based on the information associated with the plurality of sectors, and

the controller being programmed to determine an angle of arrival (AOA) estimation based on the antenna gain difference.

8. The mobile station of claim 7, wherein the information associated with the plurality of sectors is information associated with one of an antenna pattern, a boresight, a downtilt, and a signal strength value of an antenna corresponding to one of the plurality of sectors.

9. The mobile station of claim 7, wherein the controller is configured to calculate an effective radiated power (ERP) of each of a first downlink signal and a second downlink signal, the first downlink signal being associated with a first antenna and the second downlink signal being associated with a second antenna,

the controller is configured to calculate a signal difference between the first and second downlink signals based on the ERPs,

the controller is configured to normalize the first and second downlink signals based on the ERPs, and

the controller is configured to determine the antenna gain difference between the first and second downlink signals based on the normalized first and second downlink signals and the signal difference.

10. The mobile station of claim 7, wherein the angle of arrival (AOA) estimation is a bearing along a first downlink signal associated with a first antenna, the first downlink signal having a greater effective radiated power relative to a second downlink signal associated with a second antenna.

11. The mobile station of claim 7 is operable in accordance with one of a code division multiple access (CDMA) based communication protocol, and a time division multiple access (TDMA) based communication protocol.

12. In a wireless communication system, wherein a communication cell includes a plurality of sectors, and wherein a processor operates in accordance with a computer program embodied on a computer-readable medium for autonomously determining an angle of arrival (AOA) estimation of a mobile station, the computer program comprising:

a first routine that directs the processor to receive within the mobile station information associated with the plurality of sectors from a base station having a plurality of antennas, each of the plurality of antennas providing communication services to one of the plurality of sectors in the communication cell;

a second routine that directs the processor to determine an antenna gain difference based on the information associated with the plurality of sectors; and

a third routine that directs the processor to determine an angle of arrival (AOA) estimation within the mobile station based on the antenna gain difference.

13. The computer program of claim 12, wherein the first routine comprises a routine that directs the processor to receive one of an antenna pattern, a boresight, a downtilt, and a signal strength value associated with an antenna corresponding to one of the plurality of sectors.

14. The computer program of claim 12, wherein the first routine comprises a routine that directs the processor to receive within the mobile station information associated with the plurality of sectors from a base station via one of a pilot signal strength measurement message and a measurement report message.

15. The computer program of claim 12, wherein the second routine comprises:

a routine that directs the processor to calculate an effective radiated power (ERP) of a first downlink signal and a second downlink signal, the first downlink signal being associated with a first antenna and the second downlink signal being associated with a second antenna;

a routine that directs the processor to calculate a signal difference between the first and second downlink signals based on the ERPs;

a routine that directs the processor to normalize the first and second downlink signals based on the ERPs; and

a routine that directs the processor to determine the antenna gain difference between the first and second downlink signals based on the normalized first and second downlink signals and the signal difference.

16. The computer program of claim 12, wherein the third routine comprises a routine that directs the processor to determine a bearing along a first downlink signal associated with a first antenna, the first downlink signal having a greater effective radiated power relative to a second downlink signal associated with a second antenna.

17. The computer program of claim 12, wherein the medium is one of paper, a programmable gate array, application specific integrated circuit, erasable programmable read only memory, read only memory, random access memory, magnetic media, and optical media.

18. The computer program of claim 12 is operable in accordance with one of a code division multiple access (CDMA) based communication protocol, and a time division multiple access (TDMA) based communication protocol.

19. In a wireless communication system, wherein a communication cell includes a plurality of sectors, a mobile station for autonomously determining an angle of arrival (AOA) estimation, the mobile station comprising:

a means for receiving within the mobile station information associated with the plurality of sectors from a base station having a plurality of antennas, each of the plurality of antennas providing communication service to one of the plurality of sectors in the communication cell;

a means for determining an antenna gain difference based on the information associated with the plurality of sectors; and

a means for determining an angle of arrival (AOA) estimation within the mobile station based on the antenna gain difference.

20. The mobile station of claim 19, wherein the means for determining an antenna gain difference based on the information associated with the plurality of sectors comprises:

a means for calculating an effective radiated power (ERP) of each of a first downlink signal and a second downlink signal, the first downlink signal being associated with a first antenna and the second downlink signal being associated with a second antenna;

a means for calculating a signal difference between the first and second downlink signals based on the ERPs;

a means for normalizing the first and second downlink signals based on the ERPs; and

a means for determining the antenna gain difference between the first and second downlink signals based on the normalized first and second downlink signals and the signal difference.

21. In a wireless communication system, wherein a communication cell includes a plurality of sectors, a method for autonomously determining an angle of arrival (AOA) estimation of a mobile station, the method comprising:

requesting within the mobile station information associated with the plurality of sectors from a base station having a plurality of antennas, each of the plurality of antennas providing communication service to one of the plurality of sectors in the communication cell;

receiving the requested information associated with the plurality of sectors;

determining a signal difference between a first downlink signal and a second downlink signal based on the requested information associated with the plurality of sectors, the first downlink signal being associated with a first antenna of the base station and the second downlink signal being associated with a second antenna of the base station;

normalizing the first and second downlink signals to determine an antenna gain difference between the first and second downlink signals; and

determining a bearing along the first downlink signal in which the signal difference matches the antenna gain difference, the first downlink signal having greater signal strength than the second downlink signal.

* * * * *

EXHIBIT C

US007460505B2

(12) **United States Patent**
Spain

(10) **Patent No.: US 7,460,505 B2**
(45) **Date of Patent: Dec. 2, 2008**

(54) **LOCATION ESTIMATION OF WIRELESS TERMINALS THROUGH PATTERN MATCHING OF SIGNAL-STRENGTH DIFFERENTIALS**

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(73) Assignee: **Polaris Wireless, Inc.**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1011 days.

(21) Appl. No.: **10/357,645**

(22) Filed: **Feb. 4, 2003**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H04Q 7/00 (2006.01)

(52) **U.S. Cl.** **370/332**; 370/311; 370/328; 370/331; 370/333; 370/334; 455/456.1; 455/456.2; 455/456.5; 455/456.6

(58) **Field of Classification Search** ..... None
See application file for complete search history.

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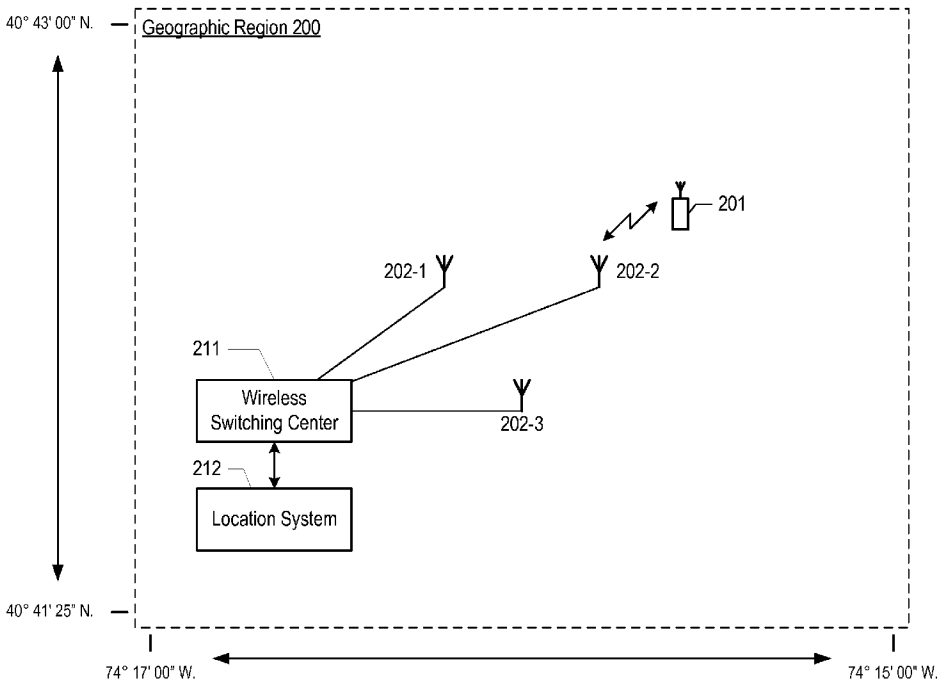
Primary Examiner—Raj K Jain
(74) *Attorney, Agent, or Firm*—DeMont & Breyer, LLC

(57) **ABSTRACT**

A method of estimating the location of a wireless terminal is disclosed that is ideally suited for use with legacy systems. The illustrative embodiment of the present invention is based on the observation that the signal strength of a signal from a transmitter is different at some locations, and, therefore, the location of a wireless terminal can be estimated by comparing the signal strength it currently observes against a map or database that correlates locations to signal strengths. For example, if a particular radio station is known to be received well at a first location and poorly at a second location, and a given wireless terminal at an unknown location is receiving the radio station poorly, it is more likely that the wireless terminal is at the second location than it is at the first location.

16 Claims, 12 Drawing Sheets



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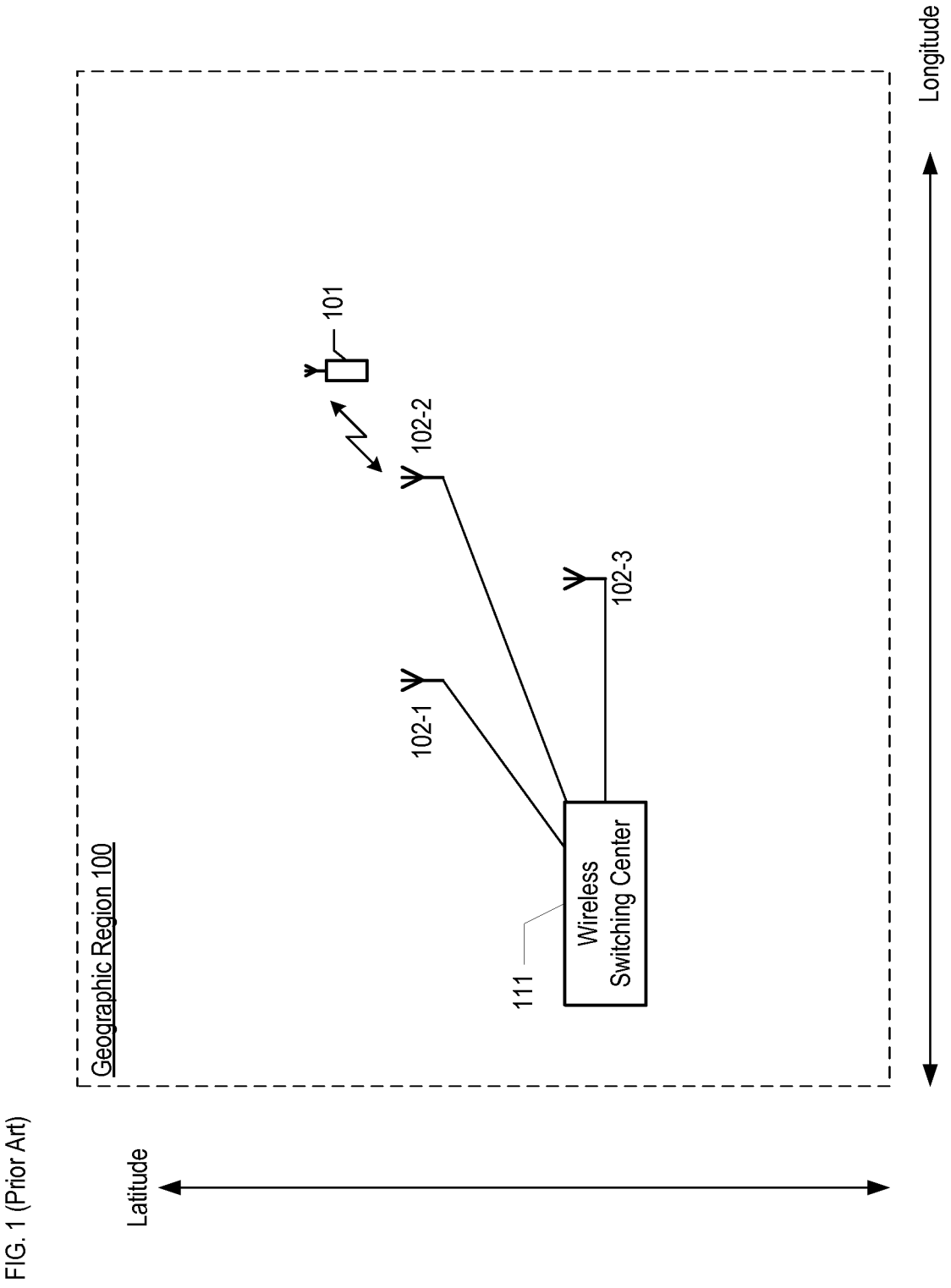

FIG. 1 (Prior Art)

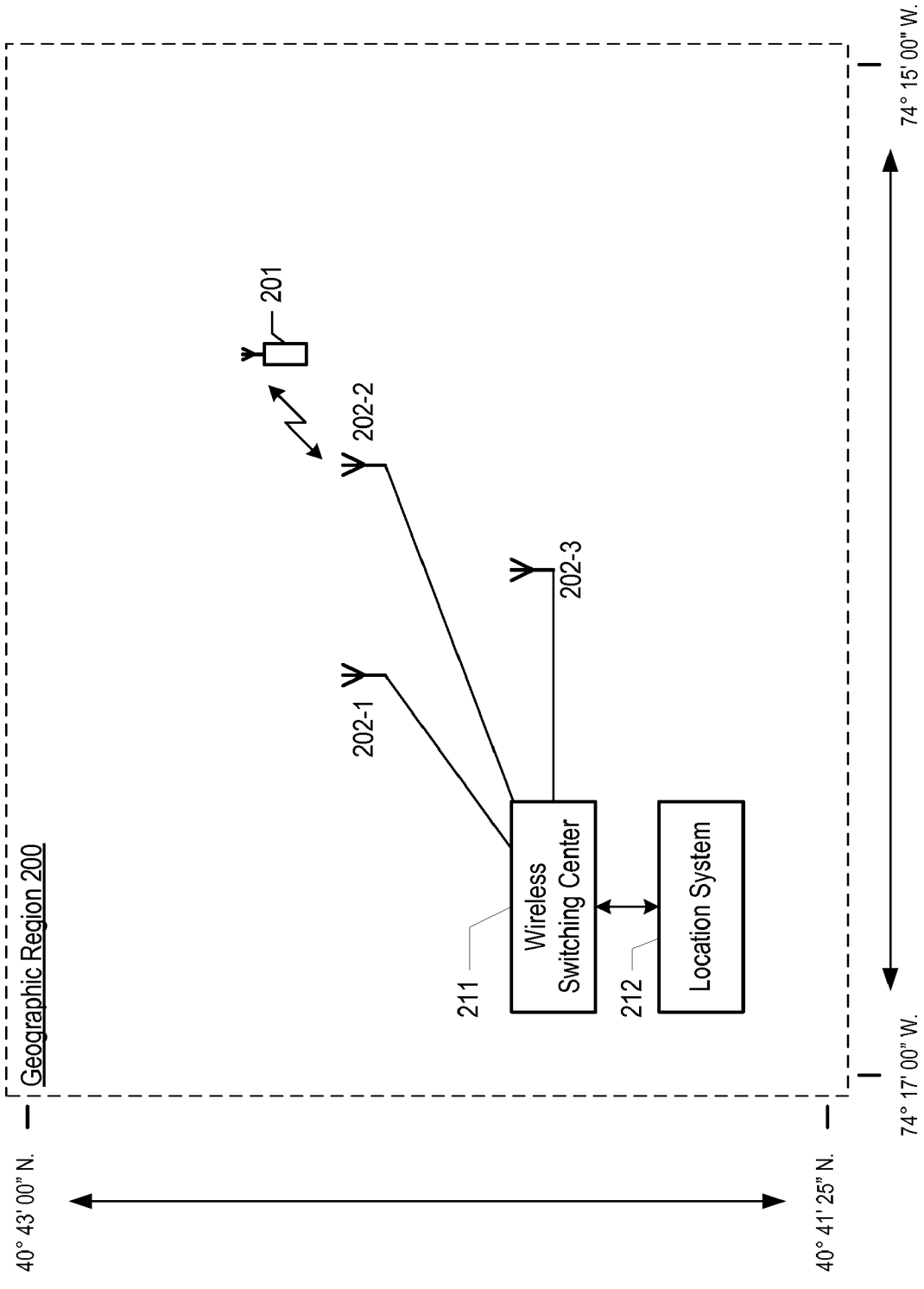
Geographic Region 200
40° 43' 00" N.
40° 41' 25" N.
74° 17' 00" W.
74° 15' 00" W.
201
202-1
202-2
202-3
Wireless Switching Center
211
Location System
212

FIG. 2

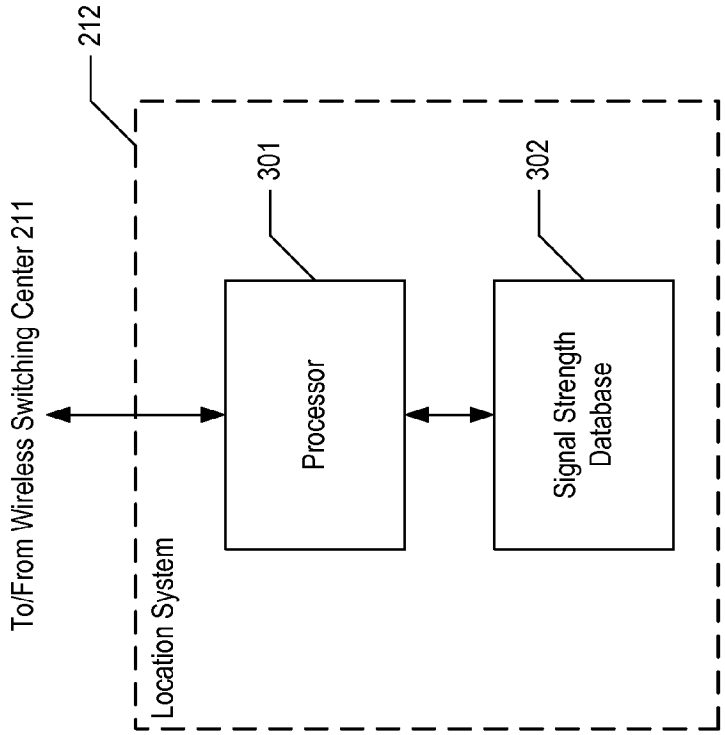
212
301
302
To/From Wireless Switching Center 211
Processor
Signal Strength Database
Location System

FIG. 3

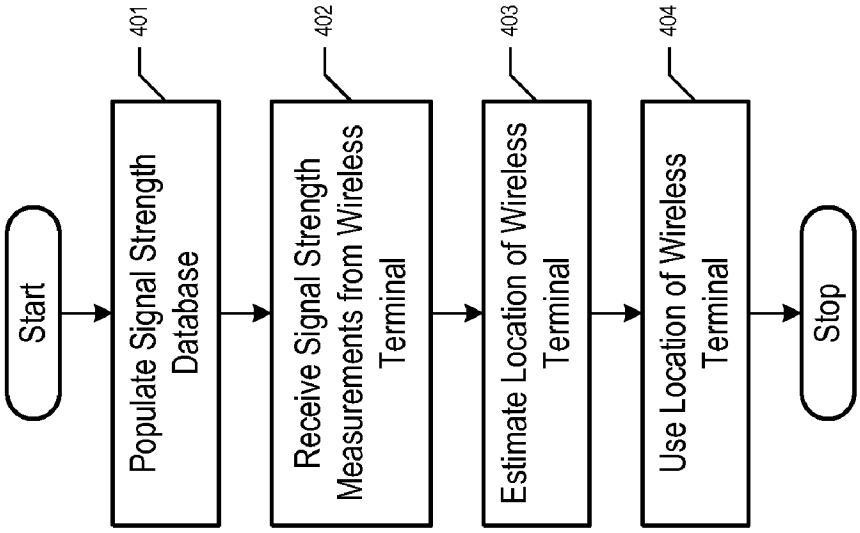
Start
401
Populate Signal Strength Database
402
Receive Signal Strength Measurements from Wireless Terminal
403
Estimate Location of Wireless Terminal
404
Use Location of Wireless Terminal
Stop

FIG. 4

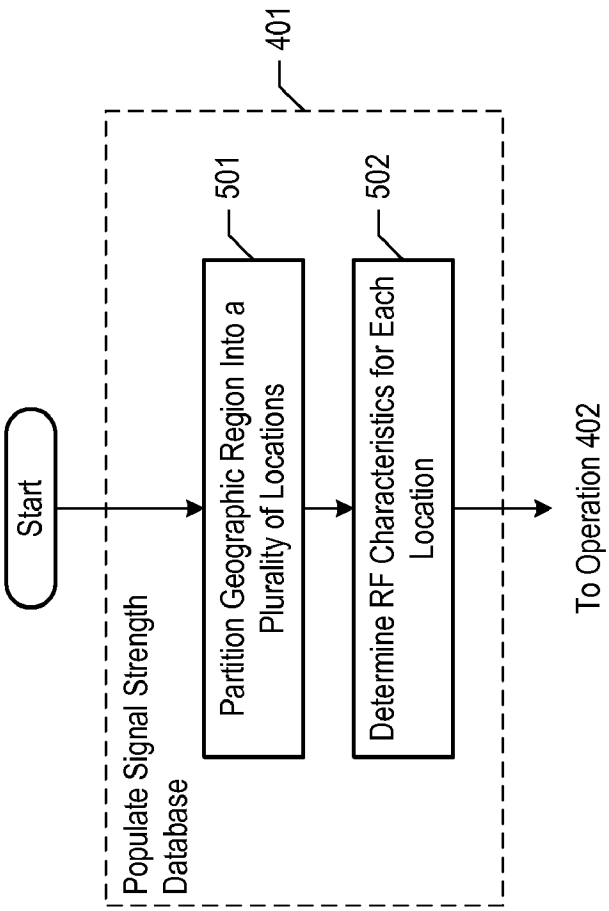
401
Start
Populate Signal Strength Database
501
Partition Geographic Region Into a Plurality of Locations
502
Determine RF Characteristics for Each Location
To Operation 402

FIG. 5

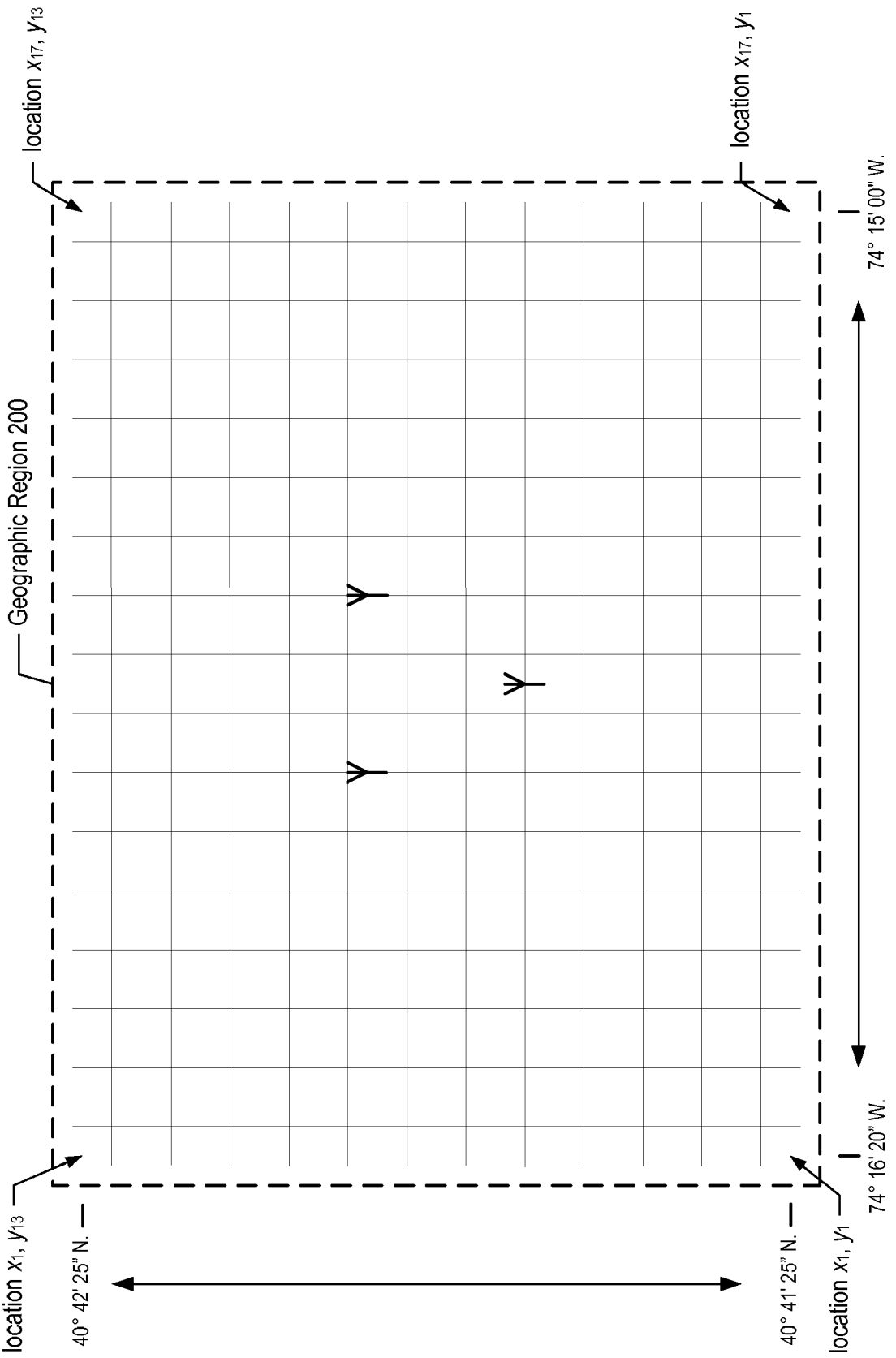
location x_{17}, y_{13}
location x_{17}, y_1
Geographic Region 200
74° 15' 00" W.
74° 16' 20" W.
location x_1, y_{13}
location x_1, y_1
40° 42' 25" N.
40° 41' 25" N.

FIG. 6

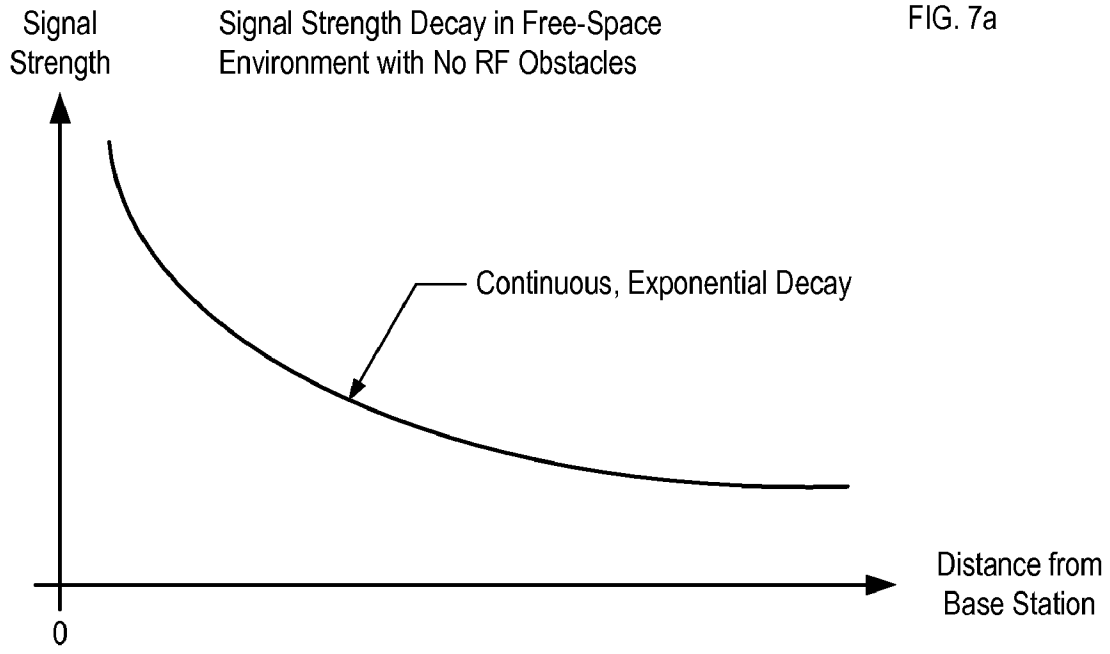
Signal Strength
Signal Strength Decay in Free-Space Environment with No RF Obstacles
Continuous, Exponential Decay
Distance from Base Station
0

FIG. 7a

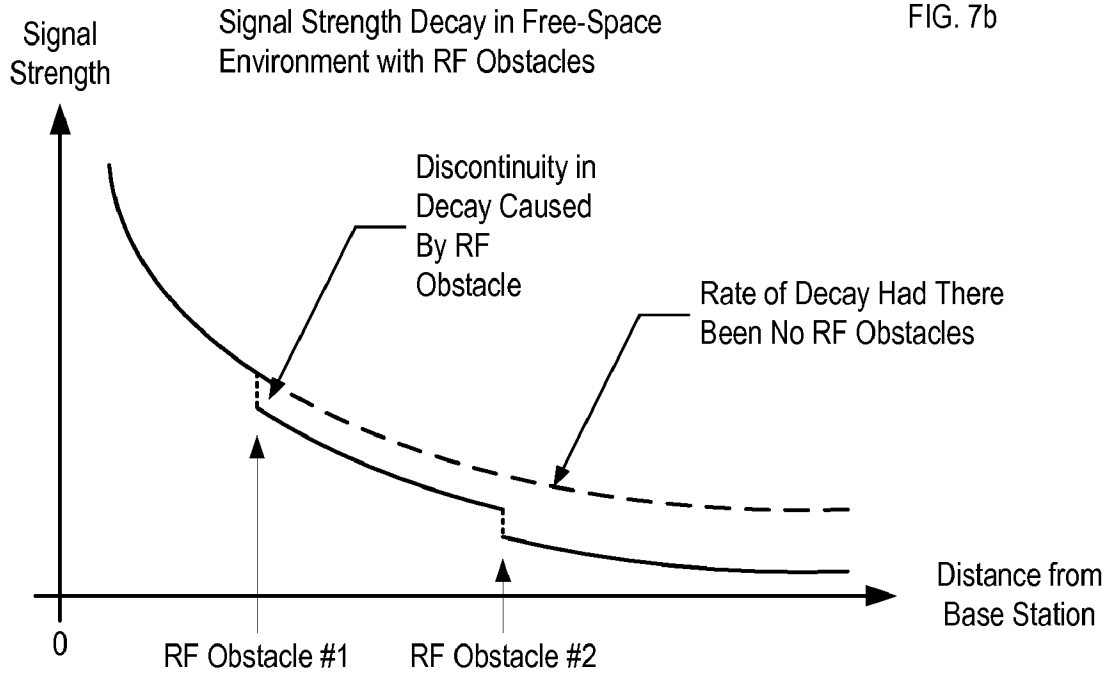
Signal Strength
Signal Strength Decay in Free-Space Environment with RF Obstacles
Discontinuity in Decay Caused By RF Obstacle
Rate of Decay Had There Been No RF Obstacles
Distance from Base Station
0
RF Obstacle #1
RF Obstacle #2

FIG. 7b

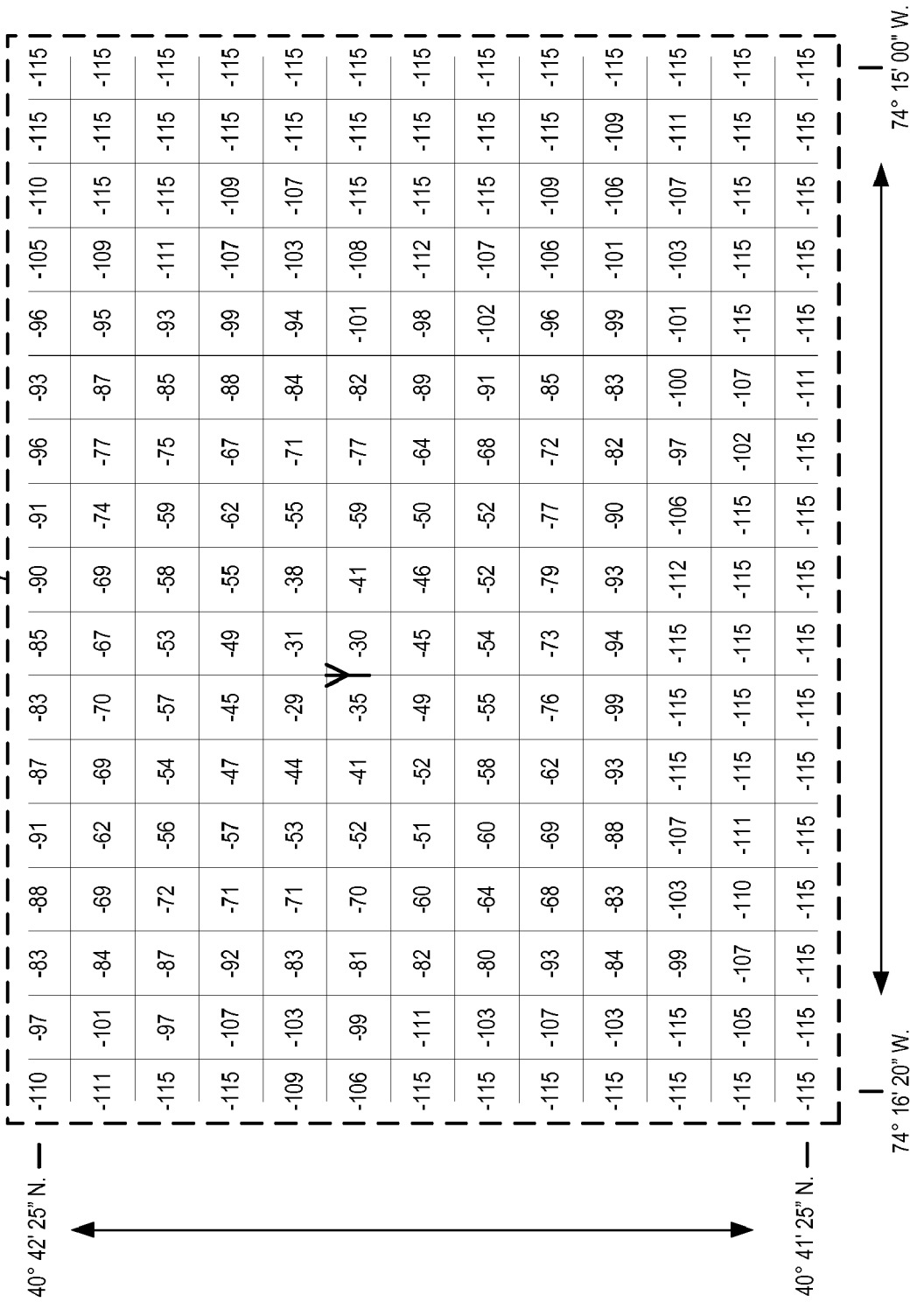
Geographic Region 200
40° 42' 25" N.
40° 41' 25" N.
74° 16' 20" W.
74° 15' 00" W.
-110 -97 -83 -88 -91 -87 -83 -85 -90 -91 -96 -93 -96 -105 -110 -115 -115
-111 -101 -84 -69 -62 -69 -70 -67 -69 -74 -77 -87 -95 -109 -115 -115 -115
-115 -97 -87 -72 -56 -54 -57 -53 -58 -59 -75 -85 -93 -111 -115 -115 -115
-115 -107 -92 -71 -57 -47 -45 -49 -55 -62 -67 -88 -99 -107 -109 -115 -115
-109 -103 -83 -71 -53 -44 -29 -31 -38 -55 -71 -84 -94 -103 -107 -115 -115
-106 -99 -81 -70 -52 -41 -35 -30 -41 -59 -77 -82 -101 -108 -115 -115 -115
-115 -111 -82 -60 -51 -52 -49 -45 -46 -50 -64 -89 -98 -112 -115 -115 -115
-115 -103 -80 -64 -60 -58 -55 -54 -52 -52 -68 -91 -102 -107 -115 -115 -115
-115 -107 -93 -68 -69 -62 -76 -73 -79 -77 -72 -85 -96 -106 -109 -115 -115
-115 -103 -84 -83 -88 -93 -99 -94 -93 -90 -82 -83 -99 -101 -106 -109 -115
-115 -115 -99 -103 -107 -115 -115 -115 -112 -106 -97 -100 -101 -103 -107 -111 -115
-115 -105 -107 -110 -111 -115 -115 -115 -115 -115 -102 -107 -115 -115 -115 -115 -115
-115 -115 -115 -115 -115 -115 -115 -115 -115 -115 -115 -111 -115 -115 -115 -115 -115

FIG. 8

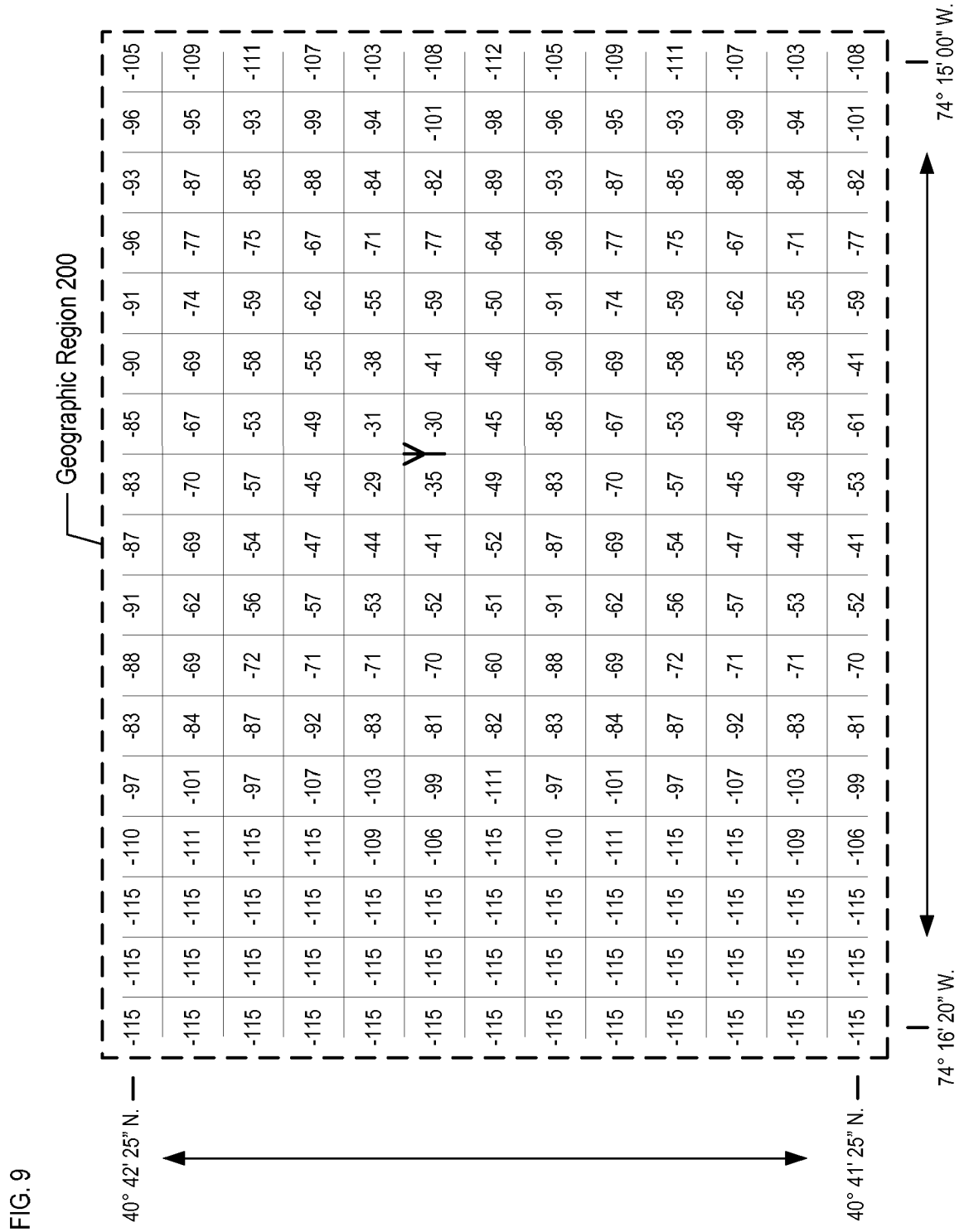

FIG. 9

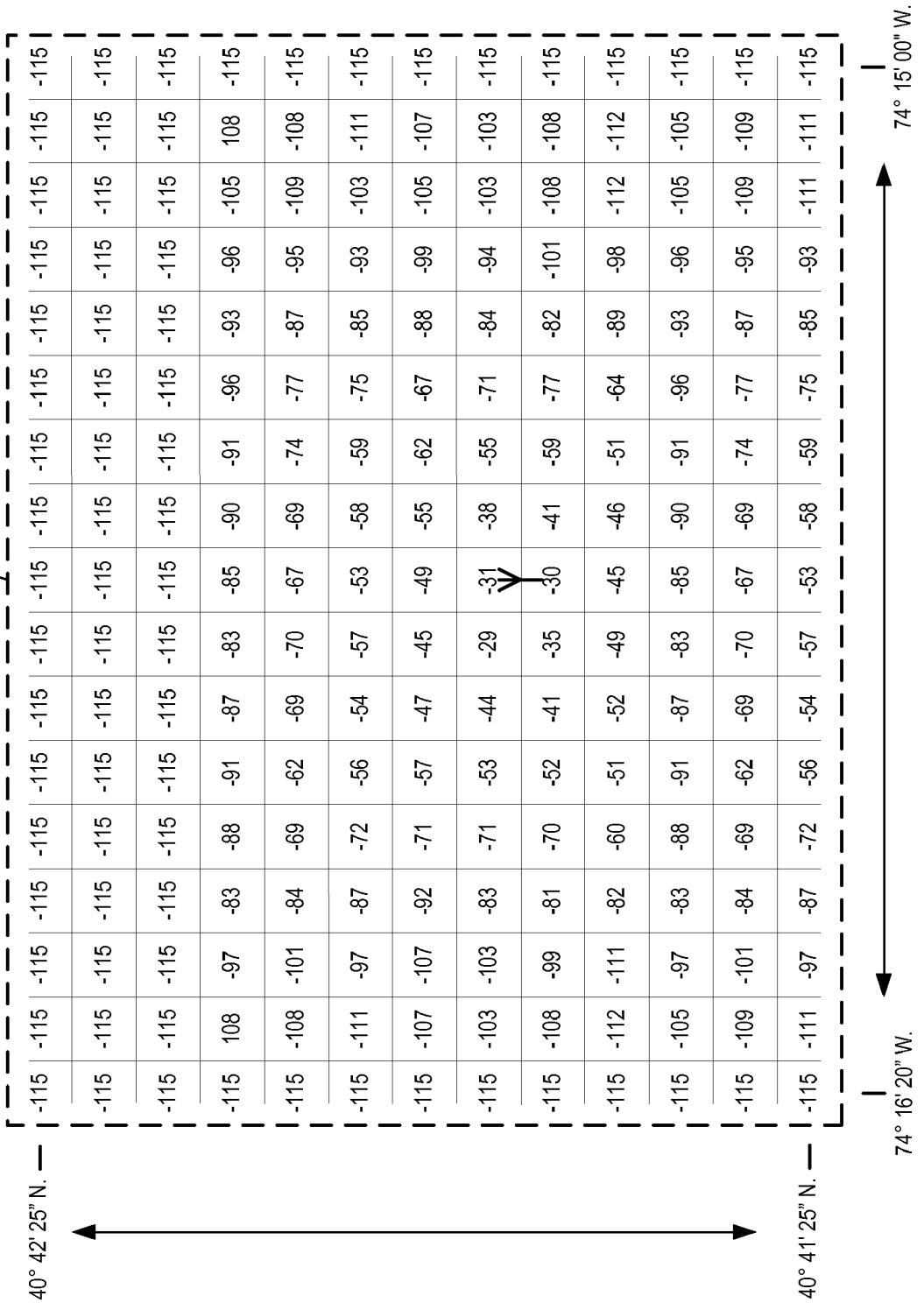

FIG. 10

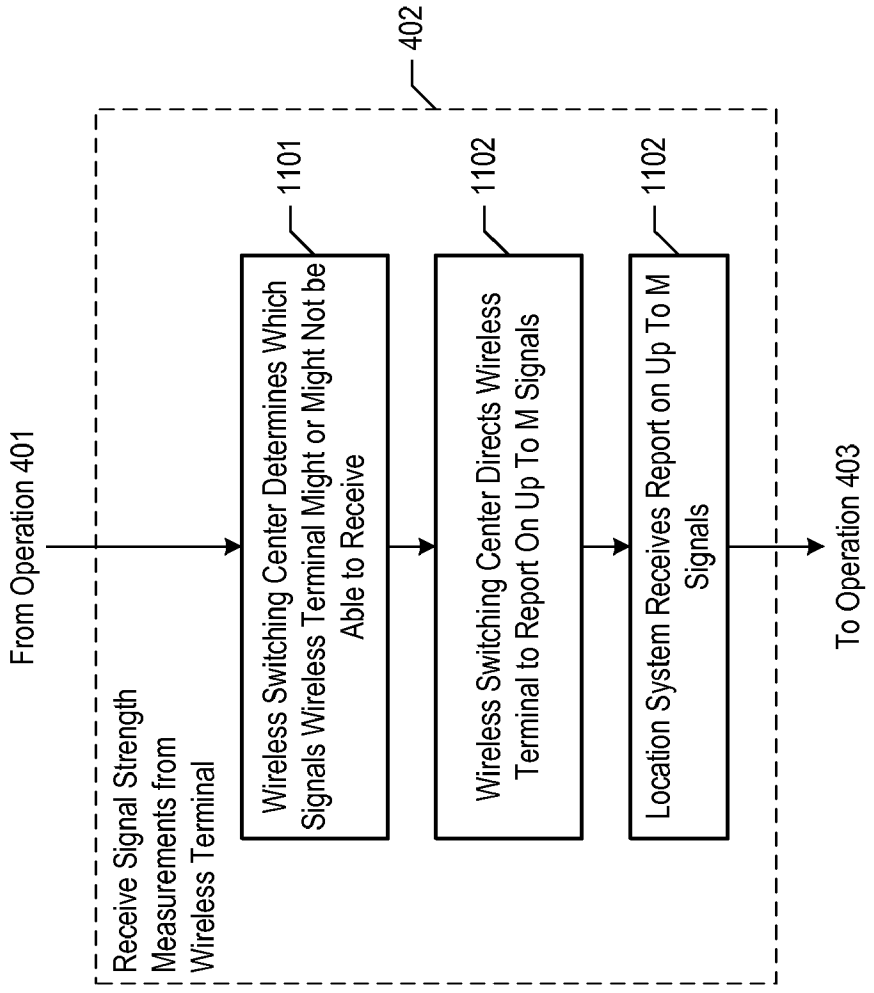
402
1101
1102
1102
From Operation 401
Receive Signal Strength Measurements from Wireless Terminal
Wireless Switching Center Determines Which Signals Wireless Terminal Might or Might Not be Able to Receive
Wireless Switching Center Directs Wireless Terminal to Report On Up To M Signals
Location System Receives Report on Up To M Signals
To Operation 403

FIG. 11

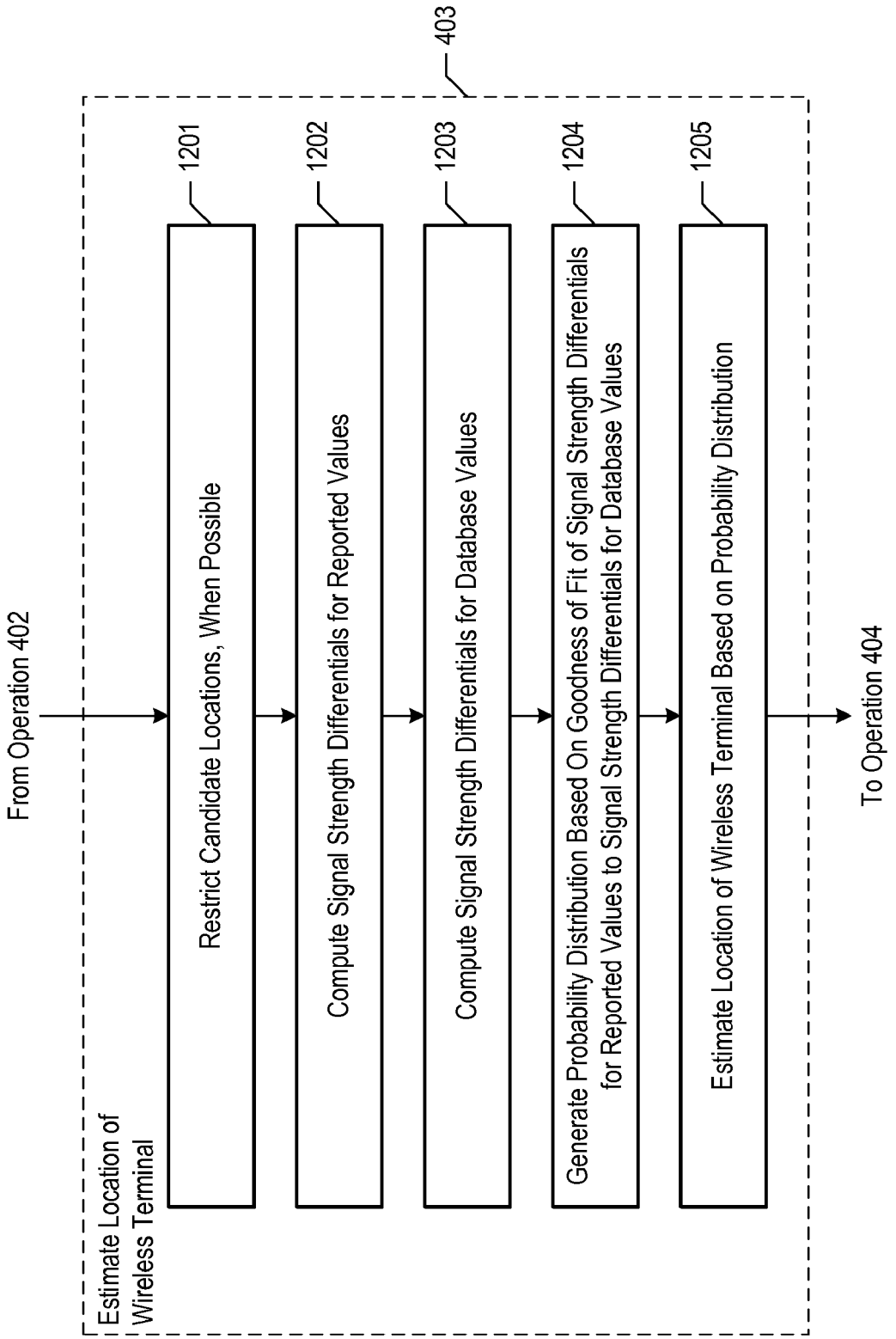
403
Estimate Location of Wireless Terminal
From Operation 402
1201
Restrict Candidate Locations, When Possible
1202
Compute Signal Strength Differentials for Reported Values
1203
Compute Signal Strength Differentials for Database Values
1204
Generate Probability Distribution Based On Goodness of Fit of Signal Strength Differentials for Reported Values to Signal Strength Differentials for Database Values
1205
Estimate Location of Wireless Terminal Based on Probability Distribution
To Operation 404

FIG. 12

LOCATION ESTIMATION OF WIRELESS TERMINALS THROUGH PATTERN MATCHING OF SIGNAL-STRENGTH DIFFERENTIALS

CROSS-REFERENCE TO RELATED APPLICATION

The underlying concepts, but not necessarily the nomenclature, of these applications are incorporated by reference:

(i) U.S. Pat. No. 6,269,246, issued 31 Jul. 2001;

(ii) U.S. patent application Ser. No. 09/532,418, filed 22 Mar. 2000;

(iii) U.S. patent application Ser. No. 10/128,128, filed 22 Apr. 2002; and

(iv) U.S. patent application Ser. No. 10/299,398, filed 18 Nov. 2002.

FIELD OF THE INVENTION

The present invention relates to telecommunications in general, and, more particularly, to a technique for estimating the location of a wireless terminal.

BACKGROUND OF THE INVENTION

FIG. **1** depicts a map of a geographic region that is serviced by a wireless telecommunications system, which system provides wireless telecommunications service to wireless terminals (e.g., wireless terminal **101**) within the region. The heart of the telecommunications system is wireless switching center **111**, which might also be known as a mobile switching center ("MSC") or a mobile telephone switching office ("MTSO").

Typically, wireless switching center **111** is connected to a plurality of base stations (e.g., base stations **102**-A through **102**-C), which are dispersed throughout the geographic area serviced by the system. As is well known to those skilled in the art, wireless switching center **111** is responsible for, among other things, establishing and maintaining calls between wireless terminals and between a wireless terminal and a wireline terminal (which is connected to the system via the local and/or long-distance networks and which are not shown in FIG. **1**).

The salient advantage of wireless telecommunications over wireline telecommunications is the mobility that is afforded to the users of the wireless telecommunications system. On the other hand, the salient disadvantage of wireless telecommunications lies in that fact that because the user is mobile, an interested party might not be able to readily ascertain the location of the user.

Such interested parties might include both the user of the wireless terminal and remote parties. There are a variety of reasons why the user of a wireless terminal might be interested in knowing his or her own location. For example, the user might be interested in telling a remote party where he or she is.

There are a variety of reasons why a remote party might be interested in knowing the location of the user. For example, the recipient of a 911 emergency call from a wireless terminal might be interested in knowing the location of the wireless terminal so that emergency services vehicles can be dispatched to that location.

There are many techniques in the prior art for estimating the location of a wireless terminal.

In accordance with one technique, the location of a wireless terminal is estimated to be at the center of the cell in which the wireless terminal is located. This technique is advantageous in that it does not require that additional hardware be added to the wireless terminal or to the wireless telecommunications system, and this means that the first technique can be inexpensively implemented in legacy systems. The first technique is only accurate, however, to a few kilometers, and, therefore, it is generally not acceptable for applications (e.g., emergency services dispatch, etc.) that require higher accuracy.

In accordance with a second technique, the location of a wireless terminal is estimated by triangulating the angle of arrival or the time of arrival of the signals transmitted by the wireless terminal to be located at various receivers. This technique is accurate to within a few hundreds of meters and is advantageous in that it can be used with legacy wireless terminals. It is disadvantageous, however, in that it generally requires that hardware be added to the telecommunication system's base stations, and this is very expensive.

In accordance with a third technique, the location of a wireless terminal is estimated by a radio navigation unit, such as a Global Positioning System receiver, that is incorporated into the wireless terminal. This technique is accurate to within tens of meters and is advantageous in that it does not require that additional hardware be added to the telecommunication system's infrastructure. The third technique is disadvantageous, however, in that it cannot be used with legacy wireless terminals that do not comprise a radio navigation unit.

Therefore, the need exists for a technique for estimating the location of a wireless terminal with higher resolution than the first technique and that can be inexpensively implemented in legacy systems.

SUMMARY OF THE INVENTION

The present invention enables the estimation of the location of a wireless terminal without the addition of hardware to either the wireless terminal or to the telecommunication system's base stations. Some embodiments of the present invention are, therefore, ideally suited for use with legacy systems.

The illustrative embodiment of the present invention is based on the observation that the signal strength of a signal from a transmitter is different at some locations, and, therefore, the location of a wireless terminal can be estimated by comparing the signal strength it currently observes against a map or database that correlates locations to signal strengths. For example, if a particular radio station is known to be received well at a first location and poorly at a second location, and a given wireless terminal at an unknown location is receiving the radio station poorly, it is more likely that the wireless terminal is at the second location than it is at the first location.

When this same principal is applied to multiple transmitters and multiple signals, the location of a wireless terminal can be discriminated among locations where the signal strength of one signal is the same. A simple example illustrates this point. A first radio station, Radio Station A, can be received well at Location 1 and Location 2, but poorly at Location 3 and Location 4, and a second radio station, Radio Station B, can be received well at Location 1 and Location 3, but poorly at Location 2 and Location 4. This information is summarized in the table below and forms the basis for a map or database that correlates location to signal strength.

TABLE 1

Illustrative Signal Strength Database (Absolute Reception)

	Radio Station A	Radio Station B
Location 1	Good Reception	Good Reception
Location 2	Good Reception	Poor Reception
Location 3	Poor Reception	Good Reception
Location 4	Poor Reception	Poor Reception

If a given wireless terminal at an unknown location can receive Radio Station A poorly and Radio Station B well, it is more likely that the wireless terminal is at Location 3 than it is at either Location 1, 2, or 4.

Furthermore, the location of a wireless terminal can be estimated with a more-than-acceptable degree of accuracy when the signal strength of each signal at each location is quantified. For example, if a particular radio station is known to be received in one location with a strength of −50 dBm, at a second location with a strength of −53 dBm, and at a third location with a strength of −55 dBm, then the reception of the signal with a strength of −56 dBm suggests that the wireless terminal is more likely at the third location than at either the first or second location.

These principals largely assume, however, that the equipment used to measure the signal strength of the signals is uniformly calibrated, and this, unfortunately, is not always the case is the real world. Many factors, including the make and model of a wireless terminal, the condition of its antenna, the state of its battery, and whether the terminal is inside a vehicle or not can introduce measurement biases that can cause errors in estimating the location of a wireless terminal.

The illustrative embodiment ameliorates the effects of these biases by pattern matching not the observed signal strengths to the predicted signal strengths themselves, but by pattern matching the pair-wise differentials of the observed signals strengths to the pair-wise differentials of the predicted signal strengths. A simple example illustrates this nuance. A first radio station, Radio Station A, can be received at −56 dBm at Location 1, −42 dBm at Location 2, −63 dBm at Location 3, and −61 dBm at Location 4, and a second radio station, Radio Station B, can be received at −63 dBm at Location 1, −56 dBm at Location 2, −65 dBm at Location 3, and −52 dBm at Location 4. This information is summarized in the table below and forms the basis for a map or database that correlates location to signal strength.

TABLE 2

Illustrative Signal Strength Database (Differential Reception)

	Radio Station A	Radio Station B	Difference
Location 1	−56 dBm	−63 dBm	−7 dBm
Location 2	−42 dBm	−56 dBm	−14 dBm
Location 3	−63 dBm	−65 dBm	−2 dBm
Location 4	−61 dBm	−52 dBm	9 dBm

If a given wireless terminal with a broken antenna and at an unknown location receives Radio Station A at −47 dBm and Radio Station B at −61 dBm, then it registers Radio Station A as 14 dBm stronger than Radio Station B. This suggests that the wireless terminal is more likely to be at Location 2 than it is at Location 1, 3, or 4.

A disadvantage of this approach is that the common bias is eliminated at the expense of (1) doubling the variance of the random measurement noise, and (b) by reducing the number of data points to match by one. Furthermore, the pair-wise subtraction introduces correlation into the relative signal strength measurement errors (i.e., all of the data points to be matched are statistically correlated). This correlation must be accounted for in calculating the likelihood of the measurement report.

The illustrative embodiment comprises: receiving a first signal-strength measurement for a first signal at the wireless terminal and a second signal-strength measurement for a second signal at the wireless terminal; and estimating the location of the wireless terminal based on the difference of the first signal-strength measurement minus the second signal-strength measurement.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a map of a portion of a wireless telecommunications system in the prior art.

FIG. **2** depicts a map of the illustrative embodiment of the present invention.

FIG. **3** depicts a block diagram of the salient components of location system **212**.

FIG. **4** depicts a broad overview of the salient operations performed by the illustrative embodiment in ascertaining the location of wireless terminal **201** in geographic region **200**.

FIG. **5** depicts a flowchart of the salient operations performed in operation **401**.

FIG. **6** depicts a map of how geographic region **200** is partitioned into 500 locations in accordance with the illustrative embodiment of the present invention.

FIG. **7***a* depicts a graph that shows that the signal-strength of an electromagnetic signal decreases, in general, as a function of the distance from the transmitter and in an environment with no radio frequency obstacles.

FIG. **7***b* depicts a graph that shows that the signal-strength of an electromagnetic signal decreases, in general, as a function of the distance from the transmitter and in an environment with two radio frequency obstacles.

FIG. **8** depicts a map of the signal-strength measurements of the signal radiated from base station **202-1** at each location in geographic region **200**.

FIG. **9** depicts a map of the signal-strength measurements of the signal radiated from base station **202-2** at each location in geographic region **200**.

FIG. **10** depicts a map of the signal-strength measurements of the signal radiated from base station **202-3** at each location in geographic region **200**.

FIG. **11** depicts a flowchart of the salient operations performed in operation

FIG. **12** depicts a flowchart of the salient operations performed in operation **403**.

DETAILED DESCRIPTION

FIG. **2** depicts a map of the illustrative embodiment of the present invention, which comprises: wireless switching center **211**, location system **212**, base stations **202-1**, **202-2**, and **202-3**, and wireless terminal **201**, which are interconnected as shown. The illustrative embodiment provides wireless telecommunications service to most of geographic region **200**, in well-known fashion, and is also capable of estimating the location of wireless terminal **201** within geographic region **200**.

The illustrative embodiment operates in accordance with the Global System for Mobile Communications (formerly known as the Groupe Speciale Mobile), which is ubiquitously

known as "GSM." After reading this disclosure, however, it will be clear to those skilled in the art how to make and use embodiments of the present invention that operate in accordance with other protocols, such as the Universal Mobile Telephone System ("UMTS"), CDMA-2000, and IS-136 TDMA.

Wireless switching center **211** is a switching center as is well-known to those skilled in the art in most respects but is different in that it is capable of communicating with location system **212** in the manner described below. After reading this disclosure, it will be clear to those skilled in the art how to make and use wireless switching center **211**.

Base stations **202-1**, **202-2**, and **202-3** are well-known to those skilled in the art and communicate with wireless switching center **211** through cables and other equipment (e.g., base station controllers, etc.) that are not shown in FIG. **2**. Although the illustrative embodiment comprises three base stations, it will be clear to those skilled in the art how to make and use embodiments of the present invention that comprise any number of base stations.

Wireless terminal **201** is a standard GSM wireless terminal, as is currently manufactured and used throughout the world. Wireless terminal **201** is equipped, in well-known fashion, with the hardware and software necessary to measure and report to wireless switching center **211** on the signal-strength of the control and traffic channels from base stations **202-1**, **202-2**, and **202-3**.

A GSM wireless terminal, such as wireless terminal **201**, is capable of reporting the signal strength of a signal as one of 64 levels between −47 dBm and −110 dBm. Any signal stronger than −47 dBm is reported as −47 dBm, and any signal weaker than −110 dBm is reported as −110 dBm.

In accordance with the illustrative embodiment of the present invention all of the specific portions of the radio frequency spectrum fall within the same band that wireless terminal **201** uses to communicate with base stations **202-1**, **202-2**, and **202-3**. In some alternative embodiments of the present invention, however, some or all of the specific portions of the radio frequency spectrum are outside the band that wireless terminal **201** uses to communicate with base stations **202-1**, **202-2**, and **202-3**. In any case, it will be clear to those skilled in the art how to make and use wireless terminal **201**.

Location system **212** is a computer system that is capable of estimating the location of wireless terminal **201**, as described in detail below. Although the illustrative embodiment depicts location system **212** as estimating the location of only one wireless terminal, it will be clear to those skilled in the art that location system **212** is capable of estimating the location of any number of wireless terminals serviced by wireless switching center **211**.

Although location system **212** is depicted in FIG. **2** as a distinct entity from wireless switching center **211**, this is done principally to highlight the distinction between the functions performed by wireless switching center **211** and the functions performed by location system **212**. In other words, it will be clear to those skilled in the art how to make and use embodiments of the present invention in which location system **212** resides within or without wireless switching center **211**.

Although—again for pedagogical purposes—wireless switching center **211**, location system **212**, and base stations **202-1**, **202-2**, and **202-3** are depicted in FIG. **2** as being within geographic region **200**, this is not necessarily so, and it will be clear to those skilled in the art how to make and use embodiments of the present invention in which some or all of these pieces of equipment are not within the region of location estimation.

FIG. **3** depicts a block diagram of the salient components of location system **212**, which comprises: processor **301** and signal-strength database **302**, which are interconnected as shown.

Processor **301** is a general-purpose processor as is well-known in the art that is capable of performing the operations described below and with respect to FIG. **4**.

Signal-strength database **302** is a non-volatile memory that stores signal-strength measurements as described below and with respect to FIG. **4**.

Overview—FIG. **4** depicts a broad overview of the salient operations performed by the illustrative embodiment in ascertaining the location of wireless terminal **201** in geographic region **200**. In summary, the tasks performed by the illustrative embodiment can be grouped for ease of understanding into four operations:

i. the population of signal-strength database **302**,
ii. the receipt of signal-strength measurements from wireless terminal **201**,
iii. the estimation of the location of wireless terminal **201**, and
iv. the use of the estimated location of wireless terminal **201**.

The details of each of these operations are described briefly below and in detail afterwards with respect to FIG. **5** though **12**.

At operation **401**, signal-strength database **302** is populated with data that associates each location within geographic region **200** with a tuple of signal-strength measurements for that location. Operation **401** is generally complex and potentially expensive, and it is, therefore, preferably performed only occasionally. The details of operation **401** are described in detail below and with respect to FIG. **5**.

At operation **402**, location system **212** receives a tuple of signal-strength measurements from wireless terminal **201**. In accordance with the illustrative embodiment, wireless terminal **201** periodically or sporadically provides a tuple of signal-strength measurements to wireless switching center **211** in well-known fashion, and the measurements are forwarded to location system **212**. The details of operation **402** are described in detail below and with respect to FIG. **11**.

At operation **403**, location system **212** estimates the location of wireless terminal **201** based on:

(i) the tuple of signal-strength measurements received in operation **402**, and
(ii) the tuples of signal-strength measurements within signal-strength database **302**.

The details of operation **403** are described in detail below and with respect to FIG. **12**.

At operation **404**, location system **212** transmits the location estimated in operation **403** to an entity (not shown) for use in an application. It is well known to those skilled in the art how to use the estimated location of a wireless terminal in an application.

At this point, each of these four operations is described in detail.

Population of Signal-Strength Database **302**—FIG. **5** depicts a flowchart of the salient operations performed in operation **401**.

At task **501**, geographic region **200** is partitioned into a plurality of tessallated locations. Geographic region **200** is rectangular and comprises 5,525 square arc-seconds, which

near the equator equals almost 5 square kilometers. After reading this specification, it will be clear to those skilled in the art how to make and use embodiments of the present invention that operate with geographic regions of any size and shape.

In accordance with the illustrative embodiment of the present invention, geographic region **200** is partitioned into a grid of 221 square locations that are designated location x_1, y_1 through location x_{17}, y_{13}. The number of locations into which geographic location **200** is partitioned is arbitrary, subject to the considerations described below. In accordance with the illustrative embodiment, each location is an area of approximately 5 arc-seconds in length by 5 arc-seconds in height. Five arc-seconds near the equator equals approximately 150 meters.

The size of the locations defines the highest resolution with which the illustrative embodiment can locate a wireless terminal. In other words, the illustrative embodiment can only estimate the location of a wireless terminal to within one location (i.e., 5 by 5 arc-seconds in the illustrative embodiment). If greater resolution is desired, for example 1 arc-second resolution, then geographic region **200** would need to be partitioned into 1 arc-second by 1 arc-second locations. If geographic region **200** were partitioned into 1 arc-second by 1 arc-second locations, there would be 5,525 squares, which is considerably more than the 221 used in the illustrative embodiment. Although the ostensibly higher resolution of 1 arc-second versus 5 arc-seconds is advantageous, there are considerable disadvantages to a large number of locations.

The number of locations to partition geographic region **200** into is based on three factors. First, as the size of each location goes down, the resolution of the embodiment increases. Second, as the size of each location goes down, the number of locations in a region increases, and, consequently, the computational complexity of operation **403** increases quickly. Third, each location must be large enough so that it has (at least slightly) different signal-strength characteristics than its adjacent areas. This is because the illustrative embodiment might—but won't necessarily—have difficulty distinguishing between adjacent location that have the same signal-strength characteristics. It will be clear to those skilled in the art how to consider these three factors when deciding how to partition a geographic region.

At task **502**, the signal-strength measurements for a signal from each base station are determined at each location in geographic region. In accordance with the illustrative embodiment, the signal used from each base station is the control channel because it is broadcast at a constant power and because wireless terminal **201** can distinguish it from every other control channel, if it can decode its BSIC (for GSM networks).

Because there are three base stations in the illustrative embodiment, each with one control channel, a tuple of three signal-strength measurements at each location must be determined.

In general, the signal-strength of an electromagnetic signal decreases as a function of the distance from the transmitter, as is depicted in FIG. **7***a*, but the topography of the region and the presence of buildings, trees, and other radio-frequency obstacles severely alters this generalization, as is depicted in FIG. **7***b*.

In accordance with the illustrative embodiment, the tuple of three signal-strength measurements for each location are determined through a combination of:

(i) a theoretical radio-frequency propagation model, and

(ii) empirical signal-strength measurements.

It will be clear to those skilled in the art how to accomplish this.

For example, one well-known modeling for outdoor radio-frequency signal propagation is adapted from the power-law decay model. The power-law decay model assumes that the base station's antenna is high above the ground and that there is line-of-sight propagation to the wireless terminal. In this case, the mean signal-strength, P, received at the wireless terminal decays in inverse proportion to the square of the distance from the transmitter,

$$P \propto \frac{1}{r^2}, \qquad \text{(Eq. 1)}$$

up to some break-point. Beyond that breakpoint, the mean power at the wireless terminal decays in inverse proportion to the fourth power of the distance from the transmitter:

$$P \propto \frac{1}{r^4} \qquad \text{(Eq. 2)}$$

The location of the break-point is determined through empirical signal-strength measurements as the location at which the ground bounce signal interferes with the line-of-sight signal.

In accordance with another well-known model, the signal-strength measurements at each location are determined by taking empirical measurements at various locations and by interpolating for the locations in between the sampled locations. This method is advantageous in that it does not require many empirical measurements to be made, but it is less accurate than taking measurements at every location.

It will be clear to those skilled in the art how to determine the signal-strength measurements for each location in the geographic region whether through:

(i) theoretical radio-frequency propagation models, or

(ii) empirical signal-strength measurements, or

(iii) any combination of i and ii.

In accordance with the illustrative embodiment, FIG. **8** depicts the signal-strength of the signal from base station **202-1** (hereinafter referred to as "Signal **1**") at each location in geographic region **200**. In general, Signal **1** is stronger near base station **202-1** and weaker far away from base station **202-1**.

In accordance with the illustrative embodiment, FIG. **9** depicts the signal-strength of the signal from base station **202-2** (hereinafter referred to as "Signal **2**") at each location in geographic region **200**. Like Signal **1**, Signal **2** is stronger near base station **202-2** and weaker far away from base station **202-2**.

In accordance with the illustrative embodiment, FIG. **10** depicts the signal-strength of the signal from base station **202-3** (hereinafter referred to as "Signal **3**") at each location in geographic region **200**. Like Signals **1** and **2**, Signal **3** is stronger near base station **202-3** and weaker far away from base station **202-3**.

When the signal-strength tuples for each location in geographic region **200** have been determined, they are stored in signal-strength database in a data structure that associates each location with the tuple for that location. The data structure is then stored in signal-strength database **302**.

TABLE 3

Signal-Strength Database			
	Signal-Strength Tuple		
Location	Strength of Signal 1	Strength of Signal 2	Strength of Signal 3
x_1, y_1	−115	−115	−115
x_2, y_1	−115	−115	−111
. . .	. . .	. . .	. . .
X_7, y_7	−45	−51	−49
X_8, y_7	−46	−52	−55
X_9, y_7	−50	−49	−62
. . .	. . .	. . .	. . .
X_{16}, y_{13}	−115	−96	−115
X_{17}, y_{13}	−115	−105	−115

Table 3 depicts a portion of an illustrative data structure for associating each location with the signal-strength tuple for that location.

The three signal-strength measurements in a row of table 1 constitute a "tuple" or non-empty set of ordered elements. For example, the signal-strength tuple at Location x_7, y_7 are the 3-tuple {−45, −51, −49}. In general, the illustrative embodiment of the present invention estimates the location of a wireless terminal by pattern matching the signal-strength measurements by the wireless terminal at a location against the signal-strength tuples in signal-strength database **302**. This process is described in detail below and with respect to operation **402**.

From task **502**, control passes to operation **402** in FIG. **4**.

Receipt of Signal-Strength Measurements from Wireless Terminal **201**—FIG. **11** depicts a flowchart of the salient operations performed in operation **402**

At task **1101**, wireless switching center **211** determines, in well-known fashion, which signals wireless terminal **201** might or might not be able to receive. In accordance with the illustrative embodiment, wireless switching center **211** determines that wireless terminal **201** might be able to receive Signal **1**, Signal **2**, and Signal **3**.

At task **1102**, wireless switching center **211** directs wireless terminal **201**, in well-known fashion, to attempt to receive the signals it might be able to receive and to report back a signal-strength value for the strongest (up to) 3 signals that wireless terminal **201** is able to receive and distinguish. In accordance with the illustrative embodiment, wireless switching center **211** directs wireless terminal **211** to monitor Signal **1**, Signal **2**, and Signal **3** and to report on all of these signals.

At task **1103**, location system **212** receives, via wireless switching center **211**, a report from wireless terminal **201** on the signals that it was directed to monitor in task **602**.

As described above, wireless terminal **201** is incapable of reporting a signal whose signal-strength is equal to −46 dBm or higher, and, therefore, when wireless terminal **201** attempts to report a signal whose signal-strength is −46 dBm or higher, wireless terminal **201** simply reports a signal-strength value of −47 dBm for that signal. The significance of this insight is that a reported signal-strength value of −47 dBm might not accurately reflect the magnitude of that signal's strength at that location. To further illustrate the significance of this insight and its effect on the design of the illustrative embodiment, this specification shall describe in detail how two different signal-strength reports are processed by the illustrative embodiment. In accordance with the first report, the signal-strength of all three signals is low enough so that wireless terminal **201** can report the actual strength of the signals. In accordance with the first report, Signal **1**=−98, Signal **2**=−64, and Signal **3**=−51. In accordance with the second report, Signal **1**=−98, Signal **2**=−64, and Signal **3**=−50. How these two types of reports are handled is described below and with respect to FIG. **12**.

It will be clear to those skilled in the art how to make and use embodiments of the present invention that perform operation **402**. From task **603**, control passes to operation **403** in FIG. **4**.

Estimation of the Location of Wireless Terminal **201**—FIG. **12** depicts a flowchart of the salient operations performed in operation **403**. For pedagogical purposes, operation **403** as depicted in FIG. **12** is described three times. First, operation **403** is described in the abstract with a focus on describing its underlying theory. Next, operation **403** is described as it is applied to the first report, and finally, operation **403** is described as it is applied to the second report.

Estimation in General—Task **1201** begins with 211 (17× 13=211) candidate locations that must be considered as the location for wireless terminal **201**, and, therefore, 211 signal-strength tuples (i.e., the 211 tuples in signal-strength database **302**) that must be processed. Tasks **1202** through **1205** can be computationally intense, and the computational burden increases with the number of candidate locations that must be considered. Therefore, location system **212** attempts, at task **1201**, to reduce the number of candidate locations that must be processed in tasks **1202** through **1205**.

To reduce the number of candidate locations that must be processed in tasks **1202** through **1205**, location system **212** uses the following observation. When a signal is reported with a maximum signal-strength (i.e., "−47" in the illustrative embodiment), location system **212** can reasonably eliminate from consideration as a candidate location every location where the signal-strength measurement for that signal is below the maximum (minus a factor for measurement errors and systematic bias). In other words, when a signal is reported with a maximum signal-strength, location system **212** can restrict consideration in tasks **1202** through **1205** to those candidate locations where signal-strength database **302** predicts the signal-strength to be greater than or equal to the maximum reportable value (minus a factor for measurement errors and systematic bias). In accordance with the illustrative embodiment, the factor for measurement errors and systematic bias is 3 dBm, and, therefore when a signal is reported with −47, location system **212** can restrict consideration in tasks **1202** through **1205** to those candidate locations where signal-strength database **302** predicts the signal-strength to be greater than or equal to −50 dBm. It will be clear to those skilled in the art how to determine and use other factors for measurement errors and systemic bias.

At task **1202**, location system **212** computes the signal-strength differentials for those reported values that are not at the maximum signal-strength. In particular, for n reported signals that are not at the maximum signal-strength, n−1 signal-strength differentials are computed where:

$$\Delta S_k = S_k - S_1 \quad \text{(Eq. 1)}$$

for k=2, 3, . . . n, wherein ΔS_k is the kth signal-strength differential, S_k is the reported signal-strength of Signal k, and S_1 is the reported signal-strength of Signal **1**. When m of the reported signals is at the maximum signal-strength (i.e., −47 dBm), then

$$n-m-1 \quad \text{(Eq. 2)}$$

pair-wise differentials for the remaining n−m signals are computed, in well-known fashion. At the end of task **1202**,

location system **212** will have computed n−m−1 pair-wise differentials, ΔS_2 through ΔS_{n-m}.

At task **1203**, location system **212** computes the signal-strength differentials for only those locations that were not eliminated from consideration in task **1201**. Furthermore, location system **212** only computes the signal-strength differentials corresponding to the differentials computed in task **1202**; the idea, of course, being to ensure that "apples are compared with apples." In particular, for n reported signals that are not at the maximum signal-strength, n−1 signal-strength differentials are computed where:

$$\Delta R_{k,x,y}=R_{k,x,y}-R_{1,x,y} \quad \text{(Eq. 3)}$$

for k=2, 3, . . . n, wherein $\Delta R_{k,x,y}$ is the kth signal-strength differential for location x,y, $R_{k,x,y}$ is the signal-strength of Signal k at location x,y in signal-strength database **302**, and $R_{1,x,y}$ is the reported signal-strength of Signal **1** at location x,y in signal-strength database **302**.

At the end of task **1203**, location system **212** will have computed n−m−**1** pair-wise differentials, $\Delta R_{2,x,y}$ through $\Delta R_{n-m,x,y}$, corresponding to the pair-wise differentials computed in task **1203**, for all the candidate locations.

At task **1204**, location system **212** compares the signal-strength differentials computed in task **1202**, ΔS_2 through ΔS_{n-m}, to the signal-strength differentials in task **1203**, $\Delta R_{2,x,y}$ through $\Delta R_{n-m,x,y}$, to generate a probability distribution that indicates the goodness of fit between the signal-strength differentials computed from the values received in operation **402** to the signal-strength differentials computed from the tuples in signal-strength database **302**. To accomplish this, the Euclidean norm at each of the i candidate locations is computed for the signal-strength differentials computed from the values received in operation **402** and each of the signal-strength differentials computed from the tuples in signal-strength database **302**. This is described in Equation 4.

$$v_{x,y}=\sqrt{\sum_{2}^{n}(\Delta R_{k,x,y}-\Delta S_k)^2} \quad \text{(Eq. 4)}$$

wherein $v_{x,y}$ is the Euclidean norm between the signal-strength tuple for location x,y in signal-strength database **302** in comparison to the signal-strength differentials computed from the values received in operation **402**.

Next, the Euclidean norms computed in Equation 4 are turned into un-normalized probabilities by Equation 5:

$$p_{x,y}=e^{\frac{-v_{x,y}^2}{\tau^2}} \quad \text{(Eq. 5)}$$

where τ^2 represents the amount of uncertainty in both ΔS_k and $\Delta R_{k,x,y}$.

And finally, the values of $P_{x,y}$ are normalized to generate the probability distribution for the location of wireless terminal **201** in geographic region **200**.

At task **1205**, location system **212** estimates the location of wireless terminal **201** based on the probability distribution generated in task **1204**. In accordance with the illustrative embodiment, location system **212** estimates the location of wireless terminal based on the geometric mean of the probability distribution generated in task **1204**. After reading this specification, however, it will be clear to those skilled in the art how to make and use embodiments of the present invention that estimate the location of wireless terminal **201** based on another function of the probability distribution generated in task **1204**, such as the maximum likelihood function.

From task **1205**, control passes to operation **404** in FIG. **4**.

Estimation as Applied to First Report (Signal **1**=−98, Signal **2**=−64, and Signal **3**=−51)—At task **1201**, location system **212** cannot eliminate any candidate locations from consideration based on the fact that none of the reported signals is at the maximum reportable value minus the factor for measurement errors and systematic bias (i.e., 3 dBm). In other words, location system **212** cannot eliminate any candidate signal from consideration because all of the signals are at −51 dBm or less. Therefore, location system **212** must consider all 221 candidate locations in tasks **1202** through **1205**.

At task **1202**, location system **212** computes two (2) signal-strength differentials for the first report in which R_1=Signal **1**=−98, R_2=Signal **2**=−64, and R_3 Signal **3**=−43. In particular, ΔR_2 and ΔR_3 are computed as depicted in Table 4.

TABLE 4

Signal-strength Differentials for Signal 1 = −98, Signal 2 = −64, and Signal 3 = −43

k	ΔR_k	$R_k - R_1$
2	34	−64 − (−98)
3	47	−51 − (−98)

At task **1203**, location system **212** computes two (2) signal-strength differentials for each of the 221 locations in signal-strength database **302**, as depicted in Table 5.

TABLE 5

Signal-strength Differentials for Each Tuple in Signal-Strength Database 302

Location	$\Delta S_{2,x,y}$	$\Delta S_{3,x,y}$
x1, y1	−110 − (−110) = 0	−110 − (−110) = 0
x2, y1	−110 − (−110) = 0	−111 − (−110) = −1
x3, y1	−110 − (−110) = 0	−97 − (−110) = 3
. . .	. . .	. . .
x16, y13	−96 − (−110) = 14	−110 − (−110) = 0
x17, y13	−105 − (−110) = 5	−110 − (−110) = 0

At task **1204**, location system **212** first computes the Euclidean norm between the signal-strength differentials in Table 2 against the signal-strength differentials for each location in Table 3 to produce the norms shown in Table 6.

TABLE 6

Euclidean Norms for Each Location (First Report)

Location	Vx, y
x1, y1	64.66
x2, y1	63.81
x3, y1	62.13
. . .	. . .
x16, y13	58.52
x17, y13	62.18

Next, the Euclidean norms in Table 6 are converted to unnormalized probabilities, as described above, and then the unnormalized probabilities are normalized, in well-known

fashion, to produce the probability distribution of the location of wireless terminal **201** at each of the 211 locations in geographic region **200**.

Estimation As Applied to Second Report (Signal **1**=−98, Signal **2**=−64, and Signal **3**=−50)—At task **1201**, location system **212** can perfunctorily eliminate most of the candidate locations from consideration because the reported signal-strength of one of the reported signals—Signal **3**=−50 dBm—is greater than the maximum reported value (−47 dBm) minus the factor for measurement errors and systematic bias (3 dBm). In other words, location system **212** can eliminate from consideration any candidate location in which S_3 is not at least −50 dBm. Therefore, location system **212** can restrict consideration in tasks **1202** through **1205** to those locations in signal-strength database **302** in which Signal **3** is predicted to be −50 dBm or greater. As can be seen in FIG. **10**, there are only 14 locations (x8, y4; x9, y4; x10, y4; x7, y5; x8, y5; x9, y5; x10, y5; x7, y6; x8, y6; x9, y6; x10, y6; x7, y7; x8, y7; x9, y7) at which Signal **3** is predicted to be −50 dBm or stronger, and, therefore, location system **212** need only perform tasks **1202** through **1205**, in the above-described fashion, on those **14** locations. By reducing the number of candidate locations that need to be processed from 221 to 14, task **1201** has greatly reduced the computational complexity of operation **403**.

It is to be understood that the above-described embodiments are merely illustrative of the present invention and that many variations of the above-described embodiments can be devised by those skilled in the art without departing from the scope of the invention. It is therefore intended that such variations be included within the scope of the following claims and their equivalents.

What is claimed is:

1. A method for estimating a location of a wireless terminal, said method comprising: receiving a first signal-strength measurement for a first signal, a second signal-strength measurement for a second signal, and a third signal-strength measurement for a third signal, wherein said first signal, said second signal and said third signal are processed by said wireless terminal; and estimating the location of said wireless terminal based on (i) the difference between said first signal-strength measurement and said second signal-strength measurement, and (ii) the difference between said first signal-strength measurement and said third signal-strength measurement.

2. The method of claim **1** wherein said first signal-strength measurement and said second signal-strength measurement are made at substantially the same time and at substantially the same location.

3. The method of claim **1** wherein the task of estimating the location of said wireless terminal comprises generating a probability distribution for the location of said wireless terminal based on the difference between said first signal-strength measurement and said second signal-strength measurement.

4. The method of claim **1** wherein said first signal-strength measurement and said third signal-strength measurement are made at substantially the same time and at substantially the same location.

5. The method of claim **1** wherein said third signal-strength measurement is at the maximum reportable value, and

wherein the task of estimating the location of said wireless terminal comprises restricting candidate locations to those where said third signal-strength measurement is expected to be at least equal to the maximum reportable value.

6. The method of claim **1** wherein said first signal is transmitted by a first transmitter at a first location and said second signal is transmitted by a second transmitter at a second location, wherein said first location is different than said second location.

7. The method of claim **1** wherein the task of estimating the location of said wireless terminal is performed at a location server.

8. A method for estimating a location of a wireless terminal, said method comprising: receiving a first signal-strength measurement for a first signal, a second signal-strength measurement for a second signal, and a third signal-strength measurement for a third signal, wherein said first signal, said second signal and said third signal are processed by said wireless terminal; and estimating the location of said wireless terminal by pattern matching (i) the difference between said first signal-strength measurement and said second signal-strength measurement and (ii) the difference between said first signal-strength measurement and said third signal-strength measurement against a signal-strength database that associates location with tuples of first signal-strength measurements, second signal-strength measurements, and third signal-strength measurements.

9. The method of claim **8** wherein said first signal-strength measurement and said second signal-strength measurement are made at substantially the same time and at substantially the same location.

10. The method of claim **8** wherein the task of estimating the location of said wireless terminal comprises generating a probability distribution for the location of said wireless terminal is based on the difference between said first signal-strength measurement and said second signal-strength measurement.

11. The method of claim **8** wherein said first signal-strength measurement and said third signal-strength measurement are made at substantially the same time and at substantially the same location.

12. The method of claim **8** wherein said third signal-strength measurement is at the maximum reportable value, and

wherein the task of estimating the location of said wireless terminal comprises restricting candidate locations to those where said third signal-strength measurement is expected to be at least equal to the maximum reportable value.

13. The method of claim **8** wherein said first signal is transmitted by a first transmitter at a first location and said second signal is transmitted by a second transmitter at a second location, wherein said first location is different than said second location.

14. The method of claim **8** wherein the task of estimating the location of said wireless terminal is performed at a location server.

15. A method for estimating a location of a wireless terminal, said method comprising: receiving a first signal-strength measurement for a first signal and a second signal-strength measurement for a second signal, wherein said first signal and said second signal are processed by said wireless terminal; and

estimating the location of said wireless terminal based on the difference between said first signal-strength measurement and said second signal-strength measurement;

wherein said first signal-strength measurement is at the maximum reportable value, and wherein the task of estimating the location of said wireless terminal comprises restricting candidate locations to those where said first signal-strength measurement is expected to be at least equal to the maximum reportable value.

16. The method of claim 15 wherein said task of estimating comprises:

pattern matching the difference between said first signal-strength measurement and said second signal-strength measurement against a signal-strength database that associates location with tuples of first signal-strength measurements and second signal-strength measurements.

* * * * *

EXHIBIT D

US007433695B2

(12) **United States Patent**
Gordon et al.

(10) **Patent No.: US 7,433,695 B2**
(45) **Date of Patent: Oct. 7, 2008**

(54) **COMPUTATIONALLY-EFFICIENT ESTIMATION OF THE LOCATION OF A WIRELESS TERMINAL BASED ON PATTERN MATCHING**

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(73) Assignee: **Polaris Wireless, Inc.**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/419,652**

(22) Filed: **May 22, 2006**

(65) **Prior Publication Data**

US 2006/0240844 A1 Oct. 26, 2006

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/194,151, filed on Aug. 1, 2005, which is a continuation of application No. 10/299,398, filed on Nov. 18, 2002, now Pat. No. 6,944,465.

(60) Provisional application No. 60/757,066, filed on Jan. 6, 2006.

(51) **Int. Cl.**
H04Q 7/20 (2006.01)

(52) **U.S. Cl.** **455/456.1**; 455/404.2; 455/456.2; 455/456.6; 455/457; 455/421

(58) **Field of Classification Search** 455/456.1, 455/404.2, 456.2, 456.3, 456.5, 456.6, 457
See application file for complete search history.

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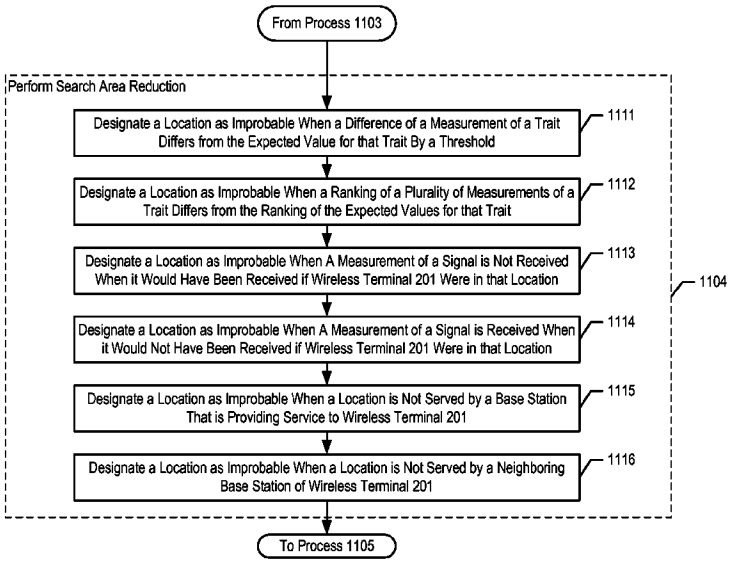
Primary Examiner—Duc Nguyen
Assistant Examiner—Huy Phan
(74) *Attorney, Agent, or Firm*—DeMont & Breyer LLC

(57) **ABSTRACT**

A method of using a non-GPS-derived technique to estimate the location of an Assisted-GPS-enabled wireless terminal for the purposes of generating location-specific assistance data for the wireless terminal is disclosed. The wireless terminal then uses the assistance data to acquire and process one or more GPS signals and to derive information that is probative of the wireless terminal's location. The GPS-derived location information is then combined with non-GPS-derived location to form an estimate of the location of the wireless terminal that is better than can be derived from either alone. This combination of GPS-derived and non-GPS techniques is particularly useful when the wireless terminal can only acquire one or two GPS signals because it is not possible to determine the location of the wireless terminal with only two GPS signals alone.

9 Claims, 32 Drawing Sheets



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J. Jimenez et al., "Mobile Location Using Coverage Information: Theoretical Analysis and Results," EURO-COST, Apr. 1999, pp. 1-9.

H. Koshima et al., "Personal Locator Services Emerge," IEEE Spectrum, Feb. 2000, pp. 41-48.

PCT International Search Report and Written Opinion of the International Searching Authority for International Application No. PCT/US2006/029513, mailed Nov. 20, 2006.

Dr. Heiko Schmitz, et al., A New Method for Positioning of Mobile Users by Comparing a Time Series of Measured Reception Power Levels with Predictions, IEEE, 0-7803-7757-5/03, pp. 1993-1997, 2003.

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Figure 1 (Prior Art)

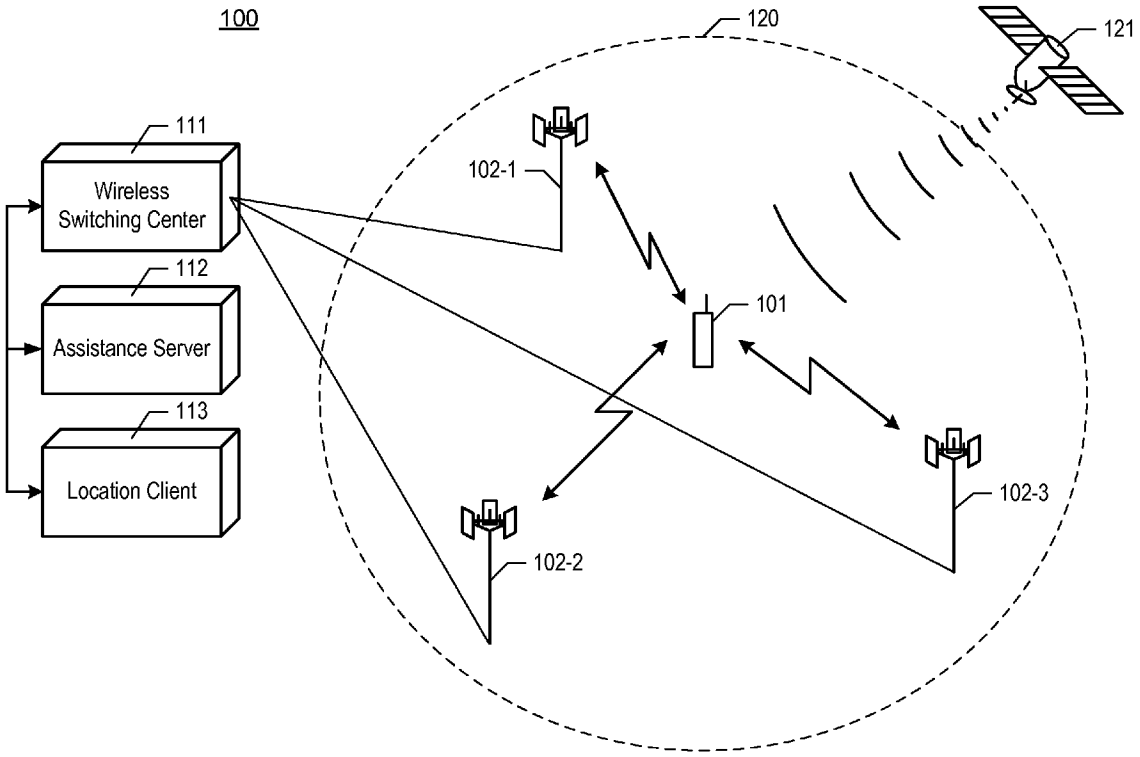


Figure 2

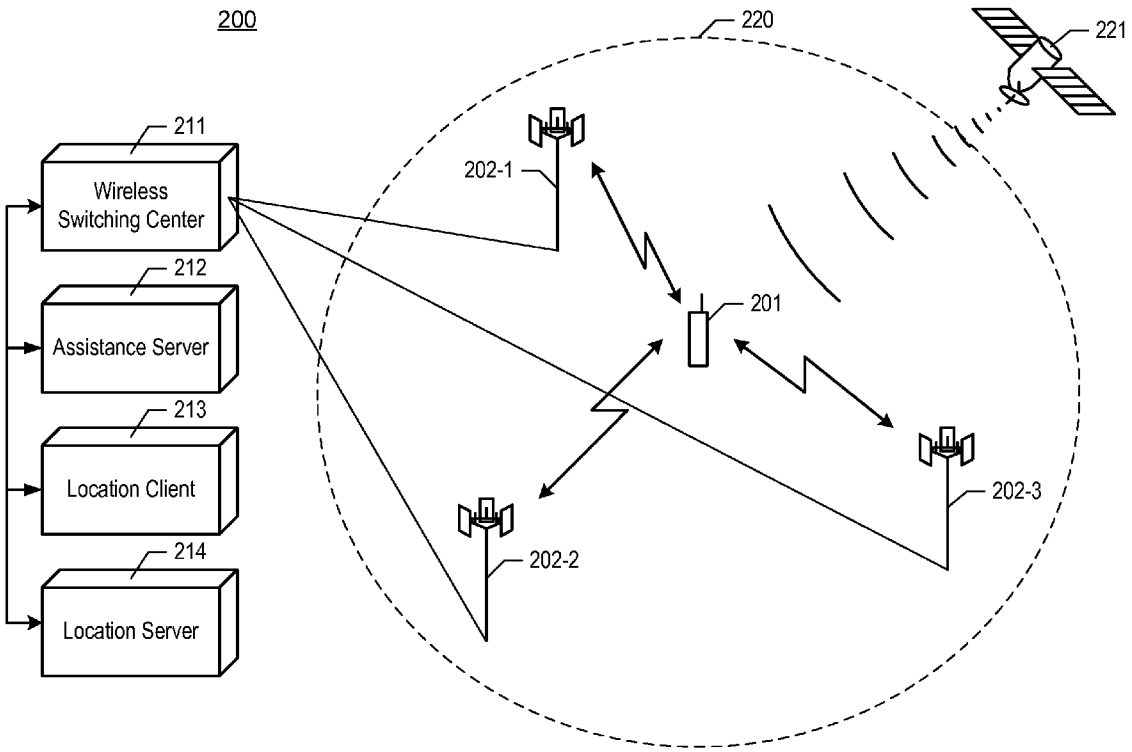

200
220
221
211
Wireless Switching Center
212
Assistance Server
213
Location Client
214
Location Server
202-1
201
202-2
202-3

Figure 3

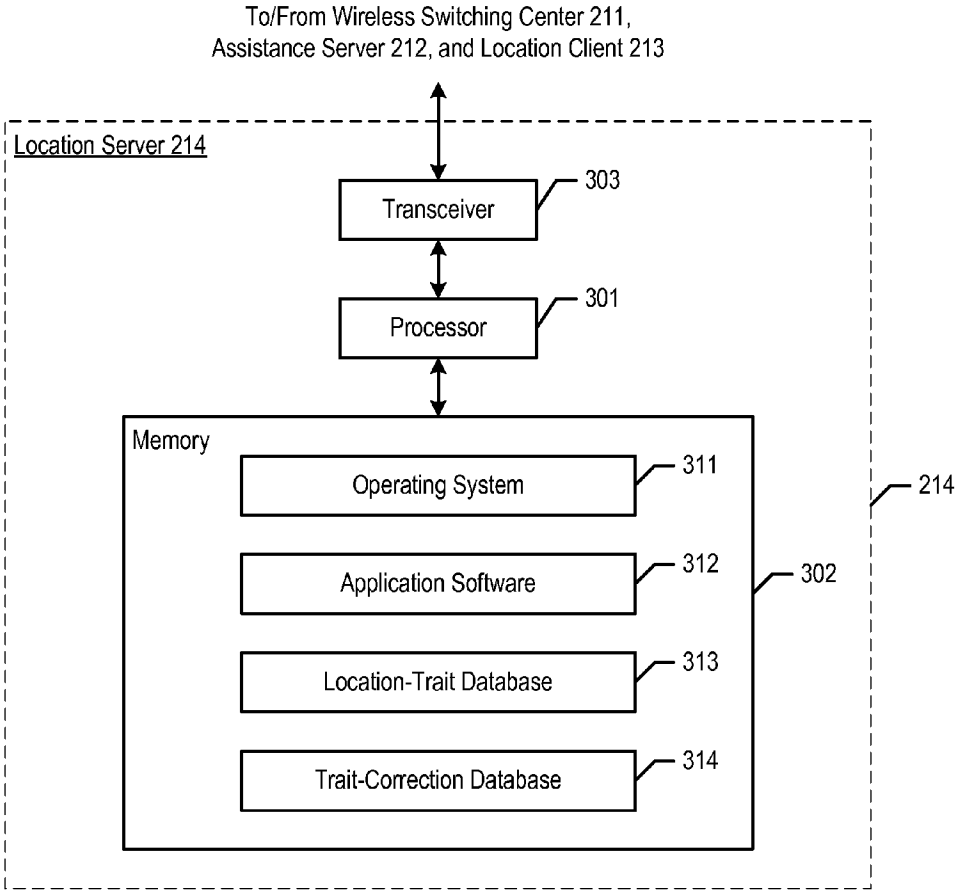

To/From Wireless Switching Center 211,
Assistance Server 212, and Location Client 213
Location Server 214
Transceiver
303
Processor
301
Memory
Operating System
311
Application Software
312
Location-Trait Database
313
Trait-Correction Database
314
302
214

Figure 4

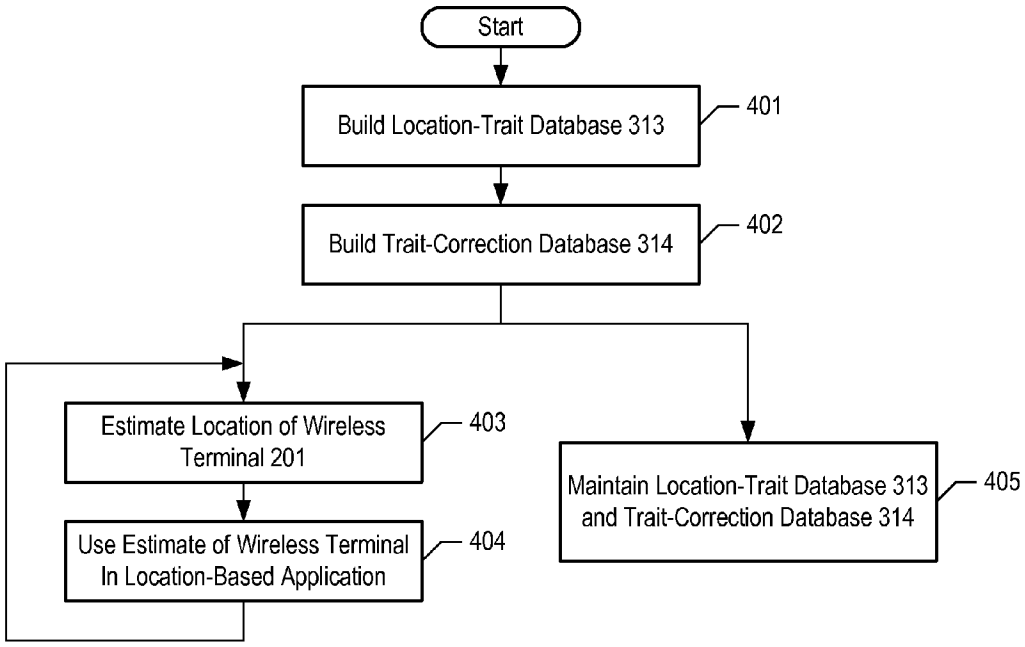

Start
Build Location-Trait Database 313
401
Build Trait-Correction Database 314
402
Estimate Location of Wireless Terminal 201
403
Use Estimate of Wireless Terminal In Location-Based Application
404
Maintain Location-Trait Database 313 and Trait-Correction Database 314
405

Figure 5

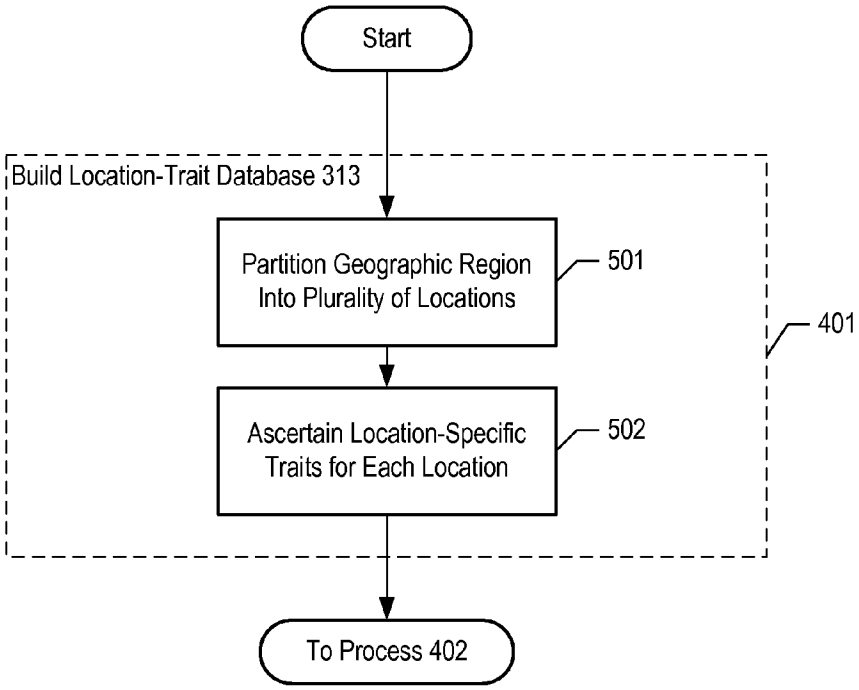

Start
Build Location-Trait Database 313
Partition Geographic Region Into Plurality of Locations
501
Ascertain Location-Specific Traits for Each Location
502
401
To Process 402

Figure 6a

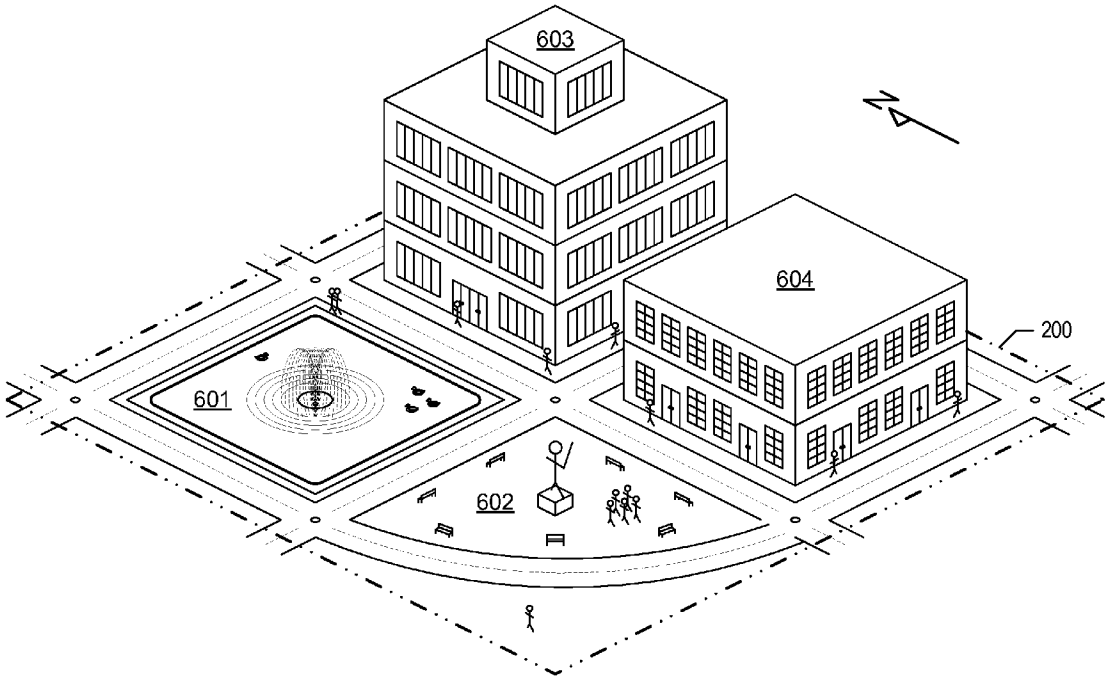


Figure 6b

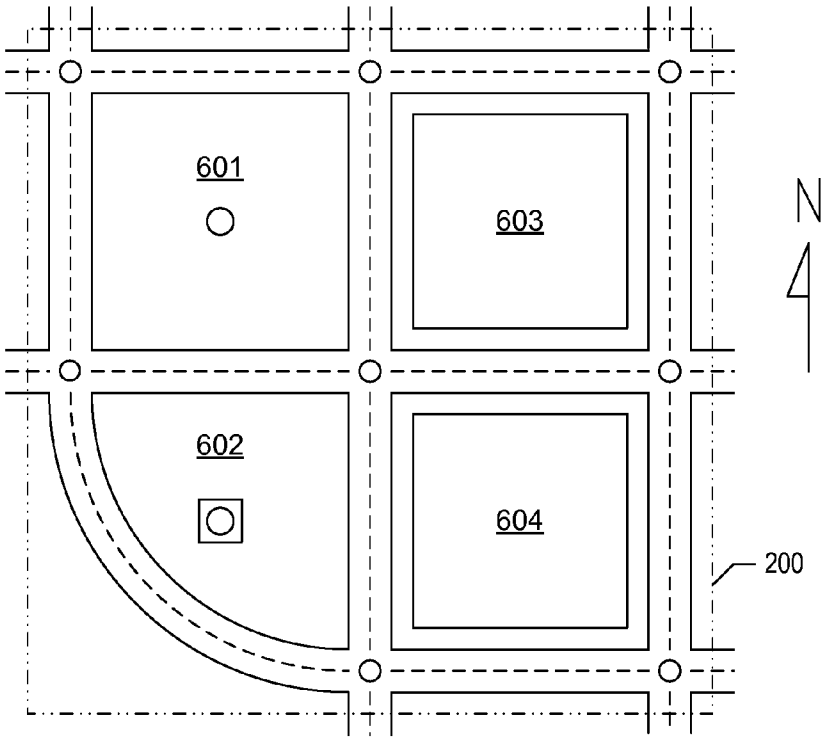


Figure 6c

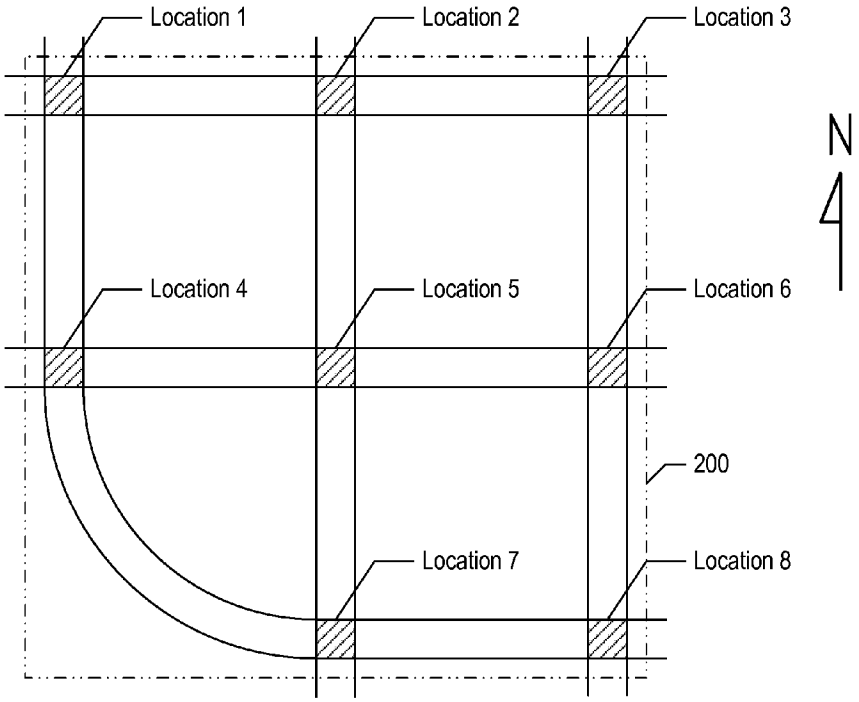

Location 1
Location 2
Location 3
N
Location 4
Location 5
Location 6
200
Location 7
Location 8

Figure 6d

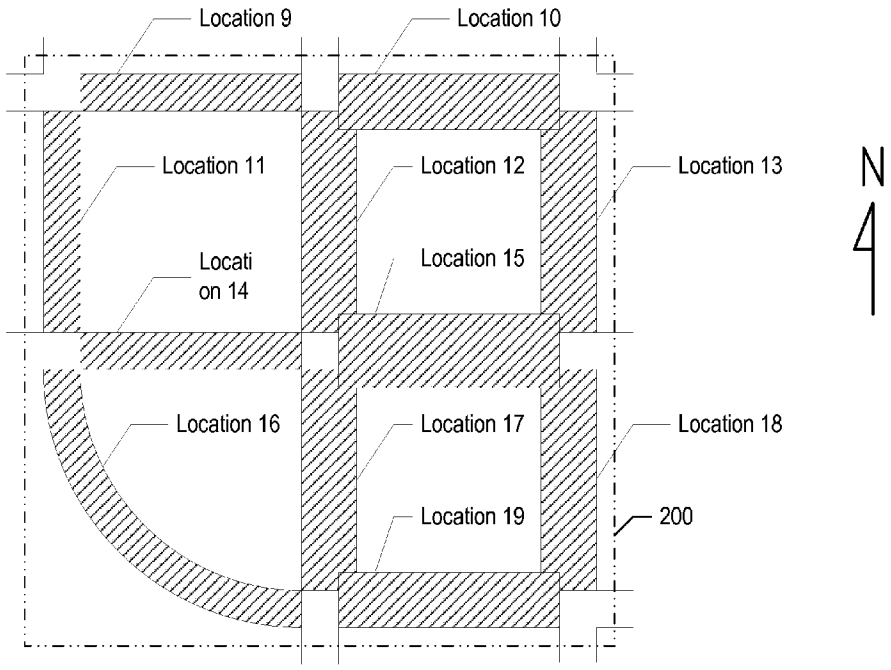

Location 9
Location 10
Location 11
Location 12
Location 13
Locati
on 14
Location 15
Location 16
Location 17
Location 18
Location 19
200
N

Figure 6e

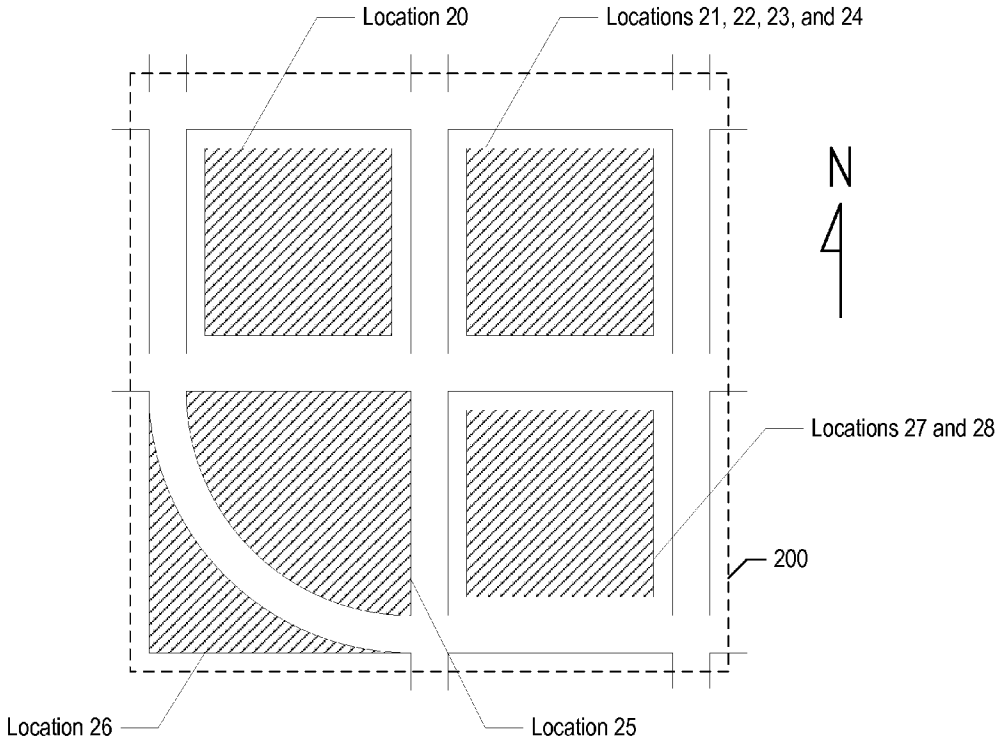

Location 20
Locations 21, 22, 23, and 24
N
Locations 27 and 28
200
Location 26
Location 25

Figure 6f

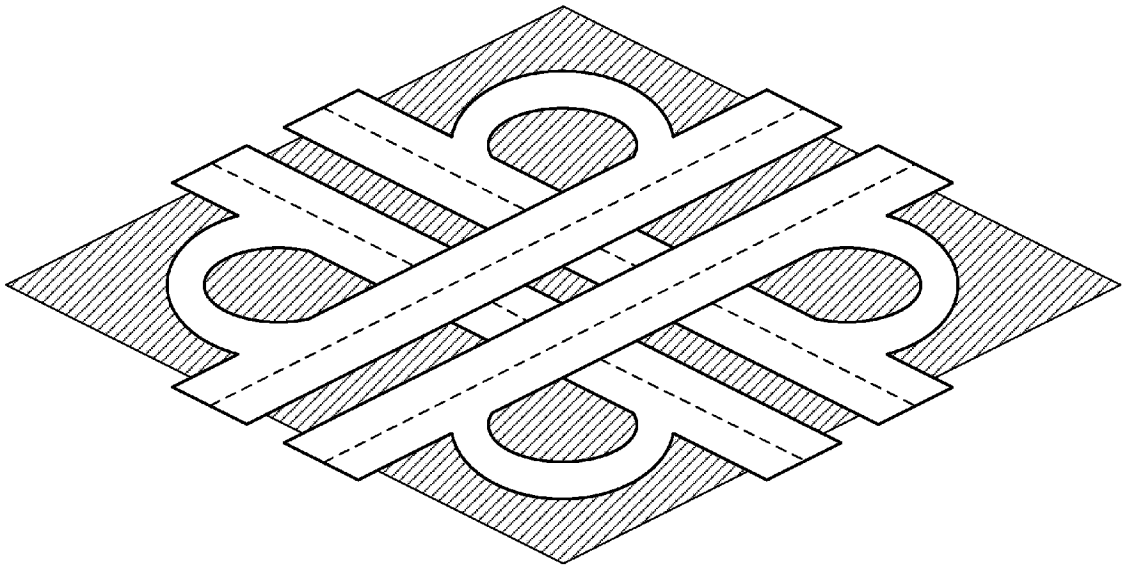


Figure 6g

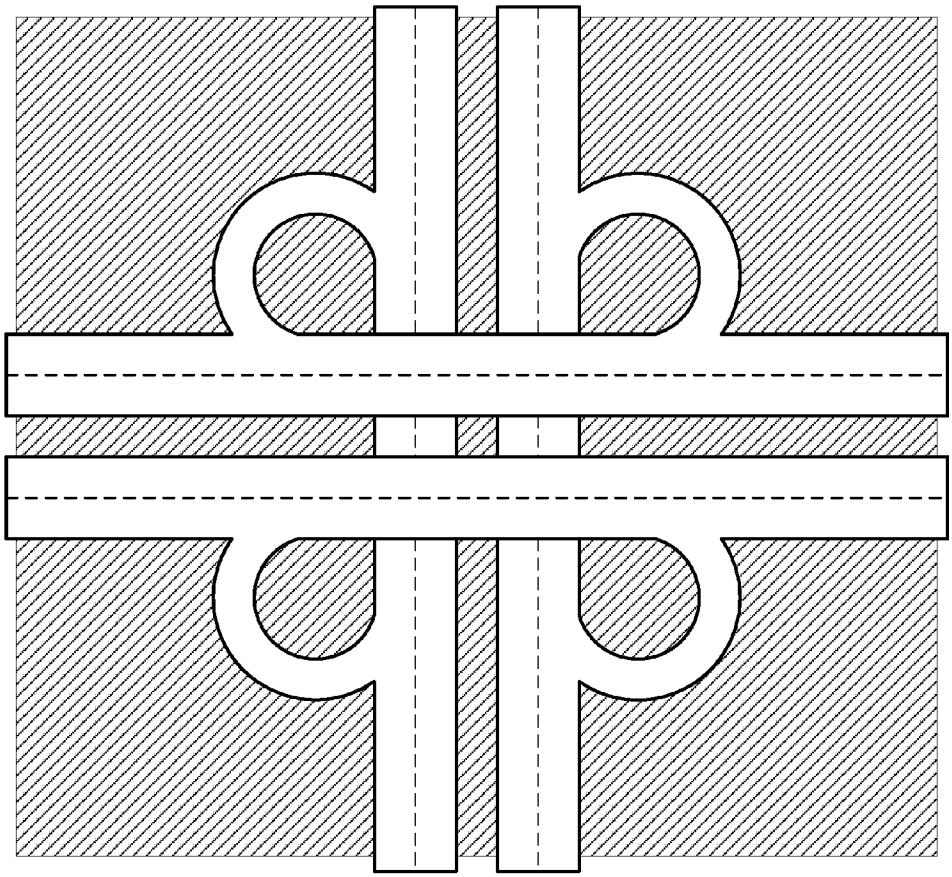


Figure 6h

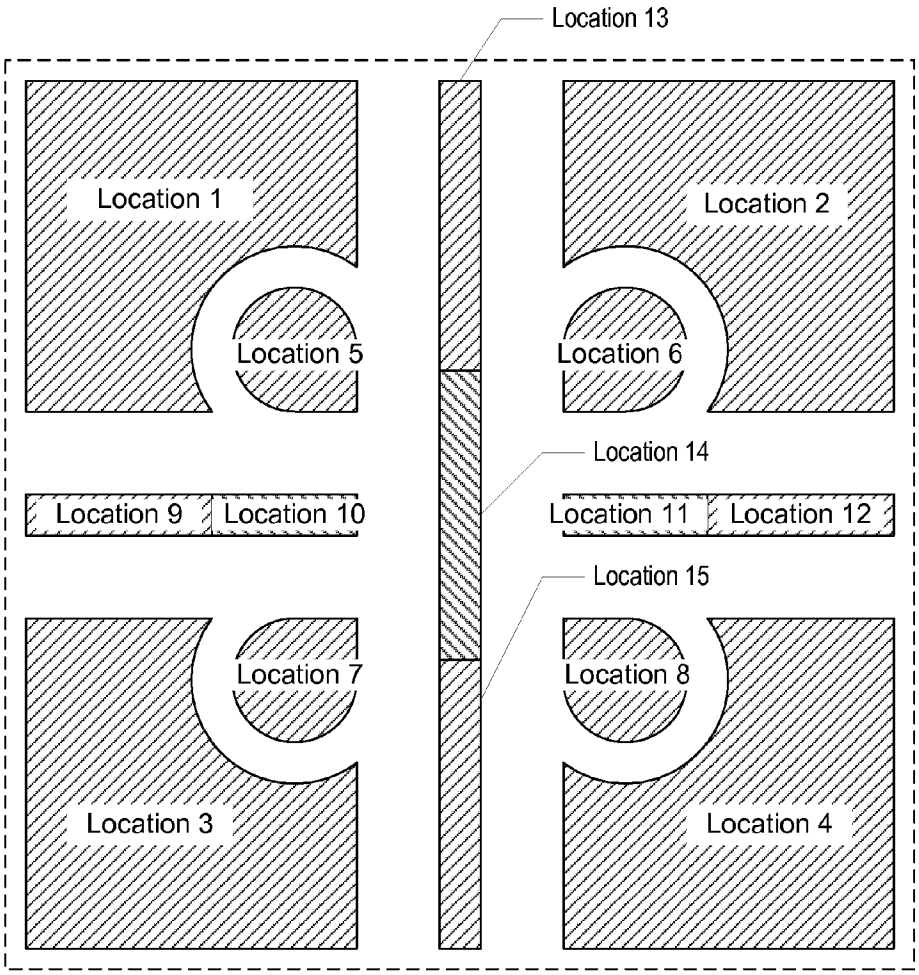

Location 13
Location 1
Location 2
Location 5
Location 6
Location 14
Location 9
Location 10
Location 11
Location 12
Location 15
Location 7
Location 8
Location 3
Location 4

Figure 6i

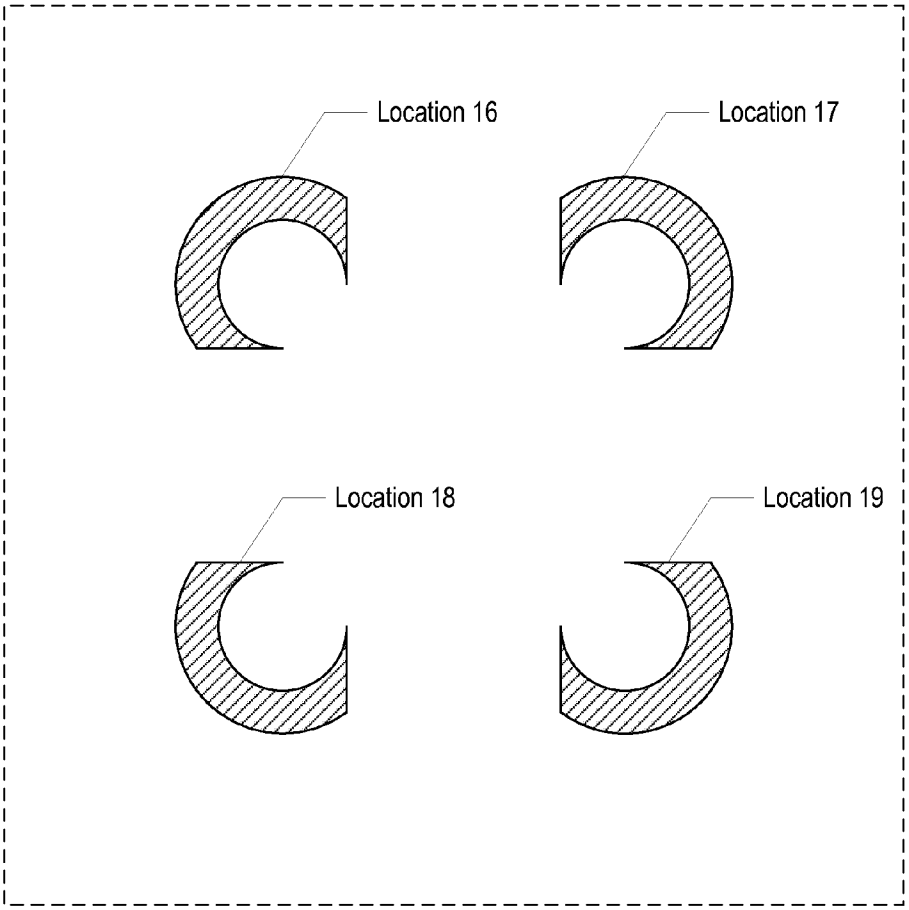


Figure 6j

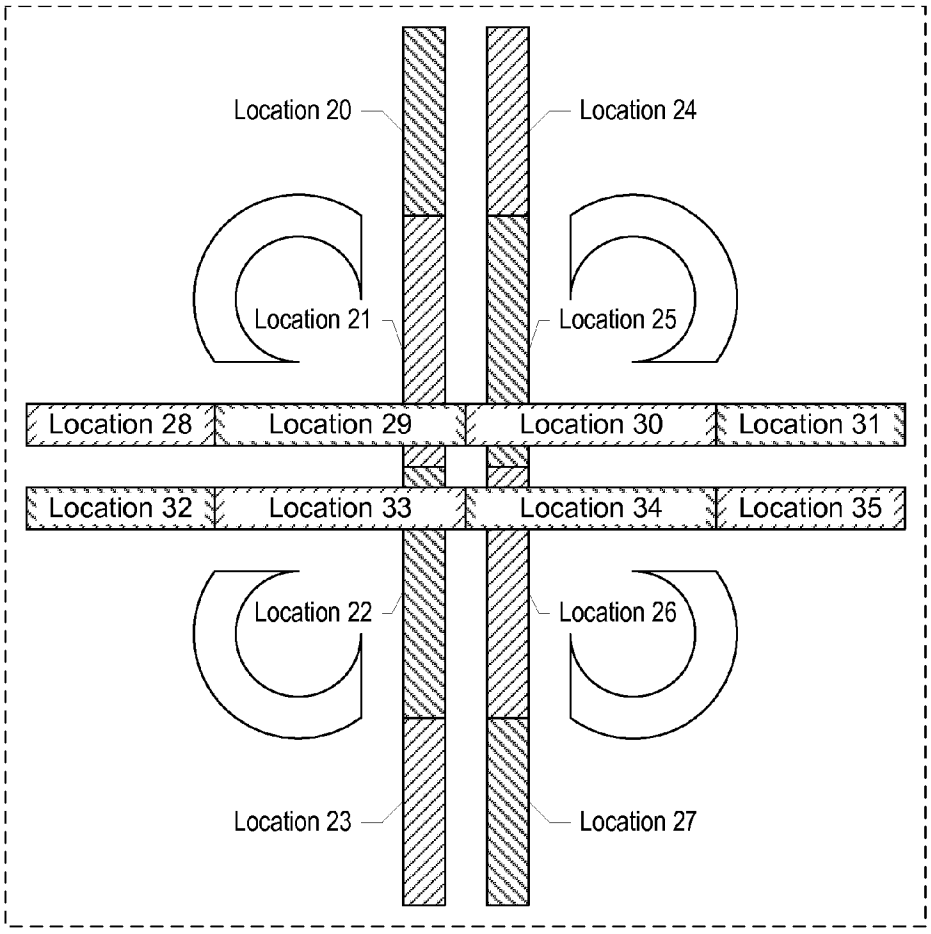

Location 20
Location 24
Location 21
Location 25
Location 28
Location 29
Location 30
Location 31
Location 32
Location 33
Location 34
Location 35
Location 22
Location 26
Location 23
Location 27

Figure 6k

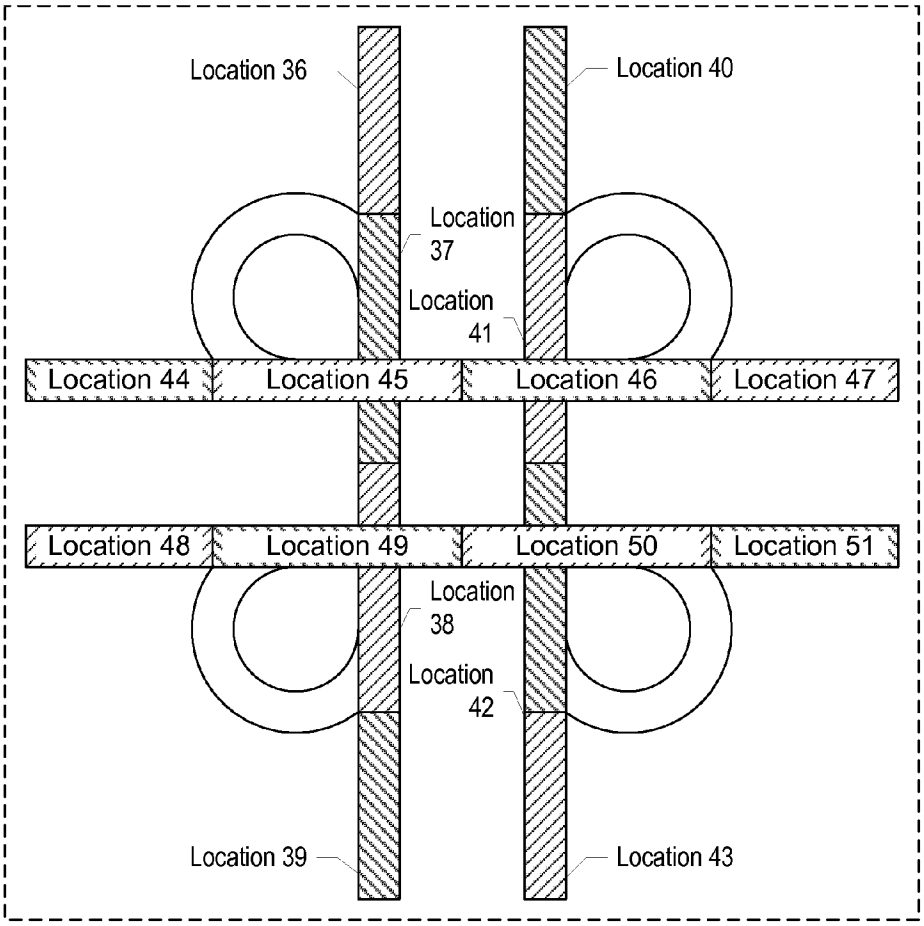

Location 36
Location 40
Location 37
Location 41
Location 44
Location 45
Location 46
Location 47
Location 48
Location 49
Location 50
Location 51
Location 38
Location 42
Location 39
Location 43

Figure 6L

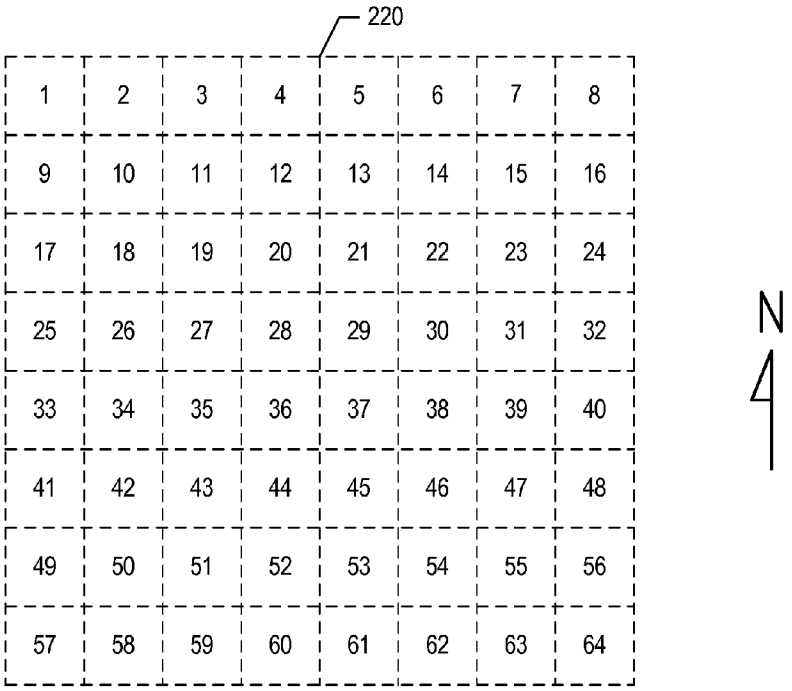

220
1 2 3 4 5 6 7 8
9 10 11 12 13 14 15 16
17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32
33 34 35 36 37 38 39 40
41 42 43 44 45 46 47 48
49 50 51 52 53 54 55 56
57 58 59 60 61 62 63 64
N

Figure 6m

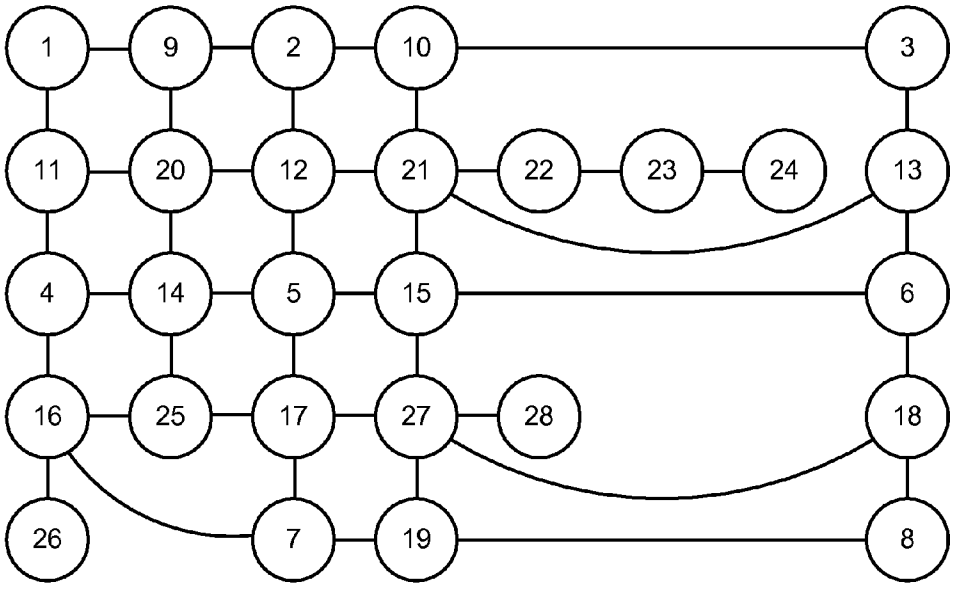
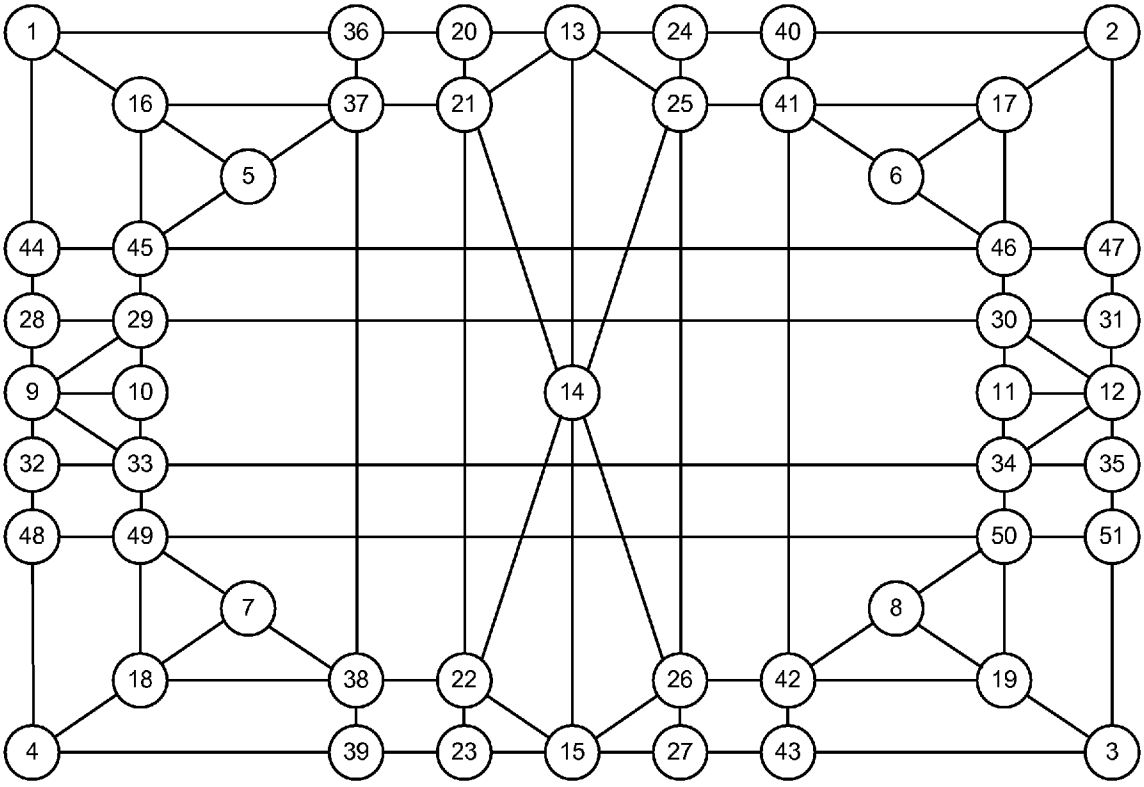


Figure 6n


1
36
20
13
24
40
2
16
37
21
25
41
17
5
6
44
45
46
47
28
29
30
31
9
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14
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12
32
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34
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18
38
22
26
42
19
4
39
23
15
27
43
3

Figure 7

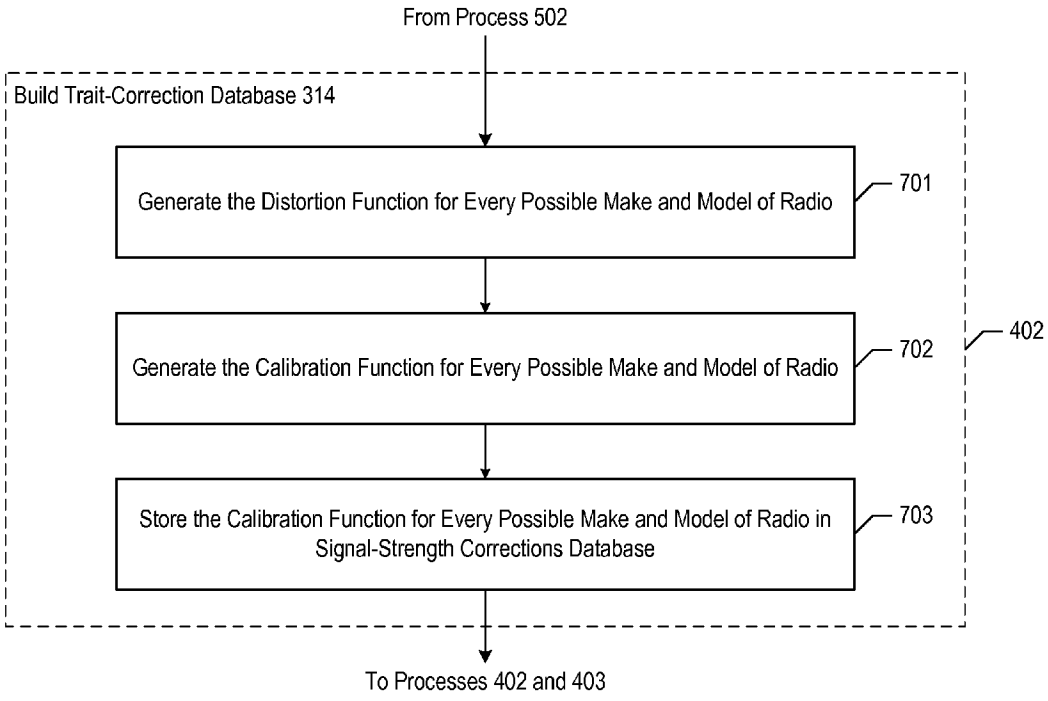

From Process 502
Build Trait-Correction Database 314
Generate the Distortion Function for Every Possible Make and Model of Radio
701
Generate the Calibration Function for Every Possible Make and Model of Radio
702
402
Store the Calibration Function for Every Possible Make and Model of Radio in Signal-Strength Corrections Database
703
To Processes 402 and 403

Figure 8a

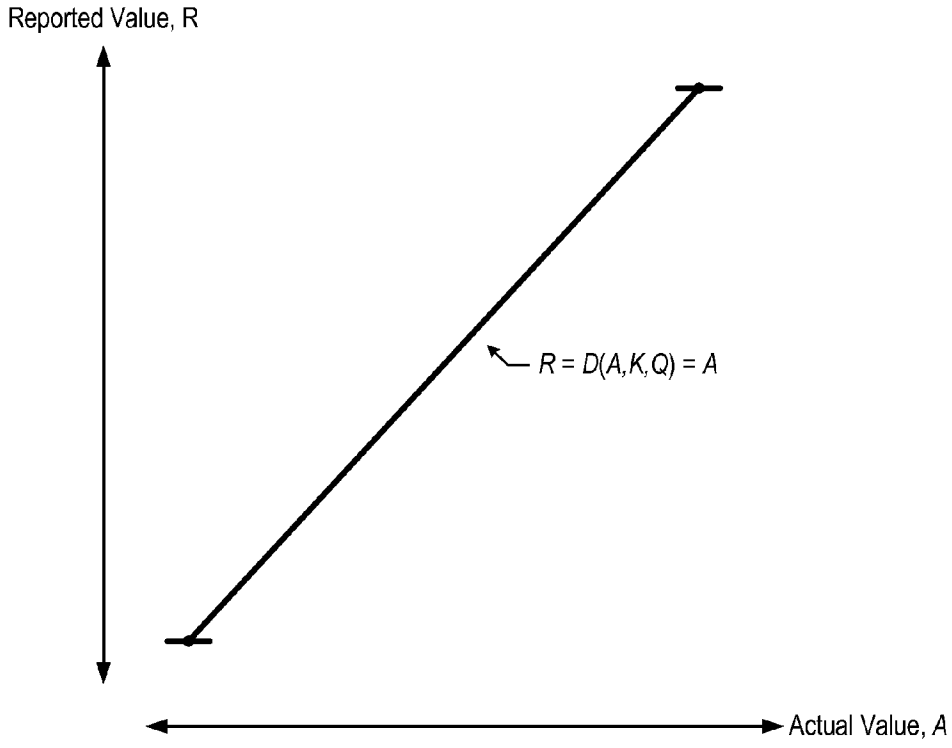


Figure 8b

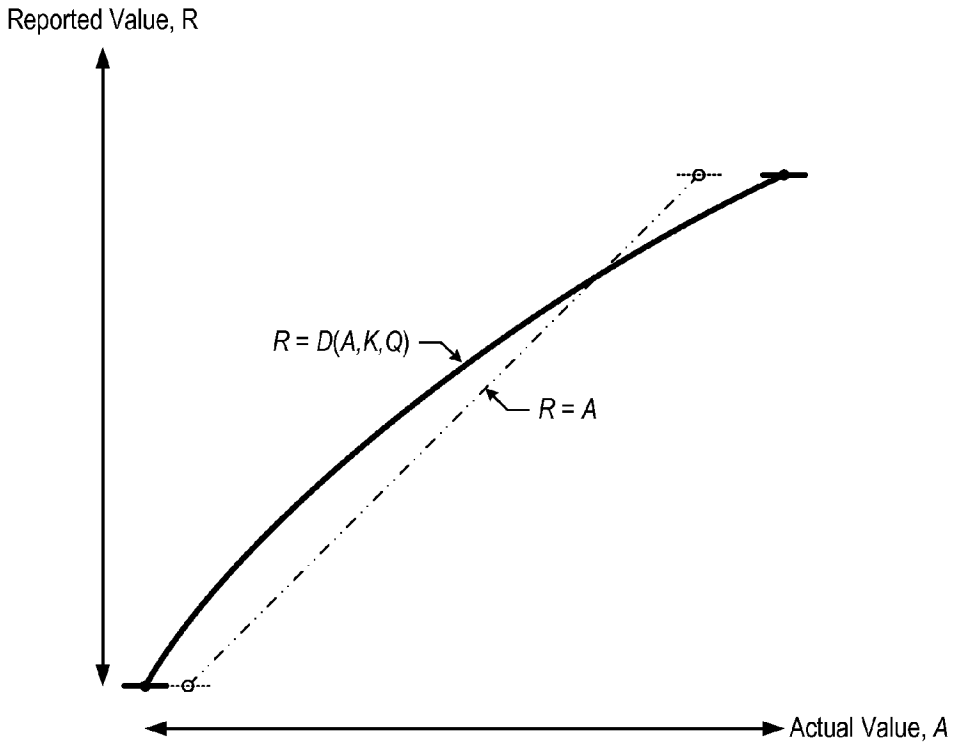


Figure 8c

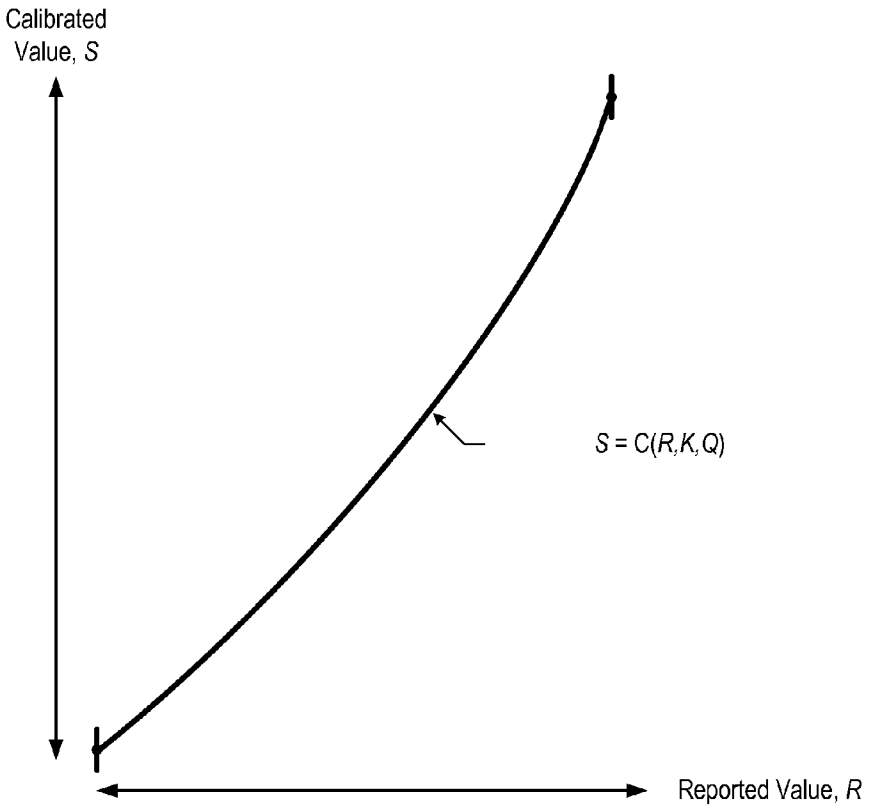


Figure 9

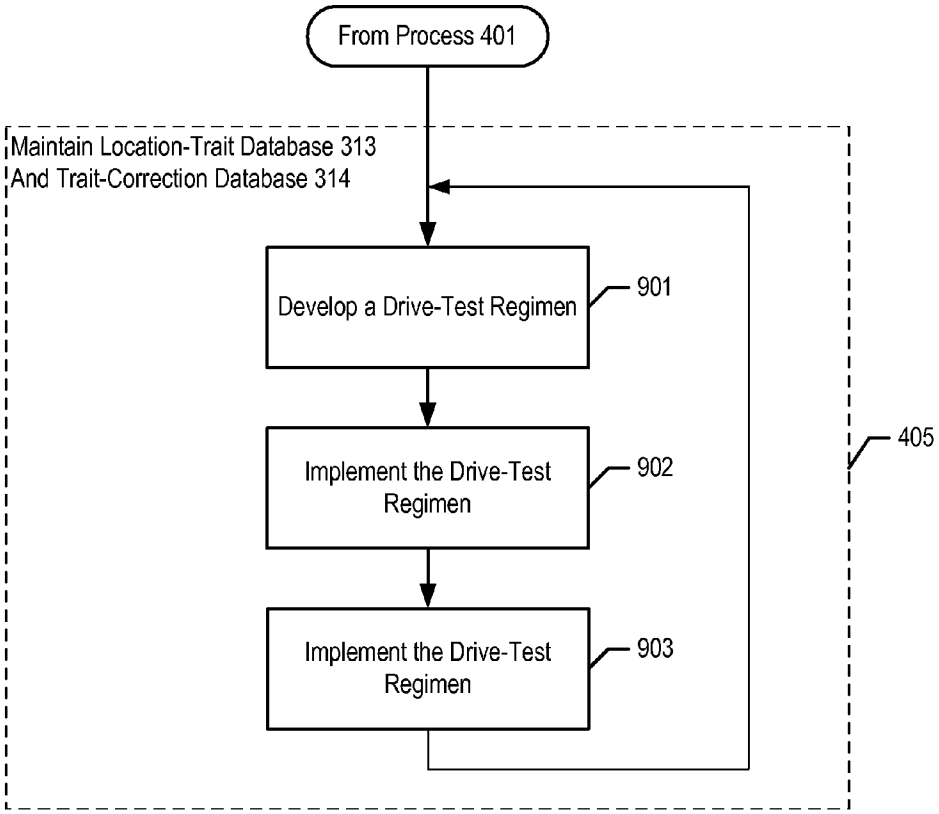

From Process 401
Maintain Location-Trait Database 313
And Trait-Correction Database 314
Develop a Drive-Test Regimen
901
Implement the Drive-Test Regimen
902
Implement the Drive-Test Regimen
903
405

Figure 10

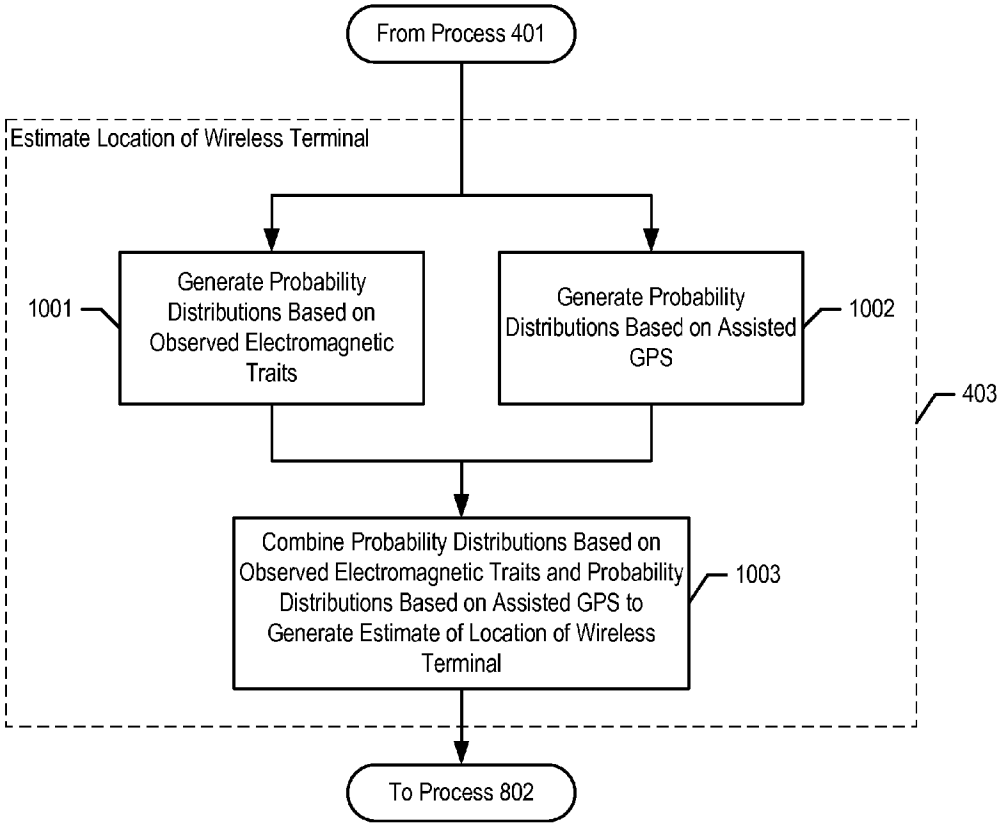

From Process 401
Estimate Location of Wireless Terminal
1001
Generate Probability Distributions Based on Observed Electromagnetic Traits
Generate Probability Distributions Based on Assisted GPS
1002
403
Combine Probability Distributions Based on Observed Electromagnetic Traits and Probability Distributions Based on Assisted GPS to Generate Estimate of Location of Wireless Terminal
1003
To Process 802

Figure 11a

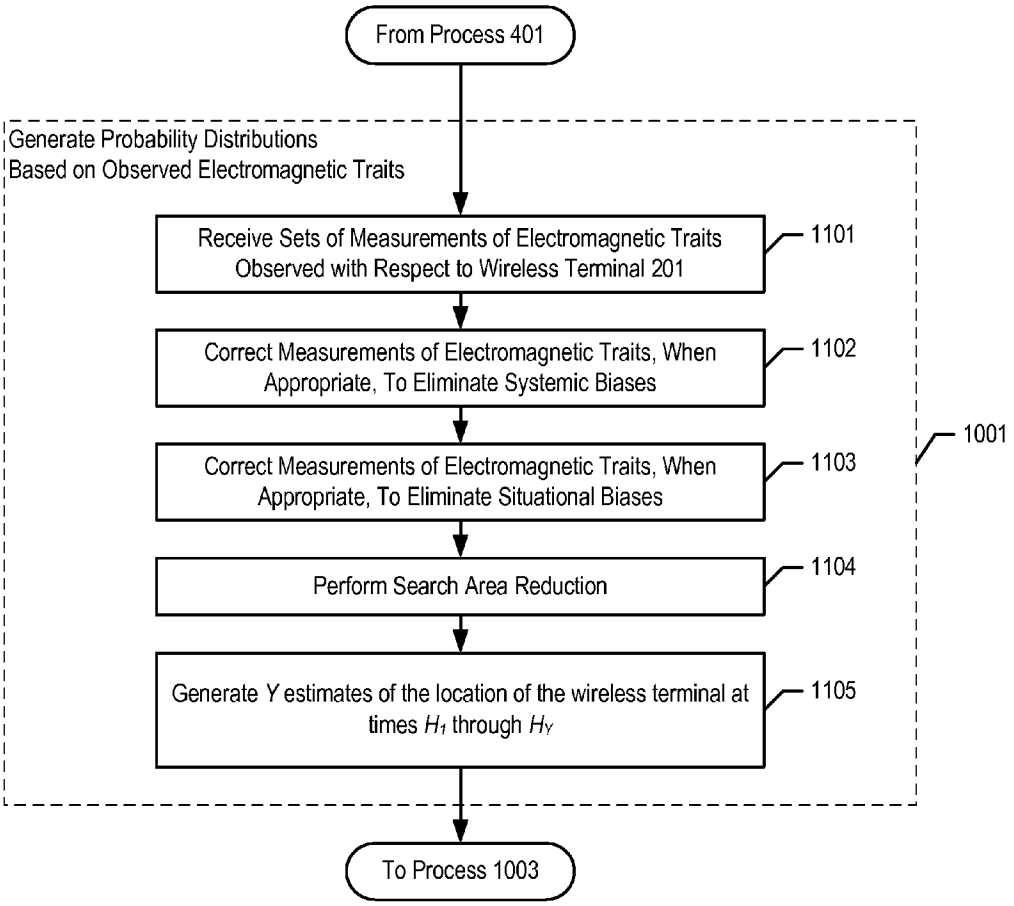

From Process 401
Generate Probability Distributions Based on Observed Electromagnetic Traits
Receive Sets of Measurements of Electromagnetic Traits Observed with Respect to Wireless Terminal 201
1101
Correct Measurements of Electromagnetic Traits, When Appropriate, To Eliminate Systemic Biases
1102
Correct Measurements of Electromagnetic Traits, When Appropriate, To Eliminate Situational Biases
1103
Perform Search Area Reduction
1104
Generate Y estimates of the location of the wireless terminal at times H_1 through H_Y
1105
1001
To Process 1003

Figure 11b

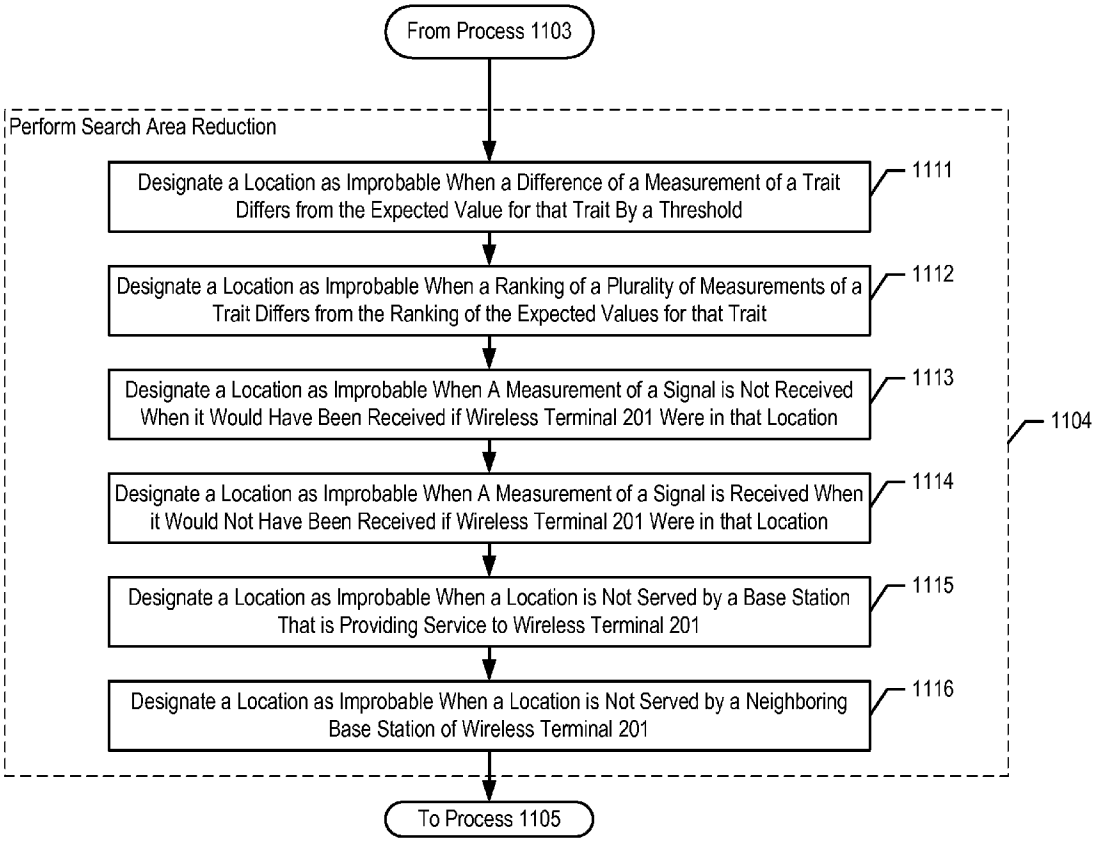

From Process 1103
Perform Search Area Reduction
Designate a Location as Improbable When a Difference of a Measurement of a Trait Differs from the Expected Value for that Trait By a Threshold
1111
Designate a Location as Improbable When a Ranking of a Plurality of Measurements of a Trait Differs from the Ranking of the Expected Values for that Trait
1112
Designate a Location as Improbable When A Measurement of a Signal is Not Received When it Would Have Been Received if Wireless Terminal 201 Were in that Location
1113
Designate a Location as Improbable When A Measurement of a Signal is Received When it Would Not Have Been Received if Wireless Terminal 201 Were in that Location
1114
Designate a Location as Improbable When a Location is Not Served by a Base Station That is Providing Service to Wireless Terminal 201
1115
Designate a Location as Improbable When a Location is Not Served by a Neighboring Base Station of Wireless Terminal 201
1116
1104
To Process 1105

Figure 11c

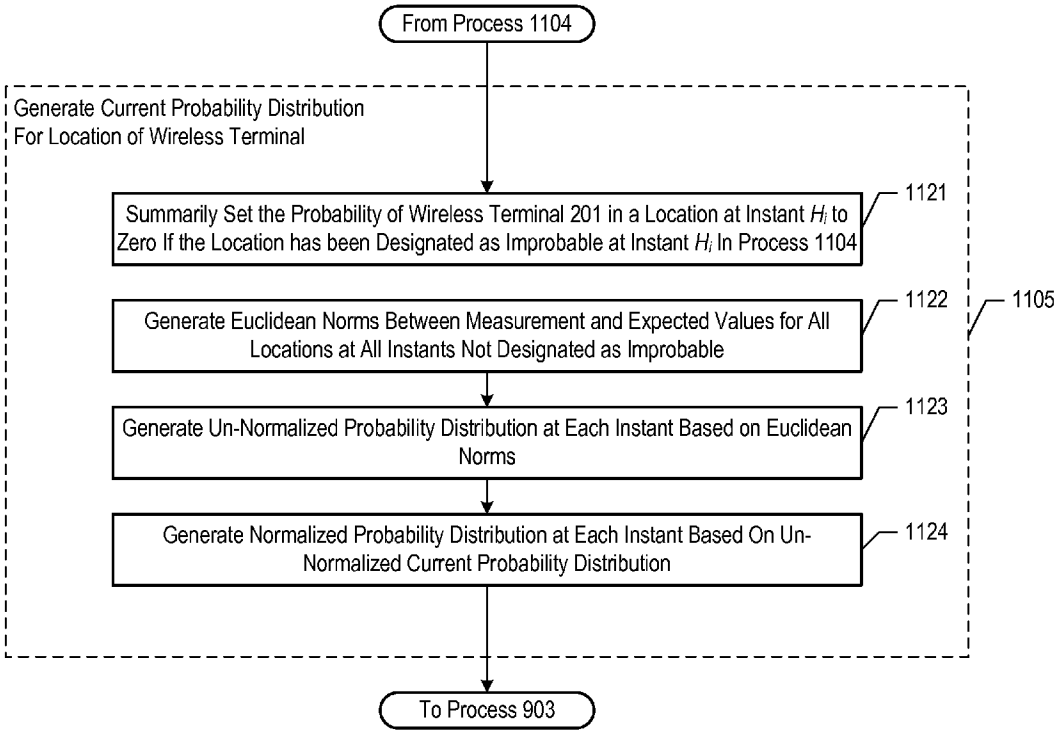

From Process 1104
Generate Current Probability Distribution For Location of Wireless Terminal
Summarily Set the Probability of Wireless Terminal 201 in a Location at Instant H_i to Zero If the Location has been Designated as Improbable at Instant H_i In Process 1104
1121
Generate Euclidean Norms Between Measurement and Expected Values for All Locations at All Instants Not Designated as Improbable
1122
1105
Generate Un-Normalized Probability Distribution at Each Instant Based on Euclidean Norms
1123
Generate Normalized Probability Distribution at Each Instant Based On Un-Normalized Current Probability Distribution
1124
To Process 903

Figure 12

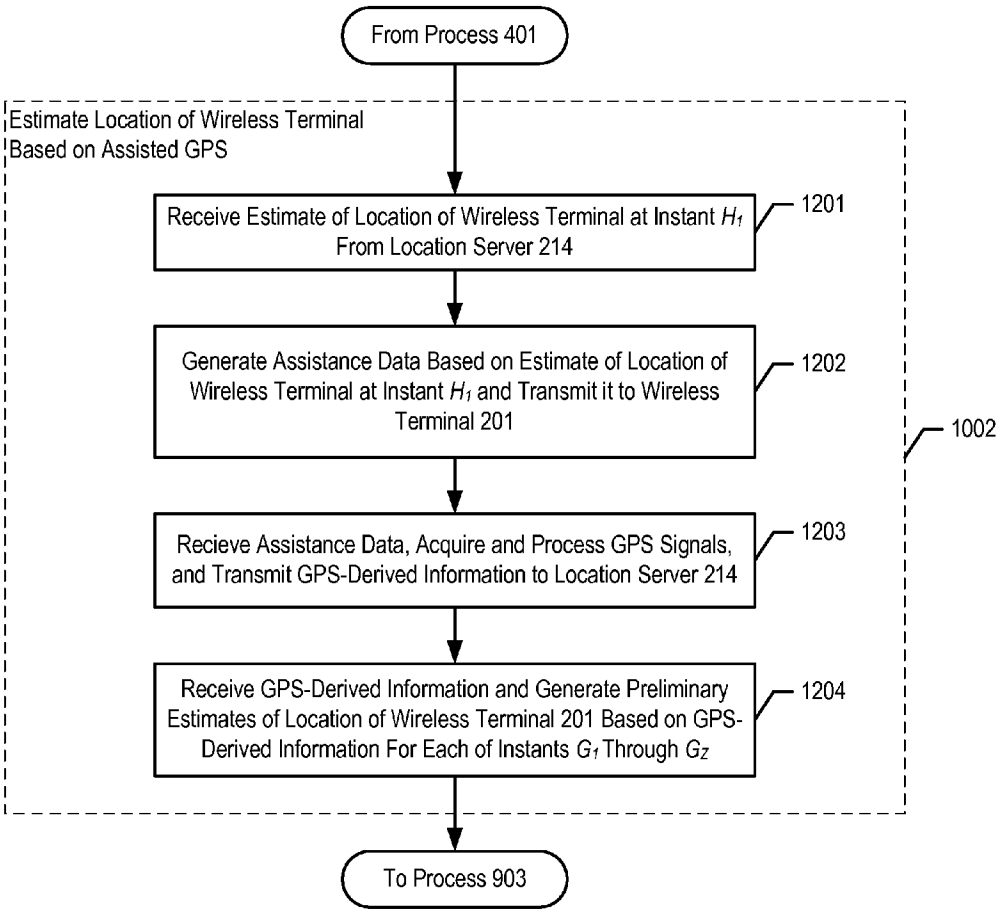

From Process 401
Estimate Location of Wireless Terminal Based on Assisted GPS
Receive Estimate of Location of Wireless Terminal at Instant H_1 From Location Server 214
1201
Generate Assistance Data Based on Estimate of Location of Wireless Terminal at Instant H_1 and Transmit it to Wireless Terminal 201
1202
1002
Recieve Assistance Data, Acquire and Process GPS Signals, and Transmit GPS-Derived Information to Location Server 214
1203
Receive GPS-Derived Information and Generate Preliminary Estimates of Location of Wireless Terminal 201 Based on GPS-Derived Information For Each of Instants G_1 Through G_Z
1204
To Process 903

Figure 13

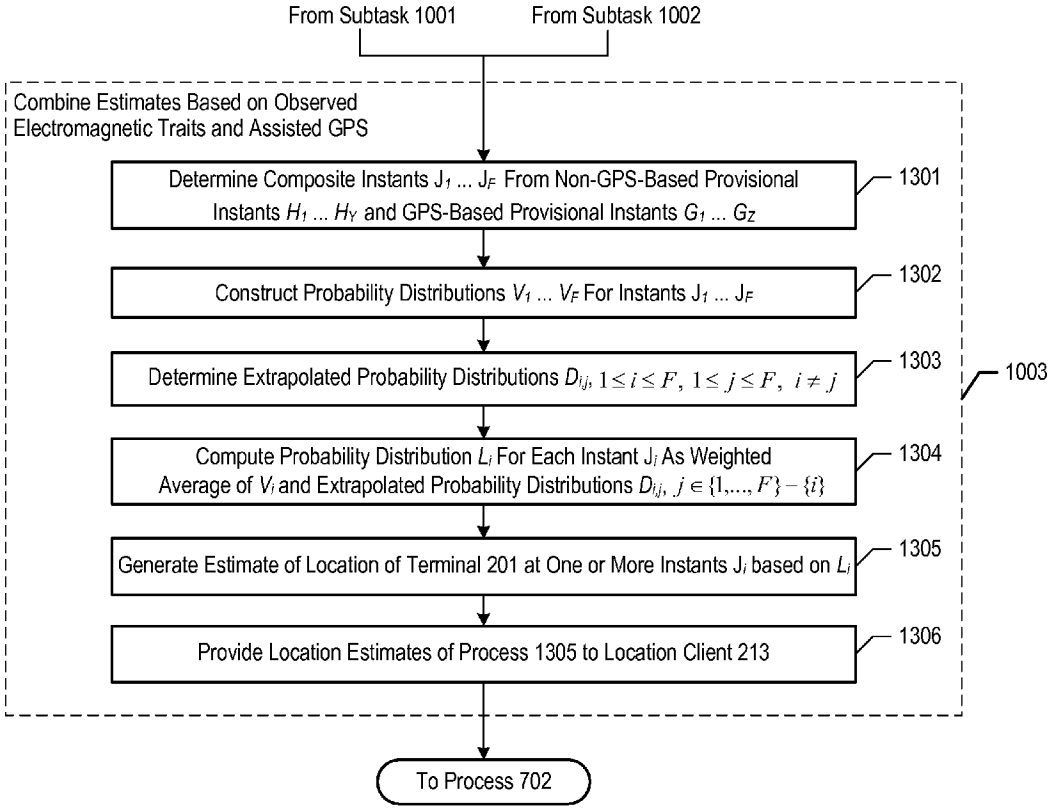

From Subtask 1001
From Subtask 1002
Combine Estimates Based on Observed Electromagnetic Traits and Assisted GPS
Determine Composite Instants $J_1 \ldots J_F$ From Non-GPS-Based Provisional Instants $H_1 \ldots H_Y$ and GPS-Based Provisional Instants $G_1 \ldots G_Z$
1301
Construct Probability Distributions $V_1 \ldots V_F$ For Instants $J_1 \ldots J_F$
1302
Determine Extrapolated Probability Distributions $D_{i,j}$, $1 \le i \le F,\ 1 \le j \le F,\ i \ne j$
1303
1003
Compute Probability Distribution L_i For Each Instant J_i As Weighted Average of V_i and Extrapolated Probability Distributions $D_{i,j}$, $j \in \{1,\ldots,F\} - \{i\}$
1304
Generate Estimate of Location of Terminal 201 at One or More Instants J_i based on L_i
1305
Provide Location Estimates of Process 1305 to Location Client 213
1306
To Process 702

Figure 14

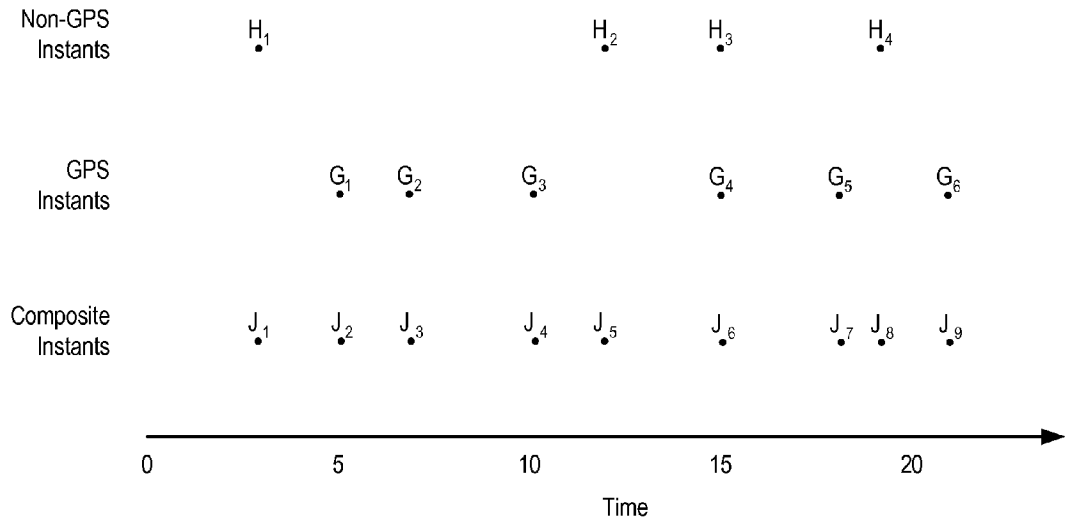
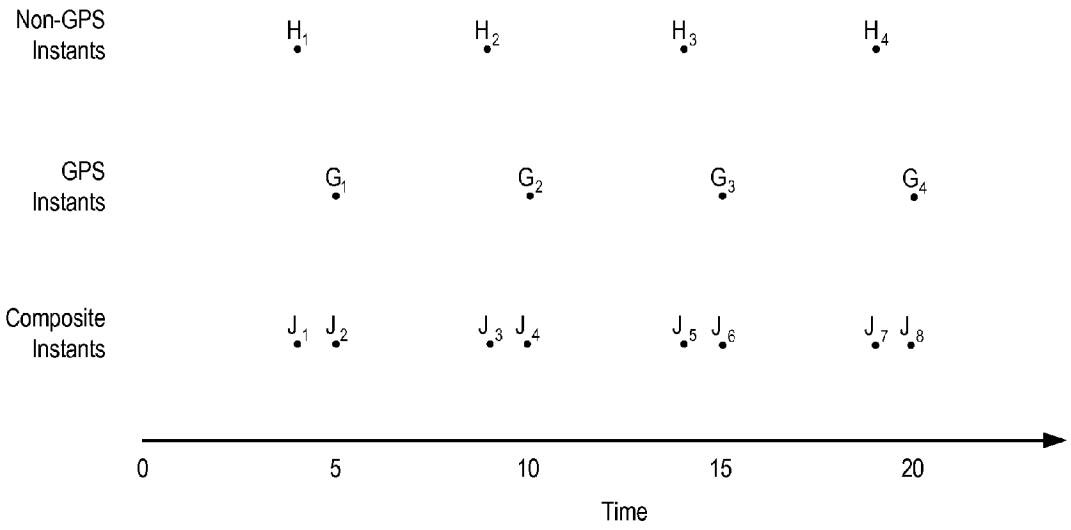

Non-GPS Instants
GPS Instants
Composite Instants
H1
H2
H3
H4
G1
G2
G3
G4
G5
G6
J1
J2
J3
J4
J5
J6
J7
J8
J9
0
5
10
15
20
Time

Figure 15


Non-GPS Instants
GPS Instants
Composite Instants
H1
H2
H3
H4
G1
G2
G3
G4
J1
J2
J3
J4
J5
J6
J7
J8
0
5
10
15
20
Time

COMPUTATIONALLY-EFFICIENT ESTIMATION OF THE LOCATION OF A WIRELESS TERMINAL BASED ON PATTERN MATCHING

This application is a continuation in part of application Ser. No. 11/194,151 filed Aug. 1, 2005 which is a continuation of Ser. No. 10/299,398 filed Nov. 18, 2002 now U.S. Pat. No. 6,944,465. This application Ser. No. 11/419,652 also claims benefit of application Ser. No. 60/757,066 filed Jan. 6, 2006.

FIELD OF THE INVENTION

The present invention relates to telecommunications in general, and, more particularly, to a technique for estimating the location of a wireless terminal and using the estimate of the location in a location-based application.

BACKGROUND

FIG. **1** depicts a diagram of the salient components of wireless telecommunications system **100** in accordance with the prior art. Wireless telecommunications system **100** comprises: wireless terminal **101**, base stations **102-1**, **102-2**, and **102-3**, wireless switching center **111**, assistance server **112**, location client **113**, and Global Positioning System ("GPS") constellation **121**. Wireless telecommunications system **100** provides wireless telecommunications service to all of geographic region **120**, in well-known fashion.

The salient advantage of wireless telecommunications over wireline telecommunications is the mobility that is afforded to the users. On the other hand, the salient disadvantage of wireless telecommunications lies in that fact that because the user is mobile, an interested party might not be able to readily ascertain the location of the user.

Such interested parties might include both the user of the wireless terminal and remote parties. There are a variety of reasons why the user of a wireless terminal might be interested in knowing his or her location. For example, the user might be interested in telling a remote party where he or she is or might seek advice in navigation.

In addition, there are a variety of reasons why a remote party might be interested in knowing the location of the user. For example, the recipient of an E 9-1-1 emergency call from a wireless terminal might be interested in knowing the location of the wireless terminal so that emergency services vehicles can be dispatched to that location.

There are many techniques in the prior art for estimating the location of a wireless terminal.

In accordance with one technique, the location of a wireless terminal is estimated to be at the center of the cell or centroid of the sector in which the wireless terminal is located. This technique is advantageous in that it does not require that additional hardware be added to the wireless terminal or to the wireless telecommunications system, and, therefore, the first technique can be inexpensively implemented in legacy systems. The first technique is only accurate (in present cellular systems), however, to within a few kilometers, and, therefore, it is generally not acceptable for applications (e.g., emergency services dispatch, etc.) that require higher accuracy.

In accordance with a second technique, the location of a wireless terminal is estimated by triangulating the angle of arrival or multilaterating the time of arrival of the signals transmitted by the wireless terminal. This technique can achieve accuracy to within a few hundreds of meters and is advantageous in that it can be used with legacy wireless terminals. The disadvantage of this second technique, however, is that it generally requires that hardware be added to the telecommunication system's base stations, which can be prohibitively expensive.

In accordance with a third technique, the location of a wireless terminal is estimated by a radio navigation unit, such as, for example, a Global Positioning System (GPS) receiver, that is incorporated into the wireless terminal. This technique is typically accurate to within tens of meters but is disadvantageous in that it does not work consistently well indoors, in heavily wooded forests, or in urban canyons. Furthermore, the accuracy of this third technique can be severely degraded by multipath reflections.

Therefore, the need exists for a technique for estimating the location of a wireless terminal with higher resolution than the first technique and without some of the costs and disadvantages of the second and third techniques.

SUMMARY OF THE INVENTION

The present invention enables the construction and use of a system that can estimate the location of a wireless terminal without some of the costs and limitations associated with techniques for doing so in the prior art.

The present invention is based on the recognition that there are traits of electromagnetic signals that are dependent on topography, the receiver, the location of the transmitter, and other factors. For example, if a particular radio station is known to be received strongly at a first location and weakly at a second location, and a given wireless terminal at an unknown location is receiving the radio station weakly, it is more likely that the wireless terminal is at the second location than at the first location.

By quantifying "strongly" and "weakly" and extending this principle to multiple traits and multiple signals, the present invention can estimate the location of a wireless terminal with greater accuracy.

The illustrative embodiment comprises: receiving a measurement of a first characteristic of a first signal that is processed by a wireless terminal; designating at least one of a plurality of possible locations of the wireless terminal as improbable; and estimating the location of the wireless terminal based on a comparison of the measurement of the first characteristic of the first signal to a predicted value of the first characteristic of the first signal for at least one of the plurality of possible locations not designated as improbable.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a map of a portion of a wireless telecommunications system in the prior art.

FIG. **2** depicts a diagram of the salient components of wireless telecommunications system **200** in accordance with the illustrative embodiment of the present invention.

FIG. **3** depicts a block diagram of the salient components of location server **214**, as shown in FIG. **2**, in accordance with the illustrative embodiment.

FIG. **4** depicts a flowchart of the salient processes performed in accordance with the illustrative embodiment of the present invention.

FIG. **5** depicts a flowchart of the salient processes performed in accordance with process **401** of FIG. **4**: building Location-Trait Database **313**.

FIGS. **6***a* through **6***k* depict geographic regions and their deconstruction into a plurality of locations.

FIG. **6**L depicts an alternative partitioning of geographic region **220** into 64 square locations.

FIG. **6***m* depicts a graphical representation of an adjacency graph of geographic region **220** as partitioned in FIGS. **6***c* through **6***e*.

FIG. **6***n* depicts a graphical representation of an adjacency graph of the highway intersection partitioned in FIGS. **6***h* through **6***k*.

FIG. **7** depicts a flowchart of the salient processes performed as part of process **402** of FIG. **4**: populating Trait-Correction Database **313**.

FIGS. **8***a* through **8***c* depict illustrative distortion and correction curves.

FIG. **9** depicts a flowchart of the salient processes performed in process **403** (of FIG. **4**): maintaining Location-Trait Database **313**.

FIG. **10** depicts a flowchart of the salient processes performed in process **701** of FIG. **7**: estimating the location of wireless terminal **201**.

FIG. **11***a* depicts a flowchart of the salient processes performed in process **901** of FIG. **9**: generating the probability distribution for the location of wireless terminal **201** based on the traits of one or more signals received by, or transmitted to, wireless terminal **201** at instants H_1 through H_Y.

FIG. **11***b* depicts a flowchart of the salient processes performed in accordance with process **1104** of FIG. **11***a*: search area reduction.

FIG. **11***c* depicts a flowchart of the salient processes performed in accordance with process **1105**: generating the probability distribution for that wireless terminal **201** at each of instants H_1 through H_Y.

FIG. **12** depicts a flowchart of the salient processes performed in process **902** of FIG. **9**: generating the probability distribution for the location of wireless terminal **201** based on GPS-derived information (i.e., information from GPS constellation **221**).

FIG. **13** depicts a flowchart of the salient processes performed in process **903** of FIG. **9**: combining non-GPS-based and GPS-based probability distributions for the location of wireless terminal **201**.

FIG. **14** depicts a first example of combining non-GPS-based instants H_1 through H_Y and GPS-based instants G_1 through G_Z into composite instants J_1 through J_F.

FIG. **15** depicts a second example of combining non-GPS-based instants H_1 through H_Y and GPS-based instants G_1 through G_Z into composite instants J_1 through J_F.

DETAILED DESCRIPTION

For the purposes of this specification, the following terms and their inflected forms are defined as follows:

- The term "location" is defined as a one-dimensional point, a two-dimensional area, or a three-dimensional volume.
- The term "staying probability" is defined as an estimate of the probability $P_S(b, T, N, W)$ that wireless terminal W in location b at calendrical time T will still be in location b at time $T+\Delta t$, given environmental conditions, N.
- The term "moving probability" is defined as an estimate of the probability $P_M(b, T, N, W, c)$ that wireless terminal W in location b at calendrical time T will be in adjacent location c at time $T+\Delta t$, given environmental conditions, N.
- The term "environmental conditions N," are defined to include one or more physical aspects of the environment, and includes, but is not limited to, the weather, the astronomical conditions, atmospheric conditions, the quantity and density of radio traffic, the quantity and density of vehicular traffic, road and sidewalk construction, etc.
- The term "calendrical time T" is defined as the time as denominated in one or more measures (e.g., seconds, minutes, hours, time of day, day, day of week, month, month of year, year, etc.).

Overview—FIG. **2** depicts a diagram of the salient components of wireless telecommunications system **200** in accordance with the illustrative embodiment of the present invention. Wireless telecommunications system **200** comprises: wireless terminal **201**, base stations **202-1**, **202-2**, and **202-3**, wireless switching center **211**, assistance server **212**, location client **213**, location server **214**, and GPS constellation **221**, which are interrelated as shown. The illustrative embodiment provides wireless telecommunications service to all of geographic region **220**, in well-known fashion, estimates the location of wireless terminal **201** within geographic region **220**, and uses that estimate in a location-based application.

In accordance with the illustrative embodiment, wireless telecommunications service is provided to wireless terminal **201** in accordance with the Universal Mobile Telecommunications System, which is commonly known as "UMTS." After reading this disclosure, however, it will be clear to those skilled in the art how to make and use alternative embodiments of the present invention that operate in accordance with one or more other air-interface standards (e.g., Global System Mobile "GSM," CDMA-2000, IS-136 TDMA, IS-95 CDMA, 3G Wideband CDMA, IEEE 802.11 WiFi, 802.16 WiMax, Bluetooth, etc.) in one or more frequency bands.

Wireless terminal **201** comprises the hardware and software necessary to be UMTS-compliant and to perform the processes described below and in the accompanying figures. For example and without limitation, wireless terminal **201** is capable of:

i. measuring one or more traits of one of more electromagnetic signals and of reporting the measurements to location server **214**, and

ii. transmitting one or more signals and of reporting the transmission parameters of the signals to location server **214**, and

iii. receiving GPS assistance data from assistance server **212** to assist it in acquiring and processing GPS ranging signals.

Wireless terminal **201** is mobile and can be at any location within geographic region **220**. Although wireless telecommunications system **200** comprises only one wireless terminal, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that comprise any number of wireless terminals.

Base stations **202-1**, **202-2**, and **202-3** communicate with wireless switching center **211** and with wireless terminal **201** via radio in well-known fashion. As is well known to those skilled in the art, base stations are also commonly referred to by a variety of alternative names such as access points, nodes, network interfaces, etc. Although the illustrative embodiment comprises three base stations, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that comprise any number of base stations.

In accordance with the illustrative embodiment of the present invention, base stations **202-1**, **202-2**, and **202-3** are terrestrial, immobile, and within geographic region **220**. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which some or all of the base stations are airborne, marine-based, or space-based, regardless of

whether or not they are moving relative to the Earth's surface, and regardless of whether or not they are within geographic region **220**.

Wireless switching center **211** comprises a switch that orchestrates the provisioning of telecommunications service to wireless terminal **201** and the flow of information to and from location server **214**, as described below and in the accompanying figures. As is well known to those skilled in the art, wireless switching centers are also commonly referred to by other names such as mobile switching centers, mobile telephone switching offices, routers, etc.

Although the illustrative embodiment comprises one wireless switching center, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that comprise any number of wireless switching centers. For example, when a wireless terminal can interact with two or more wireless switching centers, the wireless switching centers can exchange and share information that is useful in estimating the location of the wireless terminal. For example, the wireless switching centers can use the IS-41 protocol messages HandoffMeasurementRequest and HandoffMeasurementRequest2 to elicit signal-strength measurements from one another. The use of two or more wireless switching centers is particularly common when the geographic area serviced by the wireless switching center is small (e.g., local area networks, etc.) or when multiple wireless switching centers serve a common area.

In accordance with the illustrative embodiment, all of the base stations servicing wireless terminal **201** are associated with wireless switching center **211**. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which any number of base stations are associated with any number of wireless switching centers.

Assistance server **212** comprises hardware and software that is capable of performing the processes described below and in the accompanying figures. In general, assistance server **212** generates GPS assistance data for wireless terminal **201** to aid wireless terminal **201** in acquiring and processing GPS ranging signals from GPS constellation **221**. In accordance with the illustrative embodiment, assistance server **212** is a separate physical entity from location server **214**; however, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which assistance server **212** and location server **214** share hardware, software, or both.

Location client **213** comprises hardware and software that use the estimate of the location of wireless terminal **201**—provided by location server **214**—in a location-based application, as described below and in the accompanying figures.

Location server **214** comprises hardware and software that generate one or more estimates of the location of wireless terminal **201** as described below and in the accompanying figures. It will be clear to those skilled in the art, after reading this disclosure, how to make and use location server **214**. Furthermore, although location server **214** is depicted in FIG. **2** as physically distinct from wireless switching center **211**, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which location server **214** is wholly or partially integrated with wireless switching center **211**.

In accordance with the illustrative embodiment, location server **214** communicates with wireless switching center **211**, assistance server **212**, and location client **213** via a local area network; however it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which location server **214** communicates with one or more of these entities via a different network such as, for example, the Internet, the Public Switched Telephone Network (PSTN), etc.

In accordance with the illustrative embodiment, wireless switching center **211**, assistance server **212**, location client **213**, and location server **214** are outside of geographic region **220**. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which some or all of wireless switching center **211**, assistance server **212**, location client **213**, and location server **214** are instead within geographic region **220**.

Location Server **214**—FIG. **3** depicts a block diagram of the salient components of location server **214** in accordance with the illustrative embodiment. Location server **214** comprises: processor **301**, memory **302**, and local-area network transceiver **303**, which are interconnected as shown.

Processor **301** is a general-purpose processor that is capable of executing operating system **311** and application software **312**, and of populating, amending, using, and managing Location-Trait Database **313** and Trait-Correction Database **314**, as described in detail below and in the accompanying figures. It will be clear to those skilled in the art how to make and use processor **301**.

Memory **302** is a non-volatile memory that stores:

i. operating system **311**, and

ii. application software **312**, and

iii. Location-Trait Database **313**, and

iv. Trait-Correction Database **314**.

It will be clear to those skilled in the art how to make and use memory **302**.

Transceiver **303** enables location server **214** to transmit and receive information to and from wireless switching center **211**, assistance server **212**, and location client **213**. In addition, transceiver **303** enables location server **214** to transmit information to and receive information from wireless terminal **201** and base stations **202-1** through **202-3** via wireless switching center **211**. It will be clear to those skilled in the art how to make and use transceiver **303**.

Operation of the Illustrative Embodiment—FIG. **4** depicts a flowchart of the salient processes performed in accordance with the illustrative embodiment of the present invention.

In accordance with process **401**, Location-Trait Database **313** is built. For the purposes of this specification, the "Location-Trait Database" is defined as a database that maps each of a plurality of locations to one or more expected traits associated with a wireless terminal at that location. The details of building Location-Trait Database **313** are described below and in the accompanying figures.

In accordance with process **402**, Trait-Correction Database **314** is built. For the purposes of this specification, the "Trait-Correction Database" is defined as a database that indicates how the measurement of traits can be adjusted to compensate for systemic measurement errors. The details of building Trait-Correction Database **314** are described below and in the accompanying figures.

In accordance with process **403**, the location of wireless terminal **201** is estimated based on location-trait database **401**, trait-correction database **402**, and a variety of traits that vary based on the location of wireless terminal **201**. The details of process **403** are described below and in the accompanying figures.

In accordance with process **404**, the estimate of the location of wireless terminal **201** is used in a location-based

application, such as and without limitation, E 9-1-1 service. The details of process **404** are described below and in the accompanying figures.

In accordance with process **405**, Location-Trait Database **313** and Trait-Correction Database **314** are maintained so that their contents are accurate, up-to-date and complete. Process **405** is advantageous because the effectiveness of the illustrative embodiment is based on—and limited by—the accuracy, freshness, and completeness of the contents of Location-Trait Database **313** and Trait-Correction Database **314**. The details of process **405** are described below and in the accompanying figures.

Building Location-Trait Database **313**—FIG. **5** depicts a flowchart of the salient processes performed in accordance with process **401**—building Location-Trait Database **313**.

In accordance with process **501**, geographic region **220** is partitioned into B(T,N) locations, wherein B(T,N) is a positive integer greater than one, and wherein B(T,N) varies as a function of calendrical time T and the environmental conditions N. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which the number of locations that geographic region **220** is partitioned into is static. Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which the number of locations that geographic region **220** is partitioned into is not dependent on the calendrical time T or the environmental conditions N.

Some traits of the radio frequency spectrum and of individual signals are different at different locations in geographic region **220**. Similarly, some traits of the radio frequency spectrum and of individual signals transmitted by wireless terminal **201** change at base stations **202-1**, **202-2**, and **202-3** when wireless terminal **201** is at different locations. Furthermore, some traits (e.g., hand-off state, etc.) of wireless telecommunications system **200** change when wireless terminal **201** is at different locations.

When wireless terminal **201** is at a particular location, the values of the traits that vary with the location of wireless terminal **201** represent a "fingerprint" or "signature" for that location that enables location server **214** to estimate the location of wireless terminal **201**. For example, suppose that under normal conditions the traits have a first set of values when wireless terminal **201** is at a first location, and a second set of values when wireless terminal **201** is at a second location. Then when wireless terminal **201** is at an unknown location and the traits at that unknown location match the second set of values, it is more likely that wireless terminal **201** is at the second location.

Although human fingerprints and handwritten signatures are generally considered to be absolutely unique, the combination of traits associated with each location might not be absolutely unique in geographic region **220**. The effectiveness of the illustrative embodiment is enhanced, however, as differences in the values of the traits among the locations increases. It will be clear to those skilled in the art, after reading this disclosure, how to select locations and traits in order to increase the likelihood that the values of the traits associated with each location are distinguishable from the values of the traits associated with the other locations.

Each location is described by:

i. a unique identifier b,

ii. its dimensionality (e.g., one-dimension, two dimensions, three dimensions, four-dimensions, etc.),

iii. the coordinates (e.g., latitude, longitude, altitude, etc.) that define its scope (e.g., position, area, volume, etc.), which can be static or, alternatively, can vary as a function of calendrical time T or the environmental conditions N, or both the calendrical time T and the environmental conditions N.

iv. the expected value E(b, T, N, W, Q) for each trait, Q, when wireless terminal W is at location b at calendrical time T given environmental conditions, N,

v. the identities of its adjacent locations, and

vi. the staying and moving probabilities P_S(b, T, N, W) and P_M(b, T, N, W, c).

In accordance with the illustrative embodiment, the identifier of each location is an arbitrarily-chosen positive integer. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which the identifier of some or all locations is not arbitrarily chosen. Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which the identifier of some or all locations is not a positive integer.

In accordance with the illustrative embodiment, the scope of each location is three-dimensional and is described by (i) one or more three-dimensional coordinates and geometric identifiers that define its boundaries, (ii) a three-dimensional coordinate that resides at the centroid of the location, and (iii) a description of how the scope changes as a function of calendrical time T and environmental conditions N. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which the scope of some or all of the locations are one-dimensional or two-dimensional. Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which the scope of some or all of the locations are not a function of calendrical time T or environmental conditions N.

In accordance with the illustrative embodiment, the scope of two or more locations can overlap at zero, one, two, more than two, or all points of latitude and longitude (e.g., an overpass and underpass, different stories in a multi-story building as described below, etc.).

In accordance with the illustrative embodiment, the boundaries of each location are based, at least in part, on:

i. natural and man-made physical attributes of geographic region **220** (e.g., buildings, sidewalks, roads, tunnels, bridges, hills, walls, water, cliffs, rivers, etc.),

ii. legal laws governing geographic region **220** (e.g., laws that pertain to the location and movement of people and vehicles, etc.),

iii. theoretical predictions and empirical data regarding the location and movement of individuals and groups of people and vehicles in geographic region **220**,

iv. the desired accuracy of the estimates made by location server **214**, and

v. patterns of the location and movement of people and vehicles within geographic region **220**,

vi. the calendrical time T, and

vii. the environmental conditions N,

subject to the following considerations:

First, the accuracy with which wireless terminal **201** can be located potentially increases with smaller location sizes. Not all locations need to be the same size, however, and areas requiring greater accuracy can be partitioned into smaller sizes, whereas areas requiring less accuracy can be partitioned into larger sizes.

Second, as the number of locations in geographic region **220** increases, so does the computational burden on location server **214** as described below with respect to FIG. **10**.

Third, as the size of adjacent locations decreases, the likelihood increases that the expected values for the traits in those locations will be identical or very similar, which can hinder the ability of location server **214** to correctly determine when wireless terminal **201** is in one location versus the other.

With these considerations in mind, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that partition geographic region **220** into any number of locations of any size, shape, and arrangement. Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use embodiments of the present invention in which the locations are identical in size and shape.

FIG. **6***a* depicts an isometric drawing of geographic region **220** and FIG. **6***b* depicts a map of geographic region **220**. Geographic region **220** comprises water fountain **601**, park **602**, four-story building **603**, two-story building **604**, various streets, sidewalks, and other features that are partitioned into 28 locations as described below and depicted in FIGS. **6***c* through **6***e*. Although geographic region **220** comprises approximately four square blocks in the illustrative embodiment, it will be clear to those skilled in the art how to make and use alternative embodiments of the present invention with geographic regions of any size, topology, and complexity.

In accordance with the illustrative embodiment, the eight road intersections are partitioned into Locations **1** through **8**, as depicted in FIG. **6***c*. In accordance with the illustrative embodiment, the street sections and their adjacent sidewalks up to the edge of buildings **603** and **604** are partitioned into Locations **9** through **19**, as depicted in FIG. **6***d*. In accordance with the illustrative embodiment, water fountain **601** is partitioned into Location **20**, park **602** is partitioned into Location **25**, each floor of building **604** is classified as one of Locations **21**, **22**, **23**, and **24**, and each floor of building **603** is classified as of one of Locations **27** and **28**. It will be clear to those skilled in the art, however, after reading this disclosure, how to partition geographic region **220** into any number of locations of any size and shape.

In accordance with an alternative embodiment of the present invention, a geographic region that comprises a clover-leaf intersection of two, four-lane divided highways is partitioned into 51 locations. FIG. **6***f* depicts an isometric drawing of the intersection, and FIG. **6***g* depicts a map of the intersection. In accordance with the illustrative embodiment, the grass and medians have been partitioned into 15 locations as depicted in FIG. **6***g*, the four ramps have been partitioned into four locations as depicted in FIG. **6***h*, the inner or "passing" lanes have been partitioned into eight locations as depicted in FIG. **6***i*, and the outer or "travel" lanes have been partitioned into eight locations as depicted in FIG. **6***j*.

FIG. **6**L depicts an alternative partitioning of geographic region **220** into 64 square locations.

In accordance with process **502**, the expected values E(b, T, N, W, Q) for the following traits is associated with each location:

i. the expected pathloss of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is at the location, from all transmitters (e.g., base stations **202-1**, **202-2**, and **202-3**, commercial television, commercial radio, navigation, ground-based aviation, etc.), as a function of the calendrical time, T, and the environmental conditions, N; and

ii. the expected pathloss of all of the signals transmitted by wireless terminal **201** when wireless terminal **201** is in the location as receivable at base stations **202-1**, **202-2**, and **202-3**, as a function of the calendrical time, T, and the environmental conditions, N; and

iii. the expected received signal strength of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is in the location, from all transmitters, as a function of the calendrical time, T, and the environmental conditions, N; and

iv. the expected received signal strength of all of the signals transmitted by wireless terminal **201** when wireless terminal **201** is in the location as receivable at base stations **202-1**, **202-2**, and **202-3**, as a function of the calendrical time, T, and the environmental conditions, N; and

v. the expected received signal-to-impairment ratio (e.g., Eb/No, etc.) of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is in the location, from all transmitters, as a function of the calendrical time, T, and the environmental conditions, N; and

vi. the expected received signal-to-impairment ratio of all of the signals transmitted by wireless terminal **201** when wireless terminal **201** is in the location as receivable at base stations **202-1**, **202-2**, and **202-3**, as a function of the calendrical time, T, and the environmental conditions, N; and

vii. the expected received temporal difference of each pair of multipath components (e.g., one temporal difference for one pair of multipath components, a pair of temporal differences for a triplet of multipath components, etc.) of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is in the location, from all transmitters, as a function of the calendrical time, T, and the environmental conditions, N; and

viii. the expected received temporal difference of each pair of multipath components (e.g., one temporal difference for one pair of multipath components, a pair of temporal differences for a triplet of multipath components, etc.) of all of the signals transmitted by wireless terminal **201** when wireless terminal **201** is in the location as receivable at base stations **202-1**, **202-2**, and **202-3**, as a function of the calendrical time, T, and the environmental conditions, N; and

ix. the expected received delay spread (e.g., RMS delay spread, excess delay spread, mean excess delay spread, etc.) of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is in the location, from all transmitters, as a function of the calendrical time, T, and the environmental conditions, N; and

x. the expected received delay spread (e.g., RMS delay spread, excess delay spread, mean excess delay spread, etc.) of all of the signals transmitted by wireless terminal **201** when wireless terminal **201** is in the location as receivable at base stations **202-1**, **202-2**, and **202-3**, as a function of the calendrical time, T, and the environmental conditions, N; and

xi. the expected received relative arrival times of two or more multipath components of all of the signals receivable by wireless terminal **201** when wireless terminal **201** is in the location, from all transmitters (which can be determined by a rake receiver in well-known fashion), as a function of the calendrical time, T, and the environmental conditions, N; and

xii. the expected received relative arrival times of two or more multipath components of all of the signals transmitted by wireless terminal **201** when wireless terminal **201** is in the location as receivable at base stations **202-1**, **202-2**, and **202-3**, as a function of the calendrical time, T, and the environmental conditions, N; and

xiii. the expected round-trip time of all of the signals transmitted and receivable by wireless terminal **201** through base stations **202-1**, **202-2**, and **202-3**, as a function of the calendrical time, T, and the environmental conditions, N; and

xiv. the expected round-trip time of all of the signals transmitted and receivable by base stations **202-1**, **202-2**, and **202-3** through wireless terminal **201**, as a function of the calendrical time, T, and the environmental conditions, N; and

xv. the identity of the base stations that provide telecommunications service to the location, as a function of the calendrical time, T, and the environmental conditions, N; and

xvi. the identities of the neighboring base stations that provide telecommunications service to the location, as a function of the calendrical time, T, and the environmental conditions, N; and

xvii. the handover state (e.g., soft, softer, 1×, 2×, etc.) of wireless terminal **201** and wireless telecommunication system **200** when wireless terminal **201** is in the location as a function of the calendrical time, T, and the environmental conditions, N.

In accordance with the illustrative embodiment of the present invention, all signals transmitted by wireless terminal **201** are for communicating with base stations **202-1** through **202-3**, and all of the signals received by wireless terminal **201** are:

signals transmitted by base stations **202-1** through **202-3** for communicating with wireless terminal **201**,

television signals,

radio signals,

aviation signals, and

navigation signals.

It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that use different signals.

In accordance with the illustrative embodiment, the expected values of these traits are determined through a combination of:

i. a plurality of theoretical and empirical radio-frequency propagation models, and

ii. a plurality of empirical measurements of the traits within geographic region **220**, in well-known fashion. The empirical measurements of the traits are stored within location-trait database **313** and updated as described below.

In accordance with the illustrative embodiment of the present invention, each location b is described by the identities of its adjacent locations, (i.e., the locations that wireless terminal **201** can reasonably move into from location b within one time step Δt.) In accordance with the illustrative embodiment, two locations are considered to be "adjacent" when and only when they have at least two points in common. It will be clear to those skilled in the art, however, after reading this disclosure, how to make and use alternative embodiments of the present invention in which two locations are considered adjacent when they have zero points or one point in common.

Adjacency Graph—In accordance with the illustrative embodiment, a data structure is created that indicates which locations are adjacent. This data structure is called an "adjacency graph" and it is stored within Location-Trait Database **313** in sparse-matrix format. FIG. **6***m* depicts a graphical representation of the adjacency graph for the 28 locations that compose geographic area **220**, and FIG. **6***n* depicts a graphical representation of the adjacency graph for the 51 locations that compose the highway intersection in FIGS. **6***f* through **6***k*.

As described in detail below and in the accompanying figures, the adjacency graph is used in the temporal analysis of wireless terminal **201**'s movements. It will be clear to those skilled in the art, after reading this disclosure, how to make the adjacency graph for any partitioning of geographic region **220**.

In accordance with the illustrative embodiment, the staying and moving probabilities $P_S(b, T, N, W)$ and $P_M(b, T, N, W, c)$ for all b are generated based on a model of the movement of wireless terminal W that considers:

i. the topology of the adjacency graph; and

ii. the calendrical time T; and

iii. the environmental conditions N; and

iv. the natural and man-made physical attributes that affect the location and movement of wireless terminals and the entities that carry them (e.g., buildings, sidewalks, roads, tunnels, bridges, hills, walls, water, cliffs, rivers, etc.); and

v. the legal laws governing the location and movement of wireless terminals and the entities that carry them (e.g., one-way streets, etc.); and

vi. the past data for the movement of all wireless terminals; and

vii. the past data for the movement of wireless terminal W.

It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that use any subcombination of i, ii, iii, iv, v, vi, and vii to generate the staying and moving probabilities for each location b.

The moving probabilities $P_M(b, T, N, W, c)$ associated with a location b can be considered to be either isotropic or non-isotropic. For the purposes of this specification, "isotropic moving probabilities" are defined as those which reflect a uniform likelihood of direction of movement and "non-isotropic moving probabilities" are defined as those which reflect a non-uniform likelihood of direction of movement. For example, for locations arranged in a two-dimensional regular hexagonal grid the values of $P_M(b, T, N, W, c)$ of location b are isotropic if and only if they are all equal (e.g., $P_M(b, T, N, W, c)=⅙$ for each adjacent location c). Conversely, the values of $P_M(b, T, N, W, c)$ are non-isotropic if there are at least two probabilities with different values. As another example, for locations arranged in a two-dimensional "checkerboard" grid, the values of $P_M(b, T, N, W, c)$ are isotropic if and only if:

(i) the north, south, east, and west moving probabilities out of location b all equal p,

(ii) the northeast, northwest, southeast, and southwest moving probabilities out of location b all equal $p/\sqrt{2}$, and

(iii) $4p(1+1/\sqrt{2})+P_S(b, T, N, W)=1$.

Isotropic moving probabilities are simple to generate, but are considerably less accurate than non-isotropic moving probabilities that are generated in consideration of the above criteria. Therefore, in accordance with the illustrative embodiment, the moving probabilities are non-isotropic, but it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that use isotropic moving probabilities.

Populating Trait-Correction Database **313**—FIG. **7** depicts a flowchart of the salient processes performed as part of process **402**: populating Trait-Correction Database **313**.

In general, the ability of location server **214** to estimate the location of wireless terminal **201** is limited by the accuracy with which the traits are measured by wireless terminal **201**

and by base stations **202-1**, **202-2**, and **202-3**. When the nature or magnitude of the measurement errors is unpredictably inaccurate, there is little that can be done to overcome them.

In contrast, when the nature and magnitude of the measurement errors are predictable, they can be corrected, and the nature and magnitude of some measurement errors are, in fact, predictable. For example, one make and model of wireless terminal is known to erroneously measure and report the signal strength of signals by −2 dB. If the measurements from this model of wireless terminal are left uncorrected, this −2 dB error could cause location server **214** to erroneously estimate the location of the wireless terminal. In contrast, if location server **214** adds 2 dB to the measurements from that make and model of wireless terminal, the likelihood that location server **214** would erroneously estimate the location of the wireless terminal would be reduced.

Trait-Correction Database **313** comprises the information needed by location server **214** to be aware of systemic measurement errors and to correct them. A technique for eliminating some situational errors in the measurements is described below and in the accompanying figures.

In accordance with process **701**, a distortion function is generated for every radio that might provide measurements to location server **214** and for every trait whose measurements can be erroneous.

In general, the distortion function D(A,K,Q) relates the reported measurement R for a trait Q to the actual value A for that trait and the defining characteristic K of the radio making the measurement:

$$R=D(A,K,Q). \quad \text{(Eq. 1)}$$

In accordance with the illustrative embodiment, the distortion function D(A,K,Q) is provided to the owner/operator of location server **214** by the radio manufacturer. It will be clear to those skilled in the art, however, after reading this disclosure, how to generate the distortion function D(A,K,Q) for any radio without the assistance of the radio manufacturer.

An ideal radio perfectly measures and reports the value of the traits it receives and the distortion function D(A,K,Q) for one trait and for an ideal radio is depicted in FIG. **8***a*. As can be seen from the graph in FIG. **8***a*, the salient characteristic of an ideal radio is that the reported value of the measurement, R, is exactly equal to the actual value of the trait A at the radio (i.e., there is no measurement or reporting error).

In contrast, most real-world radios do not perfectly measure the traits of the signals they receive. This is particularly true for measurements of signal-strength where the errors can be large. For example, FIG. **8***b* depicts a graph of the distortion function of an illustrative real-world radio. In this case, the reported measurement is too high for some values, too low for others, and correct for only one value.

The nature and magnitude of each of the errors in the reported measurements is inherent in the distortion function D(A,K,Q), and, therefore, knowledge of the distortion function enables the measurement errors to be compensated for. In other words, when location server **214** knows exactly how a radio distorts a measurement, it can correct—or calibrate—the reported measurement with a calibration function to derive the actual value of the trait. The calibration function, denoted C(R,K,Q), is generated in process **1102**.

In accordance with the illustrative embodiment, the distortion function D(A,K,Q) for all measurements is represented in tabular form. For example, the distortion function for one type of signal-strength measurement for various radios is shown in Table 1. It will be clear to those skilled in the art, after reading this disclosure, however, how to make and use alternative embodiments of the present invention in which the distortion function for some or all measurements is not represented in tabular form. Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that comprise distortion functions for any type of measurement of any type of trait and for any radio.

TABLE 1

The Distortion function D(A, K, Q) in Tabular Form

R = D(A, K, Q)

A	K = Motorola Model A008; Q = Signal Strength	...	K = Samsung Model A800; Q = Signal Strength
−110	−115	...	−107
−109	−114	...	−106
...	...	...	...
−48	−38	...	−50
−47	−37	...	−49

The purpose of the characteristic, K, is to identify which calibration function should be used in calibrating the reported measurements from wireless terminal **201**, and, therefore, the characteristic, K, should be as indicative of the actual distortion function for wireless terminal **201** as is economically reasonable.

For example, the characteristic, K, can be, but is not limited to:

i. the unique identity of wireless terminal **201** (e.g., its electronic serial number ("ESN"), its international mobile station identifier ("IMSI"), its temporary international mobile station identifier ("TIMSI"), mobile station identification ("MSID"), its directory number ("DN"), etc.); or

ii. the model of wireless terminal **201** (e.g., Timeport **210***c*, etc.); or

iii. the make (i.e., manufacturer) of wireless terminal **201** (e.g., Motorola, Samsung, Nokia, etc.); or

iv. the identity of the radio-frequency circuitry of wireless terminal **201** (e.g., Motorola RF circuit design **465**B, etc.); or

v. the identity of one or more components of wireless terminal **201** (e.g., the part number of the antenna, the part number of the measuring component, etc.); or

viii. any combination of i, ii, iii, iv, v, vi, and vii.

The most accurate characteristic is the unique identity of wireless terminal **201** because that would enable location server **214** to use the calibration function generated for that very wireless terminal. It is unlikely, however, that this is economically feasible because it would require that every wireless terminal be tested to determine its own unique distortion function.

On the other hand, using only the make of wireless terminal **201** as the characteristic, K, is economically reasonable, but it is unlikely that a single calibration function for all of a manufacturer's wireless terminals would provide very accurate calibrated signal-strength measurements.

As a compromise, the illustrative embodiment uses the combination of make and model of wireless terminal **201** as the characteristic, K, because it is believed that the amount of variation between wireless terminals of the same make and model will be small enough that a single calibration function for that model should provide acceptably accurate calibrated measurements for every wireless terminal of that make and model.

It will be clear to those skilled in the art, however, after reading this disclosure, how to make and use alternative embodiments of the present invention in which the characteristic, K, is based on something else.

In accordance with process **502**, the calibration function C(R,K,Q) is generated for every radio that might provide measurements to location server **214** and for every trait whose measurements can be distorted.

In general, the calibration function C(R,K,Q) relates the calibrated measurement S of a trait Q, to the reported measurement R of trait Q and the defining characteristic K of the radio making the measurement:

$$S=D(R,K,Q) \quad \text{(Eq. 2)}$$

The calibration function C(R,K,Q) is the inverse of the distortion function D(A,K,Q). In other words, the salient characteristic of the calibration function C(R,K,Q) is that it satisfies the equation 3:

$$S=A=C(D(A,K,Q),K,Q) \quad \text{(Eq. 3)}$$

so that the calibrated measurement, S, is what the reported measurement, R, would have been had the radio making and reporting the measurement been ideal. It will be clear to those skilled in the art, after reading this disclosure, how to derive C(R,K,Q) from D(A,K,Q). FIG. **8***c* depicts a graph of the calibration function C(R,K,Q) for the distortion function D(A,K,Q) depicted in FIG. **8***b*.

In accordance with the illustrative embodiment, the function C(R,K,Q) is represented in tabular form, such as that shown in Table 2.

TABLE 2

The Calibration Function C(R, C, N) in Tabular Form

S = C(R, C, N)

R	C = Motorola Model A008; Q = Signal Strength	...	C = Samsung Model A800; Q = Signal Strength
−110	−115	...	−107
−109	−114	...	−106
...	...	...	...
−48	−38	...	−50
−47	−37	...	−49

In accordance with process **402**, the calibration functions C(R,K,Q) are stored in Trait-Corrections Database **313**.

Maintaining Location-Trait Database **313**—FIG. **9** depicts a flowchart of the salient processes performed in process **403**: maintaining Location-Trait Database **313** and Trait-Corrections Database **314**. The ability of the illustrative embodiment to function is based on—and limited by—the accuracy, freshness, and completeness of the information contained in Location-Trait Database **313** and Trait-Corrections Database **314**.

In accordance with process **901**, a drive-test regimen is developed that periodically makes empirical measurements throughout geographic region **220** with highly-accurate equipment to ensure the accuracy, freshness, and completeness of the information contained in Location-Trait Database **313** and Trait-Corrections Database **314**.

In accordance with process **902**, the drive-test regimen is implemented.

In accordance with process **903**, Location-Trait Database **313** and Trait-Corrections Database **314** are updated, as necessary.

Estimating the Location of Wireless Terminal **201**—FIG. **10** depicts a flowchart of the salient processes performed in process **403**: estimating the location of wireless terminal **201**. In accordance with the illustrative embodiment, process **403** is initiated by a request from location client **213** for the location of wireless terminal **201**. It will be clear to those skilled in the art, however, after reading this disclosure, how to make and use alternative embodiments of the present invention in which process **403** is initiated periodically, sporadically, or in response to some other event.

In accordance with process **1001**, Y probability distributions for the location of wireless terminal **201** are generated for each of instants H_1 through H_Y in the temporal interval ΔT, wherein Y is a positive integer, based on comparing the measurements of traits associated with wireless terminal **201** at each of instants H_1 through H_Y to expected values for those traits at those times. Each of the Y probability distributions provides a first estimate of the probability that wireless terminal **201** is in each location at each of instants H_1 through H_Y. The details of process **1001** are described below and in the accompanying figures.

In accordance with process **1002**, Z probability distributions for the location of wireless terminal **201** are generated for each of instants A_1 though A_Z in the temporal interval ΔT, wherein Z is a positive integer, based on Assisted GPS measurements at wireless terminal **201** at each of instants A_1 though A_Z. Each of the Z probability distributions provides a first estimate of the probability that wireless terminal **201** is in each location at each of instants A_1 though A_Z. The details of process **1002** are described below and in the accompanying figures.

In accordance with process **1003**, the Y probability distributions generated in process **1001** and the Z probability distributions generated in process **1002** are combined, taking into account their temporal order, to generate a second estimate of the location of wireless terminal **201**. The details of process **1003** are described below and in the accompanying figures.

Generating the Probability Distributions for the Location of Wireless Terminal **201** Based on Pattern Matching of Traits—FIG. **11***a* depicts a flowchart of the salient processes performed in process **1001**—generating the Y probability distributions for the location of wireless terminal **201** based on comparing the measurements of traits associated with wireless terminal **201** at each of instants H_1 through H_Y to expected values for those traits at those times. In accordance with the illustrative embodiment, location server **214** performs each of processes **1101** through **1105** as soon as the data necessary for performing the process becomes available to it.

In accordance with process **1101**, location server **214** receives Y non-empty sets of measurements of the traits, M_1 though M_Y, associated with wireless terminal **201**. Each set of measurements is made at one of instants H_1 through H_Y.

In accordance with the illustrative embodiment, each set of measurements comprises:

i. the pathloss of all of the signals received by wireless terminal **201** from all transmitters (e.g., base stations **202-1**, **202-2**, and **202-3**, commercial television, commercial radio, navigation, ground-based aviation, etc.); and

ii. the pathloss of all of the signals transmitted by wireless terminal **201** as received at base stations **202-1**, **202-2**, and **202-3**; and

iii. the received signal strength of all of the signals received by wireless terminal **201** from all transmitters; and

iv. the received signal strength of all of the signals transmitted by wireless terminal **201** as received at base stations **202-1**, **202-2**, and **202-3**; and

v. the received signal-to-impairment ratio of all of the signals received by wireless terminal **201** from all transmitters; and

vi. the received signal-to-impairment ratio of all of the signals transmitted by wireless terminal **201** as received at base stations **202-1**, **202-2**, and **202-3**; and

vii. the received temporal difference of each pair of multipath components of all of the signals received by wireless terminal **201** from all transmitters; and

viii. the received temporal difference of each pair of multipath components of all of the signals transmitted by wireless terminal **201** as received at base stations **202-1**, **202-2**, and **202-3**; and

ix. the received delay spread of all of the signals received by wireless terminal **201** from all transmitters; and

x. the received delay spread of all of the signals transmitted by wireless terminal **201** as received at base stations **202-1**, **202-2**, and **202-3**; and

xi. the received relative arrival times of two or more multipath components of all of the signals received by wireless terminal **201** from all transmitters; and

xii. the received relative arrival times of two or more multipath components of all of the signals transmitted by wireless terminal **201** as received at base stations **202-1**, **202-2**, and **202-3**; and

xiii. the round-trip time of all of the signals transmitted and received by wireless terminal **201** through base stations **202-1**, **202-2**, and **202-3**; and

xiv. the round-trip time of all of the signals transmitted as received at base stations **202-1**, **202-2**, and **202-3** through wireless terminal **201**; and

xv. the identity of the base stations that provide telecommunications service to wireless terminal **201**; and

xvi. the identities of the neighboring base stations that can provide telecommunications service to wireless terminal **201**; and

xvii. the handover state (e.g., soft, softer, 1×, 2×, etc.) of wireless terminal **201** and wireless telecommunication system **200**; and

xviii. an indication of the calendrical time, T; and

xix. an indication of the environmental conditions, N.

In accordance with the illustrative embodiment, wireless terminal **201** provides its measurements directly to location server **214** via the user plane and in response to a request from location server **214** to do so. This is advantageous because the quality of the estimate of the location of wireless terminal **201** is enhanced when there are no limitations on the nature, number, or dynamic range of the measurements—as might occur when measurements are required to be made in accordance with the air-interface standard. It will be clear to those skilled in the art, however, after reading this disclosure, how to make and use alternative embodiments of the present invention in which wireless terminal **201** provides its measurements periodically, sporadically, or in response to some other event. Furthermore, it will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which wireless terminal **201** provides its measurements to location server **214** via the UMTS protocol.

In accordance with the illustrative embodiment, base stations **202-1**, **202-2**, and **202-3** provide their measurements to location server **214** via wireless switching center **211** and in response to a request from location server **214** to do so. It will be clear to those skilled in the art, however, after reading this disclosure, how to make and use alternative embodiments of the present invention in which base stations **202-1**, **202-2**, and **202-3** provide their measurements to location server **214** periodically, sporadically, or in response to some other event.

As part of process **1101**, location server **214** also receives from wireless terminal **201**:

i. the identities of the base stations that provided service to wireless terminal **201** at each of instants H_1 through H_Y, and

ii. the identities of the neighboring base stations that provided service to the location of wireless terminal **201** at each of instants H_1 through H_Y.

This information is used by location server **214** in performing search area reduction, which is described in detail below.

In accordance with process **1102**, location server **214** uses the calibration functions C(R,K,Q) in the Trait-Corrections Database **314** to correct the systemic errors in the measurements received in process **1001**.

In accordance with process **1103**, location server **214** computes the differentials, in those cases that are appropriate, of the measurements to correct the situational errors in the measurements received in process **1001**. Many factors, including the condition of wireless terminal **201**'s antenna, the state of its battery, and whether or not the terminal is inside a vehicle can introduce situational measurement errors. This is particularly true for measurements of pathloss and signal strength.

The illustrative embodiment ameliorates the effects of these factors by pattern matching not the measurements themselves—whether corrected in process **1102** or not—to the expected values for those traits, but by pattern matching the pair-wise differentials of those measurements to the pair-wise differentials of the expected values for those traits. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention in which different measurements are corrected for situational errors by the use of pair-wise differentials.

A simple example involving signal strengths illustrates this approach. A first radio station, Radio Station A, can be received at −56 dBm at Location **1**, −42 dBm at Location **2**, −63 dBm at Location **3**, and −61 dBm at Location **4**, and a second radio station, Radio Station B, can be received at −63 dBm at Location **1**, −56 dBm at Location **2**, −65 dBm at Location **3**, and −52 dBm at Location **4**. This information is summarized in the table below and forms the basis for a map or database that correlates location to signal strength.

TABLE 3

Illustrative Location-Trait Database (Differential Reception)

	Radio Station A	Radio Station B	Difference
Location 1	−56 dBm	−63 dBm	−7 dB
Location 2	−42 dBm	−56 dBm	−14 dB
Location 3	−63 dBm	−65 dBm	−2 dB
Location 4	−61 dBm	−52 dBm	9 dB

If a given wireless terminal with a broken antenna and at an unknown location receives Radio Station A at −47 dBm and Radio Station B at −61 dBm, then it registers Radio Station A as 14 dBm stronger than Radio Station B. This suggests that the wireless terminal is more likely to be at Location **2** than it is at Location **1**, **3**, or **4**. If the measured signal strengths themselves were pattern matched into Location-Trait Database **313**, the resulting probability distribution for the location of wireless terminal **201** might not be as accurate.

A disadvantage of this approach is that the situational bias is eliminated at the expense of (1) doubling the variance of the random measurement noise, and (b) reducing the number of

data points to pattern match by one. Furthermore, the pairwise subtraction introduces correlation into the relative signal strength measurement errors (i.e., all of the data points to be matched are statistically correlated). It will be clear to those skilled in the art how to account for this correlation in calculating the likelihood of the measurement report.

In accordance with process **1104**, location server **214** performs a technique called "search area reduction" in preparation for process **1105**. To understand what search area reduction is and why it is advantageous, a brief discussion of process **1105** is helpful. In process **1105** location server **214** estimates the probability that wireless terminal **201** is in each location at each of instants H_1 through H_Y. This requires generating Y multi-dimensional probability distributions, one for each of instants H_1 through H_Y.

The process for generating each multi-dimensional probability distribution can be computationally intensive and the intensity depends on the number of locations that must be considered as possible locations for wireless terminal **201**. When the number of locations that must be considered is small, the process can be performed quickly enough for many "real-time" applications. In contrast, when the number of locations that must be considered is large, the process can often take too long.

Nominally, all of the locations in geographic region **220** must be considered because, prior to process **1104**, wireless terminal **201** could be in any location. In accordance with the illustrative embodiment, geographic region **220** comprises only 28 locations. In many alternative embodiments of the present invention, however, geographic region **220** comprises thousands, millions, or billions of locations. The consideration of thousands, millions, or billions of locations for each instant by location server **214** might take too long for many real-time applications.

Therefore, to expedite the performance of process **1105**, location server **214** performs some computationally-efficient tests that quickly and summarily eliminate many possible locations for wireless terminal **201** from consideration, and, therefore, summarily set to zero the probability that wireless terminal **201** is at those locations. This reduces the number of locations that must be fully considered in process **1105** and generally improves the speed with which process **1001** is performed.

In accordance with search area reduction, for each of instants H_1 through H_Y location server **214** uses six computationally efficient tests in an attempt to designate one or more locations as improbable locations for wireless terminal **201**. A location that is designated as improbable by one or more of the six tests at instant H_i is designated as improbable by process **1104** at instant H_i. To the extent that a location is designated as improbable at instant H_i, the computational burden on location server **214** of generating the probability distribution for that instant is reduced.

There are two types of errors that can be made by process **1104**. The first type of error—a Type I error—occurs when process **1104** designates a location as improbable when, in fact, it is not improbable for wireless terminal **201** to be in that location. The second type of error—a Type II error—occurs when process **1104** fails to designate a location as improbable when, in fact, it is improbable that wireless terminal **201** is in that location.

In general, a Type I error affects the accuracy with which the illustrative embodiment can estimate the location of wireless terminal **201**, and a Type II error affects the speed with which processor **1104** can generate the probability distributions. In accordance with the illustrative embodiment, the tests and their parameters are chosen to balance the number of Type I and Type II errors with the computational complexity and value of process **1104**. For example, when there are too many Type II errors, the value of process **1104** is undermined by the computational burden of process **1104**. It will be clear those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that have any number of Type I and Type II errors.

FIG. **11***b* depicts a flowchart of the salient processes performed in accordance with process **1104**: search area reduction.

In accordance with process **1111**, location server **214** designates a location as improbable when the difference between a measured value of a trait and the expected value of that trait at that location exceeds a threshold. The theory underlying this test is that a major discrepancy between a measurement of a trait and the expected value of a trait at a location suggests that the measurement was not made when wireless terminal **201** was in that location. In accordance with the illustrative embodiment, location engine **214** performs process **1111** on each measured value of each trait for each signal for each of instants H_1 through H_Y. It will be clear to those skilled in the art, after reading this disclosure, how to choose the traits and signals and thresholds to achieve the desired number of Type I and Type II errors. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that omit process **1111** or that omit testing one or more traits and/or one or more signals in process **1111**.

In accordance with process **1112**, when the magnitude of two measurements of a trait at one instant exceed a first threshold and the magnitude of the expected values for that trait at a location exceed a second threshold, location server **214** designates that location as improbable when a ranking of the two measurements differs from a ranking of the expected values. The theory underlying this test is that a major discrepancy between the ranking of the measurements of a trait and the ranking of the expected values of that trait in the location suggests that the measurements were not made when wireless terminal **201** was in that location. In accordance with the illustrative embodiment, location engine **214** performs process **1112** on each pair of measurements of each trait for each of instants H_1 through H_Y. It will be clear to those skilled in the art, after reading this disclosure, how to choose the traits and signals and thresholds to achieve the desired number of Type I and Type II errors. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that omit process **1112** or that omit testing one or more traits and/or one or more signals in process **1112**.

In accordance with process **1113**, location server **214** designates a location as improbable when a measurement of traits of a signal is not received when it is expected if wireless terminal **201** were, in fact, in that location. In accordance with the illustrative embodiment, location engine **214** performs process **1113** on each trait of each expected signal for each of instants H_1 through H_Y. This test is highly prone to Type I errors and should be used judiciously. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that omit process **1113** or that omit testing one or more traits and/or one or more signals in process **1113**.

In accordance with process **1114**, location sever **214** designates a location as improbable when a measurement of a trait of a signal is received when it is not expected if wireless terminal **201** were, in fact, in that location. In accordance with the illustrative embodiment, location engine **214** performs process **1114** on each trait of each signal for each of instants

H_1 through H_Y. In general, this test is less prone to Type I errors than the test in process **1113**. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that omit process **1114** or that omit testing one or more traits and/or one or more signals in process **1114**.

In accordance with process **1115**, location server **214** designates a location as improbable when the location is not provided wireless telecommunications service by a base station that is known to be providing service to wireless terminal **201** at that instant. The theory underlying this test is that if a base station that provided telecommunications service to wireless terminal **201** at that instant does not provide service to the location, then it suggests that wireless terminal **201** is not in that location at that instant. In general, this test is highly accurate and has a low number of both Type I and Type II errors. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that omit process **1115**.

In accordance with process **1116**, location server **214** designates a location as improbable designating a possible location as improbable when the location is not within the neighboring coverage area of a base station that is known to be a neighboring base station of wireless terminal **201**. The theory underlying this test is that if a location is not within the neighboring coverage area of a base station that is a neighbor of wireless terminal **201** at that instant, then it suggests that wireless terminal **201** is not in the location at that instant. In general, this test is highly accurate and has a low number of both Type I and Type II errors. It will be clear to those skilled in the art, after reading this disclosure, how to make and use alternative embodiments of the present invention that omit process **1116**.

A location that that is designated as improbable at instant H_i by one or more of processes **1111** through **1116** is designated as improbable by process **1104** at instant H_i.

In accordance with process **1105**, location server **214** generates each of the Y probability distribution for that wireless terminal **201** at each of instants H_1 through H_Y. To accomplish this, location server **214** performs the processes described below and in FIG. **11***c*.

FIG. **11***c* depicts a flowchart of the salient processes performed in accordance with process **1105**: generating the Y probability distribution for that wireless terminal **201** at each of instants H_1 through H_Y.

In accordance with process **1121**, location server **214** sets the probability of wireless terminal **201** being at a location at instant H_i to zero (0) if the location was designated as improbable at instant H_i by process **1104**.

In accordance with process **1122**, location server **214** generates the Euclidean norm between the measurements of a trait and the expected values for that trait at all instants and for all locations not designated as improbable by process **1104**. To accomplish this, the Euclidean norm is generated between the measurements (as corrected in process **1102**, if necessary and/or the differentials of measurements as the case may be) of the expected values for those traits in Location-Trait Database **313**. To accomplish this, the Euclidean norm is generated as described in Equation 4:

$$V(b, H_i)=\sqrt{\Sigma((E(b,H_i,N,W,Q)-M(b,H_i,N,W,Q))\cdot\omega(Q))^2} \quad \text{(Eq.4)}$$

wherein $V(b,H_i)$ is the Euclidean norm for Location b at instant H_i based on the square root of the sum of the square of the differences between each (corrected and differential, where appropriate) trait measurement M(b, H_i, N, W, Q) minus the expected value E(b, H_i, N, W, Q) for that trait, where ω(Q) is a weighting factor that indicates the relative weight to be given discrepancies in one trait versus discrepancies in the other traits.

At accordance with process **1123**, the un-normalized probabilities of the location of wireless terminal **201** at each location are generated based on the Euclidean norms generated in process **1122** as shown in Equation 5.

$$UP(b, H_i) = e^{\left(\frac{-V^2(b,H_i)}{\delta^2}\right)} \quad \text{(Eq. 5)}$$

wherein $UP(b,H_i)$ represents the un-normalized probability that wireless terminal **201** is in Location b at instant H_i, and wherein δ^2 equals:

$$\delta^2 = \delta_E^2 + \delta_M^2 \quad \text{(Eq. 6)}$$

wherein δ_E^2 is the square of the uncertainty in the error in Location-Trait Database and δ_M^2 is the square of the uncertainty in the calibrated measurements. It will be clear to those skilled in the art, after reading this disclosure, how to generate δ^2.

At process **1124**, the probabilities generated in process **1123** are normalized as described in Equation 7.

$$NP(b, H_i) = \frac{UP(b, H_i)}{\sum UP(b, H_i)} \quad \text{(Eq. 7)}$$

wherein $NP(b,H_i)$ represents the normalized probability that wireless terminal **201** is in Location b.

As part of process **1124**, location server **214** generates a preliminary estimate of the location of wireless terminal **201** at instant H_1 based on the maximum likelihood function of the normalized probability distribution at instant H_1.

Generating the Probability Distributions for the Location of Wireless Terminal **201** Based on Assisted GPS—FIG. **12** depicts a flowchart of the salient processes performed in process **1002**: generating the Z probability distributions for the location of wireless terminal **201** based on GPS-derived information (i.e., information from GPS constellation **221**).

In accordance with processes **1124** and **1201**, location server **214** transmits, and assistance server **212** receives, the preliminary estimate of the location of wireless terminal **201** at instant H_1 as generated in process **1105**.

In accordance with process **1202**, assistance server **212** generates assistance data for wireless terminal **201** based on the preliminary estimate of the location of wireless terminal **201** at instant H_1. In accordance with the illustrative embodiment, assistance server **212** generates "fully-custom" assistance data based on the estimate of the location of wireless terminal **201** at instant H_1. The assistance data is "fully-custom" because it is specifically tailored to the estimated location of wireless terminal **201** at instant H_1. It will be clear to those skilled in the art how to generate fully-custom assistance data for wireless terminal **201** based on the estimated location of wireless terminal **201** at instant H_1. As part of process **1202**, assistance server **212** transmits the assistance data to wireless terminal **201** via wireless switching center **212** in well-known fashion.

In accordance with some alternative embodiments of process **1202**, assistance server **212** pre-computes assistance data for a plurality of diverse locations within geographic region **220** and selects that pre-computed assistance data for wireless terminal **201** based on the estimated location of wireless terminal **201** at instant H_1. Because the assistance data selected for wireless terminal **201** is not specifically tailored to the estimated location of wireless terminal **201** at instant H_1, nor generic to all of geographic region **220** or to the cell or sector of the base station serving wireless terminal **201**, it is deemed "semi-custom" assistance data. In general, semi-custom assistance data is less accurate than fully-custom assistance data, but more accurate, on average, than generic assistance data, which is chosen based on cell ID alone and that is based on one location within geographic region **220**. It will be clear to those skilled in the art, after reading this disclosure, how to generate the fully-custom and semi-custom assistance data for wireless terminal **201**.

In accordance with process **1203**, wireless terminal **201** (a) receives the assistance data from assistance server **212**, in well-known fashion, (b) uses it to facilitate the acquisition and processing of one or more GPS satellite signals in well-known fashion, and (c) transmits Z non-empty sets of GPS-derived information to location server **214** for readings at instants G_1 through G_Z, where Z is a positive integer. In accordance with the illustrative embodiment of the present invention, each set of GPS-derived information comprises:

i. a GPS-derived estimate of the location of wireless terminal **201** (e.g., a latitude, longitude, and altitude coordinate, etc.), or

ii. ranging data (e.g., PRN code phase, etc.) from one or more GPS satellites, or

iii. partially-processed ranging signals (e.g., signals from which the ranging data has not yet been extracted, etc.) from one or more GPS satellites, or

iv. any combination of i, ii, and iii.

In accordance with process **1204**, location server **214** receives Z non-empty sets of GPS-derived information to location server **214** for readings at instants G_1 through G_Z and generates a probability distribution that indicates the likelihood that wireless terminal **201** is in each location at each of instants G_1 through G_Z. It will be clear to those skilled in the art how to perform process **1204**.

FIG. **13** depicts a flowchart of the salient processes performed in process **1003**—combining the Y non-GPS-based probability distributions with the Z GPS-based probability distributions to derive F refined multi-dimensional probability distributions for the location of wireless terminal **201** at each of instants J_1 through J_F, where each J_i corresponds to one of:

i. a particular instant H_Y, where $1 \leqq y \leqq Y$, or

ii. a particular instant G_Z, where $1 \leqq z \leqq Z$, or

iii. a concurrence of both a particular instant H_Y, and a particular instant G_Z, where $1 \leqq y \leqq Y$ and $1 \leqq z \leqq Z$.

In other words, each "composite" instant J_i corresponds to either an instant associated with a non-GPS-based probability distribution, or an instant associated with a GPS-based probability distribution, or an instant associated with both a non-GPS probability distribution and a GPS-based probability distribution.

In accordance with process **1003**, the Y non-GPS-based probability distributions with the Z GPS-based probability distributions are intelligently combined, taking into consideration their relative temporal occurrence to derive a refined multi-dimensional probability distribution for the location of wireless terminal **201** at instants J_1 through J_F.

To generate the refined probability distribution for the location of wireless terminal **201** at instant J_i, the probability distributions that occur before instant J_i are temporally-extrapolated progressively to instant J_i, the probability distributions that occur after instant J_i are temporally-extrapolated regressively to instant J_i, and they all are combined with the un-temporally-extrapolated probability distribution for the location of wireless terminal **201** at instant J_i. In this way, the accuracy of all of the refined probability distributions for each instant J_i are enhanced by the empirical data at other instants.

FIG. **14** depicts a first example of determining each of instants J_1 through J_F based on non-GPS-based instants H_1 through H_Y, where Y=4, and GPS-based instants G_1 through G_Z, where Z=6. As can be seen in FIG. **14**, the number of composite instants F is at most Y plus Z, and is at least the maximum of Y and Z—the former occurring when there are no coincident GPS/non-GPS probability distributions, and the latter when there are as many as possible coincident GPS/non-GPS probability distributions.

FIG. **15** depicts a second example of determining each of instants J_1 through J_F based on non-GPS-based instants and GPS-based instants. This second example illustrates that even when the non-GPS-based instants are uniformly spaced in time and the GPS-based instants are uniformly spaced in time, the composite instants are not necessarily uniformly spaced in time.

In accordance with the present invention, the time step Δt is defined as the minimum time interval between any two instants. The time step is atomic in that the time difference between any two instants is an integral multiple of time steps. (Note that two consecutive instants—whether they are non-GPS-based instants, GPS-based instants, or composite instants—might be more than a single time step apart.) The time step of the present invention is therefore similar to the time step employed in clock-driven discrete event simulations.

As will be appreciated by those skilled in the art, selecting an appropriate value for the time step Δt typically will depend on the particular application, and involves a tradeoff between (1) temporal precision and (2) available memory and processing power. As will be further appreciated by those skilled in the art, after reading this disclosure, the selected time step can affect the definition of locations, the moving and staying probabilities, and consequently the graphs that are derived from them (e.g., the adjacency graph, etc.).

In accordance with process **1301**, location server **214** determines instants J_1 through J_F, as described above.

In accordance with process **1302**, location server **214** constructs unrefined probability distributions V_1 through V_F for instants J_1 through J_F as follows:

i. if J_i corresponds to a particular H_j only, then V_i equals the non-GPS probability distribution at instant H_j,

ii. if J_i corresponds to a particular G_k only, then V_i equals the GPS probability distribution at instant G_k, and

iii. otherwise (C_i corresponds to both a particular H_j and a particular G_k), V_i equals a probability distribution that equals the normalized product of the non-GPS and GPS probability distributions at instant J_i.

In accordance with process **1303**, location server **214** determines for each instant J_i, temporally-extrapolated probability distributions $D_{i,j}$ for all $j \neq i$, $1 \leqq j \leqq F$, which are based on (i) the unrefined probability distribution V_j at instant J_j, (ii) $P_S(b, T, N, W)$, and (iii) $P_M(b, T, N, W, c)$. The extrapolated probability distribution $D_{i,j}$ is therefore a predictive probability distribution at instant J_i that is based on empirical data at

instant J_j—but not on any empirical data at other instants, including J_i.

i. the past data for the movement of all wireless terminals; and

ii. the past data for the movement of wireless terminal W; and

iii. the location, speed, and acceleration of wireless terminal W at calendrical time T; and

iv. the state of traffic signals that can affect the movement of wireless terminals in location b.

A temporally-extrapolated probability distribution can be progressed (i.e., projected into the future based on a past probability distribution). For example, if instant J_3 is one time step after instant J_2, then extrapolated probability distribution $D_{3,2}$ is derived by a single application of $P_S(b, T, N, W)$ and $P_M(b, T, N, W, c)$ to unrefined probability distribution V_2. In other words, for any location b:

$$D_{3,2}[b] = V_2[b] \cdot P_S(b, J_2, N, W) + \sum_{(c,b)\in in(b)} V_2[c] \cdot P_M(c, J_2, N, W, b) \quad \text{(Eq. 8)}$$

where in(b) is the set of arcs into location b from other locations in the adjacency graph. Similarly, a temporally-extrapolated probability distribution can be regressed (i.e., projected into the past based on a future unrefined probability distribution) based on the equation:

$$V_3[b] = D_{2,3}[b] \cdot P_S(b, J_2, N, W) + \sum_{(c,b)\in in(b)} D_{2,3}[c] \cdot P_M(c, J_2, N, W, b) \quad \text{(Eq. 9)}$$

by setting up a system of equations (9) for a plurality of locations $\{b_1, b_2, \ldots, b_\eta\}$ and solving for $\{D_{2,3}[b_1], D_{2,3}[b_2], \ldots, D_{2,3}[b_\eta]\}$ via matrix algebra.

As will be well-understood by those skilled in the art, after reading this disclosure, when consecutive instants are two or more time steps apart, then Equation 8 can be applied iteratively in well-known fashion. (Because the time step is atomic the number of iterations is always integral.) As will be further appreciated by those skilled in the art, after reading this disclosure, the extrapolated probability distributions for non-consecutive time instants (e.g., $D_{2,4}$, $D_{5,1}$, etc.) can be efficiently computed in a bottom-up fashion from the extrapolated probability distributions for consecutive time instants via dynamic programming.

In accordance with process **1304**, location server **214** computes each refined probability distribution L_i, corresponding to each instant J_i, $1 \leqq i \leqq F$, as a weighted average of:

i. the corresponding unrefined probability distribution V_i, and

ii. all available temporally-extrapolated probability distributions $D_{i,j}$, $j \neq i$:

$$L_i = \frac{V_i + \sum_{j\neq i} [\alpha^{|j-i|} \cdot D_{i,j}]}{1 + \sum_{j\neq i} \alpha^{|j-i|}} \quad \text{(Eq. 10)}$$

wherein α is a constant, $0<\alpha<1$, that acts as an "aging factor" that weights less temporally-extrapolated probability distributions more heavily that more temporally-extrapolated probability distributions because of the more temporally-extrapolated probabilities distributions are less likely to be correct than the less temporally-extrapolated probability distributions. For example, when i=4 and F=5, Equation 10 in expanded form yields:

$$L_4 = \frac{V_4 + \alpha \cdot D_{4,3} + \alpha \cdot D_{4,5} + \alpha^2 \cdot D_{4,2} + \alpha^3 \cdot D_{4,1}}{1 + 2\alpha + \alpha^2 + \alpha^3} \quad \text{(Eq. 11)}$$

Defining $D_{i,i}=V_i$, Equation 10 can be expressed in a simpler form that is particularly convenient for computer processing:

$$L_i = \frac{\sum_{j=1}^{F} [\alpha^{|j-i|} \cdot D_{i,j}]}{\sum_{j=1}^{F} \alpha^{|j-i|}} \quad \text{(Eq. 12)}$$

In accordance with process **1305**, location server **214** generates an estimate of the location of wireless terminal **201** at one or more instants J_i based on the maximum likelihood function of L_i. (As will be appreciated by those skilled in the art, after reading this disclosure, in some other embodiments of the present invention an estimate might be generated from probability distribution L_i using another function or method.)

In accordance with process **1306**, location server **214** provides the estimate(s) of the location of wireless terminal **201** generated in process **1305** to location client **213**, in well-known fashion.

It is to be understood that the above-described embodiments are merely illustrative of the present invention and that many variations of the above-described embodiments can be devised by those skilled in the art without departing from the scope of the invention. It is therefore intended that such variations be included within the scope of the following claims and their equivalents.

What is claimed is:

1. A method comprising:

receiving (i) a measurement of a first characteristic of a first signal that is processed by a wireless terminal and (ii) a measurement of the first characteristic of a second signal that is processed by the wireless terminal;

designating at least one of a plurality of possible locations of the wireless terminal as improbable;

estimating the location of the wireless terminal based on:

(i) a comparison of the measurement of the first characteristic of the first signal to a predicted value of the first characteristic of the first signal, and

(ii) a comparison of the measurement of the first characteristic of the second signal to a predicted value of the first characteristic of the second signal, for at least one of the plurality of possible locations not designated as improbable.

2. The method of claim **1** wherein designating at least one of the plurality of possible locations of the wireless terminal as improbable comprises:

designating a possible location as improbable when a ranking of the measurement of the first characteristic of the first signal and the measurement of the first characteristic of the second signal differs from a ranking of the

predicted value of the first characteristic of the first signal and the predicted value of the first characteristic of the second signal at the possible location.

3. The method of claim **1** wherein designating at least one of the plurality of possible locations of the wireless terminal as improbable comprises:

designating a possible location as improbable when a difference of the measurement of the first characteristic of the first signal and the predicted value of the first characteristic of the first signal exceeds a threshold.

4. The method of claim **1** wherein designating at least one of the plurality of possible locations of the wireless terminal as improbable comprises:

designating a possible location as improbable when the location is not provided wireless telecommunications service by a base station that is known to be providing service to the wireless terminal.

5. The method of claim **1** wherein designating at least one of the plurality of possible locations of the wireless terminal as improbable comprises:

designating a possible location as improbable when the location is not within the neighboring coverage area of a base station that is known to be a neighboring base station of the wireless terminal.

6. A method comprising:

receiving a measurement of a first characteristic of a first signal that is processed by a wireless terminal;

designating at least one of a plurality of possible locations of the wireless terminal as improbable; and

estimating the location of the wireless terminal based on a comparison of the measurement of the first characteristic of the first signal to a predicted value of the first characteristic of the first signal for at least one of the plurality of possible locations not designated as improbable;

wherein designating at least one of the plurality of possible locations of the wireless terminal as improbable comprises:

designating a possible location as improbable when a measurement of the first characteristic of a second signal is not received when it would have been received if the wireless terminal were, in fact, at that location.

7. A method comprising:

receiving (i) a measurement of a first characteristic of a first signal that is processed by the wireless terminal and (ii) an indication that a measurement of the first characteristic of a second signal is not received;

designating at least one of a plurality of possible locations of the wireless terminal as improbable; and

estimating the location of the wireless terminal based on a comparison of the measurement of the first characteristic of the first signal to a predicted value of the first characteristic of the first signal for at least one of the plurality of possible locations not designated as improbable;

wherein designating at least one of the plurality of possible locations of the wireless terminal as improbable comprises:

designating a possible location as improbable when the measurement of the first characteristic of the second signal is not received when it would have been received if the wireless terminal were, in fact, at that location.

8. A method comprising:

receiving (i) a measurement of a first characteristic of a first signal that is processed by the wireless terminal and (ii) an indication that a measurement of the first characteristic of a second signal is not received;

designating at least one of a plurality of possible locations of the wireless terminal as improbable; and

estimating the location of the wireless terminal based on a comparison of the measurement of the first characteristic of the first signal to a predicted value of the first characteristic of the first signal for at least one of a plurality of possible locations not designated as improbable;

wherein designating at least one of the plurality of possible locations of the wireless terminal as improbable comprises:

designating a possible location of the wireless terminal as improbable when that possible location is not provided wireless telecommunications service by a first base station that is known to be providing service to the wireless terminal; and

designating a possible location of the wireless terminal as improbable when the measurement of the first characteristic of the second signal is not received when it would have been received if the wireless terminal were, in fact, at that location.

9. The method of claim **8** further comprising:

designating a possible location as improbable when a ranking of the measurement of the first characteristic of the first signal and the measurement of the first characteristic of the second signal differs from a ranking of the predicted value of the first characteristic of the first signal and the predicted value of the first characteristic of the second signal at the possible location.

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EXHIBIT E

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(12) **United States Patent**
Krumm et al.

(10) **Patent No.: US 7,250,907 B2**
(45) **Date of Patent: Jul. 31, 2007**

(54) **SYSTEM AND METHODS FOR DETERMINING THE LOCATION DYNAMICS OF A PORTABLE COMPUTING DEVICE**

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See application file for complete search history.

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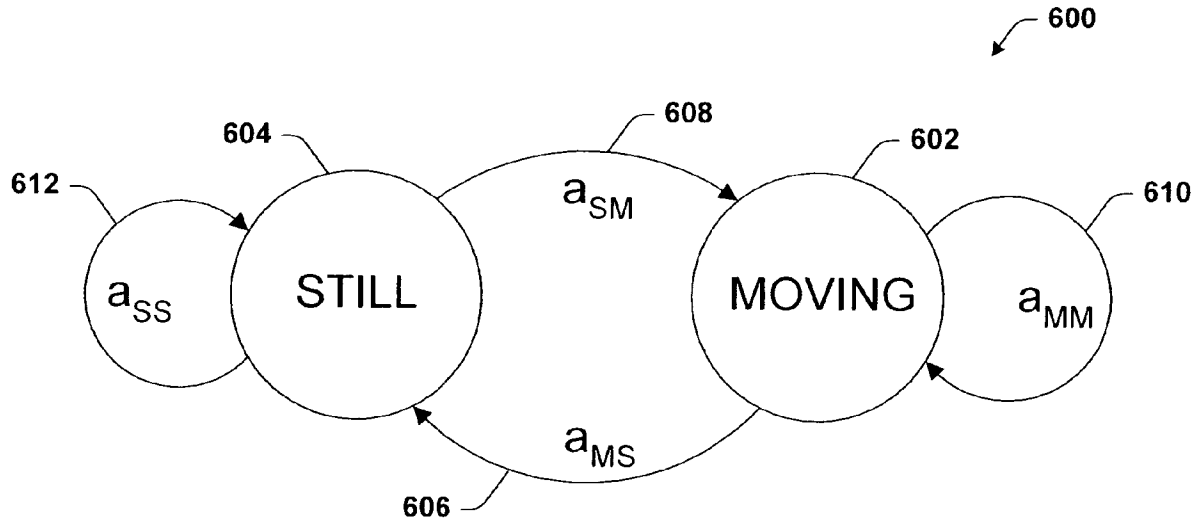
(57) **ABSTRACT**

A location system for locating and determining the motion and velocity of a wireless device. The methods include direct inferences about whether a device is in motion versus static based on a statistical analysis of the variation of radio signal strengths over time. The system is trained according to a sparse set of identified locations from which signal strengths are measured. The system uses the signal properties of the identified locations to interpolate for a new location of the wireless device. The system uses a probabilistic graph where the identified locations of the floor plan, expected walking speeds of pedestrians, and independent inference of whether or not the device is in motion are used to determine the new location of the device.

47 Claims, 11 Drawing Sheets



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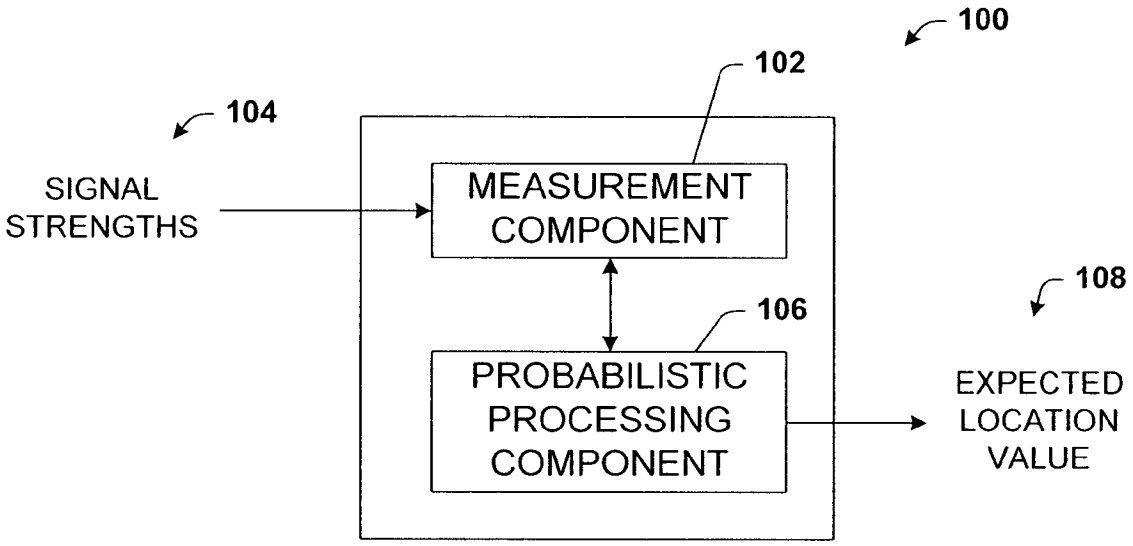
100
102
104
SIGNAL STRENGTHS
MEASUREMENT COMPONENT
106
108
PROBABILISTIC PROCESSING COMPONENT
EXPECTED LOCATION VALUE

FIG. 1

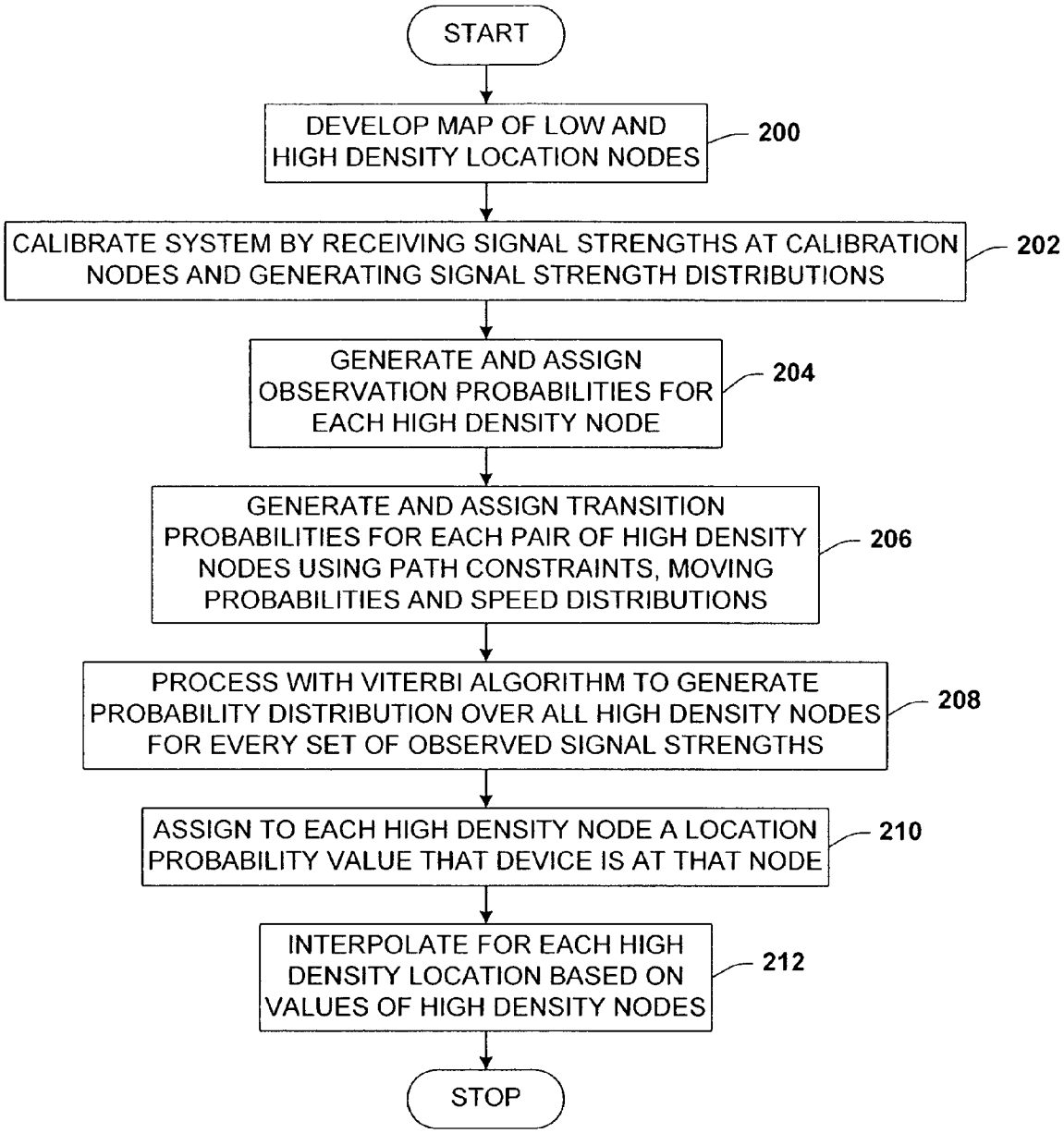
START
DEVELOP MAP OF LOW AND HIGH DENSITY LOCATION NODES
200
CALIBRATE SYSTEM BY RECEIVING SIGNAL STRENGTHS AT CALIBRATION NODES AND GENERATING SIGNAL STRENGTH DISTRIBUTIONS
202
GENERATE AND ASSIGN OBSERVATION PROBABILITIES FOR EACH HIGH DENSITY NODE
204
GENERATE AND ASSIGN TRANSITION PROBABILITIES FOR EACH PAIR OF HIGH DENSITY NODES USING PATH CONSTRAINTS, MOVING PROBABILITIES AND SPEED DISTRIBUTIONS
206
PROCESS WITH VITERBI ALGORITHM TO GENERATE PROBABILITY DISTRIBUTION OVER ALL HIGH DENSITY NODES FOR EVERY SET OF OBSERVED SIGNAL STRENGTHS
208
ASSIGN TO EACH HIGH DENSITY NODE A LOCATION PROBABILITY VALUE THAT DEVICE IS AT THAT NODE
210
INTERPOLATE FOR EACH HIGH DENSITY LOCATION BASED ON VALUES OF HIGH DENSITY NODES
212
STOP

FIG. 2

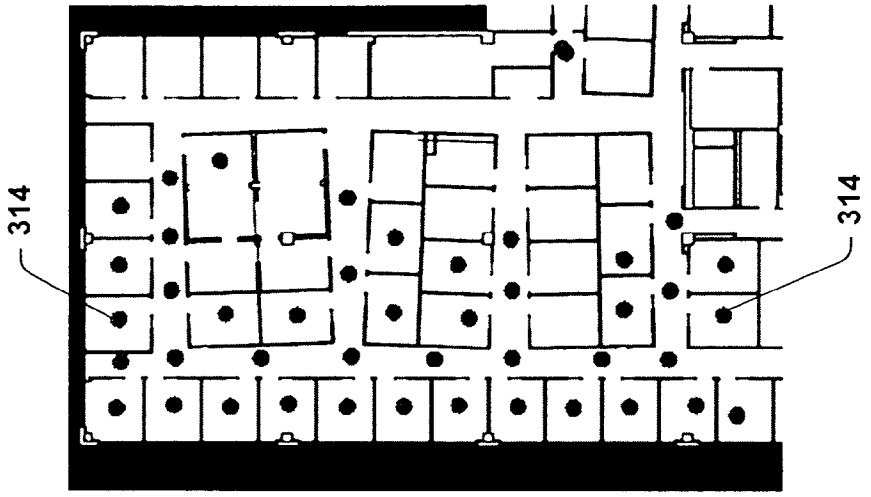

FIG. 3C

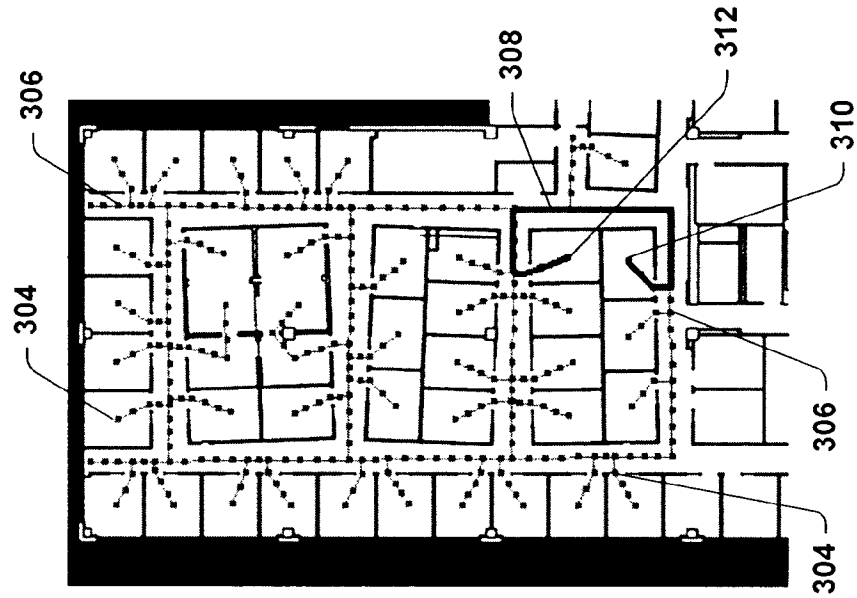

FIG. 3B

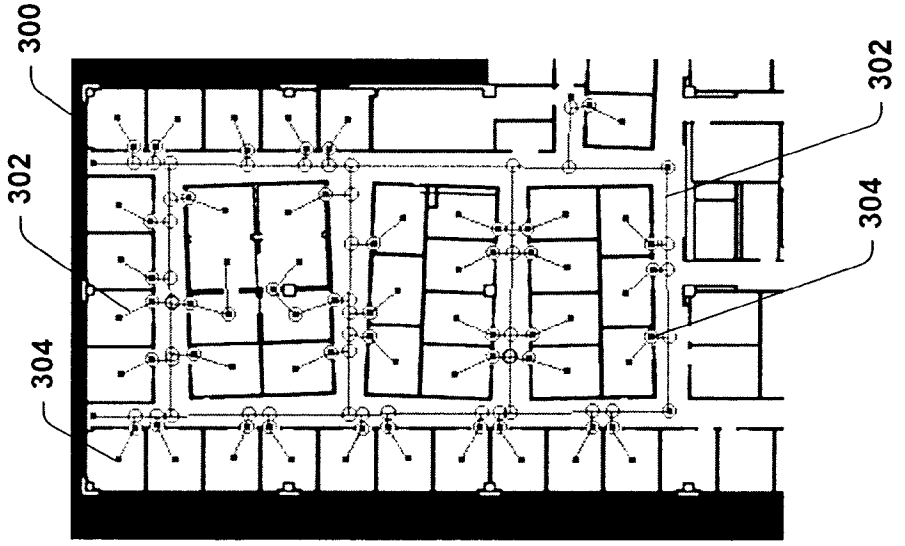

FIG. 3A

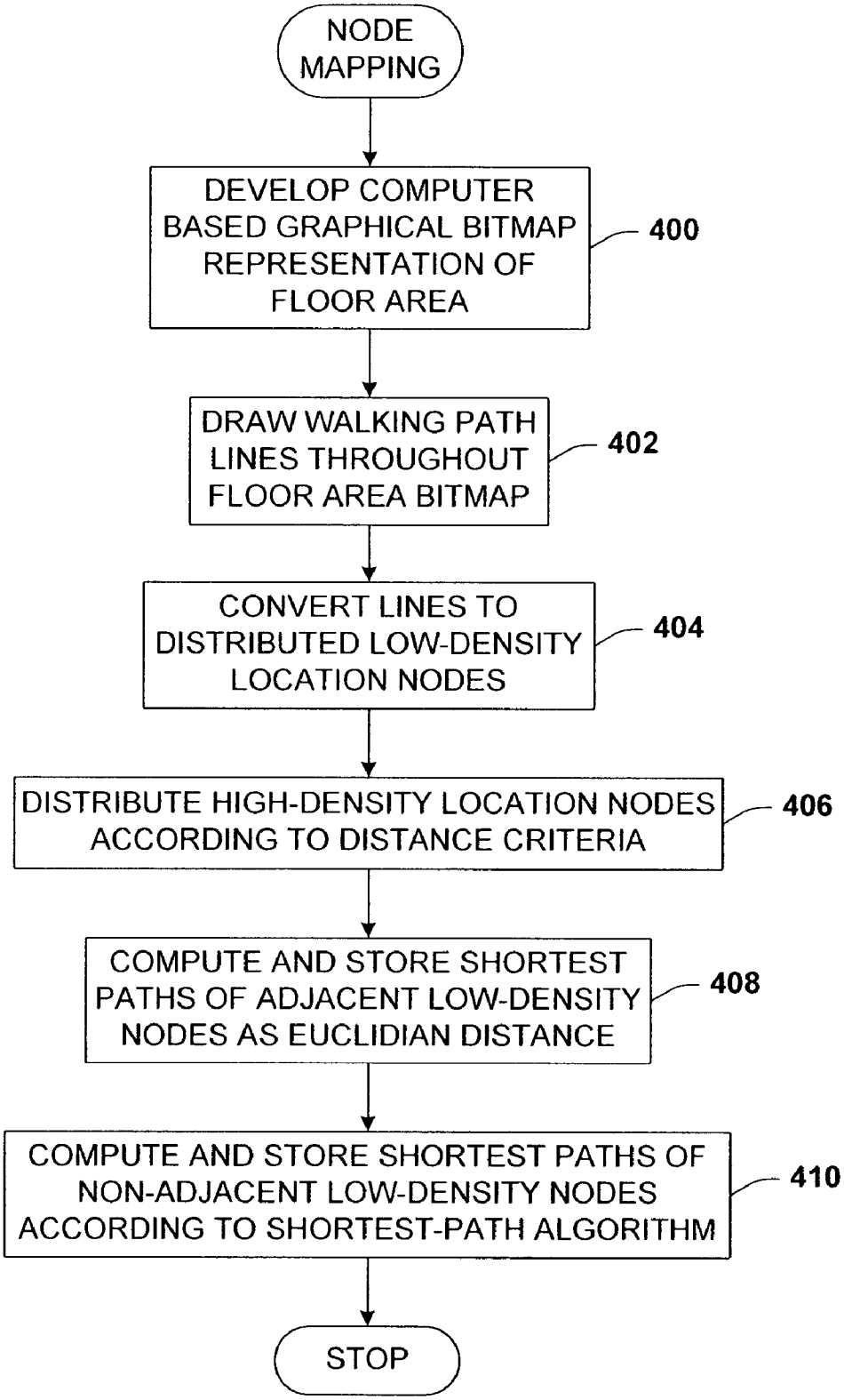
NODE MAPPING
DEVELOP COMPUTER BASED GRAPHICAL BITMAP REPRESENTATION OF FLOOR AREA
400
DRAW WALKING PATH LINES THROUGHOUT FLOOR AREA BITMAP
402
CONVERT LINES TO DISTRIBUTED LOW-DENSITY LOCATION NODES
404
DISTRIBUTE HIGH-DENSITY LOCATION NODES ACCORDING TO DISTANCE CRITERIA
406
COMPUTE AND STORE SHORTEST PATHS OF ADJACENT LOW-DENSITY NODES AS EUCLIDIAN DISTANCE
408
COMPUTE AND STORE SHORTEST PATHS OF NON-ADJACENT LOW-DENSITY NODES ACCORDING TO SHORTEST-PATH ALGORITHM
410
STOP

FIG. 4

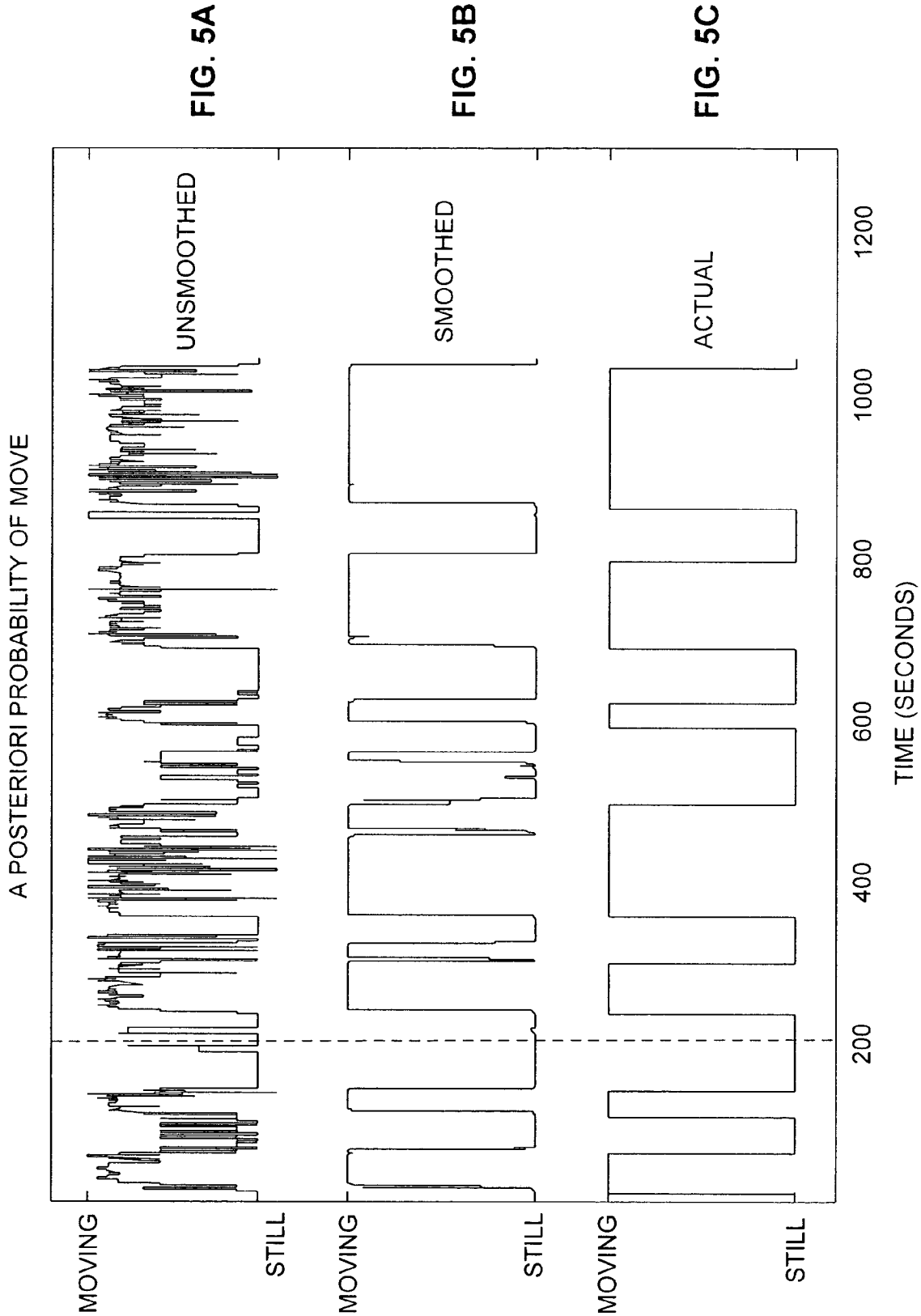
FIG. 5A
FIG. 5B
FIG. 5C
UNSMOOTHED
SMOOTHED
ACTUAL
A POSTERIORI PROBABILITY OF MOVE
MOVING
STILL
MOVING
STILL
MOVING
STILL
200
400
600
800
1000
1200
TIME (SECONDS)

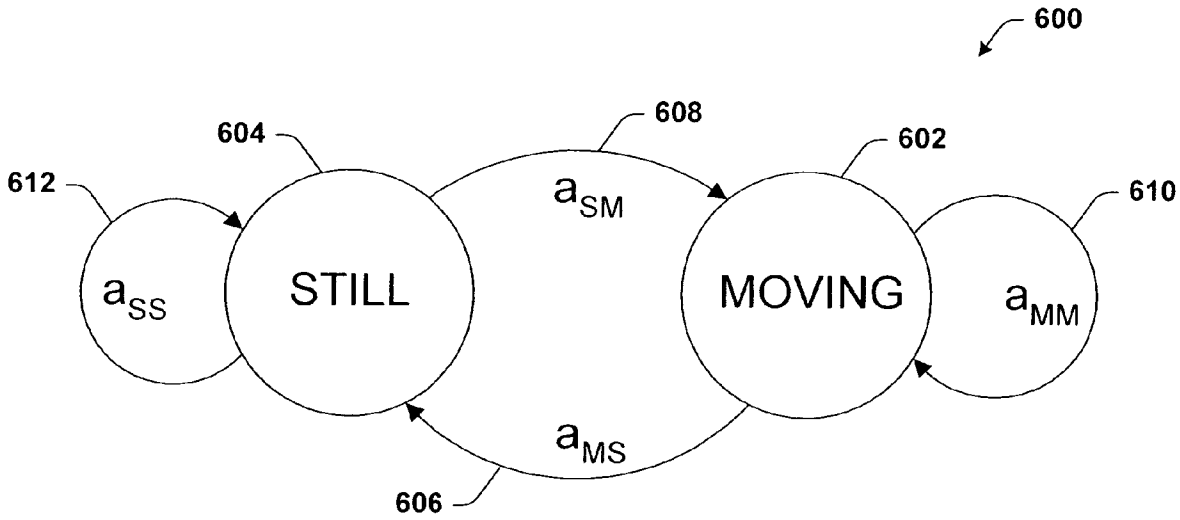

FIG. 6

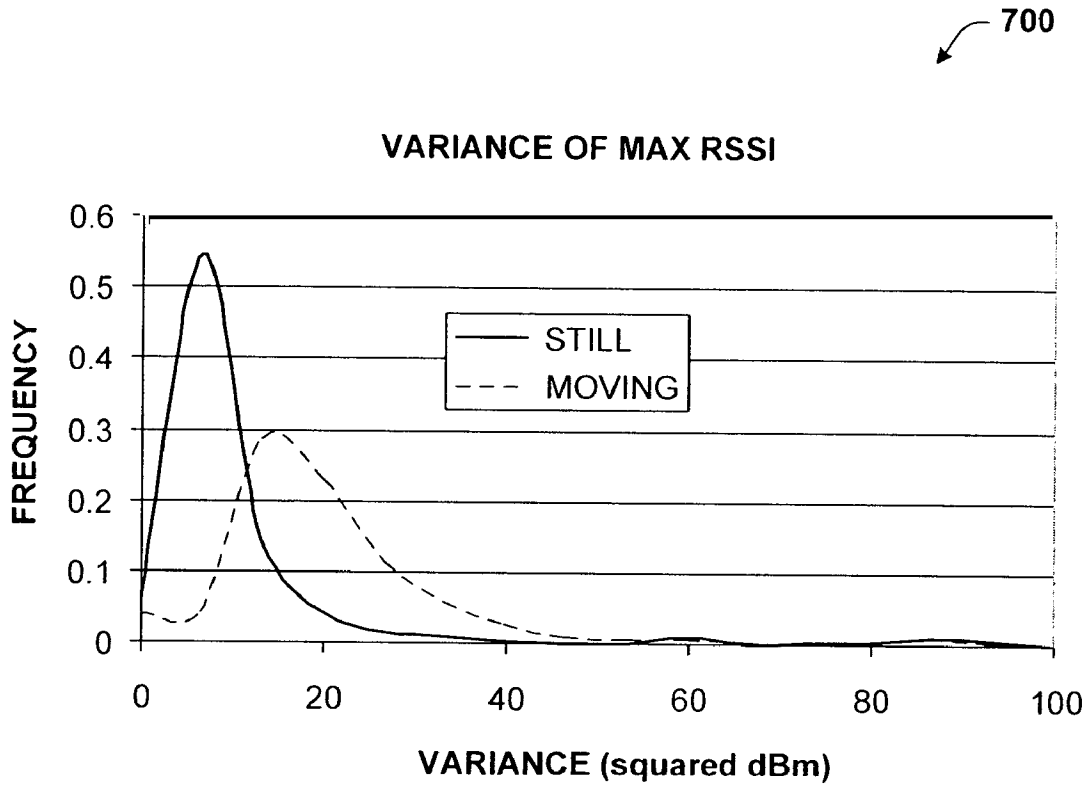
700
VARIANCE OF MAX RSSI
FREQUENCY
0.6
0.5
0.4
0.3
0.2
0.1
0
STILL
MOVING
0
20
40
60
80
100
VARIANCE (squared dBm)

FIG. 7

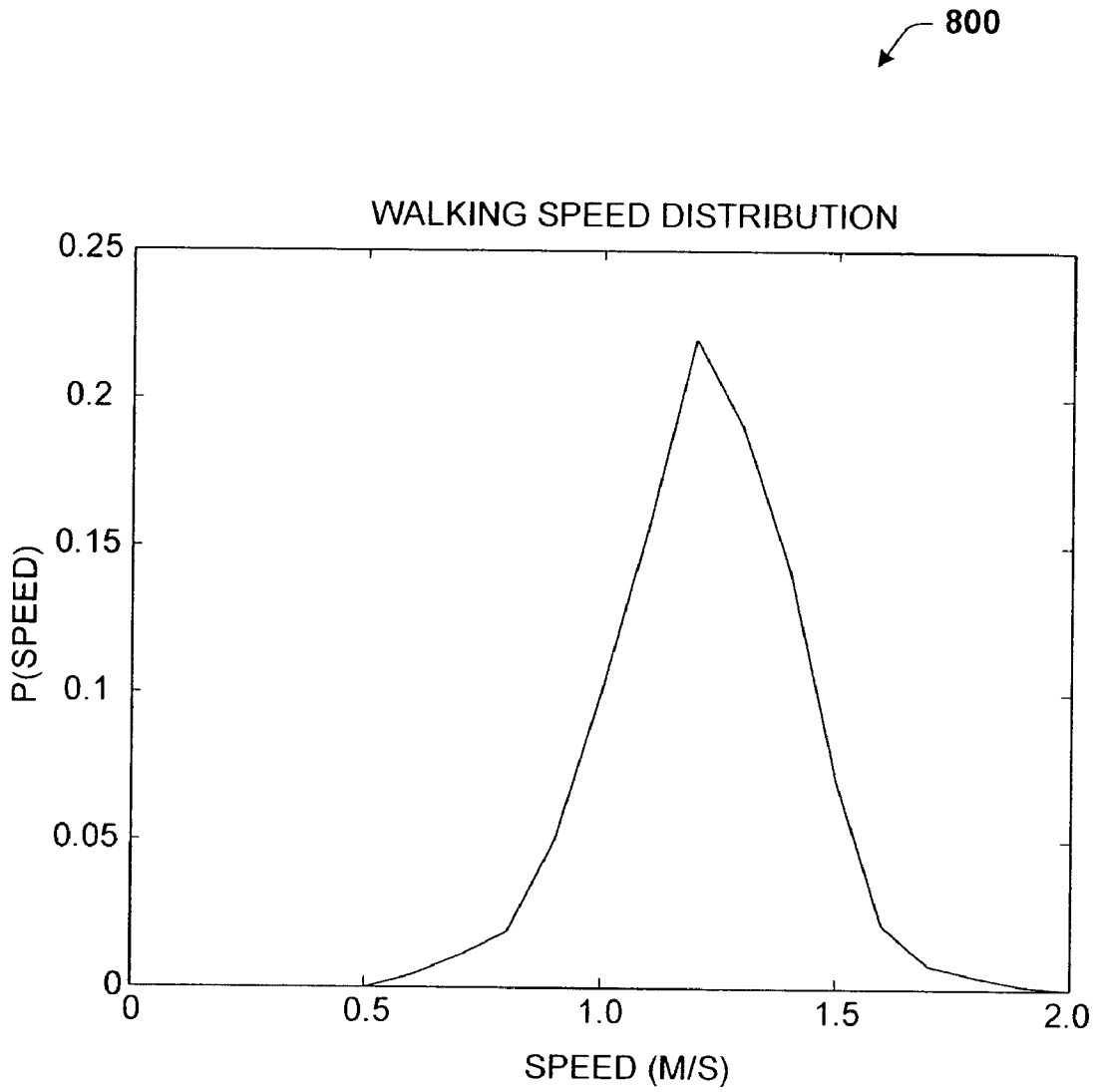
800
WALKING SPEED DISTRIBUTION
P(SPEED)
0.25
0.2
0.15
0.1
0.05
0
0
0.5
1.0
1.5
2.0
SPEED (M/S)

FIG. 8

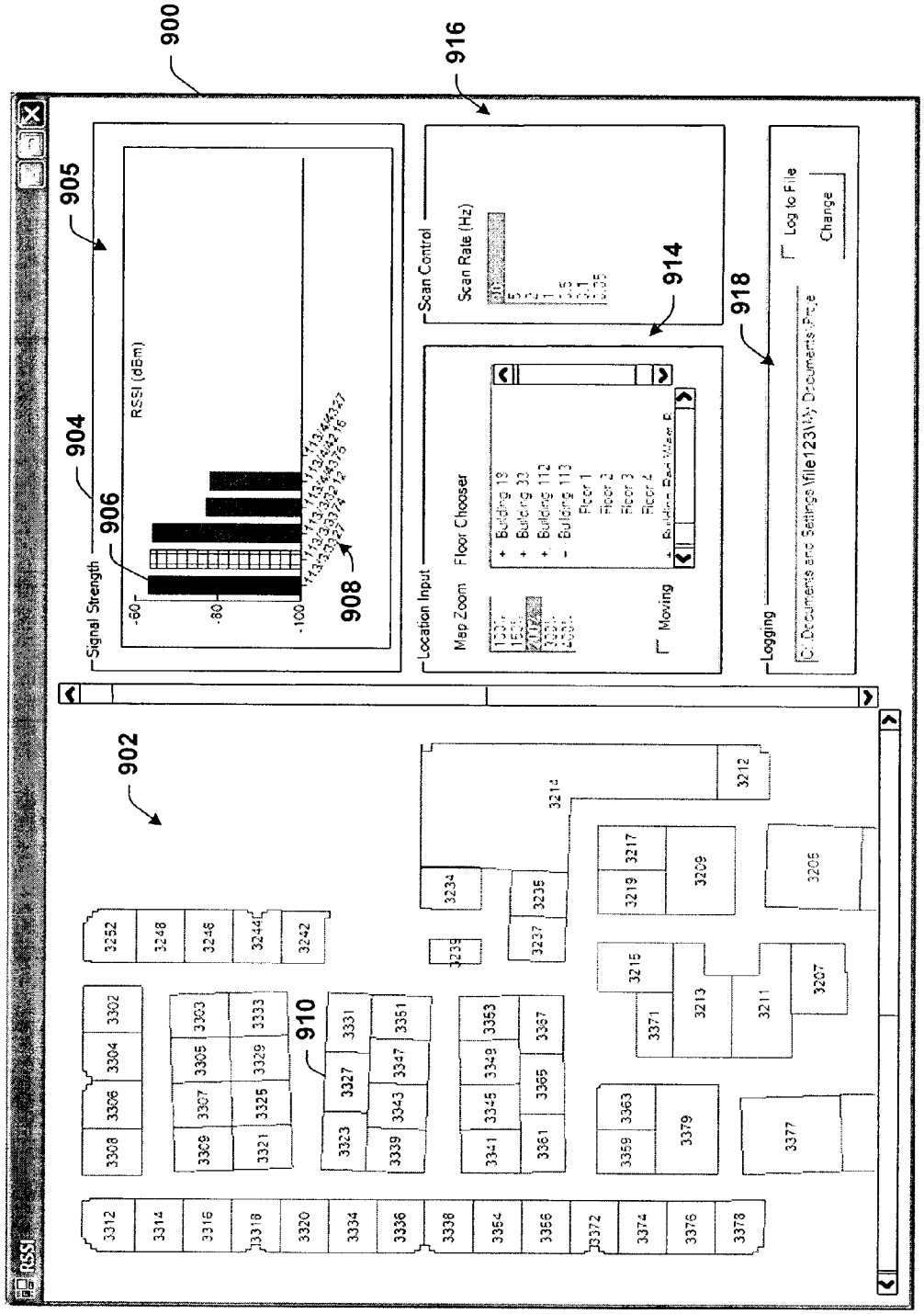
900
916
905
904
906
908
902
910
914
918
Signal Strength
RSSI (dBm)
-60
-80
-100
Scan Control
Scan Rate (Hz)
Location Input
Map Zoom
Floor Chooser
Building 19
Building 33
Building 112
Building 113
Floor 1
Floor 2
Floor 3
Floor 4
Moving
Logging
Log to File
Change
rssi

FIG. 9

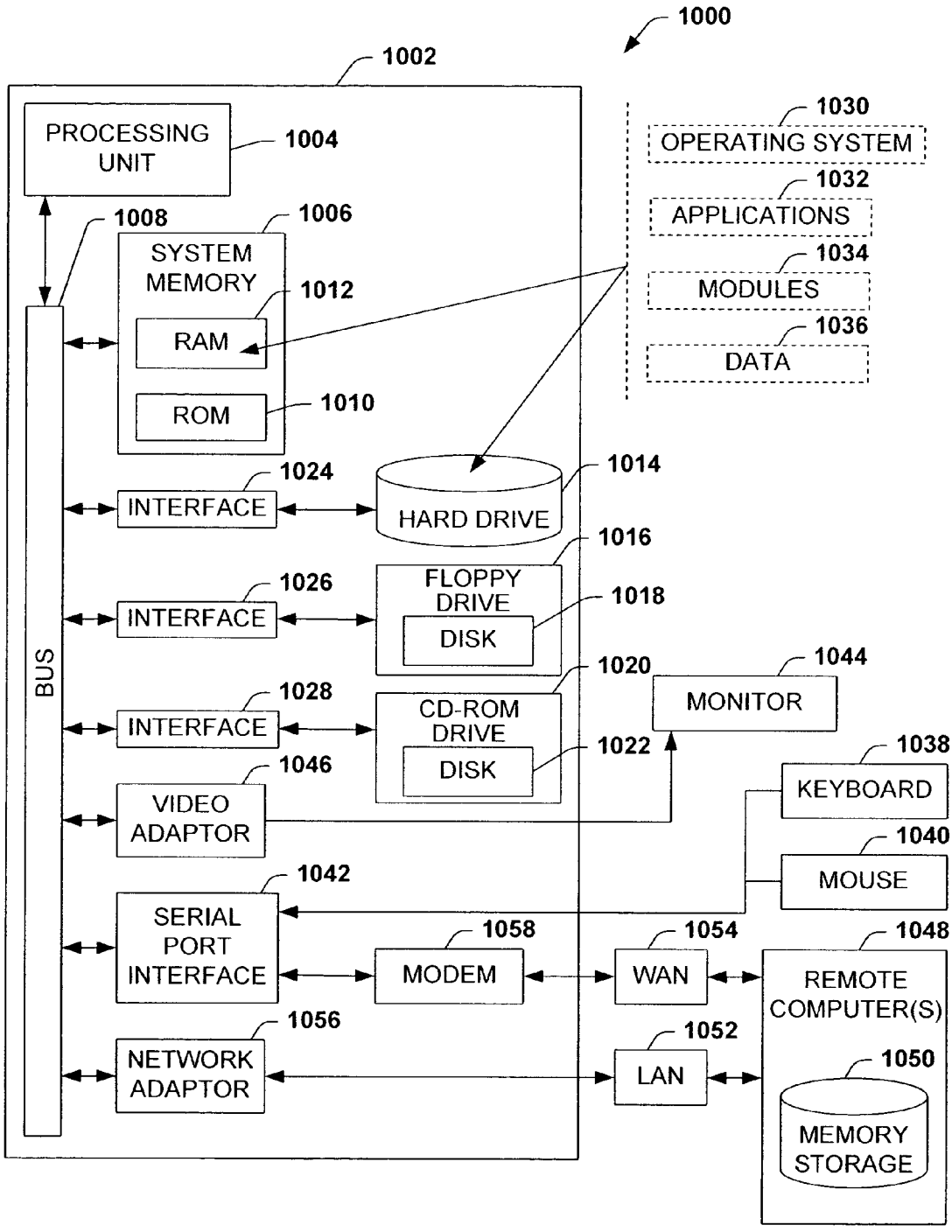
1000
1002
PROCESSING UNIT
1004
1008
1006
SYSTEM MEMORY
1012
RAM
ROM
1010
BUS
1030
OPERATING SYSTEM
1032
APPLICATIONS
1034
MODULES
1036
DATA
1024
INTERFACE
HARD DRIVE
1014
1016
1026
INTERFACE
FLOPPY DRIVE
DISK
1018
1028
INTERFACE
CD-ROM DRIVE
DISK
1020
1022
1044
MONITOR
1046
VIDEO ADAPTOR
1038
KEYBOARD
1040
MOUSE
1042
SERIAL PORT INTERFACE
1058
MODEM
1054
WAN
1048
REMOTE COMPUTER(S)
1056
NETWORK ADAPTOR
1052
LAN
1050
MEMORY STORAGE

FIG. 10

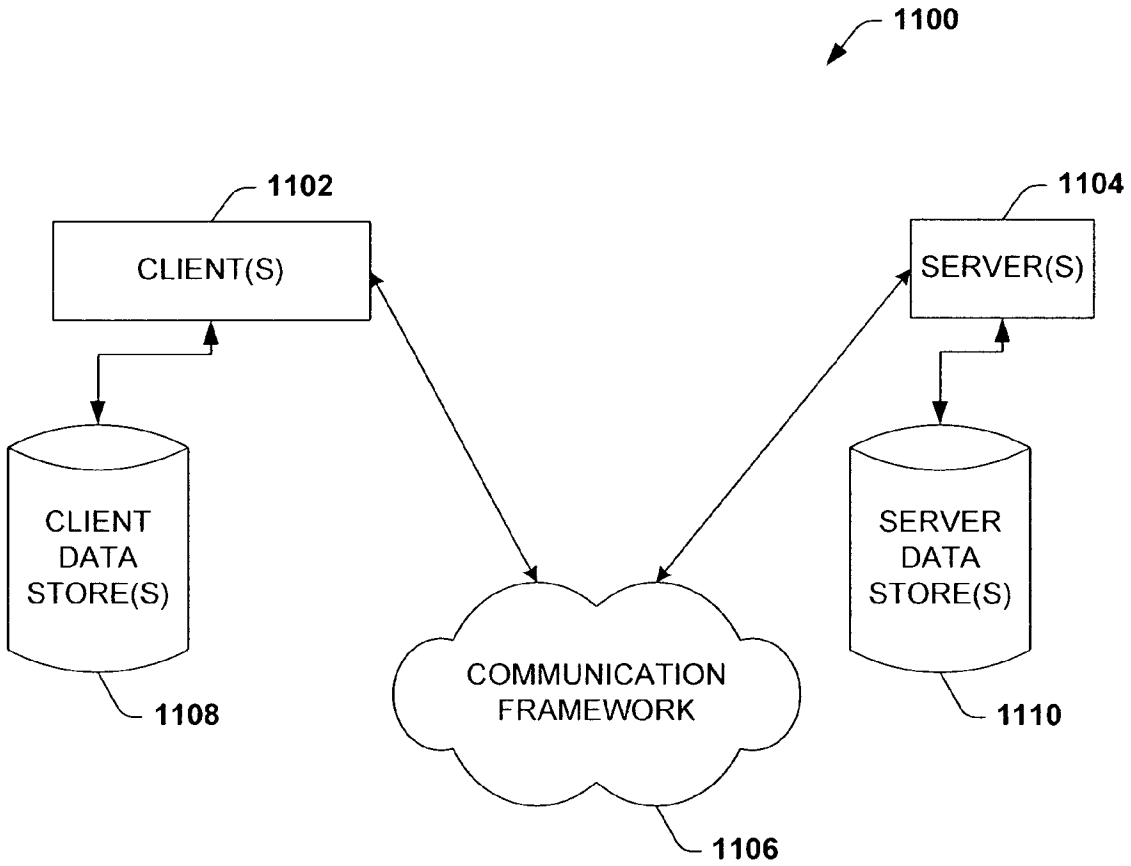
1100
1102
CLIENT(S)
1104
SERVER(S)
CLIENT DATA STORE(S)
SERVER DATA STORE(S)
COMMUNICATION FRAMEWORK
1108
1110
1106

FIG. 11

SYSTEM AND METHODS FOR DETERMINING THE LOCATION DYNAMICS OF A PORTABLE COMPUTING DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to pending U.S. patent application Ser. No. 10/423,093 entitled "CALIBRATION OF A DEVICE LOCATION MEASUREMENT SYSTEM THAT UTILIZES WIRELESS SIGNAL STRENGTHS", filed Apr. 25, 2003.

TECHNICAL FIELD

This invention relates to equipment location systems, and more specifically. to a probabilistic location system that determines device location and motion using wireless signal strengths.

BACKGROUND OF THE INVENTION

The increasing ubiquity of wireless network access has motivated the creation of several methods aimed at identifying the location of a wireless client based on radio signal strength measurements. Although these location-based systems continue to improve in terms of accuracy and ease of use, prior efforts have not yet considered the use of the ambient wireless infrastructure to identify in a direct manner the dynamics of the client such as its motion and velocity. The same signals used for inferring location can be used for inferring dynamics. The information about dynamics. in turn. are useful for helping to infer both the client location and context, in general. Direct access to knowledge about the motion of a client has implications for the best way to fuse a series of signals received over time. For instance, knowledge that a client is motionless would let a location algorithm fuse a set of estimates for the current location into a single estimate with higher certainty. Knowledge of whether a mobile device (and user associated with a mobile client) is in motion may be useful, for example, to provide a signal about if and how to alert a user with an important message. It may be preferred to withhold messages until a user has arrived at a location, or only to let the most important messages through when a user is moving. In another example, it may be preferred to compress a message through summarization or truncation when a user is moving, or raise the volume of an alerting modality, or increase the size of the text of a display.

Location information may be employed to find people, places, and objects of interest. Beyond providing access to the current status of people and items, location information can support presence-forecasting services, which services provide information about a user's future presence or availability. In other applications, location is also useful for identifying the best way to relay notifications to a user, given device availabilities and the cost of interruption associated with different contexts. Location information may also be harnessed for the task of marshalling a set of nearby devices or device components.

Outdoor applications can rely on decoding timing signals from GPS (Global Positioning Service) or GLONASS (Global Navigation Satellite System) satellite navigation systems to obtain high-confidence location information. Unfortunately, no comparably ubiquitous means of measuring location is available for indoor applications. Although specialized systems such as active badges or radio frequency identification (RFID) tags can work well indoors, their installation costs may be prohibitive—and they require users to carry an extra device.

A promising alternative to relying on such specialized location systems is to infer location by accessing signals generated by an existing IEEE 802.11 wireless infrastructure (hereinafter also denoted as "Wi-Fi") of the building. Wi-Fi installations have been diffusing quickly into private and public spaces. In parallel, increasing numbers of mobile devices equipped with IEEE 802.11 network interface hardware or built-in Wi-Fi sensing are becoming available. As the Wi-Fi infrastructure becomes more ubiquitous, location techniques exploiting the ambient radio signals can grow with it, despite the fact that Wi-Fi was never intended for inferring location.

Developing methods for accessing device information from an existing IEEE 802.11 Wi-Fi networking infrastructure is attractive as the use of ambient signals and receivers bypasses the need for special broadcasting and sensing hardware. Prior efforts on ascertaining location from IEEE 802.11 wireless signals have relied on the construction of detailed models of transmission and burdensome calibration efforts, aimed at mapping signals to locations.

The capability to identify the location of wireless clients indoors by measuring signal strengths from multiple IEEE 802.11 access points is not new. Matching signal strength signatures is the same basic technique used by all location-from-802.11 techniques, including a first one, called RADAR. Using a manually calibrated table of signal strengths, the RADAR nearest-neighbor algorithm gave a median spatial error of approximately 2.94 meters. In follow-on work, this error was reduced to approximately 2.37 meters using a Viterbi-like algorithm. Further research also precomputed signal strength signatures using a model of radio propagation and a floor plan of the building.

This reduced the calibration effort at the expense of increasing their median location error to 4.3 meters.

Another conventional system, and perhaps the most accurate IEEE 802.11 location system, used Bayesian reasoning and a hidden Markov model (HMM). This system took into account not only signal strengths, but also the probability of seeing an access point from a given location. Like other work, it was based on a manual calibration. The system explicitly modeled orientation and achieved a median spatial error of about one meter using calibration samples taken approximately every 1.5 meters (five feet) in hallways. Many additional conventional systems have been employed using, for example, signal-to-noise ratios instead of the more commonly used raw signal strengths, and a formula that was used for approximating the distance to an access point as a function of signal strength.

Wi-Fi-centric systems have several attractive features, including privacy of location information. All location computations can be performed on the client device, and the device does not need to reveal the identity of the user or other information to the wireless interfaces to the wired network. The combination of growing ubiquity of Wi-Fi infrastructure, existing capable client devices, and privacy solutions make IEEE 802.11 a compelling way to identify location.

However, what is still needed is a Wi-Fi location-based system that requires less training time while providing additional information related to location dynamics.

SUMMARY OF THE INVENTION

The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is not intended to identify key/critical elements of the invention or to delineate the scope of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

The present invention disclosed and claimed herein, in one aspect thereof, comprises architecture for determining the state of motion and location of a portable computing device by analyzing the strengths of wireless signals in a wireless network. Having information about moving versus not moving and more accurate location information is useful for a variety of applications, including for systems that make decisions about the best time and device for alerting a user. The invention facilitates tracking of individuals and/or components, as well as providing relevant information (e.g., based on state, as well as inferred future state) to a user in a wireless network. The invention also facilitates optimizing communications, e.g., maintaining communications and data throughput.

More specifically, the present invention introduces a coherent probabilistic interpretation of signal strengths and visible access points, and employs an HMM representation. However, the present invention is distinct in its use of more sophisticated models than conventional systems for providing estimates of state transition probabilities, which leads to reduced calibration effort. The novel system works from a connected graph of discrete (x,y) high-density location nodes on the floor of the building. Upon the receipt of a set of signal strengths, the HMM is used to compute the probability that the device is at each of the location nodes. At each point in time, each pair of location nodes has a transition probability associated therewith that gives the probability that the device will move from the first member of the pair to the second. These transition probabilities are a function of elapsed time since the last signal strength reading, the distance between the pair of nodes, and the probability that the device is currently in motion. Rather than considering the distance between a pair of nodes to be the Euclidian distance, the shortest path distance is based on a constraint-sensitive path-planning algorithm that takes into consideration the walls of a building floor plan such that paths cannot pass through walls.

The invention includes probabilistic methods for enhancing robustness and reducing the training (or calibration) effort associated with location services based on ambient IEEE 802.11 infrastructures. The disclosed architecture employs a probabilistic graph where locations are nodes and transition probabilities among nodes are derived as a function of the building (or floor plan) layout, expected walking speeds of pedestrians, and an independent inference of whether or not a device is in motion. Calibration of signal strengths is relatively easy compared to other systems of this type. The present invention provides a relatively accurate location sensing system while minimizing calibration effort by including interpolation of signal strengths from a sparsely sampled set of calibration nodes, exploiting path constraints imposed by the building's interior structure (e.g., walls and doors), integrating the consideration of human pedestrian speeds, making independent inferences about whether or not a client device is in motion, and folding in these inferences into the location analysis. Thus the mobile client is as smart as possible in order to maintain accuracy in spite of sparse calibration data, which can be tedious to obtain. Overall, the present invention provides a principled framework representing a superior tradeoff between accuracy and calibration effort by including path, time, and rate constraints that are important for extracting valuable data out of the typically noisy raw signal data.

The disclosed system facilitates visiting a much sparser set of location nodes for calibration then conventional systems. Interpolation is employed to estimate observation probabilities at the high-density location nodes from the lower density calibration nodes. This significantly reduces the necessary calibration effort. The graph of location nodes, transition probabilities, and observation probabilities are combined with a Viterbi algorithm to compute a probability distribution over the high-density nodes from every set of observed signal strengths obtained during live operation of the system. The expected value of device location is reported as an ultimate result, showing that the median error is approximately 1.53 meters.

To the accomplishment of the foregoing and related ends, certain illustrative aspects of the invention are described herein in connection with the following description and the annexed drawings. These aspects are indicative, however, of but a few of the various ways in which the principles of the invention may be employed and the present invention is intended to include all such aspects and their equivalents. Other advantages and novel features of the invention may become apparent from the following detailed description of the invention when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a block diagram of a system for facilitating determination of location dynamics of the present invention.

FIG. **2** illustrates a flow chart of processes of the probability component of the present invention.

FIG. **3**A illustrates a graphical representation of the low-density nodes on the floor plan, as drawn by someone setting up the system.

FIG. **3**B illustrates a graphical representation of the high-density nodes automatically added to the low-density nodes on the floor plan.

FIG. **3**C illustrates a graphical representation of the calibration nodes of the floor plan used to obtain signal strength readings, as provided by the data collection system of the present invention.

FIG. **4** illustrates a flow chart of the process for establishing low-density and high-density nodes for use by computer drawing or mapping program of the disclosed architecture.

FIG. **5**A illustrates a plot of the raw unsmoothed a posteriori probabilities of whether or not a device is moving over time.

FIG. **5**B illustrates a plot of the smoothed a posteriori probabilities of whether or not a device is moving over time.

FIG. **5**C illustrates a plot of the actual state of motion of the device associated with FIGS. **5**A and **5**B.

FIG. **6** illustrates a state diagram of a 2-state Markov model used for determining the dynamic state of a device.

FIG. **7** illustrates a plot of histograms of the variances for the still and moving cases.

FIG. **8** illustrates a plot of a conventional distribution of human walking speeds used in accordance with the present invention.

FIG. **9** illustrates a screenshot of a graphical user interface of the data collection program for facilitating signal strength logging of the calibration data.

FIG. **10** illustrates a block diagram of a computer operable to execute the disclosed architecture.

FIG. **11** illustrates a schematic block diagram of an exemplary computing environment in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It may be evident, however, that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to facilitate describing the present invention.

As used in this application, the terms "component" and "system" are intended to refer to a computer-related entity, either hardware, a combination of hardware and software, software, or software in execution. For example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a server and the server can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers.

As used herein, the term "Inference" refers generally to the process of reasoning about or inferring states of the system, environment, and/or user from a set of observations as captured via events and/or data. Inference can be employed to identify a specific context or action, or can generate a probability distribution over states, for example. The inference can be probabilistic—that is, the computation of a probability distribution over states of interest based on a consideration of data and events. Inference can also refer to techniques employed for composing higher-level events from a set of events and/or data. Such inference results in the construction of new events or actions from a set of observed events and/or stored event data, whether or not the events are correlated in close temporal proximity, and whether the events and data come from one or several event and data sources.

Referring now to FIG. **1**, there is illustrated a block diagram of a system **100** for facilitating determination of the location and instantaneous dynamics of the present invention. A measurement component **102** receives as one input signal strengths **104** derived from wireless signals associated with multiple wireless network interfaces, also called access points (APs). Note that the measurement component **102** may also be configured to receive the raw signals, and then process these raw signals to obtain the signal strength data thereof. In any case, the signal strength data **104** is processed and utilized by a probabilistic processing component **106** to ultimately report as an output an expected value **108** that a portable device is at a location as well as a probability that it is currently in motion.

As is described in greater detail hereinbelow, the probabilistic processing component **106** employs a probabilistic graph where locations are represented as location nodes, and transition probabilities among the location nodes are derived as a function of the building (or floor plan) layout, expected walking speeds of pedestrians, and an independent inference of whether or not a device is in motion.

The probabilistic component **106** uses more sophisticated models than conventional systems for providing estimates of state transition probabilities, which leads to a reduction in calibration effort. More specifically, the system **100** provides a probabilistic interpretation of signal strengths and visible access points, and employs a hidden Markov model (HMM) representation. Upon the receipt of a set of the signal strengths **104**, the HMM is used to compute the probability that the portable device is at each of the location nodes. At each point in time, each pair of nodes has a transition probability associated therewith that gives the probability that the device will move from the first member of the pair to the second. These transition probabilities are a function of elapsed time since the last signal strength reading, the distance between the pair of nodes, and the probability that the device is currently in motion. Rather than considering the distance between a pair of nodes to be the Euclidian distance, the shortest path distance is based on a constraint-sensitive path-planning algorithm that takes into consideration the walls of a building floor plan such that paths cannot pass through walls.

The system **100** provides a relatively accurate location sensing system while minimizing calibration effort by including interpolation of signal strengths from a sparsely sampled set, exploiting path constraints imposed by a building's interior structure (e.g., walls and doors), integrating a consideration of human pedestrian speeds, making independent inferences about whether or not a client device is in motion, and folding in these inferences into the location analysis. Thus the mobile client is as smart as possible in order to maintain accuracy in spite of sparse calibration data, which can be tedious to obtain. Overall, the present invention provides a principled framework representing a superior tradeoff between accuracy and calibration effort by including path, time, and rate constraints that are important for extracting valuable data out of the typically noisy raw signal data.

The probability component **106** significantly reduces calibration effort by employing regression by interpolating to estimate observation probabilities at the high-density location nodes from the lower density calibration nodes. The graph of location nodes, transition probabilities, and observation probabilities are combined with the Viterbi algorithm to compute a probability distribution over the location nodes from every set of observed signal strengths. The expected value of location is reported as an ultimate result, showing that the median error is approximately 1.53 meters.

The likely speed of the portable device is considered explicitly, by inferring the likelihood that a device is moving. A model for inferring motion in described in greater detail hereinbelow. The speed of the portable device is computed as the expected velocity, based on a consideration of the probability distribution of human pedestrian speeds and on an inference of whether or not the device is moving.

The graph of location nodes, transition probabilities, and observation probabilities are combined with the Viterbi algorithm to compute a probability distribution over the location nodes from every set of observed signal strengths. The present invention reports the expected value of location as its ultimate result.

Referring now to FIG. **2**, there is illustrated a flow chart of processes of the probability component of the present invention. While, for purposes of simplicity of explanation, the one or more methodologies shown herein, e.g., in the form of a flow chart, are shown and described as a series of

acts, it is to be understood and appreciated that the present invention is not limited by the order of acts, as some acts may, in accordance with the present invention, occur in different orders and/or concurrently with other acts from that shown and described herein. For example, those skilled in the art will understand and appreciate that a methodology could alternatively be represented as a series of interrelated states or events, such as in a state diagram. Moreover, not all illustrated acts may be required to implement a methodology in accordance with the present invention.

The disclosed architecture uses IEEE 802.11 signal strengths to estimate the location and infer motion of a portable device. The signals come from statically placed IEEE 802.11 access points that provide a wireless link between mobile devices and a wired network.

Note that the novel architecture is not restricted to using access points, since other types of wireless RF transmitters may be employed in lieu of or in combination with the access points. For example, in an asset management location system, a Real Time Locating System (RTLS) may utilize the benefits of the disclosed invention. A RTLS is fully automated system that continually monitors the location of assets and/or personnel, and typically utilizes battery-operated radio tags and a cellular locating system to detect the presence and location of the tags. The locating system is usually deployed as a matrix of locating devices that are installed at a spacing of anywhere from fifty to one thousand feet. These locating devices determine the locations of the radio tags, which tags may be placed on any item or person. Thus the signal strengths are received from RF transmitters that activate the transponder tags to determine where the item is located, or the location and/or movement of the person. In this respect, the RTLS system may be calibrated and analyzed in the same way.

Initially, a floor plan of the area to be calibrated is used to develop low-density nodes, which are a set of nodes that define a sparse network of locations in the floor plan that approximate walking paths typically used by the user of a portable device. Utilizing the floor plan facilitates selecting the nodes used in interpolation process. The low-density nodes are the endpoints of straight-line segments of the network, and are a subset of the total number of nodes that will eventually be used to infer the device motion and location. Once the low-density nodes are developed, high-density nodes are interspersed automatically by the computer in the floor plan of low-density nodes according to user-defined spatial criteria.

Measuring the signal strengths at various locations of the floor plan is the calibration process that yields a number of probability distribution functions at every high-density node, where each probability distribution function gives the probability of "seeing" a given signal strength from a given access point, at that high-density node. The probability distributions of a given high-density node are called the observation probabilities for that node. Since it would be impractical to visit each location of the floor plan and record signal strengths, a much sparser set of location nodes is visited for calibration. Interpolation is then employed to estimate observation probabilities at the high-density nodes from the calibration nodes. This significantly reduces the necessary calibration effort.

Thus, at **200**, a computer generated and processable map of the floor plan is developed for establishing thereon both the low and high-density location nodes. Although combined at **200**, the low-density nodes are developed first by manual entry, followed by automatic population of the floor plan with the high-density nodes interspersed among the low-density nodes. At **202**, the system is then trained by a calibration process that measures and records signal strengths at each of a set of calibration nodes. The location of the calibration nodes is not necessarily chosen to be the same as that of the low-density and/or high-density node locations, although this may occur incidentally. The calibration process facilitates the derivation of signal strength distributions for each calibration node. At **204**, observation probabilities are generated and assigned to each high-density node based on the observed signal strengths at a calibration node.

At **206**, transition probabilities are generated and assigned for each pair of high-density nodes using path constraint information, moving/still probabilities information, and speed distribution data between each pair of high-density nodes. At **208**, a Viterbi algorithm is used to combine elements of the HMM to produce a set of probabilities for all high-density nodes for all observed signal strengths. Other algorithms may also be used. Each high-density node is then assigned a location probability value that the portable device is at that node, as indicated at **210**. Interpolation is used based upon the high-density data to determine the likelihood that the device is at or near a high-density node, as indicated at **212**. The process then reaches a Stop block.

Referring now to FIG. **3**A, there is illustrated a graphical representation of the low-density location nodes on a floor plan **300**, as drawn by someone setting up the system. In order to facilitate path constraints imposed by the floor plan structure **300** (e.g., walls and doors), the disclosed location system provides a graphical representation of discrete location nodes. Initially, as shown in FIG. **3**A, the user utilizes the floor plan **300** of the area that will be calibrated to manually draw lines that represent the likely walking paths **302** between all locations of the area to be calibrated. This introduces a network of low-density nodes **304** (that includes endpoint nodes and intermediate straight-line segments endpoints nodes) into the floor plan **300**.

FIG. **3**B illustrates a graphical representation of the floor plan that includes the high-density nodes automatically interspersed among the low-density nodes. A data collection algorithm automatically calculates and distributes the set of high-density nodes among the set of low-density location nodes according to spatial criteria input by the user. Thus FIG. **3**B shows the total set of discrete nodes mapped onto the floor plan **300**, which includes all of the low-density location nodes used for inferring device location at the high-density nodes. A heavy line **308** shows the shortest path between two location nodes (**310** and **312**). Edge weights (i.e., the connections between the nodes) are defined as the distances between any two adjacent nodes. FIG. **3**C illustrates a graphical representation of the floor plan calibration node locations **314** for measuring signal strength readings.

Once all data is processed through a Viterbi algorithm, the result is a number attached to each location node (**304** and **306**) giving the probability that the device is at or near that location.

Referring now to FIG. **4**, there is illustrated a flow chart of the process for establishing low-density and high-density nodes for use by computer drawing or mapping program of the disclosed architecture. At **400**, a computer-based graphical bitmap representation is generated of the floor plan to be calibrated. A drawing program is provided that displays as the background a bitmap of a building floor plan. The bitmap for the floor plan may be obtained from an electronic database of floor plans or from a scanned blueprint. The transformation between pixels and floor coordinates is computed with a simple least squares fit solution for the trans-

formation matrix based on corresponding points in the bitmap and on the actual floor plan.

At **402**, to place the low-density nodes, a set of human path lines or tracks that approximate walkways that might be taken is manually drawn via the mapping program interface throughout the floor plan, as shown previously in FIG. **3**A. These tracks represent the feasible walking paths of a user and a portable device that may be followed as the user moves throughout the floor plan area. The drawing program allows a user to draw straight lines on the floor plan whose end points can be anchored to a certain location or hinged anywhere on a previously drawn line. The program also provides simple editing controls for moving lines and end points. Once all the path lines have been drawn, the program converts the lines to the low-density nodes by processing each path straight-line endpoint as a location node, as indicated at **404**.

At **406**, the mapping program automatically distributes high-density nodes among the low-density nodes throughout the floor plan bitmap, according to spatial criteria provided by the user. For example, where the spacing is one meter, a total of 317 low-density and high-density nodes are generated for this floor plan, as illustrated in FIG. **3**B.

The high-density nodes represent a graph that is a fully connected, bidirectional graph so that every node connects to every other node. At **408**, the shortest paths to adjacent high-density nodes are computed as the Euclidean distance and stored. The edges shown in FIG. **3**B are only the edges between adjacent nodes, and the edge weights are the Euclidian distance between the nodes. At **410**, the shortest path through non-adjacent high-density nodes is computed according to a shortest-path algorithm and stored. The shortest paths are computed using a shortest path algorithm by noted scientist Edsger W. Dijkstra. For non-adjacent nodes, the edge weight is the shortest path distance through a sequence of adjacent nodes. All the distances are stored for later use by the HMM.

The shortest path distances embody the path constraints imposed by the floor plan structure. For instance, FIG. **3**B illustrates with the thick line **312** the shortest path connecting the approximate centers of two offices. This is the shortest path between the two endpoints (**310** and **312**), and it encapsulates the fact that to get between these two points, a device would have to travel at least as long as the shortest path, as opposed to the direct Euclidian distance, which is much shorter. Formally, the distance between nodes i and j is called d_{ij}. These distances are used later to compute realistic transition probabilities between all nodes in the graph. The transition probabilities are described in greater detail hereinbelow.

The discrete nature of the nodes causes a slight problem in that the device to be located is likely not precisely at any of the predefined low-density or high-density nodes.

This challenge is mitigated by the fact that the nodes are fairly close together (no more than one meter separates adjacent nodes), and that in the end a continuous position estimate is computed based on the expected value of the discrete probability distribution over all the node coordinates. However, for a variety of potential location-specific applications, this resolution is usually enough.

In computing the location probabilities, the Viterbi algorithm used for the HMM seeks the best position by optimizing over all possible paths through the nodes with respect to the history of measured signal strengths. Another way to achieve this respect for past measurements is via the use of a Kalman filter, which has the advantage of being continuous. However, the Kalman filter neither allows the sort of path constraints imposed herein nor the capability of representing multimodal probability distributions over location, as the more general HMM formulation does. Another alternative to the HMM formulation is a particle filter, which has been used for robot localization. A particle filter could embody the same sort of path constraints, but carries the risk of being more expensive to compute.

Determining Motion of the Portable Device

As indicated previously, location inferences consider inferences about the state of motion of a device. That is, in order to utilize transition probabilities between pairs of high-density nodes, movement or lack thereof by the portable device must be considered. Thus the likelihood that a device is moving or at rest needs to be determined. The discrimination of a device in motion versus at rest is challenging a priori as IEEE 802.11 signals from multiple APs change in strength chaotically, even when a system is at rest due to multiple factors, including people walking in regions between multiple APs and devices. Even in light of such "twinkling" of the signal from different APs at rest, the methods described herein provide valuable inferences about whether a device is moving versus still by examining the nature and degree of the flickering of signals from different APs over a short time window. The core notion behind the method is that a statistical analysis can exploit the greater variation of signal strengths from APs when a device is in motion than when it is still; signal strengths typically appear to vary differently when the device is in motion than when it is still.

Referring now to FIG. **6**, there is illustrated a state diagram of a 2-state Markov model **600** used for determining the dynamic state of a device. As shown, the model **600** includes the moving state **602** and still state **604**. A transition **606** from moving to still is defined by a_{MS}, and the transition **608** from still to moving is defined by a_{SM}. When the device remains in a moving state, this is represented by the loopback path **610**, defined as a_{MM}. Similarly, when the device remains motionless, this is represented by the loopback path **612**, defined as a_{SS}. Note that the HMM for the dynamic state of the device (moving vs. still) is different from the HMM for the location of the device.

Unsmoothed State Probabilities

Referring now to FIG. **5**A, there is illustrated a plot of the unsmoothed a posteriori probability of a device moving over time. These probabilities are computed based on a feature that captures the variation of the signal strength over time. That is, at any given time, the access point with the strongest signal is sensed, and then the variance of that access point's signal over a short interval ending at the given time is computed. The portable computer measuring system utilizes a data collection program that is trained by collecting a set of labeled signal strengths by alternately walking around measuring signal strengths, and then stopping within an office. This process is performed over a thirty-minute period while recording the signal strengths. The data collection program also records whether or not the wirelessly connected laptop was moving. The variances are computed with a 20-sample window, which translates to approximately sixty-three readings per access point at a sampling rate of 3.16 Hz.

Referring now to FIG. **7**, there is illustrated a plot **700** of histograms of the variances for the still and moving cases, as described hereinabove. Using σ_{max}^2 to represent the windowed variance of the current maximum signal strength, the histograms are used to represent the conditional probability distributions $p(\sigma_{max}^2|\text{still})$ and $p(\sigma_{max}^2|\text{moving})$. Given a value of σ_{max}^2, estimations are made for the probability of

moving, $p(moving|\sigma_{max}^2)$ and the probability of being still, $p(still|\sigma_{max}^2)=1-p(moving|\sigma_{max}^2)$. Using a Bayes rule classifier, it can be said that the posterior probability of the client moving is,

$$p(moving \mid \sigma_{\max}^2) = \frac{p(\sigma_{\max}^2 \mid moving)p(moving)}{p(\sigma_{\max}^2 \mid moving)p(moving) + p(\sigma_{\max}^2 \mid still)p(still)} \quad (1)$$

Here, p(still) and p(moving) are the a priori probabilities of the dynamic state of the device. In lieu of any other information about the priors, both are set to 0.5.

Using the histograms on the set of 3200 test readings taken several days after the training data, classification into categories as to whether the device was "still" or "moving" was made correctly in approximately 85% of the data. The posterior probabilities over time computed this way are illustrated in FIG. **5**A.

Note that instead of using the Bayes rule classifier, the subject invention can employ various statistical analyses for carrying out various aspects of the subject invention. For example, a process for determining which destination is to be selected for the synchronization process can be facilitated via an automatic classification system and process. Such classification can employ a probabilistic and/or statistical-based analysis (e.g., factoring into the analysis utilities and costs) to prognose or infer an action that a user desires to be automatically performed. For example, a Bayesian network model or support vector machine (SVM) classifier can be employed. Another classification approach includes decision trees. Classification as used herein also is inclusive of statistical regression that is utilized to develop models of priority. Such models can consider multiple observations beyond overall variance, including details of the structure of the distribution over signals from multiple APs, such as considerations of the relationship between the largest signal and others, different modes of distributions over signals over time, and notions of relative strengths.

Smoothed State Probabilities

Referring now to FIG. **5**B, there is illustrated a plot of the smoothed a posteriori probabilities of a device the moving over time. A plot of the unsmoothed probability of moving, $p(moving|\sigma_{max}^2)$ as a function of time for the 3200 test points is shown in FIG. **5**A.

It is clear that the unsmoothed a posteriori probability jumps from high to low too often given the process that is being modeled. It is known that people and their devices do not transition from still to moving this often, so it is desirable to smooth the a posteriori probabilities by imposing explicit transition probabilities governing the still and moving states. FIG. **5**C illustrates the actual data for the smoothed and unsmoothed probability plots of FIGS. **5**A and **5**B.

Instead of simply trying to estimate the probability of a state q_T at time T from a single feature $\sigma_{max.T}^2$ at that time, the most likely sequence of states $Q=q_1, q_2, \ldots, q_T$ is found from a sequence of observations $O=\sigma_{max.1}^2, \sigma_{max.2}^2, \ldots, \sigma_{max.T}^2$. In this case, there are only two possible states, i.e., still and moving, thus $q_1 \epsilon \{S,M\}$. For simplicity, a first order Markov assumption is used to govern the transition between states, which means that the probability of the current state is independent of all but the most recent state, so that $P(q_{t+1}=j|q_t=i)=a_{ij}$, where a_{ij} is a transition probability and i, $j \epsilon \{S,M\}$.

The transition probabilities can be estimated from the assumptions about human behavior. It is proposed that a person will make m moves over a period of s seconds. If the signal strength sampling rate is r, there will be s/r total samples in the time period. The probability of a move occurring on one of these samples is then mr/s. If each still-to-move transition (SM) is assumed to eventually be accompanied by a move-to-still (MS) transition then,

$$a_{SM} = a_{MS} = \min(mr/s, 1) \quad (2)$$
$$a_{SS} = 1 - a_{SM}$$
$$a_{MM} = 1 - a_{MS}$$

The min( ) function keeps the transition probability within range. The equations for a_{SS} and a_{MM} come from the constraint that $a_{SS}+a_{SM}=a_{MM}+a_{MS}=1$.

For a typical office worker, it is estimated that ten moves (i.e., m=10) occur in one eight-hour day, giving s=28,800 seconds. At the radio signal strength indicator (RSSI) sampling rate of 3.16 Hz, the values of a_{SM} and a_{MS} are calculated to be the following:

$$a_{SM}=a_{MS}=0.0011$$
$$a_{SS}=a_{MM}=0.9989 \quad (3)$$

Another element of the Markov model is the initial probabilities of being in the still or moving states, π_S and π_M, respectively. For lack of any other information, both are set to 0.5.

Because the states cannot be directly observed, the Markov model is actually "hidden". What is observed at each sample time t is $\sigma_{max.t}^2$, which is probabilistically connected to the actual state through $p(\sigma_{max.t}^2|q_t=still)$ and $p(\sigma_{max.t}^2|q_t=move)$.

All the elements necessary for an HMM have now been determined, i.e., states, transition probabilities, initial state probabilities, and observation probabilities. The Viterbi algorithm is used to compute the a posteriori state probabilities $P(q_T=still|O)$ and $P(q_T=moving|O)$ at the current time T. The Viterbi algorithm gives an efficient method of computing the state probabilities based on all the past observations $O=\sigma_{max.1}^2, \sigma_{max.2}^2, \ldots, \sigma_{max.T}^2$. The algorithm is recursive and so does not require the storage of previous observations. Thus, by running it on the observation at T, all the previous observations are implicitly being taken into account. Because of this efficiency, the Viterbi algorithm is re-run on every new observation.

The overall effect of using the HMM is that the transition probabilities tend to make the system more reluctant to change states due to slight or brief changes in the state-conditional probability densities $p(\sigma_{max.t}^2|q_t=still)$ and $p(\sigma_{max.t}^2|q_t=moving)$. However, for some values of σ_{max}^2, one or both of these densities drop to zero because the histogram bin for that σ_{max}^2 was never filled during training. If just one of the densities is zero, then the probability of being in that state also drops to zero, even if evidence for the opposite state is weak and even if the probability of transitioning to the opposite state is very low.

To help smooth over these occasional state blips due to less-than-complete training data, a standard mathematical hack of adding a slight offset to the state-conditional probabilities is used. In particular,

$$p\cdot(\sigma_{max.t}^2|q_t=still)=p(\sigma_{max.t}^2|q_t=still)+\alpha$$
$$p\cdot(\sigma_{max.t}^2|q_t=moving)=p(\sigma_{max.t}^2|q_t=moving)+\alpha \quad (4)$$

Where is alpha is chosen to be $\alpha=0.01$, and $p\cdot(\cdot)$ is used instead of $p(\cdot)$ for the HMM. While this offset violates one of the most fundamental characteristics of probability densities (that they integrate to one), it does make the smoothing work much better.

Using the transition probabilities computed above and the α-offset, a state-conditional density $P(q_T=|\text{moving}|O)$ is computed for each sample in the 3200-point test data set. FIG. **5**B illustrates the resulting plot. This shows how using transition probabilities and a sense of past state make the state probabilities much less jumpy. The classification error rate drops from approximately 15.5% to 12.6% by using the HMM smoothing. While the gain in classification accuracy is small, the real gain comes in the reduction of falsely reported state transitions. There were fourteen actual transitions in the test set. Unsmoothed classification reports 172 transitions (158 too many), and smoothed classification reports twenty-four transitions (only ten too many). Reducing false transitions is important for both helping to localize a wireless device (an important aspect of the disclosed architecture) and for inferring the context of a user. In terms of context, if the device were judged to be moving, this would likely mean that the person carrying the device is moving between locations and is neither in a meeting nor in an office.

Transition Probabilities for Location

The previous section showed how to calculate the probability that a Wi-Fi device is in motion. This is one of the ingredients in computing the transition probabilities between location nodes, which are ultimately used in an HMM for computing location. Qualitatively, the transition probabilities to nearby nodes are desired to be larger than that to far away nodes. To quantify motion, the shortest path distances described hereinabove are used along with a probability distribution of human pedestrian speeds. For a more accurate speed distribution, the HMM-smoothed estimate of $p(\text{moving}|\sigma_{max}^2)$ is used from the previous description.

Speed between Nodes

A probability distribution of human pedestrian speeds will now be derived. In an office building, people mostly walk to get from place to place. The distribution of walking speeds can be approximated using a plot of FIG. **8** of the distribution of human walking speeds, which may be obtained from conventional studies. This distribution of walking speeds is denoted mathematically herein as P(walking speed|moving). Further, people sometimes shuffle slowly from place to place, and they sometimes sprint. This behavior is modeled with a uniform distribution of speeds ranging from zero to a maximum of approximately 10.22 meters/second (an estimate of the maximum human running speed), and denoted mathematically as P(other speed|moving). It is assumed that when a person is moving, he/she spends a fraction ω walking and the rest of the time at some other speed. Given a person is moving, his/her speed distribution is then,

$$P(s|\text{moving})=\omega P(\text{walking speed}|\text{moving})+(1-\omega)P(\text{other speed}|\text{moving}) \quad (5)$$

Here s represents speed in meters/second, and assume that ω is 0.9.

The unconditional P(s) takes into account the probability that the person is either moving or still, which comes from the dynamic inference from the previous section. Abbreviating these as P(moving) and P(still), P(s) is defined as,

$$P(s)=P(s|\text{moving})P(\text{moving})+P(s|\text{still})P(\text{still}), \quad (6)$$

where $P(s|\text{still})=\delta(0)$, because a person's walking speed is zero when still. Here $\delta(x)$ is the Dirac delta function. This gives a probability distribution of human pedestrian speeds based on whether or not it is thought that the person is moving, and if so, the distribution of walking speeds and maximum possible running speed.

Transition Probabilities

The transition probability between two location nodes is proportional to the probability of a human traveling at a speed necessary to traverse the distance between the nodes. If a device has moved from node i to node j, its speed had to be rd_{ij}, where r is the RSSI sampling rate (e.g., 3.16 Hz in the disclosed example) and d_{ij} is the shortest path distance between the two nodes, as explained above. The probability of observing this speed is $p_{ij}=P(s=rd_{ij})$ These probabilities must be normalized so that all transition probabilities emanating from a node sum to one. Thus the transition probability is,

$$a_{ij} = p_{ij} \Big/ \sum_{j=1}^{N} p_{ij}, \quad (7)$$

where N=317 is the number of location nodes. These are the transition probabilities used to calculate the most likely path through the nodes. These probabilities encapsulate what is known about the floor plan layout and the speed of the device. Since the a_{ij} are a function of P(moving), which changes over time, the a_{ij} must be recomputed at every time step. The Viterbi algorithm used to calculate the most likely path does not need to store past transition probabilities, so the necessary updates do not translate into increased memory requirements.

Signal Strength Observation Likelihoods

When inferring a location, the device's signal strengths are compared against signal strength probability distributions determined previously during calibration at different location nodes in the building. These previously seen signal strength distributions are estimated based on data from physically carrying the device to a set of known calibration nodes. A straightforward implantation would require visiting all N=317 high-density location nodes for calibration. Since approximately sixty seconds is spent at each calibration point, calibrating at each location node would be prohibitive. Instead, the calibration readings are taken at a much smaller number of locations (sixty-three in this example), and used to interpolate at the high-density location nodes. This means calibration occurred at about 20% of the number of points used in the graph of high-density location nodes.

Gathering Signal Strength Distributions

Following is a description of how signal strengths are gathered according to the floor plan and how the signal strength probability distributions are interpolated to all high-density location nodes.

Referring now to FIG. **9**, there is illustrated a screenshot of a graphical user interface (GUI) **900** of the data collection program for facilitating signal strength logging of the calibration data. The GUI **900** facilitates the display of a graphical representation **902** of the floor plan of FIG. **3**A, and rooms thereof. The user indicates the location of the portable receiving device by selecting an (x,y) location from the floor representation **902** via a mouse, keyboard, or other conventional input device. Additionally, there is presented a signal strength subwindow **904** for presenting a signal strength indicator plot **905** that displays a representation of the measured signal strengths from nearby transmitters. For example, a first bar **906** includes a first color or fill pattern

that indicates the signal was received from a transmitter on the current floor being calibrated. Associated with the bar **906** is data **908** that indicates the signal strength data, the floor on which the room is located, and the room number of the transmitter (i.e., **113/3/3327**). In this particular example, the transmitter was in building number (**113**), room number **3327** (also denoted graphically at **910**) of the third floor (3).

A second bar identification **912** may be used to indicate measurements received from transmitters on floors other than the current floor being calibrated. The bar **912** is associated with room **113/4/4327**, which is a room **4327** on the fourth floor of building **113**. It is to be appreciated that the GUI can be programmed to provide a wide variety of graphical responses to measure signals, including flashing bars, and text, audio output signals, etc., commonly available for providing such interface features.

The interface **900** also includes a Location Input subwindow **914** that allows the user to zoom in on a floor map via a Map Zoom subwindow, and choose a floor for calibration via a Floor Chooser subwindow.

The interface **900** further includes a Scan Control subwindow **916** for selecting the scan rate (in Hertz) for signal detection. The user can also direct logging of the data to a location on the receiving device via a Logging path field **918**. The user may also select a remote network storage location by entering the corresponding network path in the path field **918**. Once entered, all data is automatically stored in the designated file location.

The IEEE 802.11 signal strength distributions were gathered by carrying the wirelessly connected laptop computer to different low-density calibration nodes in the building while making measurements of the signal strengths at those locations. These sixty-three low-density node locations are shown in FIG. **3**A. The portable computer executed the data collection program for recording both locations and signal strengths.

The program, one interface window of which is shown above in FIG. **9**, allows the user to indicate his or her location by clicking on the floor plan map while simultaneously recording signal strengths from all "visible" IEEE 802.11 access points. The map makes it easy to indicate the device's approximate location for calibration. An alternative to using a map like this would be to measure points on the floor. However, this would be prohibitively time-consuming for calibrating a large building. Therefore, the positions on the map were approximated by standing in locations that were easy to identify on the map, like the centers of offices and intersections of hallways. The calibration locations were only as accurate as could be determined by selecting the positions on the map. However, this is a necessary compromise to reduce the calibration effort to a realistic level for larger deployments.

At each calibration location node, as illustrated in FIG. **3**C, signal strength readings were taken for sixty seconds while slowly rotating the device in place. The rotational aspect was to factor out the effects of orientation. This is in contrast to a conventional system that modeled and recorded orientation explicitly. With this data, discrete probability distributions were constructed describing for each calibration point, the probability of seeing a given access point and the probability distribution of signal strengths from that access point. In mathematical terms, the calibration points are $\underline{x}_i^{(c)}$, i=1 . . . N_c, and the building's access points are designated AP_i i=1 . . . N_{AP}. The probability of detecting access point AP_i from calibration location $\underline{x}_j^{(c)}$ is $p(AP_i|\underline{x}_j^{(c)})$. This probability was estimated simply by the ratio of the number of times the access point was detected to the number of times all access points were scanned during calibration at the given calibration node. (Note that sixty seconds of scanning at a scan rate of 3.16 Hz translates to querying all access points approximately 190 times from every location.) This probability might be expected to be either zero or one, corresponding to being out of range or in range of an access point. The disclosed experiment shows that the probability takes on values between zero and one, as well, as shown in FIG. **7**, which shows the histogram of the observed values of $p(AP_i|\underline{x}_j^{(c)})$ for all access points and all calibration node locations. Given this variation, it is important to model this effect.

If signals from an access point were measurable from a given location, then a normalized histogram of signal strengths was also constructed to represent $p(s_k \leqq s < s_{k+1}|AP_i, \underline{x}_j^{(c)})$. Here s is the signal strength and the s_k are the edges of the histogram bins. For this implementation, s_k ranges from −120 dBm to 0 dBm in thirty steps. (Note that dBm denotes decibel milliwatts, and is the usual unit for IEEE 802.11 signal strength.) The overall result of the calibration captured both how often a given access point could be seen from a given location, and if it could be seen, the distribution of signal strengths. These probabilities embody the signal strength signatures that are used to infer a device's location from the signal strengths it observes.

Interpolating Signal Strength Distributions

The sixty-three calibration points were relatively widely spaced, with an average of approximately 2.64 meters to each point's nearest neighbor. It is desirable to achieve higher spatial resolution with a set of location nodes spaced more densely than the calibration nodes. As shown in FIG. **3**A, the high-density location nodes are much more dense than the calibration nodes. In order to infer location over the dense set of location nodes, signal strength signatures need to be computed at each of the high-density location nodes. This means the probability distributions at the sparse set of calibration nodes needs to be extended into the denser set of high-density nodes. This is accomplished by interpolation, using radial basis functions.

From calibration measurements taken at the calibration nodes, the probabilities at the calibration points are known: $p(AP_i|\underline{x}_j^{(c)})$ describes the probability of seeing a given access point from a calibration point $\underline{x}_j^{(c)}$, and $p(s_k \leqq s < s_{k-1}|AP_i, \underline{x}_j^{(c)})$ describes the distribution of signal strengths seen from an access point AP_i at calibration point $\underline{x}_j^{(c)}$. What are wanted are the probabilities at the high-density location nodes, $\underline{x}_i^{(l)}$. The access point probabilities may be considered as a continuous function that was sampled at the calibration points. Likewise, the discrete probabilities of the signal strength distribution may be considered as a continuous function over 2-D space. To facilitate interpolation, the signal strength characteristics of each calibration point are represented by a vector $\underline{d}_j^{(c)}$ consisting of the access point probabilities and the discrete probabilities of the signal strength distribution from calibration point $\underline{x}_j^{(c)}$. More precisely, if there are N_{AP} access points, and if signal strengths are discretized into K bins (i.e. $s_{k,\ k=1 \ldots K}$), then the vector $\underline{d}_j^{(c)}$ has N_{AP} elements representing the probability of seeing a given access point and an additional KN_{AP} elements representing the signal strength distributions for each access point. (If the access point was not seen from a calibration point $\underline{x}_j^{(c)}$, then its signal strength distribution is set to all zeros.) Thus the goal is to interpolate from the calibration pairs $(\underline{x}_j^{(c)}, \underline{d}_j^{(c)})$, j=1 . . . N_c to probabilities for the high-density location nodes $(\underline{x}_i^{(l)}, \underline{d}_i^{(l)})$, i=1 . . . N_l.

This interpolation is preformed using normalized radial basis functions. which is a common choice for such tasks.

The radial basis function formulation makes a weighted sum of a set of 2-D basis functions centered on the calibration points to produce the k^{th} component of the $\underline{d}$ vector for the chosen point $\underline{x}$:

$$d_k(\underline{x}) = \sum_{l=1}^{N_l} \left(\frac{\beta_{jk} K(\|\underline{x} - \underline{x}_j^{(c)}\|)}{\sum_{l=1}^{N_l} K(\|\underline{x} - \underline{x}_l^{(c)}\|)} \right) \quad (8)$$

For the kernel function K(r), it is chosen as $K(r)=\exp(-r^2/\sigma^2)$. After some experimentation, sigma was chosen to be $\sigma=1.0$ as a parameter that produced good results. The weights β_{jk} were computed with standard least squares fitting to the calibration points.

Radial basis functions were evaluated at every location node $\underline{x}_i^{(I)}$, producing a corresponding vector of probability parameters $\underline{d}_i^{(I)}$. The parameters are then extracted to form the access point probabilities $p(AP_i|\underline{x}_j^{(I)})$ and signal strength probabilities $p(s_k \leqq s < s_{k+1}|AP_i, \underline{x}_j^{(I)})$, thus going from probabilities at a relatively sparse set of calibration points to estimated probabilities at the denser set of location nodes. The normalized radial basis function is neither guaranteed to produce probabilities in the range [0,1] nor probability distributions that integrate to one. In practice it came close, however, requiring only slight clamping and normalizing to restore the proper range.

Inferring Location Using HMM

The basic ingredients of an HMM have been summarized as the following: states, initial state probabilities, transition probabilities, and observation probabilities. The states of the HMM for location are the high-density location nodes $\underline{x}_i^{(I)}$, $i=1 \ldots N_l$ produced with the drawing program. With no other data about where a device might be located, the initial state probabilities π_i, $i=1 \ldots N_l$ are uniformly distributed over the location nodes, i.e. $\pi_i=1/N_l$. The transition probabilities are described hereinabove, and are sensitive to the building's layout, expected pedestrian speeds, and the inference on whether or not the device is moving. The observation probabilities come from the interpolated probabilities, also described hereinabove.

For inferring location at time T the device scans for signal strengths from all access points. The result is an indicator vector $\underline{l}_T$ with one Boolean element for each of the N_{AP} access points indicating whether or not the access point was detected. The other result is a vector of signal strengths $\underline{s}_T$ that gives the signal strength for each detected access point. Corresponding elements in these two vectors correspond to the same access point. If the access point was not detected, then the signal strength value for that access point can be any value, because it is not used. The probability of seeing this scan at location $\underline{x}_i^{(I)}$ is

$$P(\underline{l}_T, \underline{s}_T \mid \underline{x}_i^{(I)}) = \prod_{j=1}^{N_{AP}} \begin{cases} p(AP_j \mid \underline{x}_i^{(I)}) p(s_{T_j} \mid AP_j, \underline{x}_i^{(I)}) & \text{if } l_{T_j} = \text{true} \\ 1 - p(AP_j \mid \underline{x}_i^{(I)}) & \text{if } l_{T_j} = \text{false} \end{cases} \quad (9)$$

Here l_{Tj} means the j^{th} element of $\underline{l}_T$, and s_{Tj} means the j^{th} element of $\underline{s}_T$. Each multiplicand in this product represents one access point, implying that the scan result for each access point is independent of the other access points. If the j^{th} access point was seen (l_{Tj}=true), then the multiplicand represents the probability of seeing this access point at the observed signal strength s_{Tj}. If the j^{th} access point was not seen (l_{Tj}=false), then the multiplicand represents the probability of not seeing this access point.

These HMM elements are combined with the Viterbi algorithm to produce a set of state probabilities over the high-density location nodes, i.e., $p_t(\underline{x}_i^{(I)})$. For the final location estimate, the expected value of the location is as follows:

$$x_T = \frac{\sum_{i=1}^{N_l} p_T(x_i^{(l)}) x_i^{(l)}}{\sum_{i=1}^{N_l} p_T(x_i^{(l)})} \quad (10)$$

The disclosed architecture when used against the floor plan example provides significant improvements over conventional systems by reducing calibration effort and while improving accuracy. Because the constraints and dynamics of location nodes are carefully modeled, high accuracy is maintained in spite of reduced calibration, compared to conventional systems of this type. Application to the example herein showed a median error of approximately 1.53 meters without onerous calibration effort. In addition to location, the system also infers whether or not the device is moving, which can be an important indicator of the user's context.

Computing locations from IEEE 802.11 signal strengths is attractive because many office areas spaces are already wired with IEEE 802.11 access points, and more and more mobile devices will be equipped with wireless network hardware. While applied herein to IEEE 802.11 signals, the novel architecture may be easily applied to other types of location sensing, as indicated hereinabove, as well as serving as a platform for sensor fusion.

Referring now to FIG. **10**, there is illustrated a block diagram of a computer operable to execute the disclosed architecture. In order to provide additional context for various aspects of the present invention, FIG. **10** and the following discussion are intended to provide a brief, general description of a suitable computing environment **1000** in which the various aspects of the present invention may be implemented. While the invention has been described above in the general context of computer-executable instructions that may run on one or more computers, those skilled in the art will recognize that the invention also may be implemented in combination with other program modules and/or as a combination of hardware and software. Generally, program modules include routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the inventive methods may be practiced with other computer system configurations, including single-processor or multiprocessor computer systems, minicomputers, mainframe computers, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which may be operatively coupled to one or more associated devices.

The illustrated aspects of the invention may also be practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices.

With reference again to FIG. **10**, there is illustrated an exemplary environment **1000** for implementing various aspects of the invention includes a computer **1002**, the computer **1002** including a processing unit **1004**, a system memory **1006** and a system bus **1008**. The system bus **1008** couples system components including, but not limited to the system memory **1006** to the processing unit **1004**. The processing unit **1004** may be any of various commercially available processors. Dual microprocessors and other multi-processor architectures also can be employed as the processing unit **1004**.

The system bus **1008** can be any of several types of bus structure including a memory bus or memory controller, a peripheral bus and a local bus using any of a variety of commercially available bus architectures. The system memory **1006** includes read only memory (ROM) **1010** and random access memory (RAM) **1012**. A basic input/output system (BIOS), containing the basic routines that help to transfer information between elements within the computer **1002**, such as during start-up, is stored in the ROM **1010**.

The computer **1002** further includes a hard disk drive **1014**, a magnetic disk drive **1016**, (e.g., to read from or write to a removable disk **1018**) and an optical disk drive **1020**, (e.g., reading a CD-ROM disk **1022** or to read from or write to other optical media). The hard disk drive **1014**, magnetic disk drive **1016** and optical disk drive **1020** can be connected to the system bus **1008** by a hard disk drive interface **1024**, a magnetic disk drive interface **1026** and an optical drive interface **1028**, respectively. The drives and their associated computer-readable media provide nonvolatile storage of data, data structures, computer-executable instructions, and so forth. For the computer **1002**, the drives and media accommodate the storage of broadcast programming in a suitable digital format. Although the description of computer-readable media above refers to a hard disk, a removable magnetic disk and a CD, it should be appreciated by those skilled in the art that other types of media which are readable by a computer, such as zip drives, magnetic cassettes, flash memory cards, digital video disks, cartridges, and the like, may also be used in the exemplary operating environment, and further that any such media may contain computer-executable instructions for performing the methods of the present invention.

A number of program modules can be stored in the drives and RAM **1012**, including an operating system **1030**, one or more application programs **1032**, other program modules **1034** and program data **1036**. It is appreciated that the present invention can be implemented with various commercially available operating systems or combinations of operating systems.

A user can enter commands and information into the computer **1002** through a keyboard **1038** and a pointing device, such as a mouse **1040**. Other input devices (not shown) may include a microphone, an IR remote control, a joystick, a game pad, a satellite dish, a scanner, or the like. These and other input devices are often connected to the processing unit **1004** through a serial port interface **1042** that is coupled to the system bus **1008**, but may be connected by other interfaces, such as a parallel port, a game port, a universal serial bus ("USB"), an IR interface, etc. A monitor **1044** or other type of display device is also connected to the system bus **1008** via an interface, such as a video adapter **1046**. In addition to the monitor **1044**, a computer typically includes other peripheral output devices (not shown), such as speakers, printers etc.

The computer **1002** may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer(s) **1048**. The remote computer(s) **1048** may be a workstation, a server computer, a router, a personal computer, portable computer, microprocessor-based entertainment appliance, a peer device or other common network node, and typically includes many or all of the elements described relative to the computer **1002**, although, for purposes of brevity, only a memory storage device **1050** is illustrated. The logical connections depicted include a local area network (LAN) **1052** and a wide area network (WAN) **1054**. Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets and the Internet.

When used in a LAN networking environment, the computer **1002** is connected to the local network **1052** through a network interface or adapter **1056**. The adaptor **1056** may facilitate wired or wireless communication to the LAN **1052**, which may also include a wireless access point disposed thereon for communicating with the wireless adaptor **1056**. When used in a WAN networking environment, the computer **1002** typically includes a modem **1058**, or is connected to a communications server on the LAN, or has other means for establishing communications over the WAN **1054**, such as the Internet. The modem **1058**, which may be internal or external, is connected to the system bus **1008** via the serial port interface **1042**. In a networked environment, program modules depicted relative to the computer **1002**, or portions thereof, may be stored in the remote memory storage device **1050**. It will be appreciated that the network connections shown are exemplary and other means of establishing a communications link between the computers may be used.

Referring now to FIG. **11**, there is illustrated a schematic block diagram of an exemplary computing environment **1100** in accordance with the present invention. The system **1100** includes one or more client(s) **1102**. The client(s) **1102** can be hardware and/or software (e.g., threads, processes, computing devices). The client(s) **102** can house cookie(s) and/or associated contextual information by employing the present invention, for example. The system **1100** also includes one or more server(s) **1104**. The server(s) **1104** can also be hardware and/or software (e.g., threads, processes, computing devices). The servers **1104** can house threads to perform transformations by employing the present invention, for example. One possible communication between a client **1102** and a server **1104** may be in the form of a data packet adapted to be transmitted between two or more computer processes. The data packet may include a cookie and/or associated contextual information, for example. The system **1100** includes a communication framework **1106** (e.g., a global communication network such as the Internet) that can be employed to facilitate communications between the client(s) **1102** and the server(s) **1104**. Communications may be facilitated via a wired (including optical fiber) and/or wireless technology. The client(s) **1102** are operably connected to one or more client data store(s) **1108** that can be employed to store information local to the client(s) **1102** (e.g., cookie(s) and/or associated contextual information). Similarly, the server(s) **1104** are operably connected to one or more server data store(s) **1110** that can be employed to store information local to the servers **1104**.

What has been described above includes examples of the present invention. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the present invention, but one of ordinary skill in the art may recognize that many further combinations and permutations of the present invention are possible. Accordingly, the present invention is

intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

What is claimed is:

1. A system effectuated on a machine that determines location dynamics of a mobile device, comprising:

a measuring component that employs a graph outlining probable ambulatory routes to process signal properties related to identified locations; and

a probability processing component that derives at least one of a still state and moving state of the mobile device, a transition probability between two of the identified locations, an initial state probability of the mobile device, a velocity value between the two identified locations, and an observation probability based on the signal properties at each of the two identified locations.

2. The system of claim **1**, the probability processing component outputting a probability that the mobile device is currently in motion.

3. The system of claim **1**, the probability processing component employs a statistical analysis that factors variance of signal strengths when the mobile device is in motion versus when the mobile device is still.

4. The system of claim **3**, the signal strength variance is temporally analyzed.

5. The system of claim **3**, the analysis further considers at least one of structure of the variance(s), different signal distributions over time, and relative signal strengths.

6. The system of claim **1**, the signal properties obtained from an IEEE 802.11 device.

7. The system of claim **1**, the signal properties obtained from radio broadcasts of AM or FM radio as used by traditional commercial broadcasters.

8. The system of claim **1**, the probability processing component utilizes a hidden Markov model to determine state transition probabilities.

9. The system of claim **1**, any two of the identified locations having associated therewith a transition probability that indicates a probability that the mobile device will move from a first identified location to a second identified location.

10. The system of claim **9**, the transition probability is a function of elapsed time since a last signal strength measurement, the distance between the any two identified locations, and a probability that the mobile device is currently in motion.

11. The system of claim **1**, a shortest path between two of the identified locations is based upon a constraint-sensitive path-planning algorithm that considers physical bafflers between the two identified locations.

12. The system of claim **1**, a probable speed of the mobile device is explicitly considered by inferring a likelihood that the mobile device is in motion.

13. The system of claim **1**, the speed of the mobile device is computed from at least one of an expected velocity based upon consideration of a probability distribution of human pedestrian speeds and the inference of motion.

14. The system of claim **1**, each of the identified locations associated with an observation probability.

15. The system of claim **1**, a graph of identified locations, associated transition probabilities, and observation probabilities are combined using a Viterbi algorithm that computes a probability distribution over the identified locations from every set of measured signal properties.

16. The system of claim **15**, an output of the Viterbi algorithm is a probability value associated with each identified location giving a probability that the mobile device is at that respective identified location.

17. The system of claim **1**, the probability processing component generates an observation probability for each of the identified locations based on the signal properties received at that identified location.

18. The system of claim **1**, the probability processing component automatically causing to be stored a probability distribution of signal strengths of a wireless transmitter when the transmitter is sensed from one of the identified locations.

19. The system of claim **18**, the probability distribution of signal strengths is associated with the one identified location.

20. The system of claim **1**, the probability processing component outputs an expected value representing a location of the mobile device.

21. The system of claim **1**, each of the identified locations calibrated using signal properties measured at that location.

22. The system of claim **1**, the inference of motion determined according to a variance of the signal strengths over time.

23. The system of claim **1**, further comprising a mapping component that maps a discrete low-density node with each of the identified locations.

24. The system of claim **1**, further comprising a mapping component that maps a discrete low-density node with each of the identified locations, and distributes high-density nodes among the low-density nodes according to predetermined spatial criteria.

25. The system of claim **1**, further comprising a mapping component that maps a discrete low-density node with each of the identified locations, and determines distances between the low-density nodes.

26. The system of claim **25**, the mapping component interspersing high-density nodes among the low-density nodes, and the probability processing component utilizing distances between pairs of the high-density nodes to calculate transition probabilities the corresponding pair of high-density nodes.

27. The system of claim **1**, the probability processing component determining a location of the mobile device by calculating a continuous position estimate of the location of the mobile device based upon an expected value of a discrete probability distribution over all of the identified locations.

28. The system of claim **1**, the probability processing component using a maximum-likelihood decoding algorithm to optimize over all possible paths between the identified locations with respect to a history of the measured signal properties.

29. The system of claim **1**, the inference of motion representative of the likelihood that the mobile device is at least one of in motion and at rest.

30. The system of claim **1**, the probability processing component using at least one of a Bayesian rule and a support vector machine to determine a posterior probability that the mobile device is moving.

31. The system of claim **1**, the probability processing component capturing quantitatively a variation in signal strength of a wireless transmitter by sensing the wireless transmitter with the strongest signal, and calculating a variance of that strongest signal over time.

32. The system of claim 1, the probability processing component performing a smoothing operation on posterior probability data of the mobile device.

33. The system of claim 32, the smoothing operation accomplished by imposing explicit transition probabilities on the posterior probability data, which explicit transition probabilities govern still and moving states of the mobile device.

34. The system of claim 1, the probability processing component uses an interpolation function that extends probability distributions of the identified locations to new locations.

35. A computer according to the system of claim 1.

36. The system of claim 1, the probability processing component using calibration data to approximate the location of the mobile device relative to the identified locations.

37. A machine implemented system that facilitates tracking a mobile device, comprising:

a component that receives radio signals associated with the mobile device; and

a probability processing component that utilizes a model of ambulatory pathways and path constraints imposed by a building's interior structure to directly infer a likelihood that the mobile device is in motion versus static based on an analysis of statistics of variation of one or more of the radio signals over time.

38. A system that facilitates tracking a mobile device, comprising:

a tangible machine component that receives radio signals associated with the mobile device; and

a probability processing component that directly infers a probability distribution over velocity of the mobile device based on employment of a model of available humanly accessible routes and an analysis of statistics of variation of one or more of the radio signals over time and ascertains a speed of the mobile device, the probability processing component further employs an interpolation function that extends probability distributions of the identified locations to new locations.

39. A wireless device location system, comprising:

means for measuring signal properties related to identified locations, the signal properties measured from at least one wireless signal associated with one or more wireless network interface;

means for determining an inference of motion of the mobile device based at least in part in the measured signal properties;

means for approximating a location of the mobile device based at least in part on the inference of motion and a graph that maps possible humanly accessible routes; and

means for determining a speed of the mobile device.

40. A method implemented on a machine for determining the location dynamics of a mobile device, comprising:

utilizing a tangible machine component to measure signal properties related to identified locations;

generating a location constraint model by employing a constraint-sensitive path-planning algorithm that considers physical barriers between two of the identified locations;

based at least in part on the location constraint model and signal properties, calculating with probability data an inference of motion of the mobile device; and

approximating a location of the mobile device based at least in part on the inference of motion.

41. The method of claim 40, further comprising calibrating the identified locations by measuring the signal properties from each of the identified locations.

42. The method of claim 40, the location of the mobile device approximated using regression function.

43. The method of claim 40, the location dynamics including velocity, which velocity of the mobile device is computed from at least one of an expected velocity based upon consideration of a probability distribution of human pedestrian speeds and on an inference of whether or not the mobile device is moving.

44. The method of claim 40, the probability data including path data generated from a constraint-sensitive path-planning algorithm that considers physical barriers between two of the identified locations.

45. The method of claim 40, the probability data including observation probability data generated for each of the identified locations, which observation probability data is based on received signal strengths at the respective identified locations.

46. The method of claim 40, further comprising automatically generating and associating transition probability data with each of the identified locations using path constraints, moving probability data, and speed distribution data.

47. The method of claim 40, the location of the mobile device approximated with respect to a floor of a building.

* * * * *

EXHIBIT F

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	Method to modify calibration data used to locate a mobile unit
First Named Inventor/Applicant Name:	Martin Alles
Filer:	Jason P. DeMont/Kelly Havey
Attorney Docket Number:	466-333us1

Filed as Large Entity

ex parte reexam Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
REQUEST FOR EX PARTE REEXAMINATION	1812	1	17750	17750
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**17750**

Electronic Acknowledgement Receipt

EFS ID:	13818455
Application Number:	90012694
International Application Number:	
Confirmation Number:	6575
Title of Invention:	Method to modify calibration data used to locate a mobile unit
First Named Inventor/Applicant Name:	Martin Alles
Customer Number:	22897
Filer:	Jason P. DeMont/Kelly Havey
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Attorney Docket Number:	466-333us1
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Filing Date:	
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Application Type:	Reexam (Third Party)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$17750
RAM confirmation Number	331
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Information Disclosure Statement (IDS) Form (SB08)	IDS_1_466-333us1.pdf	612374 df30f8b7634ef010be42d6164e2ba87976d8fdef	no	4
Warnings:					
Information:					
2		reexam_req_466-333us1_d.pdf	16948613 28bdd356dd925184a1582570314e01cea005fd05	yes	160

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Reexam - Affidavit/Decl/Exhibit Filed by 3rd Party	1	24
	Reexam Certificate of Service	25	25
	Reexam - Affidavit/Decl/Exhibit Filed by 3rd Party	26	160

Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	29877 748a54a4dd9dc1dbde1b6605d20cb3e325c6f1c3	no	2
Warnings:					
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		Total Files Size (in bytes):	17590864		

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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.

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Bib Data Sheet

CONFIRMATION NO. 6575

SERIAL NUMBER	FILING OR 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
90/012,694	09/24/2012 RULE	342	3662	466-333us1

APPLICANTS

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

This application is a REX of 12/026,333 02/05/2008 PAT 7561104
which claims benefit of 60/899,379 02/05/2007

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

Foreign Priority claimed	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ yes ☐ no			21	2
35 USC 119 (a-d) conditions met ☐ yes ☐ no ☐ Met after Allowance				
Verified and Acknowledged Examiner's Signature Initials				

ADDRESS

79172

TITLE

Method to modify calibration data used to locate a mobile unit

FILING FEE RECEIVED		
17750	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