Electronic Acknowledgement Receipt

EFS ID:	12552347
Application Number:	13176298
International Application Number:	
Confirmation Number:	4342
Title of Invention:	Feedback Control in an FDD TDD-CDMA System
First Named Inventor/Applicant Name:	Paul Howard
Customer Number:	22242
Filer:	Steven Glen Parmelee/Helen Donegan
Filer Authorized By:	Steven Glen Parmelee
Attorney Docket Number:	9010-99460-US
Receipt Date:	16-APR-2012
Filing Date:	05-JUL-2011
Time Stamp:	17:07:54
Application Type:	Utility under 35 USC 111(a)

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	Transmittal Letter	99460_IDS_Transmittal.pdf	119732 69d53c42c6a431215df4d56f10e37ae77c8bc359	no	2

Warnings:	
Information:	

2	Information Disclosure Statement (IDS) Form (SB08)	99460_IDS_Form_04172012.pdf	613551 c3410bfc23f516a8808c9713173224af5a7892a7	no	6
Warnings:					
Information:					
3	Foreign Reference	DE10201270.pdf	1259492 c97c9af0ef20af16e29d225fa93f5164743e63f4	no	22
Warnings:					
Information:					
4	Foreign Reference	EP1467582.pdf	813379 9c4886edb72366d5dd97b856649046e5823931e7	no	24
Warnings:					
Information:					
5	Foreign Reference	EP1615384.pdf	3416640 8fdda84528d62582d189590a15a636677add6d00	no	98
Warnings:					
Information:					
6	Foreign Reference	EP1681780.pdf	727224 b5a42e7b6da801c8e0a5377cb94595faf5fa2842	no	19
Warnings:					
Information:					
7	Non Patent Literature	NPL1_04172012.pdf	233015 66eec22f063af8be2f4c3039537e6234b00f0ea4	no	6
Warnings:					
Information:					
8	Non Patent Literature	NPL2_04172012.pdf	295745 83736c0763bfa7f80bd9b066defe20d6ada10416	no	13
Warnings:					
Information:					
9	Non Patent Literature	NPL3_04172012.pdf	321220 91c82a619ddf53236c927b176ccbb347e4f4a22b	no	13
Warnings:					
Information:					
10	Non Patent Literature	NPL4_04172012.pdf	333670 f5bea271009f2d12a82030482b4e9998b1438edd	no	13
Warnings:					
Information:					

11	Non Patent Literature	NPL5_04172012.pdf	1338909 cd66b0c8a1f87ad4aa57e10794291355b1064418	no	42
Warnings:					
Information:					
12	Non Patent Literature	NPL6_04172012.pdf	1065030 faad24ea260456e7d9aebb52f645b3b9a60a8791	no	45
Warnings:					
Information:					
13	Non Patent Literature	NPL7_04172012.pdf	323981 5f20fe03be78cf01c120e79bfcedefcbecae9443	no	9
Warnings:					
Information:					
14	Non Patent Literature	NPL8_04172012.pdf	227134 5bc4d868804a36f086b34eaa587576bd3b206844	no	7
Warnings:					
Information:					
15	Non Patent Literature	NPL9_04172012.pdf	65694 4f0343f2e24450da797b0703cbb0540c729432e4	no	3
Warnings:					
Information:					
		Total Files Size (in bytes):	11154416		

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

Application No.	13/176,298
Filed:	July 5, 2011
First Named Inventor:	Paul Howard
Title:	**FEEDBACK CONTROL IN AN FDD TDD-CDMA SYSTEM**
Art Unit:	2473
Examiner:	Not Yet Assigned
Attorney Docket:	9010-99460-US
Customer No.:	22242

Confirmation No. 4342

CERTIFICATE OF EFS-WEB TRANSMISSION

I hereby certify that this IDS Transmittal is being transmitted via the United States Patent and Trademark Office (USPTO) electronic filing system (EFS-Web) to the USPTO on April 16, 2012.

Helen Donegan, Legal Assistant
to Steven Parmelee
Registration No. 28,790

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

INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Sir:

Pursuant to the duty of disclosure under 37 C.F.R. § 1.56, and in accordance with MPEP § 601 and 37 C.F.R. §§ 1.97 and 1.98, Applicants and the undersigned attorney bring the information listed on Form PTO/SB/08a, filed concurrently herewith, to the attention of the Examiner.

Pursuant to 37 C.F.R. § 1.97(h), the filing of this Information Disclosure Statement shall not be construed to be an admission that the information cited in this statement is, or is considered to be, prior art or is material to patentability as defined in 37 C.F.R. § 1.56(b).

The Commissioner is hereby authorized to charge any additional fees which may be required with respect to this communication, or credit any overpayment, to Deposit Account No. 06-1135.

Respectfully submitted,

FITCH, EVEN, TABIN & FLANNERY

Dated: April 16, 2012

Steven G. Parmelee
Registration No. 28,790
sgparm@fitcheven.com

120 South LaSalle Street, Suite 1600
Chicago, Illinois 606033406
Telephone (312) 577-7000
Facsimile (312) 577-7007

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/176,298	07/05/2011	Paul Howard	9147-99460-US

CONFIRMATION NO. 4342

22242
FITCH EVEN TABIN & FLANNERY
120 SOUTH LASALLE STREET
SUITE 1600
CHICAGO, IL 60603-3406

PUBLICATION NOTICE

OC000000051010353

Title: Feedback Control in an FDD TDD-CDMA System

Publication No.US-2011-0280165-A1
Publication Date:11/17/2011

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/176,298	07/05/2011	2472	1298	9147-99460-US	24	3

CONFIRMATION NO. 4342

CORRECTED FILING RECEIPT

22242
FITCH EVEN TABIN & FLANNERY
120 SOUTH LASALLE STREET
SUITE 1600
CHICAGO, IL 60603-3406

OC000000049560451

Date Mailed: 08/30/2011

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Paul Howard, Bristol, UNITED KINGDOM;

Assignment For Published Patent Application

WIRELESS TECHNOLOGY SOLUTIONS LLC, New York, NY

Power of Attorney: The patent practitioners associated with Customer Number 22242

Domestic Priority data as claimed by applicant

This application is a CON of 11/646,692 12/27/2006 PAT 8,009,639

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 07/14/2011

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/176,298**

Projected Publication Date: 11/17/2011

Non-Publication Request: No

Early Publication Request: No

Title

Feedback Control in an FDD TDD-CDMA System

Preliminary Class

370

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as

set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No. 13/176,298

Filed: July 5, 2011

Applicants: Paul Howard

Title: **FEEDBACK CONTROL IN AN FDD TDD-CDMA SYSTEM**

Art Unit: 2473

Examiner: Not Yet Assigned

Attorney Docket: 9147-99460-US

Customer No.: 22242

Confirmation No. 4342

This Letter Transmitting Corrected Application Data Sheet and Request for Updated Filing Receipt was electronically filed on August 25, 2011 using the U.S. Patent and Trademark Office's EFS Web

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

ATTENTION: Office of Initial Patent Examination
Filing Receipt Corrections

LETTER TRANSMITTING CORRECTED APPLICATION DATA SHEET ALONG WITH REQUEST FOR CORRECTED FILING RECEIPT

Sir:

Please substitute the attached Application Data Sheet 37 CFR 1.76 for the document originally submitted with the filing of the application on July 5, 2011. This is being submitted to correct an inadvertent error in the inventor's Residence Address.

It is respectfully requested that the United States Patent and Trademark Office issue a corrected Updated Filing Receipt to incorporate the change herein requested (On page 1 of the Filing Receipt, Applicant(s), , please change "Briston" to -- Bristol --).

IPR2025-00221 Exhibit 2007 Page 10 of 2358

The Commissioner is hereby authorized to charge any additional fees which may be required with respect to this communication, or credit any overpayment, to Deposit Account No. 06-1135.

Respectfully submitted,

FITCH, EVEN, TABIN & FLANNERY

Dated: August 25, 2011

Steven G. Parmelee
Registration No. 28,790

120 South LaSalle Street, Suite 1600
Chicago, Illinois 60603-3406
Telephone (312) 577-7000
Facsimile (312) 577-7007

UNITED STATES PATENT AND TRADEMARK OFFICE

Docketed 08/12/11 pa #2 Helen

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

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/176,298	07/05/2011	2473	1298	9147-99460-US	24	3

CONFIRMATION NO. 4342

UPDATED FILING RECEIPT

22242
FITCH EVEN TABIN & FLANNERY
120 SOUTH LASALLE STREET
SUITE 1600
CHICAGO, IL 60603-3406

OC000000049201905

Date Mailed: 08/11/2011

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s) Bristol

Paul Howard, ~~Briston~~, UNITED KINGDOM;

Assignment For Published Patent Application

WIRELESS TECHNOLOGY SOLUTIONS LLC, New York, NY

Power of Attorney: The patent practitioners associated with Customer Number 22242

Domestic Priority data as claimed by applicant

This application is a CON of 11/646,692 12/27/2006 PAT 8,009,639

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 07/14/2011

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/176,298**

Projected Publication Date: 11/17/2011

Non-Publication Request: No

Early Publication Request: No

Title

Feedback Control in an FDD TDD-CDMA System

Preliminary Class

370

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

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set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

PTO/SB/14 (07-07)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	9147-99460-US
	Application Number	
Title of Invention	Feedback Control in an FDD TDD-CDMA System	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Paul		Howard	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Bristol	Country Of Residence[i]	UK

Citizenship under 37 CFR 1.41(b)[i] UK

Mailing Address of Applicant:

Address 1	Tennyson Cottage, Tennyson Road		
Address 2	Horfield		
City	Bristol	State/Province	
Postal Code	BS7 8SB	Country[i]	UK

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	22242		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	Feedback Control in an FDD TDD-CDMA System		
Attorney Docket Number	9147-99460-US	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	5	Suggested Figure for Publication (if any)	

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	9147-99460-US
	Application Number	
Title of Invention	Feedback Control in an FDD TDD-CDMA System	

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	**Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	22242		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	11646692	2006-12-27

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			○ Yes ◉ No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 Remove

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	9147-99460-US
	Application Number	
Title of Invention	Feedback Control in an FDD TDD-CDMA System	

If the Assignee is an Organization check here. ☒			
Organization Name	Wireless Technology Solutions LLC		
Mailing Address Information:			
Address 1	550 Madison Avenue		
Address 2			
City	New York	**State/Province**	NY
Country [i]	US	Postal Code	10022
Phone Number		Fax Number	
Email Address			
Additional Assignee Data may be generated within this form by selecting the **Add** button.		Add	

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Steven G. Parmelee/			Date (YYYY-MM-DD)	2011-08-25
First Name	Steven G.	Last Name	Parmelee	Registration Number	28790

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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 records.

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.

Electronic Acknowledgement Receipt

EFS ID:	10809726
Application Number:	13176298
International Application Number:	
Confirmation Number:	4342
Title of Invention:	Feedback Control in an FDD TDD-CDMA System
First Named Inventor/Applicant Name:	Paul Howard
Customer Number:	22242
Filer:	Steven Glen Parmelee/Helen Donegan
Filer Authorized By:	Steven Glen Parmelee
Attorney Docket Number:	9147-99460-US
Receipt Date:	25-AUG-2011
Filing Date:	05-JUL-2011
Time Stamp:	10:00:21
Application Type:	Utility under 35 USC 111(a)

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	Request for Corrected Filing Receipt	99460_Request_For_Filing_Receipt_1.PDF	235985 c4e66ba3a8be87591a138e89d288b357f3ebfdd4	no	5

Warnings:	
Information:	

2	Application Data Sheet	99460_Application_Data_Sheet.pdf	964779 fdb26c17089e998f5b4603fca993a8d20a93ca8f	no	4

Warnings:	
Information:	
Total Files Size (in bytes):	1200764

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.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/176,298

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	330
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	540
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	220
TOTAL CLAIMS (37 CFR 1.16(i))	24 minus 20 =	* 4			OR	x 52 =	208
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 220 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $270 ($135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1298

APPLICATION AS AMENDED - PART II

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

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

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/176,298	07/05/2011	2473	1298	9147-99460-US	24	3

CONFIRMATION NO. 4342

UPDATED FILING RECEIPT

22242
FITCH EVEN TABIN & FLANNERY
120 SOUTH LASALLE STREET
SUITE 1600
CHICAGO, IL 60603-3406

OC000000049201905

Date Mailed: 08/11/2011

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Paul Howard, Briston, UNITED KINGDOM;

Assignment For Published Patent Application

WIRELESS TECHNOLOGY SOLUTIONS LLC, New York, NY

Power of Attorney: The patent practitioners associated with Customer Number 22242

Domestic Priority data as claimed by applicant

This application is a CON of 11/646,692 12/27/2006 PAT 8,009,639

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 07/14/2011

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/176,298**

Projected Publication Date: 11/17/2011

Non-Publication Request: No

Early Publication Request: No

Title

Feedback Control in an FDD TDD-CDMA System

Preliminary Class

370

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as

set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.: 13/176,298	Confirmation No. 4342
Filed: July 5, 2011	This Response to Notice to File Corrected Application Papers was electronically filed on August 2, 2011 using the U.S. Patent and Trademark Office's EFS Web
Applicant: Paul Howard	
Title: FEEDBACK CONTROL IN AN FDD TDD-CDMA SYSTEM	
Art Unit: 2473	
Examiner: Not Yet Assigned	
Attorney Docket No.: 9147-99460-US	
Customer No.: 22242	

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

RESPONSE TO NOTICE TO FILE CORRECTED APPLICATION PAPERS

Sir:

In response to the Notice to File Corrected Application Papers dated March 28, 2011

☐ A copy of the Notice to File Missing Parts is enclosed.

☐ A Preliminary Amendment is enclosed.

☐ An Application Data Sheet 37 CFR 1.76, is enclosed.

☒ 1 sheet of drawings are enclosed. ☒ Formal ☐ Informal

☐ An Assignment of the invention to _____, and Recordation Form Cover Sheet - Patents Only - Form PTO-1595, are enclosed.

☐ A check in the amount of $_____ to cover the fee for recording the assignment is enclosed.

☐ The Recordation Form Cover Sheet includes authorization to charge our Deposit Account for recording the assignment.

☒ The fees are calculated below:

☐	Provisional Application Filing Fee				$ 200.00		
	Application size fee for each additional 50 sheets that exceeds 100 sheets			____ x	$ 250.00	=	$
	Surcharge Fee				$ 50.00		
	Search Fee				$ 100.00		
	Examination Fee				$ 130.00		
	Total Fees					$	0.00
	☐ Applicant(s) assert entitlement to Small Entity Status (37 C.F.R. § 1.27), reducing the Total Fees by half to:					$	0.00
☒	Basic Filing Fee - Utility				$ 300.00		
	Independent Claims	____ - 3 =	0	x	$ 200.00	= $	0.00
	Total Claims	____ - 20 =	0	x	$ 50.00	= $	0.00
	Fee for Multiple Dependent Claims				$ 360.00		
	Surcharge Fee				$ 130.00	$	
	Application Size Fee for each additional 50 sheets that exceeds 100 sheets			____ x	$ 250.00	=	
	Search Fee				$ 500.00		
	Examination Fee				$ 200.00		
	Total Fees					$	
	☐ Applicant(s) assert entitlement to Small Entity Status (37 C.F.R. § 1.27), reducing the Total Fees by half to:						
☐	Basic Filing Fee - Design				$ 200.00		
	Surcharge Fee				$ 130.00		
	Search Fee				$ 100.00		
	Examination Fee				$ 130.00		
	Total Fees					$	0.00

☐ Applicant(s) assert entitlement to Small Entity Status (37 C.F.R. § 1.27), reducing the Total Fees by half to: $ 0.00

☐ A check in the amount of $_____ to cover the above fees is enclosed.

☒ Charge $_____to Deposit Account No. 06-1135.

☒ The Commissioner is hereby authorized to charge any additional fees which may be required in this application under 37 C.F.R. §§1.16-1.17 during its entire pendency, or credit any overpayment, to Deposit Account No. 06-1135. Should no proper payment be enclosed herewith, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 06-1135. This sheet is filed in duplicate.

August 2, 2011
Date

Steven G. Parmelee
Registration No. 28,790

FITCH, EVEN, TABIN & FLANNERY
120 South LaSalle Street, Suite 1600
Chicago, Illinois 60603-3406
Telephone: (312) 577-7000
Facsimile: (312) 577-7007

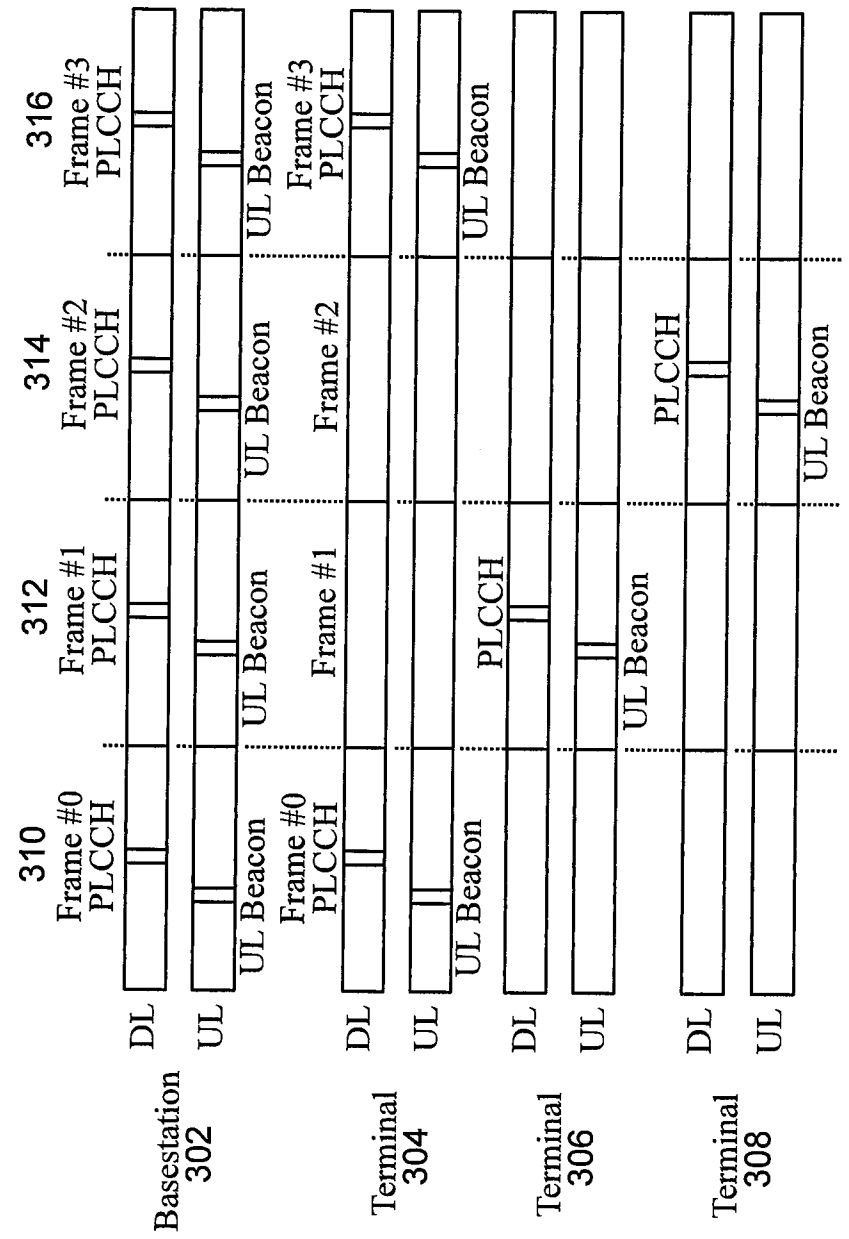

310
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Frame #2
PLCCH
316
Frame #3
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UL
Basestation
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UL Beacon
UL Beacon
UL Beacon
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UL Beacon
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UL Beacon
Terminal
306
UL Beacon
PLCCH
Terminal
308
UL Beacon

Figure 3

Electronic Acknowledgement Receipt

EFS ID:	10649594
Application Number:	13176298
International Application Number:	
Confirmation Number:	4342
Title of Invention:	Feedback Control in an FDD TDD-CDMA System
First Named Inventor/Applicant Name:	Paul Howard
Customer Number:	22242
Filer:	Steven Glen Parmelee/Helen Donegan
Filer Authorized By:	Steven Glen Parmelee
Attorney Docket Number:	9147-99460-US
Receipt Date:	02-AUG-2011
Filing Date:	05-JUL-2011
Time Stamp:	15:47:23
Application Type:	Utility under 35 USC 111(a)

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	Applicant Response to Pre-Exam Formalities Notice	99460_ResponseToNoticeToFileCorrectedApplicationPapers_1.PDF	90273 b60bcc84830ef7052047f44c7f811b5d15f5ccba	no	3

Warnings:	
Information:	

2	Drawings-only black and white line drawings	99460_Drawing_Sheet_3_1.PDF	22318 a3298abc0d7a1823a8e1734ebc1cc99b55436107	no	1

Warnings:	
Information:	
Total Files Size (in bytes):	112591

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.

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/176,298	07/05/2011	Paul Howard	9147-99460-US

CONFIRMATION NO. 4342

22242
FITCH EVEN TABIN & FLANNERY
120 SOUTH LASALLE STREET
SUITE 1600
CHICAGO, IL 60603-3406

FORMALITIES LETTER

OC000000048800841

Date Mailed: 07/19/2011

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Filing Date Granted

An application number and filing date have been accorded to this application. The application is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given TWO MONTHS from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

The required item(s) identified below must be timely submitted to avoid abandonment:

- Replacement drawings in compliance with 37 CFR 1.84 and 37 CFR 1.121(d) are required. The drawings submitted are not acceptable because:
  - Numbers, letters, and reference characters on the drawings must measure at least 0.32 cm (1/8 inch) in height. See Figure(s) 3.

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web.
https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

/hnguyen/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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
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www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/176,298	07/05/2011	2473	1298	9147-99460-US	24	3

CONFIRMATION NO. 4342

22242
FITCH EVEN TABIN & FLANNERY
120 SOUTH LASALLE STREET
SUITE 1600
CHICAGO, IL 60603-3406

FILING RECEIPT

OC000000048800840

Date Mailed: 07/19/2011

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Paul Howard, Briston, UNITED KINGDOM;

Assignment For Published Patent Application

WIRELESS TECHNOLOGY SOLUTIONS LLC, New York, NY

Power of Attorney: The patent practitioners associated with Customer Number 22242

Domestic Priority data as claimed by applicant

This application is a CON of 11/646,692 12/27/2006

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

If Required, Foreign Filing License Granted: 07/14/2011

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/176,298**

Projected Publication Date: To Be Determined - pending completion of Corrected Papers

Non-Publication Request: No

Early Publication Request: No

Title

Feedback Control in an FDD TDD-CDMA System

Preliminary Class

370

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as

set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/176,298	07/05/2011	Paul Howard	9147-99460-US

CONFIRMATION NO. 4342

22242
FITCH EVEN TABIN & FLANNERY
120 SOUTH LASALLE STREET
SUITE 1600
CHICAGO, IL 60603-3406

POA ACCEPTANCE LETTER

OC000000048776474

Date Mailed: 07/19/2011

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 07/05/2011.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/llvuong/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/176,298

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	330
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	540
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	220
TOTAL CLAIMS (37 CFR 1.16(i))	24 minus 20 =	* 4			OR	x 52 =	208
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 220 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $270 ($135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1298

APPLICATION AS AMENDED - PART II

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

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

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

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

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

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

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	9147-99460-US
First Inventor	Paul Howard
Title	Feedback Control in an FDD TDD-CDMA
Express Mail Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☐ **Fee Transmittal Form** (e.g., PTO/SB/17)
2. ☐ **Applicant claims small entity status.** See 37 CFR 1.27.
3. ☑ **Specification** [*Total Pages* 19]
   Both the claims and abstract must start on a new page
   (For information on the preferred arrangement, see MPEP 608.01(a))
4. ☑ **Drawing(s)** (*35 U.S.C. 113*) [*Total Sheets* 5]
5. **Oath or Declaration** [*Total Sheets* 1]
   a. ☐ Newly executed (original or copy)
   b. ☑ A copy from a prior application (37 CFR 1.63(d))
   (for continuation/divisional with Box 18 completed)
   i. ☐ DELETION OF INVENTOR(S)
   Signed statement attached deleting inventor(s) name in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. ☑ **Application Data Sheet.** See 37 CFR 1.76
7. ☐ **CD-ROM or CD-R** in duplicate, large table or Computer Program *(Appendix)*
   ☐ Landscape Table on CD
8. **Nucleotide and/or Amino Acid Sequence Submission**
   (if applicable, items a. – c. are required)
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ Paper
   c. ☐ Statements verifying identity of above copies

ADDRESS TO: **Commissioner for Patents**
P.O. Box 1450
Alexandria VA 22313-1450

ACCOMPANYING APPLICATION PARTS

9. ☐ **Assignment Papers** (cover sheet & document(s))
   Name of Assignee
10. ☐ **37 CFR 3.73(b) Statement** *(when there is an assignee)* ☐ **Power of Attorney**
11. ☐ **English Translation Document** *(if applicable)*
12. ☐ **Information Disclosure Statement** (PTO/SB/08 or PTO-1449)
    ☐ Copies of citations attached
13. ☐ **Preliminary Amendment**
14. ☐ **Return Receipt Postcard** (MPEP 503)
    (*Should be specifically itemized)*
15. ☐ **Certified Copy of Priority Document(s)**
    (if foreign priority is claimed)
16. ☐ **Nonpublication Request** under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.
17. ☑ Other: General Authorization for Petition for Extension of Time

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title, or in an Application Data Sheet under 37 CFR 1.76:*

☑ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: 11/646,692

Prior application information: *Examiner* Ronald B. Abelson *Art Unit:* 2476

19. CORRESPONDENCE ADDRESS

☑ The address associated with Customer Number: 22242 ***OR*** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone		Email	

Signature	/Steven G. Parmelee/	Date	2011-07-05
Name (Print/Type)	Steven G. Parmelee	Registration No. (Attorney/Agent)	28,790

This collection of information is required by 37 CFR 1.53(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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

Privacy Act Statement

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

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

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

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:	Paul Howard
Filed:	Herewith
Title:	FEEDBACK CONTROL IN AN FDD TDD-CDMA SYSTEM
Attorney Docket:	9147-99460-US
Customer No.:	22242

This Authorization was electronically filed on April 21, 2011 using the USPTO's EFS-Web.

GENERAL AUTHORIZATION FOR PETITION FOR EXTENSION OF TIME UNDER 37 C.F.R. § 1.136(a)(3)

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

Sir:

Applicant(s) hereby request under 37 C.F.R. §1.136(a)(3) by this general authorization that any concurrent or future reply submitted by Applicant(s) to the United States Patent and Trademark Office for the above-identified patent application requiring a petition for an extension of time under §1.136(a) for its timely submission be treated as incorporating therein a petition for an extension of time for the appropriate length of time.

If Applicant(s) do not timely pay for any extension fee(s) pursuant to 37 C.F.R. §1.136(a) which may become due for this application under 37 C.F.R. §1.17, the Commissioner is hereby authorized to charge such fee(s), and any additional fees which may be required in this application under 37 C.F.R. §§1.16-1.17 during its entire pendency, or credit any overpayment, to Deposit Account No. 06-1135.

Date: July 5, 2011

Steven G. Parmelee
Registration No. 28,790

FITCH, EVEN, TABIN & FLANNERY
120 South LaSalle Street, Suite 1600
Chicago, Illinois 60603-3406
Telephone: (312) 577-7000
Facsimile: (312) 577-7007

PTO/SB/14 (07-07)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	9147-99460-US
	Application Number	
Title of Invention	Feedback Control in an FDD TDD-CDMA System	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Paul		Howard	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Briston	Country Of Residence[i]	UK

Citizenship under 37 CFR 1.41(b)[i] UK

Mailing Address of Applicant:

Address 1	Tennyson Cottage, Tennyson Road		
Address 2	Horfield		
City	Bristol	State/Province	
Postal Code	BS7 8SB	Country[i]	UK

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	22242		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	Feedback Control in an FDD TDD-CDMA System		
Attorney Docket Number	9147-99460-US	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	5	Suggested Figure for Publication (if any)	

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	9147-99460-US
	Application Number	
Title of Invention	Feedback Control in an FDD TDD-CDMA System	

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	**Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	22242		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	11646692	2006-12-27

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			○ Yes ◉ No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 Remove

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	9147-99460-US
	Application Number	
Title of Invention	Feedback Control in an FDD TDD-CDMA System	

If the Assignee is an Organization check here. ☒			
Organization Name	Wireless Technology Solutions LLC		
Mailing Address Information:			
Address 1	550 Madison Avenue		
Address 2			
City	New York	**State/Province**	NY
Country [i]	US	Postal Code	10022
Phone Number		Fax Number	
Email Address			
Additional Assignee Data may be generated within this form by selecting the **Add** button.		Add	

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Steven G. Parmelee/			Date (YYYY-MM-DD)	2011-07-05
First Name	Steven G.	Last Name	Parmelee	Registration Number	28790

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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

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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 records.

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.

FEEDBACK CONTROL IN AN FDD TDD-CDMA SYSTEM

BACKGROUND OF THE INVENTION

[0001] Time division-code division multiple access (TD-CDMA) is an air interface technology that combines the benefits of the three elemental concepts in a universal mobile telecommunication system (UMTS): time division multiple access (TDMA); code division multiple access (CDMA); and time division duplex (TDD). TDD, in particular, uses the same radio channel for both uplink and downlink communications, and discriminates between signals by separating the transmissions in time. One of the benefits obtained by operating both links on the same frequency is the ability to exploit channel reciprocity.

[0002] Channel reciprocity gives equipment the ability to derive information about uplink channel conditions from downlink channel conditions based upon signals received by the user equipment (UE). Pathloss is one example of channel information that can be obtained from channel reciprocity. Knowledge of the uplink pathloss enables open-loop power control to be employed for uplink transmissions. For example, uplink power control is important for the operation of the CDMA element of TD-CDMA as it counteracts the near-far effect that would otherwise be encountered if all UEs transmitted at a fixed power regardless of the uplink pathloss.

[0003] The open-loop uplink power control feature provides a significant advantage when coupled with a multiple access data transmission system that is used for packet-based communication and/or shared channels. When access to a limited number of uplink channels is shared between a large population of terminals it is imperative that access to the channels can be switched between terminals with minimal latency. A data terminal that can derive information needed to access uplink channels from the downlink transmissions (beacon signals) has a significant advantage over a terminal that relies on the (lengthy) configuration of a dedicated channel in order to establish a feedback channel.

[0004] However, channel reciprocity cannot always be guaranteed. For example TDD transmissions may not be permitted in certain frequency spectrum allocations; this is a regulatory issue and may be used to protect other wireless equipment in the same or adjacent frequency bands.

In these situations the correlation between uplink and downlink channels is lost because the channels are transported on carrier frequencies that are separated in frequency by an amount that is greater than the coherence bandwidth of the channel (usually, only a few MHz separation is sufficient to cause the uplink and downlink fading profiles to be independent).

[0005] In high speed mobile applications, the time delay between downlink and uplink transmissions may exceed the coherence time of the channel. The maximum time delay that can be tolerated is a function of the mobile speed and the RF carrier frequency used, with the coherence time reducing with increasing speed and RF carrier frequency. Also, the use of multiple transmit and/or receive antennas at the network and/or the mobile terminal can introduce unintentional decorrelation between the uplink and downlink channels.

[0006] If the TD-CDMA air interface is to be used in applications where the correlation between the uplink and downlink path loss is not guaranteed, then it would be advantageous to find a substitute for channel reciprocity.

BRIEF SUMMARY OF THE INVENTION

[0007] Although it is desirable to support air interfaces where the pathloss is not reciprocal, known conventional methods do not deal directly with the evolution or adaptation of an air interface that uses channel reciprocity to deliver key features and advantages where channel reciprocity is not guaranteed. The adaptation provided in embodiments of the invention introduces a new technique for uplink channel control that uses a feedback scheme as a substitute for the absence of channel reciprocity, with minimal impact on the ability of the air interface to support uplink shared channels.

[0008] Embodiments of the present invention enable active feedback control between a base station and user equipment (UE). In particular, the operation of a system designed for TDD, or unpaired operation, is expanded to operate in FDD, or paired, mode. For example, an uplink beacon function (for power control) and a modified random access process substitute for the information lost due to the lack of channel reciprocity in paired operation. Embodiments of the invention allow a terminal to transmit the uplink physical channel control signal (UL_Beacon) independently from the uplink physical channel. Therefore, the implementation of closed loop feedback may operate in

the absence of an uplink physical channel. In one embodiment, a UE allocates a time slot for a beacon signal separated from the time slots for data in a frame. A second time slot is allocated within the frame for the base station to transmit a control signal in response to the beacon signal. The control signal instructs the UE to adjust a transmission parameter.

[0009] A UL_Beacon signal may be combined with a physical layer common control channel (PLCCH) to form a feedback system. A dedicated timeslot groups all of the UL_Beacon signals from multiple UEs in a specific uplink timeslot. By grouping the UL_Beacon signals together, embodiments obtain separation between the UL_Beacon signals and the standard uplink physical channels. Additionally, in a synchronous system embodiments of the invention detect and cancel the UL_Beacon signals from other cell sites (inter-cell interference). The PLCCH carries feedback information to the UEs that are transmitting UL_Beacon signals. The PLCCH can share a timeslot with other physical channels by exploiting the CDMA aspect of the system.

[0010] In other embodiments, the number of supported UEs can be increased by fractionating the use of the UL_Beacon and PLCCH across a multiframe period. Fractionation may also prevent timeslot blocking where half duplex UEs have a long UL/DL switching time. Additionally, support for half duplex terminals is implicit due to the nature of the TDMA frame structure. The system may manage the allocation of resource across the population of terminals such that the full capacity of the base station can be utilized even when only half-duplex terminals are deployed. In embodiments of the invention, full-duplex terminals can be still be supported along with half duplex UEs.

[0011] Moreover, in other embodiments, a radio resource control (RRC) connected state covers the subset of terminals that are in cell forward access channel (Cell_FACH), which are also transmitting UL_Beacon and receiving PLCCH, thus creating an active control feedback channel. Management of the UEs that are in Cell_Active state may remove users that are less active, and may add users that are newly active while retaining users that may have on-going data transfer requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figure 1 illustrates a cellular communication system according to embodiments of the invention;

[0013] Figure 2 illustrates a timeslot arrangement for uplink and downlink messages supporting the UL_Beacon and its corresponding PLCCH within a TD-CDMA frame structure modified to support FDD according to embodiments of the invention;

[0014] Figure 3 illustrates fractionation in different frames at the base station according to embodiments of the invention;

[0015] Figure 4 illustrates UTRA RRC connected modes according to embodiments of the invention;

[0016] Figure 5 illustrates a computer system that may be employed to implement embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Figure 1 illustrates an example of a cellular communication system according to embodiments of the invention. The network includes a user equipment (UE) domain, a radio access network (RAN) domain, and a core network domain. The UE domain includes user equipment 110 that communicate with at least one base station 112 in the RAN domain via a wireless interface. The RAN domain may also include a network controller (RNC) 118 (e.g., radio network controller), such as that used in UMTS systems. Alternatively, such functionality may be distributed between the Node Bs and an access gateway (AGW)(not shown) or other controller in the core network. Figure 1 also illustrates an optional radio resource manager (RRM) 114. The RRM may perform functions otherwise performed by the Node Bs or an AGW in some embodiments.

[0018] The core network (CN) 116 includes, in this example, a serving GPRS support node (SGSN) 120, and a gateway GPRS support node (GGSN) 122. The core network is coupled to an external network 124. The SGSN 120 is responsible for session control, including keeping track of

the location of the UEs. The GGSN 122 concentrates and tunnels user data within the core network 116 to the ultimate destination (e.g., an Internet service provider) in the external network 124. Further details may be found in the 3GPP UMTS technical specifications, such as TS23.246 v6.4.0 "3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Multimedia Broadcast/Multicast Service (MBMS); Architecture and Functional Description (Release 6)," published by the 3GPP Support Office, 650 Route des Lucioles - Sophia Antipolis, Valbonne - FRANCE, which are incorporated by reference herein.

[0019] Further details regarding exemplary communications systems that may implement embodiments of the invention may be found in 3GPP UMTS technical specifications, such as TR 23.882, "3GPP System Architecture Evolution: Report on Technical Options and Conclusions"; TR 25.912, "Feasibility Study for Evolved UTRA and UTRAN"; TS 23.101, "General Universal Mobile Telecommunications System (UMTS) Architecture," all of which are incorporated by reference herein.

TDD to FDD Evolution

[0020] A system designed for operation in Time Division Duplex (TDD) mode has base stations and terminals that transmit and receive at orthogonal points in time. In normal operation terminals are in receive mode when the base station is transmitting, and base stations are in receive mode when terminals are transmitting. In conventional TDD implementations, neither base stations nor the terminals are able to transmit and receive at the same points in time because the same frequency is used for uplink and downlink communication.

[0021] Such a system can be adjusted to operate in Frequency Division Duplex (FDD) mode, where the uplink and downlink communications occur on different frequencies. According to embodiments of the invention, to make full and efficient use of the frequency spectrum resources, the base stations are adapted to transmit and receive at the same time. This is possible since the uplink and downlink communications now occur on different frequencies. The terminals, however, retain the restriction of transmitting and receiving at orthogonal points in time to retain the simplicity of not having to transmit and receive at the same time (e.g., no duplexer required). The

full use of the frequency spectrum is then obtained by allocating the resource across a plurality of terminals.

[0022] Additional measures may be needed if there are aspects of the air interface that rely on the channel reciprocity that can be assumed for TDD systems. In the case of TD-CDMA, modifications may be made for the correct operation of uplink power control and rate adaptation. This can be achieved by defining an uplink physical control channel used for estimating the uplink channel conditions and a downlink channel used to feed back control information to the terminal. These channels may not need an associated data physical channel to be operational.

[0023] Modifications may be made to the random access channel. This may be achieved by introducing an additional indicator step at the start of any physical random access. A new uplink physical channel carries the random access indicators. A new downlink physical channel carries the response to received uplink indicators.

Uplink Physical Channel Control Signal

[0024] When pathloss reciprocity is not available, the combination of an uplink physical channel control signal with a downlink feedback channel may be used to keep the terminal informed of the condition of the uplink channel. The uplink physical control signal is referred to herein as an "Uplink Beacon" (UL_Beacon).

[0025] In general, a system that supports shared channels may also support shared access to a large number of terminals. To extract the maximum benefit from the resulting trunking gain, shared channels can be quickly and efficiently re-allocated between the population of UEs. To obtain rapid access to the uplink shared channels, terminals can transmit at the correct power with their first transmission so that latency can be kept to a minimum.

[0026] According to embodiments of the invention, the RNC or other controller (e.g., other controller having its functionality in the core network) allocates resources so that the physical channel control signal is separate from the uplink (shared) physical channel. Thus, terminals are able to transmit an UL_Beacon independently of their access to the uplink shared channel. The system may implement a closed loop control system, in which the base station detects the received

power and/or other channel information from the UL_Beacon, and sends controlling commands back to each terminal to keep the terminal informed of the channel conditions observed at the base station.

[0027] In certain embodiments, the closed loop control system is simply based on the UL_Beacon power received at the base station. The base station may send power control commands on a shared downlink channel to each terminal based on the power received from the UL_Beacon signal. Each power control command may, for example, indicate whether terminal power should be increased or decreased by a predetermined amount. This downlink channel is referred to as the "Physical Layer Control Channel" (PLCCH). The capacity of the PLCCH may be matched to the number of bits required in the feedback field and the number of UL_Beacon signals that can be simultaneously supported. That is, each UL_Beacon may correspond to one bit of the PLLCH. All terminals transmitting UL_Beacon signals may receive this channel and extract the relevant feedback field.

[0028] It is possible to extend the complexity of the control loop by sending control commands based on other aspects of the UL_Beacon signal as received by the base station, such as time-of-arrival, and channel impulse response. The amount of resource that is required for the feedback channel increases with the size (in bits) of the feedback information to each UE.

[0029] For example, for air interface technologies with a TDMA element, it is possible to adapt the TDMA frame structure to provide separation between the UL_Beacon and the normal physical channels by dedicating at least one uplink time slot per frame (or at least one time slot per multi-frame) to carrying UL_Beacon signals.

[0030] By placing UL_Beacon signals in a dedicated timeslot, a dedicated detection scheme can be applied which may include performance enhancing features such as intra-cell cancelling (for alleviating the effects of cross-correlation interference between UL_Beacon signals transmitted by multiple terminals in the same cell), or inter-cell cancelling (for reducing the interference from neighboring cells in the case where the UL_Beacon timeslots are time synchronized). Cross-interference between UL_Beacon and normal uplink bursts is avoided by the separation obtained from the use of separate time slots.

[0031] Those skilled in the art will recognize that there are a large number of possibilities for the arrangement of a UL_Beacon and its associated PLCCH within the frame structure according to embodiments of the invention. More than one UL_Beacon and PLCCH per frame could be supported if the feedback update rate is required to be faster than the frame rate (at the expense of system capacity). For system applications that can tolerate a slower feedback rate, embodiments may fractionate the use of the UL_Beacon timeslot (and the associated PLCCH).

[0032] When fractionation is employed, the RNC or other controller may allocate the UL_Beacon timeslot in a given frame to a group of terminals depending on the current fractionation phase, thus increasing the number of terminals that can be supported with active physical channel feedback control. The maximum fractionation cycle length may be determined by the feedback update rate that the system requires in order to meet its performance targets.

[0033] Figure 2 illustrates an example of a timeslot arrangement supporting the UL_Beacon and its corresponding PLCCH within a TD-CDMA frame structure modified to support FDD. In this example, the PLCCH 212 shares a timeslot with another downlink shared channel. This is possible since normal downlink physical channels are used to transmit the PLCCH. The downlink frame also comprises a downlink beacon timeslot 206, an access control timeslot 208, and normal traffic carrying timeslots 210. The uplink frame comprises a UL_Beacon control timeslot 216, an access control timeslot 218, and normal traffic carrying timeslots 214.

[0034] Figure 3 illustrates an example where fractionation is employed. The UL_Beacon and PLCCH timeslots are active in every frame at the base station 302. However, terminal 304, terminal 306, and terminal 308 have been assigned a different fractionation phase. Figure 3 illustrates the case where the fractionation phase is 3. For example, the fractionation phase of terminal 304 occurs in frame #0 310, the fractionation phase of terminal 306 occurs in frame #1 312, and the fractionation phase of terminal 308 occurs in frame #2. Since the fractionation phase is 3, the phase for terminal 304 occurs again in frame #3 316.

Half Duplex Terminals

[0035] Embodiments of the invention enable terminals to operate in half duplex or full duplex mode. In a half duplex system, base stations and terminals do not transmit and receive simultaneously. When such a system is evolved to operate in paired spectrum, it becomes inefficient if base stations retain their half duplex operation. It is not necessarily inefficient for the terminals to do so, however, since half duplex operation may have some advantages in the design and implementation of the terminal.

[0036] Nonetheless, there are some points that should be considered. For example, a single terminal may not be able to access all transmit and all receive slots. Therefore, the system may have to manage resources across the population of terminals to ensure all the available resources at the base station are efficiently utilized. To prevent blocking of timeslots, half duplex terminals may be operated with a fractionation cycle of greater than one. In particular, this may also apply for the case where there are more than one UL_Beacon timeslot per frame. There is a time delay for half duplex terminals to switch between transmit and receive functions. In some cases this delay exceeds the guard period inserted between consecutive timeslots. In the half duplex terminal case, the terminal is unable to transmit and receive on adjacent timeslots. This will affect the locations of the UL_Beacon, PLCCH, and other common channels. Accordingly, the timeslot arrangement may be adjusted when the system is configured.

Terminal Management

[0037] Embodiments of this invention separate uplink control from the uplink physical traffic. This allows the control feedback to operate even when the terminal does not have data to send, with the consequence that uplink shared channels can be used with maximum efficiency.

[0038] To use shared channels efficiently, a relatively large user base may be needed. At the same time, the network resources required to support the control feedback channels for these terminals need to be minimized. In general, the number of users that can be supported with active control feedback channels is smaller than the typical number of users per cell. Therefore, the terminals in this active state may be managed.

[0039] In UMTS terminology, embodiments of the invention provide a new Universal Terrestrial Radio Access- Radio Resource Control-Connected (UTRA RRC-Control) sub-state into the system. UTRA systems already support the idea of different RRC-Connected states (see, TS25.331 Radio Resource Control (RRC) Protocol Specification, which is incorporated herein by reference), e.g., CELL_DCH, CELL_FACH etc. This sub-state is referred to as the CELL_ACTIVE state. Figure 4 illustrates this sub-state in context with other UTRA RRC-connected states. A UE in a Cell_Active sub-state transmits the physical channel control part of the uplink physical channel only, and nothing else (i.e., no data).

[0040] As shown in Figure 4, CELL_ACTIVE sub-state is a sub-state of CELL_FACH state 404. In general, UEs in CELL_FACH state have an RRC connection, but they may not be actively transferring data. Out of the population of UEs in CELL_FACH state 404, a smaller number of UEs, determined by the network to be the most-active UEs, are supported in a CELL_ACTIVE state 406. In this state, the UEs transmit the physical channel control signal and listen to the associated feedback channel from the network. Because the UE is aware of the uplink pathloss conditions from the feedback channel, it can have instant access to the uplink shared channels, and the resource allocator (controller) in the network can treat the UE accordingly.

[0041] The rules governing which UEs are maintained in CELL_ACTIVE state are decided by the network (e.g., through the RNC) and may be based on factors such as the volume of data transfer required by the UE, the data transfer rate required by a UE, the frequency of short bursts of data transfer, the total number of UEs in CELL_FACH state, the time since the last data transfer, the UE power saving requirements, etc.

[0042] Note that UEs in CELL_ACTIVE state have their transmitters active, therefore it is necessary for these UEs to monitor the status of the downlink and automatically come out of CELL_ACTIVE state if the downlink is deemed to be out-of-synchronization (for example, very high downlink errors or low received signal strength). This feature prevents UEs continuing to transmit in a state where the feedback channel may be unreliable and thus causing interference.

[0043] While the invention has been described in terms of particular embodiments and illustrative figures, those of ordinary skill in the art will recognize that the invention is not limited to

the embodiments or figures described. Although embodiments of the present invention are described, in some instances, using UMTS terminology, those skilled in the art will recognize that such terms are also used in a generic sense herein, and that the present invention is not limited to such systems.

[0044] Those skilled in the art will recognize that the operations of the various embodiments may be implemented using hardware, software, firmware, or combinations thereof, as appropriate. For example, some processes can be carried out using processors or other digital circuitry under the control of software, firmware, or hard-wired logic. (The term "logic" herein refers to fixed hardware, programmable logic and/or an appropriate combination thereof, as would be recognized by one skilled in the art to carry out the recited functions.) Software and firmware can be stored on computer-readable media. Some other processes can be implemented using analog circuitry, as is well known to one of ordinary skill in the art. Additionally, memory or other storage, as well as communication components, may be employed in embodiments of the invention.

[0045] Figure 5 illustrates a typical computing system 500 that may be employed to implement processing functionality in embodiments of the invention. Computing systems of this type may be used in the the radio controllers, the base stations, and the UEs, for example. Those skilled in the relevant art will also recognize how to implement the invention using other computer systems or architectures. Computing system 500 may represent, for example, a desktop, laptop or notebook computer, hand-held computing device (PDA, cell phone, palmtop, etc.), mainframe, server, client, or any other type of special or general purpose computing device as may be desirable or appropriate for a given application or environment. Computing system 500 can include one or more processors, such as a processor 504. Processor 504 can be implemented using a general or special purpose processing engine such as, for example, a microprocessor, microcontroller or other control logic. In this example, processor 504 is connected to a bus 502 or other communications medium.

[0046] Computing system 500 can also include a main memory 508, such as random access memory (RAM) or other dynamic memory, for storing information and instructions to be executed by processor 504. Main memory 508 also may be used for storing temporary variables or other

intermediate information during execution of instructions to be executed by processor 504. Computing system 500 may likewise include a read only memory ("ROM") or other static storage device coupled to bus 502 for storing static information and instructions for processor 504.

[0047] The computing system 500 may also include information storage system 510, which may include, for example, a media drive 512 and a removable storage interface 520. The media drive 512 may include a drive or other mechanism to support fixed or removable storage media, such as a hard disk drive, a floppy disk drive, a magnetic tape drive, an optical disk drive, a CD or DVD drive (R or RW), or other removable or fixed media drive. Storage media 518, may include, for example, a hard disk, floppy disk, magnetic tape, optical disk, CD or DVD, or other fixed or removable medium that is read by and written to by media drive 514. As these examples illustrate, the storage media 518 may include a computer-readable storage medium having stored therein particular computer software or data.

[0048] In alternative embodiments, information storage system 510 may include other similar components for allowing computer programs or other instructions or data to be loaded into computing system 500. Such components may include, for example, a removable storage unit 522 and an interface 520, such as a program cartridge and cartridge interface, a removable memory (for example, a flash memory or other removable memory module) and memory slot, and other removable storage units 522 and interfaces 520 that allow software and data to be transferred from the removable storage unit 518 to computing system 500.

[0049] Computing system 500 can also include a communications interface 524. Communications interface 524 can be used to allow software and data to be transferred between computing system 500 and external devices. Examples of communications interface 524 can include a modem, a network interface (such as an Ethernet or other NIC card), a communications port (such as for example, a USB port), a PCMCIA slot and card, etc. Software and data transferred via communications interface 524 are in the form of signals which can be electronic, electromagnetic, optical or other signals capable of being received by communications interface 524. These signals are provided to communications interface 524 via a channel 528. This channel 528 may carry signals and may be implemented using a wireless medium, wire or cable, fiber

optics, or other communications medium. Some examples of a channel include a phone line, a cellular phone link, an RF link, a network interface, a local or wide area network, and other communications channels.

[0050] In this document, the terms "computer program product," "computer-readable medium" and the like may be used generally to refer to media such as, for example, memory 508, storage device 518, or storage unit 522. These and other forms of computer-readable media may store one or more instructions for use by processor 504, to cause the processor to perform specified operations. Such instructions, generally referred to as "computer program code" (which may be grouped in the form of computer programs or other groupings), when executed, enable the computing system 500 to perform functions of embodiments of the present invention. Note that the code may directly cause the processor to perform specified operations, be compiled to do so, and/or be combined with other software, hardware, and/or firmware elements (e.g., libraries for performing standard functions) to do so.

[0051] In an embodiment where the elements are implemented using software, the software may be stored in a computer-readable medium and loaded into computing system 500 using, for example, removable storage drive 514, drive 512 or communications interface 524. The control logic (in this example, software instructions or computer program code), when executed by the processor 504, causes the processor 504 to perform the functions of the invention as described herein.

[0052] It will be appreciated that, for clarity purposes, the above description has described embodiments of the invention with reference to different functional units and processors. However, it will be apparent that any suitable distribution of functionality between different functional units, processors or domains may be used without detracting from the invention. For example, functionality illustrated to be performed by separate processors or controllers may be performed by the same processor or controller. Hence, references to specific functional units are only to be seen as references to suitable means for providing the described functionality, rather than indicative of a strict logical or physical structure or organization.

[0053] Although the present invention has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the claims. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognize that various features of the described embodiments may be combined in accordance with the invention.

[0054] Furthermore, although individually listed, a plurality of means, elements or method steps may be implemented by, for example, a single unit or processor. Additionally, although individual features may be included in different claims, these may possibly be advantageously combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. Also, the inclusion of a feature in one category of claims does not imply a limitation to this category, but rather the feature may be equally applicable to other claim categories, as appropriate.

CLAIMS

What is claimed is:

1. A method for enabling active control feedback between a base station and user equipment (UE) in a wireless communications network, the method comprising:

allocating a first time slot within a frame for a UE to transmit a beacon signal to the base station, wherein the beacon signal is separate from data signals in the frame;

allocating a second time slot within the frame for the base station to transmit a control signal in response to the beacon signal, the control signal for providing a basis upon which the UE adjusts a transmission parameter; and

allocating other timeslots for the base station to operate in full duplex FDD mode.

2. The method of claim 1, wherein data signals are not allocated to the first time slot.

3. The method of claim 1, wherein the first and second time slots operate in full duplex FDD mode.

4. The method of claim 1, wherein the transmission parameter comprises power.

5. The method of claim 1, wherein the control signal is based upon at least one factor from the group consisting of: path loss computed based upon the received power of the beacon signal; time of arrival of the beacon signal; and channel impulse response in response to the beacon signal.

6. The method of claim 1, wherein allocating a second time slot to the control signal comprises allowing another downlink signal, separated in the code domain from the control signal, to share the second time slot with the control signal.

7. The method of claim 1, wherein

allocating a first time slot within a frame for the UE comprises allocating the first time slot within at least some successive frames to different UEs for transmission of respective different beacon signals, and

allocating a second time slot within a frame for the base station comprises allocating the second time slot to the base station for transmission of different control signals within the at least some successive frames to the different UEs .

8. The method of claim 1, further comprising determining to which UE the first time slot should be allocated based upon at least one factor from the group consisting of: expected volume of data transfer expected; required data transfer rate; frequency of short bursts of data transfer; total number of UEs connected to the network; time since last data transfer; and UE power saving requirements.

9. A controller for enabling active control feedback between a base station and UE in a wireless communications network, the controller comprising logic for:

allocating a first time slot within a frame for a UE to transmit a beacon signal to the base station, wherein the beacon signal is separate from data signals in the frame;

allocating a second time slot within the frame for the base station to transmit a control signal in response to the beacon signal, the control signal for providing a basis upon which the UE adjusts a transmission parameter; and

allocating other timeslots for the base station to operate in full duplex FDD mode.

10. The controller of claim 9, wherein data signals are not allocated to the first time slot.

11. The controller of claim 9, wherein the first and second time slots operate in full duplex FDD mode.

12. The controller of claim 9, wherein the transmission parameter comprises power.

13. The controller of claim 9, wherein the control signal is based upon at least one factor from the group consisting of: path loss computed based upon the received power of the beacon signal; time of arrival of the beacon signal; and channel impulse response in response to the beacon signal.

14. The controller of claim 9, wherein the logic for allocating a second time slot to the control signal comprises logic for allowing another downlink signal, separated in the code domain from the control signal, to share the second time slot with the control signal.

15. The controller of claim 9, wherein

the logic for allocating a first time slot within a frame for the UE comprises logic for allocating the first time slot within at least some successive frames to different UEs for transmission of respective different beacon signals, and

the logic for allocating a second time slot within a frame for the base station comprises logic for allocating the second time slot to the base station for transmission of different control signals within the at least some successive frames to the different UEs .

16. The controller of claim 9, further comprising logic for determining to which UE the first time slot should be allocated based upon at least one factor from the group consisting of: expected volume of data transfer expected; required data transfer rate; frequency of short bursts of data transfer; total number of UEs connected to the network; time since last data transfer; and UE power saving requirements.

17. A computer-readable medium comprising program code for enabling active control feedback between a base station and UE in a wireless communications network, the program code for:

allocating a first time slot within a frame for a UE to transmit a beacon signal to the base station, wherein the beacon signal is separate from data signals in the frame;

allocating a second time slot within the frame for the base station to transmit a control signal in response to the beacon signal, the control signal for providing a basis upon which the UE adjusts a transmission parameter; and

allocating other timeslots for the base station to operate in full duplex FDD mode.

18. The computer-readable medium of claim 17, wherein data signals are not allocated to the first time slot.

19. The computer-readable medium of claim 17, wherein the first and second time slots operate in full duplex FDD mode.

20. The computer-readable medium of claim 17, wherein the transmission parameter comprises power.

21. The computer-readable medium of claim 17, wherein the control signal is based upon at least one factor from the group consisting of: path loss computed based upon the received power of the beacon signal; time of arrival of the beacon signal; and channel impulse response in response to the beacon signal.

22. The computer-readable medium of claim 17, wherein the program code for allocating a second time slot to the control signal comprises program code for allowing another downlink signal, separated in the code domain from the control signal, to share the second time slot with the control signal.

23. The computer-readable medium of claim 17, wherein

the program code for allocating a first time slot within a frame for the UE comprises program code for allocating the first time slot within at least some successive frames to different UEs for transmission of respective different beacon signals, and

the program code for allocating a second time slot within a frame for the base station comprises program code for allocating the second time slot to the base station for transmission of different control signals within the at least some successive frames to the different UEs .

24. The computer-readable medium of claim 17, further comprising program code for determining to which UE the first time slot should be allocated based upon at least one factor from the group consisting of: expected volume of data transfer expected; required data transfer rate; frequency of short bursts of data transfer; total number of UEs connected to the network; time since last data transfer; and UE power saving requirements.

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ABSTRACT

Active control feedback between a base station and user equipment in a wireless communications network is achieved by allocating a first time slot within a frame for a UE to transmit a beacon signal to the base station, where the beacon signal is separate from data signals in the frame, allocating a second time slot within the frame for the base station to transmit a control signal in response to the beacon signal, and allocating other timeslots for the base station to operate in full duplex FDD mode. The control signal provides a basis upon which the UE adjusts a transmission parameter, such as power.

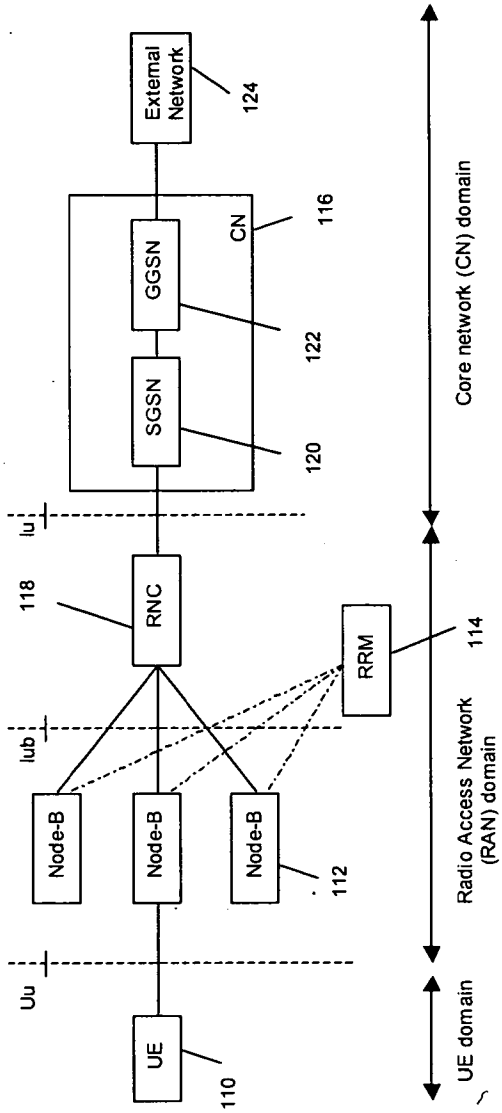

External Network
124
CN
116
GGSN
122
SGSN
120
Core network (CN) domain
Iu
118
RNC
RRM
114
Iub
Node-B
Node-B
Node-B
112
Radio Access Network (RAN) domain
Uu
UE
110
UE domain

Figure 1

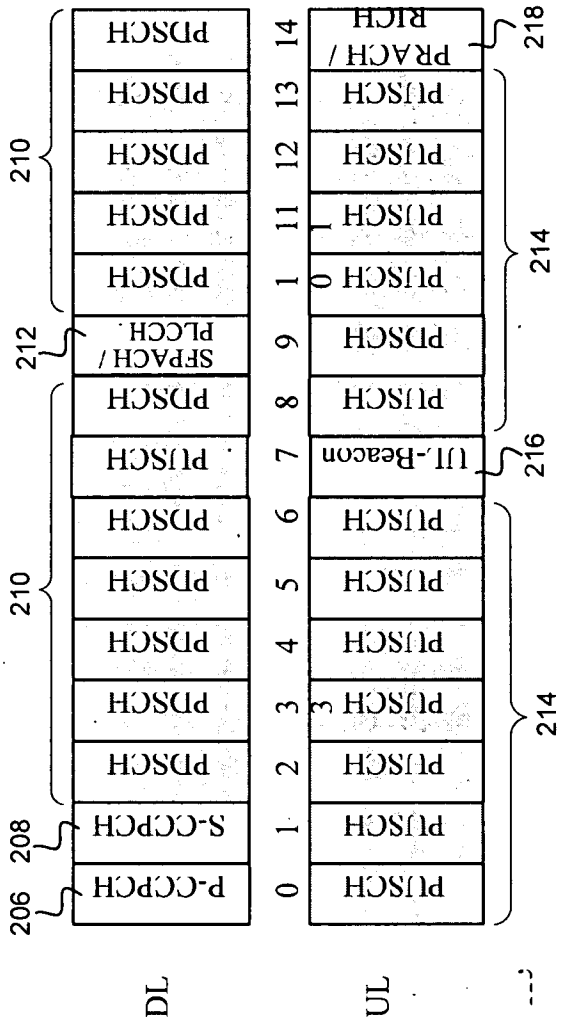


Figure 2

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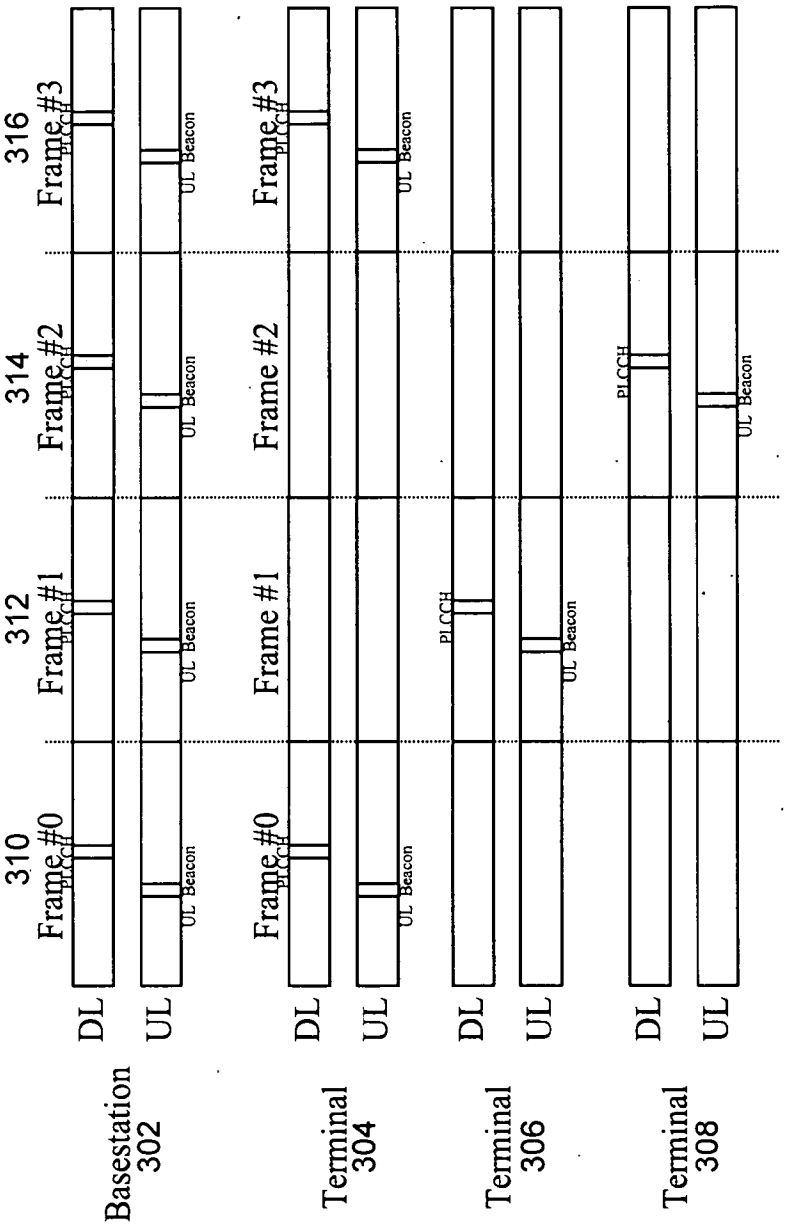

310
312
314
316
Frame #0
Frame #1
Frame #2
Frame #3
PLCCH
UL Beacon
DL
UL
Basestation 302
Terminal 304
Terminal 306
Terminal 308

Figure 3

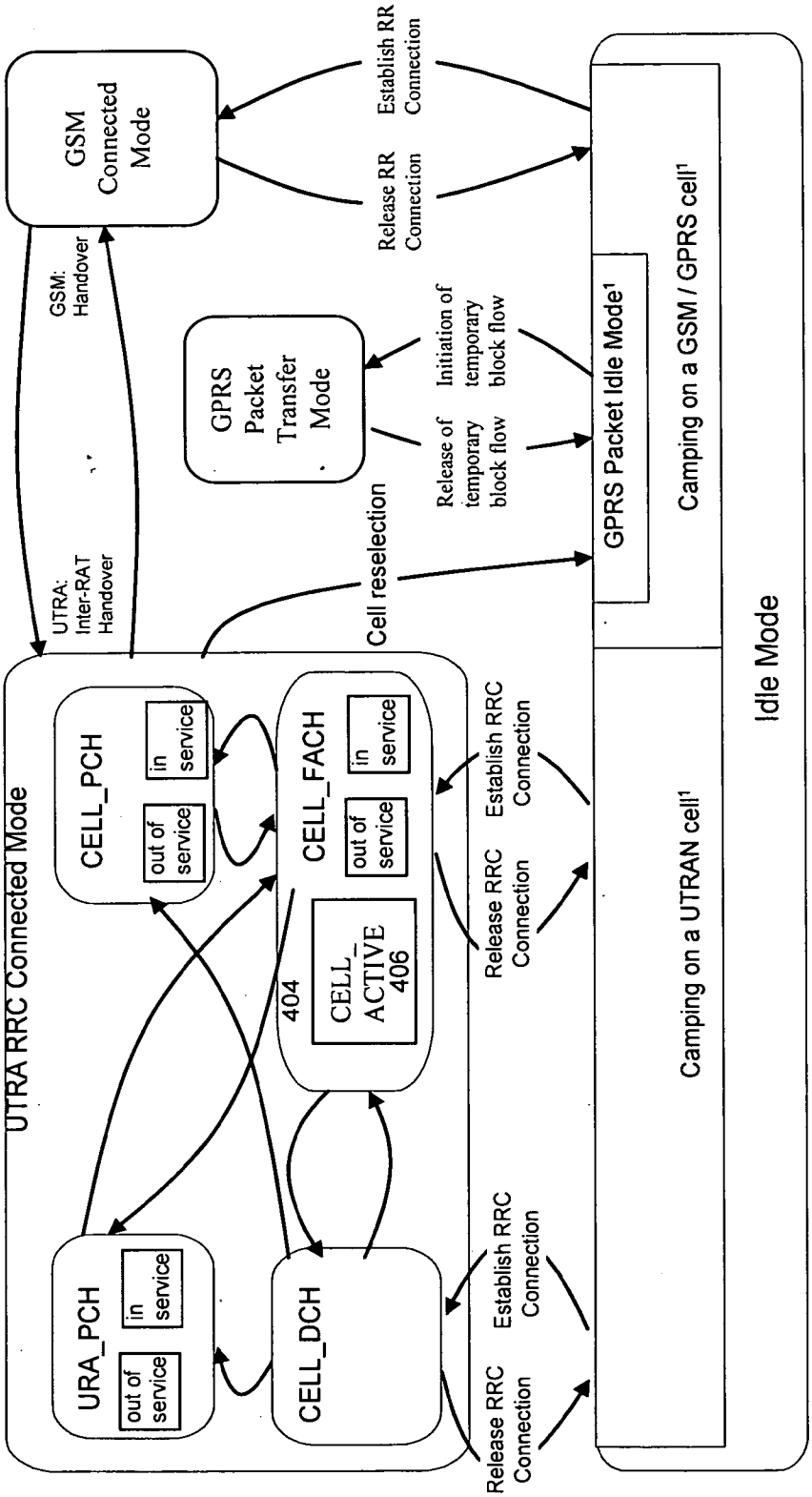

GSM Connected Mode
Establish RR Connection
Release RR Connection
GSM: Handover
GPRS Packet Transfer Mode
Initiation of temporary block flow
Release of temporary block flow
UTRA: Inter-RAT Handover
Cell reselection
GPRS Packet Idle Mode[1]
Camping on a GSM / GPRS cell[1]
UTRA RRC Connected Mode
CELL_PCH
in service
out of service
CELL_FACH
in service
out of service
404
CELL_ACTIVE 406
Establish RRC Connection
Release RRC Connection
URA_PCH
in service
out of service
CELL_DCH
Establish RRC Connection
Release RRC Connection
Camping on a UTRAN cell[1]
Idle Mode

Figure 4

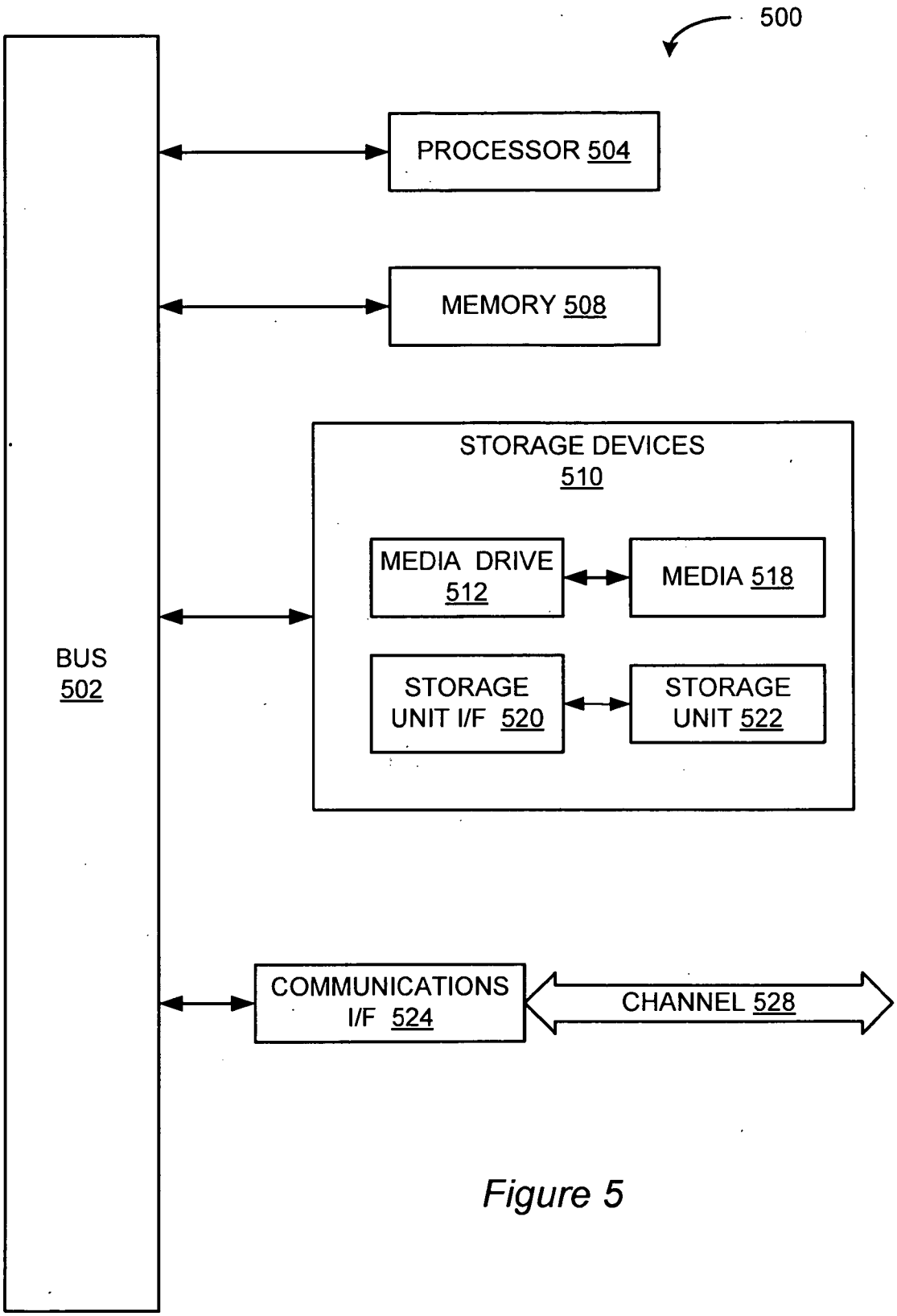

500
PROCESSOR 504
MEMORY 508
STORAGE DEVICES 510
MEDIA DRIVE 512
MEDIA 518
STORAGE UNIT I/F 520
STORAGE UNIT 522
BUS 502
COMMUNICATIONS I/F 524
CHANNEL 528

Figure 5

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	FEEDBACK CONTROL IN AN FDD TDD-CDMA SYSTEM

As the below named inventor(s), I/we declare that;

This declaration is directed to:

☐ The attached application, or

☒ Application No. 11/648,692, filed on 12/27/2006

☐ as amended on _____ (if applicable);

I/we believe that I/we am/are the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought.

I/we have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above.

I/we acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me/us to be material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

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All statements made herein of my/our own knowledge are true, all statements made herein 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 are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

FULL NAME OF INVENTOR(S)

Inventor one: Paul HOWARD

Signature: _____ Citizen of: United Kingdom

Inventor two: _____

Signature: _____ Citizen of: _____

Inventor three: _____

Signature: _____ Citizen of: _____

Inventor four: _____

Signature: _____ Citizen of: _____

☐ Additional inventors or a legal representative are being named on _____ additional form(s) attached hereto.

PAGE 7/9 * RCVD AT 4/2/2007 6:48:11 PM [Eastern Daylight Time] * SVR:USPTO-EFXRF-5/18 * DNIS:2738300 * CSID:415 2687522 * DURATION (mm-ss):02-02

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Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	Feedback Control in an FDD TDD-CDMA System
First Named Inventor/Applicant Name:	Paul Howard
Filer:	Steven Glen Parmelee/Helen Donegan
Attorney Docket Number:	9147-99460-US

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	330	330
Utility Search Fee	1111	1	540	540
Utility Examination Fee	1311	1	220	220
Pages:				
Claims:				
Claims in excess of 20	1202	4	52	208
Miscellaneous-Filing:				
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1298**

Electronic Acknowledgement Receipt

EFS ID:	10451996
Application Number:	13176298
International Application Number:	
Confirmation Number:	4342
Title of Invention:	Feedback Control in an FDD TDD-CDMA System
First Named Inventor/Applicant Name:	Paul Howard
Customer Number:	22242
Filer:	Steven Glen Parmelee/Helen Donegan
Filer Authorized By:	Steven Glen Parmelee
Attorney Docket Number:	9147-99460-US
Receipt Date:	05-JUL-2011
Filing Date:	
Time Stamp:	16:05:26
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1298
RAM confirmation Number	2704
Deposit Account	061135
Authorized User	

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	99460_Utility_Patent_Application_Transmittal.pdf	244156 c9db05fa372da722179d75da9a6360d66d0a0bdf	no	2
Warnings:					
Information:					
2	Authorization for Extension of Time all replies	99460_GeneralAuthorizationForPetitionForExtensionOfTime_1.PDF	43016 d7bf45f7f54abeb4375492bfbd2435d853eb8d7d	no	1
Warnings:					
Information:					
3	Application Data Sheet	99460_Application_Data_Sheet.pdf	964780 3b2081062fe1e0c7e615527ae975b8d83a308f4b	no	4
Warnings:					
Information:					
4		99460_Specification_Claims_Abstract.pdf	877010 a28e9f6b3cea882f7ad45743b1341872afdab3ac	yes	19

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	14
Claims	15	18
Abstract	19	19

Warnings:					
Information:					
5	Drawings-only black and white line drawings	99460_Drawings.pdf	84345 306ef1d7de2ba3db404036abbe5b27f7e3cb4e60	no	5
Warnings:					
Information:					
6	Oath or Declaration filed	99460_Declaration.pdf	69869 cc4aafcd67e8fabcddae3c5d4bf73f081b10cecc	no	1
Warnings:					
Information:					

7	Fee Worksheet (SB06)	fee-info.pdf	36652 34b4e96cfc80903cdf89d418155b21e4e364f318	no	2

Warnings:	
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STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Paul Howard

Application No./Patent No.: 13/176,298 Filed/Issue Date: July 5, 2011

Titled: Feedback Control in an FDD TDD-CDMA System

Wireless Technology Solutions LLC , a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. ☒ the assignee of the entire right, title, and interest in;

2. ☐ an assignee of less than the entire right, title, and interest in (The extent (by percentage) of its ownership interest is _____ %); or

3. ☐ the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy therefore is attached.

OR

B. ☒ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: See Attached Patent Abstract of Title To: _____

The document was recorded in the United States Patent and Trademark Office at

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2. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

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☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.



Signature July 5, 2011

Date

Steven G. Parmelee Attorney for Applicant

Printed or Typed Name Title

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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I hereby appoint:

☑ Practitioners associated with the Customer Number: 22242

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3 73(b) to:

☑ The address associated with Customer Number: 22242

OR

☐ Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address:

Wireless Technology Solutions LLC
550 Madison Avenue
New York, New York 10022

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	4/11/2011
Name	ED SCHUMMER	Telephone	+1-415-874-9541
Title	CEO		

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11/646,692 FEEDBACK CONTROL IN AN FDD TDD-CDMA SYSTEM 9147-96652-US 07-05-2011::16:02:57

Patent Assignment Abstract of Title

Total Assignments: 6

Application #: 11646692 **Filing Dt:** 12/27/2006 **Patent #:** NONE **Issue Dt:**
PCT #: NONE **Publication #:** US20080159185 **Pub Dt:** 07/03/2008
Inventor: Paul Howard
Title: FEEDBACK CONTROL IN AN FDD TDD-CDMA SYSTEM

Assignment: 1

Reel/Frame: 019106 / 0467 **Received:** 04/03/2007 **Recorded:** 04/03/2007 **Mailed:** 04/04/2007 **Pages:** 2
Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).
Assignor: HOWARD, PAUL **Exec Dt:** 04/03/2007
Assignee: IPWIRELESS, INC.
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Correspondent: ROBERT A. SALTZBERG
MORRISON & FOERSTER LLP
425 MARKET STREET
SAN FRANCISCO, CA 94105

Assignment: 2

Reel/Frame: 022102 / 0891 **Received:** 01/14/2009 **Recorded:** 01/14/2009 **Mailed:** 01/15/2009 **Pages:** 25
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Assignor: IPWIRELESS, INC. **Exec Dt:** 12/24/2008
Assignee: NORTHROP GRUMMAN INFORMATION TECHNOLOGY, INC.
1840 CENTURY PARK EAST
LOS ANGELES, CALIFORNIA 90067-2199
Correspondent: COLMAN B. RAGAN
787 SEVENTH AVENUE
WILLKIE FARR & GALLAGHER LLP
NEW YORK, NY 10019

Assignment: 3

Reel/Frame: 024006 / 0144 **Received:** 03/01/2010 **Recorded:** 03/01/2010 **Mailed:** 03/01/2010 **Pages:** 38
Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).
Assignor: NORTHROP GRUMMAN INFORMATION TECHNOLOGY, INC. **Exec Dt:** 11/03/2009
Assignee: IPWIRELESS, INC.
90 NEW MONTGOMERY STREET
SUITE 315
SAN FRANCISCO, CALIFORNIA 94105
Correspondent: FITCH EVEN TABIN & FLANNERY
120 SOUTH LASALLE STREET
SUITE 1600
CHICAGO, IL 60603-3406

Assignment: 4

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Assignors: IPWIRELESS, INC. **Exec Dt:** 11/03/2009
IPWIRELESS U.K. LIMITED **Exec Dt:** 11/03/2009
IPW HOLDINGS, INC. **Exec Dt:** 11/03/2009
IPWIRELESS PTE LIMITED **Exec Dt:** 11/03/2009
Assignee: NORTHROP GRUMMAN INFORMATION TECHNOLOGY, INC. NOW KNOWN AS NORTHROP GRUMMAN SYSTEMS CORPORATION BY REASON OF MERGER
1840 CENTURY PARK EAST
LOS ANGELES, CALIFORNIA 90067
Correspondent: WILLKIE FARR & GALLAGHER
787 SEVENTH AVENUE
CARE OF COLMAN B. RAGAN
NEW YORK, NY 10019

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Reel/Frame: 024305 / 0231 **Received:** 04/29/2010 **Recorded:** 04/29/2010 **Mailed:** 04/29/2010 **Pages:** 13
Conveyance: RELEASE BY SECURED PARTY (SEE DOCUMENT FOR DETAILS).
Assignor: NORTHROP GRUMMAN SYSTEMS CORPORATION (SUCCESSOR BY MERGER TO NORTHROP GRUMMAN INFORMATION TECHNOLOGY, INC.) **Exec Dt:** 04/23/2010
Assignee: IPWIRELESS, INC.
90 NEW MONTGOMERY STREET

SUITE 315
SAN FRANCISCO, CALIFORNIA 94105

Correspondent: TIMOTHY FRANKLIN
599 LEXINGTON AVENUE
SHEARMAN & STERLING LLP - IP DOCKETING
NEW YORK, NY 10022

Assignment: 6

Reel/Frame: 024305 / 0492 **Received:** 04/29/2010 **Recorded:** 04/29/2010 **Mailed:** 04/29/2010 **Pages:** 8

Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).

Assignor: IP WIRELESS, INC. **Exec Dt:** 04/23/2010

Assignee: WIRELESS TECHNOLOGY SOLUTIONS LLC
550 MADISON AVENUE
NEW YORK, NEW YORK 10022

Correspondent: OBLON, SPIVAK, ET AL.
1940 DUKE STREET
ALEXANDRIA, VA 22314

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EFS ID:	10453670
Application Number:	13176298
International Application Number:	
Confirmation Number:	4342
Title of Invention:	Feedback Control in an FDD TDD-CDMA System
First Named Inventor/Applicant Name:	Paul Howard
Customer Number:	22242
Filer:	Steven Glen Parmelee/Helen Donegan
Filer Authorized By:	Steven Glen Parmelee
Attorney Docket Number:	9147-99460-US
Receipt Date:	05-JUL-2011
Filing Date:	
Time Stamp:	17:14:45
Application Type:	Utility under 35 USC 111(a)

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	Power of Attorney	99460_Power_of_Attorney_1.PDF	292855 6887e6b6e6872cbfe51f4ab25fea64e053e2b0a0	no	5

Warnings:	
Information:	

Total Files Size (in bytes):	292855

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.

Electronic Acknowledgement Receipt

EFS ID:	12582885
Application Number:	13176298
International Application Number:	
Confirmation Number:	4342
Title of Invention:	Feedback Control in an FDD TDD-CDMA System
First Named Inventor/Applicant Name:	Paul Howard
Customer Number:	22242
Filer:	Steven Glen Parmelee/Helen Donegan
Filer Authorized By:	Steven Glen Parmelee
Attorney Docket Number:	9010-99460-US
Receipt Date:	19-APR-2012
Filing Date:	05-JUL-2011
Time Stamp:	15:46:43
Application Type:	Utility under 35 USC 111(a)

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		99460_Preliminary_Amendment.pdf	547929 e9b30bd1f9b77f9e6c86985585e55a15606f6d3a	yes	9

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Preliminary Amendment	1	1
	Specification	2	2
	Claims	3	8
	Applicant Arguments/Remarks Made in an Amendment	9	9
Warnings:			
Information:			
	Total Files Size (in bytes):	547929	

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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.

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

PTO/SB/06 (07-06)
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
13/176,298	07/05/2011	

APPLICATION AS FILED – PART I

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

APPLICATION AS AMENDED – PART II

AMENDMENT	04/19/2012	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0	X $ =		OR	X $60=	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $250=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

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

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

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

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

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

Legal Instrument Examiner:
/DAVID SASFAI/

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

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PTO/SB/06 (07-06)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
13/176,298	07/05/2011	

APPLICATION AS FILED – PART I

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

APPLICATION AS AMENDED – PART II

AMENDMENT	04/19/2012	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 22	Minus	** 20	= 2	X $ =		OR	X $60=	120
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $250=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**120**

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

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

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

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

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

Legal Instrument Examiner:
/DAVID SASFAI/

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

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	13176298
Filing Date	2011-07-05
First Named Inventor	Howard, Paul
Art Unit	2473
Examiner Name	Not Yet Assigned
Attorney Docket Number	9010-99460-US

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
	1	5056109		1991-10-08	Gilhousen et al.	
	2	5265119		1993-11-23	Gilhousen et al.	
	3	5485486		1996-01-16	Gilhousen et al.	
	4	6061784		2000-05-09	Tarsky et al.	
	5	6567459		2003-05-20	Hakkinen et al.	
	6	6978151		2005-12-20	Choi et al.	
	7	7120134		2006-10-10	Tiedemann, Jr. et al.	
	8	7215657		2007-05-08	Toshimitsu et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Attorney Docket Number	9010-99460-US

	9	8009639		2011-08-30	Howard	

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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
	1	20020075891		2002-06-20	Souissi	
	2	20020168993		2002-11-14	Choi et al.	
	3	20040152473		2004-08-05	Kuwano et al.	
	4	20040203419		2004-10-14	Crocker et al.	
	5	20060093026		2006-05-04	Montojo et al.	
	6	20060211417		2006-09-21	Pedlar	
	7	20070173256		2007-07-26	Laroia et al.	

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FOREIGN PATENT DOCUMENTS Remove

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	13176298
Filing Date	2011-07-05
First Named Inventor	Howard, Paul
Art Unit	2473
Examiner Name	Not Yet Assigned
Attorney Docket Number	9010-99460-US

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] ¡	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	DE10201270	DE		2002-08-08	Samsung Electronics Co., Ltd.		☐
	2	EO1467582	EP		2004-10-13	Telefonaktiebolaget LM Ericsson		☐
	3	EP1615384	EP		2006-01-11	Qualcomm Incorporated		☐
	4	EP1681780	EP		2006-07-19	Fujitsu Limited		☐

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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	"3 UMTS Interfaces," UMTS Protocols and Protocol Testing, pp. 9-14, located at <http://www.tek.com/Measurement/App.sub.--Notes/2F.sub.--14251/eng/int- erfaces.pdf>.	☐
	2	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Feasibility Study for Evolved UTRA and UTRAN (Release 7)," (Mar. 2006). 3GPP:Valbonne, France, TS 25.912 v0.0.4:1-13.	☐
	3	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3GPP System Architecture Evolution: Report on Technical Options and Conclusions (Release 7)," (Jul. 2005). 3GPP:Valbonne, France, TS 23.882 v0.3.0:1-13.	☐
	4	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; General UMTS Architecture (3G TS23.101 version 3.0.1)," (Apr. 1999). 3GPP:Valbonne, France, TS 23.101 v3.0.1:1-13.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13176298
	Filing Date	2011-07-05
	First Named Inventor	Howard, Paul
	Art Unit	2473
	Examiner Name	Not Yet Assigned
	Attorney Docket Number	9010-99460-US

	5	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Multimedia Broadcast/Multicast Service (MBMS); Architecture and Functional Description (Release 6); 3GPP: Valbonne, France; 3GPP TS 23.246 v.6.4.0 (2004-09);	☐
	6	"UMTS Protocols and Protocol Testing," Tektronix, The International Engineering Consortium, pp. 1-45, located at <http://www.rfpeople.com/docs/umts.pdf>.	☐
	7	Ghadialy, Z. "Tutorial: Medium Access Control (MAC) in 3G/UMTS Protocol Stack," located at <http://www.3g4g.co.uk/Tutorial/ZG/zg.sub.--mac.html> visited on Jun. 20, 2007. (9 pages).	☐
	8	International Engineering Consortium. "Universal Mobile Telecommunications System (UMTS) Protocols and Protocol Testing," located at <http://www.iec.org/online/tutorials/umts/topic02.html> visited on Jun. 20, 2007. (7 pages).	☐
	9	International Preliminary Report on Patentability issued on Jun. 30, 2009 from PCT Application No. PCT/EP20071064483.	☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13176298
	Filing Date	2011-07-05
	First Named Inventor	Howard, Paul
	Art Unit	2473
	Examiner Name	Not Yet Assigned
	Attorney Docket Number	9010-99460-US

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	/Steven G. Parmelee/	Date (YYYY-MM-DD)	2012-04-16
Name/Print	Steven G. Parmelee	Registration Number	28,790

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.**

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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.

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENT- UND MARKENAMT

(12) **Offenlegungsschrift**

(10) **DE 102 01 270 A 1**

(51) Int. Cl.[7]:
H 04 J 3/16
H 04 B 7/204
// H04J 13/02,H04Q 7/20

(21) Aktenzeichen: 102 01 270.9
(22) Anmeldetag: 15. 1. 2002
(43) Offenlegungstag: 8. 8. 2002

DE 102 01 270 A 1

(30) Unionspriorität:
01-2131 15. 01. 2001 KR

(71) Anmelder:
Samsung Electronics Co., Ltd., Suwon, Kyonggi, KR

(74) Vertreter:
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Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

Rechercheantrag gem. Paragraph 43 Abs. 1 Satz PatG ist gestellt

Prüfungsantrag gem. § 44 PatG ist gestellt

(54) Verfahren und Vorrichtung für das Steuern der Sendeleistung in einem NB-TDD CDMA Kommunikationssystem

(57) Ein TDD (Zeitduplex) CDMA (Vielfachzugriff durch Kodetrennung) Kommunikationssytem führt eine Leistungssteuerung in einer Leistungssteuerbetriebsart mit geschlossener Schleife in einer Datenübertragungszeitdauer durch, wobei sie aber die Leistungssteuerung unter Verwendung eines modifizierten Leistungssteuerverfahrens mit offener Schleife und eines Leistungssteuerverfahrens mit offener Schleife als auch das Leistungssteuerverfahren mit geschlossener Schleife in einer Übertragungspausenzeitdauer durchführt, um somit die anfängliche Übertragungsleistung nach dem Ende der Übertragungspausenzeitdauer passend einzustellen.

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Beschreibung

PRIORITÄT

[0001] Diese Anmeldung beansprucht die Priorität einer Anmeldung mit dem Titel "A Power Control Method in Narrow Band Time Division Duplexing Code Division Multiple Access Communication", die beim koreanischen Patentamt am 15. Januar 2001 eingereicht wurde, und der die Seriennummer 2001-2131 zugewiesen wurde, wobei der Inhalt dieser Anmeldung hiermit durch Bezugnahme eingeschlossen wird.

HINTERGRUND DER ERFINDUNG

GEBIET DER ERFINDUNG

[0002] Die vorliegende Erfindung betrifft allgemein NB-TDD (Narrow Band Time Division Duplexing, schmalbandige Zeitduplexsysteme) CDMA (Vielfachzugriff durch Kodetrennung) Kommunikationssysteme und insbesondere eine Vorrichtung und ein Verfahren für das Steuern der Übertragungsleistung beim Auftreten einer Übertragungspause.

BESCHREIBUNG DES STANDS DER TECHNIK

[0003] Im allgemeinen kann eine dritte Generation der mobilen Kommunikationssysteme als FDD-Kommunikationssysteme (Frequency Division Duplexing Kommunikationssysteme), die sich bei der Übertragung in Aufwärtsrichtung in der Frequenz von der Übertragung in Abwärtsrichtung unterscheiden, und als WB/NB-TDD (Wide Band/Narrow Band Time Division Duplexing, Breitband/Schmalband, Zeitduplex) Kommunikationssysteme, die die Übertragung in Aufwärtsrichtung von der Übertragung in Abwärtsrichtung auf der Zeitbasis trennen, klassifiziert werden. Das WB-TDD Kommunikationssystem und das FDD-Kommunikationssystem verwendet eine Chiprate von 3,48 MHz, während das NB-TDD-Kommunikationssystem eine Chiprate von 1,28 MHz verwendet.

[0004] Im NB-TDD-Kommunikationssystem wird eine Kommunikation zwischen einer UE (Benutzerausrüstung) und einem Knoten B durch einen Kanal, der zwischen ihnen angeordnet ist, durchgeführt. Da die Daten diskontinuierlich (oder als Impulsfolge) durch den Kanal auf einer Zeitmultiplexbasis übertragen werden, kann es sein, daß lange Übertragungspausen auftreten. Somit kann es sein, daß wenn ein Übertragungssignal in Aufwärtsrichtung oder Abwärtsrichtung nach jeder Übertragungspause übertragen wird, daß sich seine anfängliche Übertragungsleistung durch die Übertragungspause nicht auf einem passenden Pegel befindet.

[0005] Wie oben angegeben wurde, umfaßt die dritte Generation eines asynchronen mobilen Kommunikationssystems, die eine Zeitmultiplextechnik verwendet, das WB-TDD-System und das NB-TDD-System. Ein Hauptunterschied zwischen dem WB-TDD-System und dem NB-TDD-System liegt in einer Chiprate: das WB-TDD-System verwendet eine Chiprate von 3,48 MHz, während das NB-TDD-System eine Chiprate von 1,28 MHz verwendet. Weiterhin verwendet das WB-TDD-System und das NB-TDD-System ein Leistungssteuerverfahren für eine Übertragung in Aufwärtsrichtung/Abwärtsrichtung für das maximale Steuern der Interferenzen zwischen den UEs im Knoten B und den Interferenzen zu einem anderen Knoten B. Ein Unterschied in einem Übertragungsleistungssteuerverfahren zwischen dem WB-TDD-System und dem NB-TDD-System wird nachfolgend hier beschrieben.

[0006] Zuerst erfolgt eine Beschreibung eines Übertragungsleistungssteuerverfahrens für das WB-TDD-Kommunikationssystem.

[0007] Das WB-TDD-Kommunikationssystem verwendet ein Leistungssteuerverfahren mit offener Schleife für die Übertragungsleistungssteuerung in Aufwärtsrichtung, und ein Leistungssteuerverfahren mit geschlossener Schleife für eine Übertragungsleistungssteuerung in Abwärtsrichtung. Im Leistungssteuerverfahren mit offener Schleife, das für das Steuern der Übertragungsleistung einer UE in einem WB-TDD-Kommunikationssystem in Aufwärtsrichtung verwendet wird, mißt die UE einen Ausbreitungsverlust eines primären gemeinsamen physikalischen Steuerkanals (P-CCPCH), der von einem Knoten B übertragen wird, und steuert passend seine Aufwärtsübertragungsleistung auf der Basis des gemessenen Ausbreitungsverlusts, so daß der Knoten B ein Kanalsignal, das durch die UE gesendet wird, korrekt empfangen kann. Hier dient der P-CCPCH als ein Kanal für das Übertragen der Information des Knotens B und der Systeminformation (SI) an die UEs im Knoten B. Der P-CCPCH wird mit einer konstanten Übertragungsleistung übertragen, und ein Übertragungsleistungspegel des P-CCPCH wird an die UEs im Konten B übertragen. Die UE kann den Ausbreitungsverlust vom Knoten B unter Verwendung der Übertragungsinformation auf dem Übertragungsleistungspegel des P-CCPCH messen. Weiterhin empfängt im Leistungssteuerverfahren mit geschlossener Schleife, das für das Steuern der Übertragungsleistung in Abwärtsrichtung des Knotens B im WB-TDD-Kommunikationssystem verwendet wird, die UE ihr Signal vom Knoten B, und mißt dann einen Pegel (oder ein Signal-zu-Interferenz-Verhältnis (SIR)) des empfangenen Signals. Wenn der Pegel des Signals, das vom Knoten B empfangen wurde, kleiner als ein vorbestimmter Schwellwert ist, so überträgt die UE einen TPC-Befehl (Übertragungsleistungsbefehl), der den Knoten B anweist, seine Übertragungsleistung zu erhöhen. Im Gegensatz dazu sendet, wenn der Pegel des Signals, das vom Knoten B empfangen wird, höher oder gleich dem Schwellwert ist, die UE einen TPC-Befehl, der den Knoten B anweist, seine Übertragungsleistung zu erniedrigen. Der Knoten B steuert dann die Übertragungsleistung in Abwärtsrichtung auf der Basis des TPC-Befehls, der von der UE empfangen wurde, so daß die Übertragungsleistung, die von der UE empfangen wurde, einen konstanten Pegel aufweisen kann. Dieses Verfahren wird als das "Leistungssteuerverfahren mit geschlossener Schleife" bezeichnet. Mit anderen Worten, das WB-TDD-Kommunikationssystem, wie es oben angegeben wurde, verwendet das Leistungssteuerverfahren mit geschlossener Schleife für die abwärtige Übertragungsleistungssteuerung und das Leistungssteuerverfahren mit offener Schleife für die Übertragungsleistungssteuerung in Aufwärtsrichtung.

[0008] Im Gegensatz zum WB-TDD-Kommunikationssystem spezifiziert das 3GPP (Partnerschaftsprojekt der dritten Generation) TSG (Technical Special Group) RAN (Radio Access Network) TR (Technical Report), daß das NB-TDD-Kommunikationssystem das Leistungssteuerverfahren mit geschlossener Schleife sowohl für die Übertragungsleistungssteuerung in Aufwärtsrichtung als auch für die Übertragungsleistungssteuerung in Abwärtsrichtung verwendet. Ein Hauptunterschied zwischen dem Leistungssteuerverfahren mit offener Schleife und dem Leistungssteuerverfahren mit geschlossener Schleife besteht darin, ob der TPC-Befehl übertragen werden soll oder nicht. Im WB-TDD-Kommunikationssystem wird, da das Leistungssteuerverfahren mit geschlossener Schleife nur für die Übertragung in Abwärtsrichtung verwendet wird, der TPC-Befehl nur durch die

Aufwärtsverbindung übertragen. Im NB-TDD-Kommunikaitonssystem wird jedoch, da das Leistungssteuerverfahren sowohl für die Übertragungen in Aufwärtsrichtung als auch in Abwärtsrichtung verwendet wird, der TPC-Befehl sowohl durch die Aufwärtsverbindung als auch die Abwärtsverbindung übertragen.

[0009] Als nächstes wird eine Aufwärtsverbindung/Abwärtsverbindung-Übertragungsleistungssteuerverfahren für das NB-TDD-System hier unter Bezug auf **Fig.** 1 beschrieben.

[0010] **Fig.** 1 zeigt eine Struktur eines Unterrahmens eines NB-TDD-Kommunikationssystems. Wenn man **Fig.** 1 betrachtet, weist ein Unterrahmen eine Länge von 5 ms auf, und zwei Unterrahmen bilden einen Rahmen. Somit weist der Rahmen eine Länge von 10 ms auf, und er wird zu einem Funkrahmen, einer Grundfunkübertragungseinheit im mobilen Kommunikationssystem der dritten Generation. Der 10 ms Funkrahmen wird zu einer Grundfunkübertragungseinheit, die gemeinhin in den FDD, WB-TDD und NB-TDD Kommunikationssystemen verwendet wird.

[0011] Der Unterrahmen besteht aus sieben Zeitschlitzen TS0-Ts6, einem Pilotzeitschlitz in Abwärtsrichtung (DwPTS oder Pilotkanal in Abwärtsrichtung (DwPCH)) **102**, einem Pilotzeitschlitz in Aufwärtsrichtung (UpPTS oder Pilotkanal in Aufwärtsrichtung (UpPCH)) **104**, und eine Schutzperiode (GP) **103**. Von den Zeitschlitzen TS0–TS6 sind die Zeitschlitze TS0 und TS4–TS6, die durch Abwärtspfeile dargestellt sind, Zeitschlitze in Abwärtsrichtung, die vom Knoten B zur UE übertragen werden, während die Zeitschlitze TS1–TS3, die durch Aufwärtspfeile dargestellt werden, Zeitschlitze in Aufwärtsrichtung sind, die von der UE zum Knoten B übertragen werden. Da das NB-TDD-Kommunikationssystem von der Übertragung in Aufwärtsrichtung zur Übertragung in Abwärtsrichtung und umgekehrt in einer Zeitschlitzeinheit umschaltet, so weist es die Zeitschlitze des Unterrahmens für die Übertragung in Aufwärtsrichtung und die Übertragung in Abwärtsrichtung gemäß den folgenden Regeln zu.

[0012] In der Unterrahmenstruktur muß der erste Zeitschlitz (TS0) **101** fest für die Übertragung in Abwärtsrichtung verwendet werden, und der DwPTS **102** ist eine Zeitdauer, während der der Knoten B eine vorbestimmte Kodesequenz zur UE überträgt, so daß die UE eine Synchronisation in Abwärtsrichtung erwerben kann. Der UpPTS **104** ist eine Zeitdauer, während der die UE eine vorbestimmte Kodesequenz zum Knoten B für die Synchronisation in Aufwärtsrichtung überträgt. Weiter stellt ein Schaltpunkt (SP) **110** einen Punkt da, wo die Übertragung in Abwärtsrichtung geschaltet wird. Die GP **103** ist eine Zeitdauer, während derer keine Übertragung stattfindet, wobei sie errichtet wurde, um eine Interferenz zwischen dem DwPTS **102** und dem UpPTS **104** durch eine mögliche Überlappung zwischen ihnen zu verhindern. Ein Schaltpunkt **111** ist ein Zeitpunkt für das Trennen der Übertragung in Aufwärtsrichtung von der Übertragung in Abwärtsrichtung der Zeitschlitze, bei denen es sich nicht um den ersten Zeitschlitz (TS0) **101** handelt. Hier wird der Schaltpunkt **111** variabel eingestellt, so daß die Anzahl der Schlitze in Aufwärtsrichtung größer als die Anzahl der Schlitze in Abwärtsrichtung ist, wenn eine größere Menge der Übertragungsdaten in Aufwärtsrichtung vorhanden ist, während die Anzahl der Schlitze in Abwärtsrichtung größer ist als die Anzahl der Schlitze in Aufwärtsrichtung, wenn eine größere Menge der Übertragungsdaten in Abwärtsrichtung vorhanden ist.

[0013] **Fig.** 2 zeigt ein Verfahren für das Zuweisen der Kanäle in Aufwärtsrichtung/Abwärtsrichtung an die UEs durch einen Konten B im NB-TDD-Kommunikationssystem. Aus Gründen der Einfachheit wird in **Fig.** 2 angenommen, daß ein Knoten B einen Kanal in Aufwärtsrichtung/Abwärtsrichtung einer UE zuweist. Betrachtet man die **Fig.** 2, so sind dort ein erster Funkrahmen **201**, ein zweiter Funkrahmen **202**, eine (K–1)-ter Funkrahmen **203** und ein K-ter Funkrahmen **204** gezeigt. Jeder Funkrahmen besteht aus zwei Unterrahmen. Das heißt, der erste Funkrahmen **201** besteht aus einem ersten Unterrahmen **211** und einem zweiten Unterrahmen **212**; der zweite Funkrahmen **202** besteht aus einem ersten Unterrahmen **221** und einem zweiten Unterrahmen **222**; der (K–1)-te Funkrahmen **203** besteht aus einem ersten Unterrahmen **231** und einem zweiten Unterrahmen **232**; und der K-te Funkrahmen **204** besteht aus einem ersten Unterrahmen **241** und einem zweiten Unterrahmen **242**.

[0014] In **Fig.** 2 informiert, wenn die UE eine Kanalzuweisungsanforderung an den Knoten B sendet, oder der Knoten B aufgefordert wird, einen Kanal an die UE zuzuweisen, der Knoten B die UE über solche Ressourcen, wie den Funkrahmen, den Unterrahmen, den Zeitschlitz und den Kanaleinteilungskode, der für die Übertragung in Abwärtsrichtung verwendet werden soll. Von den Ressourcen, die für die Kanalzuweisung verwendet werden, ist der Kanaleinteilungskode ein orthogonaler Kode. Bei der Übertragung in Abwärtsrichtung dient der orthogonale Kode dazu, einen Transportkanal in Abwärtsrichtung, der einer spezifische UE zugewiesen ist, von den Kanälen in Abwärtsrichtung, die anderen UEs zugewiesen sind, und die denselben Zeitschlitz verwenden, zu unterscheiden, indem unterschiedliche orthogonale Kodes den jeweiligen UEs zugewiesen werden. Für die Übertragung in Aufwärtsrichtung verwendet der Knoten B ortohogonale Kodes bei der Identifizierung der unterschiedlichen UEs, die denselben Zeitschlitz verwenden. Natürlich können für die Übertragung in Aufwärtsrichtung/Abwärtsrichtung durch den Orthogonalkode zwei oder mehr unterschiedliche Orthogonalkodes derselben UE zugewiesen werden, um eine Datenrate der Übertragung in Abwärtsrichtung zur UE und die Übertragung in Aufwärtsrichtung von der UE zu erhöhen. Weiterhin wird ein OVSF-Kode (Orthogonal Variable Spreading Factor), der in den asynchronen mobilen Kommunikationssystemen verwendet wird, typischerweise für den Kanaleinteilungskode, der im NB-TDD Kommunikationssystem verwendet wird, verwendet. Hier ist der OVSF-Kode dadurch gekennzeichnet, daß seine Länge gemäß einem Spreizungsfaktor (SF) für eine Datenspreizung variabel ist. Wenn beispielsweise der Spreizungsfaktor 4 ist (SF = 4), so wird ein Datenband um das Vierfache erweitert.

[0015] In diesem Fall wird die Länge des verwendeten Kanalzuteilungskodes 4, und es werden 4 verfügbare (SF = 4) Kanalzuteilungskodes erzeugt. Die Datenspreizfaktoren, die im NB-TDD-Kommunikationssystem verwendet werden, sind 1, 2, 4, 8 und 16, und wenn der Spreizungsfaktor mehr und mehr zunimmt, so nimmt die Datenrate der Übertragungsdaten ab.

[0016] In **Fig.** 2 besteht ein Verfahren für die Bestimmung von Kanälen in Aufwärtsrichtung/Abwärtsrichtung zwischen dem Knoten B und der UE darin, einen Kanal in Abwärtsrichtung mit einigen der Zeitschlitze, die für die Übertragung in Abwärtsrichtung verwendet werden, unter den Zeitschlitzen des Unterrahmens **211**, und einen spezifischen Kanalzuteilungskode zu errichten, und darin, einen Kanal in Aufwärtsrichtung mit einigen der Zeitschlitze, die für die Übertragung in Aufwärtsrichtung unter den Zeitschlitzen des Unterrahmens **211** verwendet werden, und einen spezifischen Kanalzuteilungskode zu errichten. Die Kanäle in Abwärtsrichtung/Aufwärtsrichtung (Zeitschlitze und Kanalzuteilungskodes), die zwischen der UE und dem Knoten B errichtet sind, werden wiederholt in einer Funkrahmeneinheit

verwendet, und wenn es notwendig ist, so können die Kanäle in Aufwärtsrichtung/Abwärtsrichtung (Zeitschlitze und Kanalzuteilungskodes) zwischen der UE und dem Knoten B wieder errichtet werden. Eine Wiederholungsperiode der Kanäle in Aufwärtsrichtung/Abwärtsrichtung zwischen der UE und dem Knoten B und dieAnzahl der Funkrahmen, nachdem eine Wiedererrichtung durchgeführt werden soll, kann vom Typ und der Menge der Daten, die zwischen der UE und dem Knoten B ausgetauscht werden, abhängen. Zusätzlich kann, wenn die Menge der Übertragungsdaten in Aufwärtsrichtung größer ist als die Menge der Übertragungsdaten in Abwärtsrichtung der Transportkanal in Aufwärtsrichtung häufiger als der Transportkanal in Abwärtsrichtung wiederholt werden. In **Fig.** 2 ist der K-te Rahmen **204** ein Rahmen, bei dem der Datenaustausch zwischen der UE und dem Knoten B endet.

[0017] **Fig.** 3 zeigt eine typische Struktur eines Zeitschlitzes in einem Unterrahmen. Die in **Fig.** 3 dargestellte Zeitschlitzstruktur kann sowohl für eine Übertragung in Aufwärtsrichtung als auch in Abwärtsrichtung verwendet werden. Die Datensymbole **311** und **317** werden für eine Übertragung von Übertragungsdaten in Aufwärtsrichtung und in Abwärtsrichtung verwendet, und TFCIs (Transport Format Combination Indicators, Transportformatkombinationsindikatoren) **312** und **316** dienen dazu, eine Datenrate eines Kanals in Abwärtsrichtung vom Knoten B zur UE oder Datenraten der Kanalzuteilungskodes für die Übertragung eines Kanals in Abwärtsrichtung den den Typ der Daten anzuzeigen. Weiterhin haben für den Kanal in Aufwärtsrichtung die TFCIs dieselbe Funktion wie beim Kanal in Abwärtsrichtung. Eine Mitambel **313** wird verwendet, um UEs, die denselben Zeitschlitz verwenden, zu identifizieren, oder um Kanäle in Abwärtsrichtung, die denselben Zeitschlitz in den WB-TDD und NB-TDD Kommunikationssystemen verwenden, zu identifizieren. Weiterhin wird für die Übertragungen in Aufwärtsrichtung/Abwärtsrichtung die Mitambel **313** für eine Kanalschätzung verwendet, und für die Übertragung in Abwärtsrichtung werden verschiedene Mitambels verwendet, um einen Verlust der Kanalausbreitung vom Knoten B zur UE zu messen. Alternativ kann der Knoten Bs verschiedene Mitambels für die Identifikation des Knotens Bs verwenden. Es wird eine spezielle Sequenz für die Mitambel **313** verwendet, und die Anzahl der speziellen Sequenzen, die für die Mitambel verwendet werden, beträgt 128. Die Kanalzuteilungskodes und die Mitambelsequenzen, die unter Bezug auf **Fig.** 2 beschrieben werden, weisen unterschiedliche Eigenschaften und Typen auf, und dies wird für eine Übertragung in Aufwärtsrichtung unter Bezug auf **Fig.** 3 beschrieben. Für die Übertragung in Aufwärtsrichtung wird der Kanalzuteilungskode, wie ein orthogonaler Kode, für die Datensymbole **311** und **317** verwendet, und er dient dazu, Daten von den UEs, die mit den Datensymbolen **311** und **317** übertragen werden, zu unterscheiden. Eine Mitambel **313** dient zur Identifizierung, welche UE Daten überträgt, und die Mitambel **313** ist kein Subjekt der Bandausdehnung mit einem Kanalzuteilungskode.

[0018] Zusätzlich wird eine SS (Synchronization Shift, Synchronisationsverschiebung) **314** verwendet, um einen Synchronisationssteuerbefehl zu übertragen, wenn die Synchronisation zwischen der UE und dem Knoten B durch eine Änderung in der Distanz zwischen der UE und dem Knoten B während der Signalübertragung oder durch andere Gründe mißlungen ist. In Erwiderung auf den Befehl, der durch die SS **314** übertragen wurde, kann die UE einen Übertragungspunkt in einer %-Chip-Einheit steuern. Weiterhin ist die GP **318** eine Periode für das Trennen des aktuellen Zeitschlitzes vom nächsten Zeitschlitz. Die GP **318** dient als ein Schutz, um Interferenzen zwischen einem Signal in Aufwärtsrichtung und einem Signal in Abwärtsrichtung zu verhindern, wenn das Übertragungsschlitzsignal in Abwärtsrichtung in der Übertragungsschlitzperiode der Aufwärtsrichtung empfangen wird, oder wenn das Übertragungsschlitzsignal in Aufwärtsrichtung in der Übertragungsschlitzperiode der Abwärtsrichtung empfangen wird. Schließlich wird der TPC-Befehl (Übertragungsleistungssteuerbefehl) **315** für das Steuern einer Übertragungleistung des Knotens B in Abwärtsrichtung verwendet, wenn er durch die Aufwärtsverbindung übertragen wird, und der TPC **315** wird für das Steuern der Übertragungsleistung in Aufwärtsrichtung der UE verwendet, wenn er durch die Abwärtsverbindung übertragen wird. Hier wird ein Verfahren für das Bestimmen des TPC-Befehls **315** und das anschließende Übertragen des bestimmten TPC-Befehls für die Leistungssteuerung der Übertragung in Aufwärtsrichtung und die Leistungssteuerung der Übertragung in Abwärtsrichtung getrennt beschrieben.

Leistungssteuerung der Übertragung in Aufwärtsrichtung

[0019] Im Leistungssteuerverfahren für die Übertragung in Aufwärtsrichtung empfängt der Knoten B Daten, die von der UE durch die Aufwärtsverbindung übertragen werden, korrekt, indem ein Pegel der Leistung der Übertragung in Aufwärtsrichtung, die durch die UE übertragen wird, gesteuert wird, und er steuert die Leistung der Übertragung in Aufwärtsrichtung so, daß die empfangenen Daten nicht als Interferenz zu einem Signal wirken, das von einer anderen UE zum Knoten B durch einen übermäßig hohen Pegel der Übertragungsleistung der UE übertragen wird. Im NB-TDD Kommunikationssystem mißt der Knoten B für die Leistungssteuerung der Übertragung in Aufwärtsrichtung ein Signal-zu-Interferenz-Verhältnis (SIR) eines Signals, das über einen zugewiesenen physikalischen Kanal (DPCH) durch die UE übertragen wird, und vergleicht den gemessenen SIR-Wert mit einem vorbestimmten SIR-Wert (SIR_{Ziel}). Um die Daten, die über den zugewiesenen Kanal der UE in Aufwärtsrichtung übertragen werden, korrekt zu empfangen, überträgt der Knoten B einen Übertragungsleistungsabschaltbefehl an die UE in Abwärtsrichtung, wenn der gemessene SIR-Wert größer als oder gleich dem SIR-Zielwert ist. Wenn der gemessene SIR-Wert kleiner als der SIR-Zielwert ist, so überträgt der Knoten B einen Übertragungsleistungserhöhungsbefehl an die UE. Weiter ist der DPCH ein physikalischer Kanal für das Übertragen von Benutzerdaten und Signalisierungsinformation von einer oberen Lage, und er wird nur durch die UE, die durch den Knoten B bezeichnet ist, verwendet, und die anderen UEs teilen nicht den DPCH, der einer spezifischen UE zugewiesen ist.

Leistungssteuerung der Übertragung in Abwärtsrichtung

[0020] Im Leistungssteuerverfahren der Übertragung in Abwärtsrichtung steuert die UE die Übertragungsleistung eines Signals vom Knoten B n Abwärtsrichtung, so daß die UE das Signal in Abwärtsrichtung korrekt und ohne Fehler empfangen kann. Das Leistungssteuerverfahren der Übertragung in Abwärtsrichtung wird in derselben Weise wie das Leistungssteuerverfahren der Übertragung in Aufwärtsrichtung durchgeführt. Das heißt, die UE mißt ein SIR eines DPCH-Signals in Abwärtsrichtung vom Knoten B und vergleicht den gemessenen SIR-Wert mit einem vorbestimmten SIR-Zielwert. Wenn als Ergebnis des Vergleichs der gemessene SIR-Wert kleiner als der SIR-Zielwert ist, überträgt die UE einen Übertragungsleistungserhöhungsbefehl in Aufwärtsrichtung an den Knoten B. Sonst überträgt, wenn der gemessene SIR-Wert größer oder gleich dem SIR-Zielwert ist, die UE einen Übertragungsleistungsabsenkbefehl in

Aufwärtsrichtung zum Knoten B, so daß der Knoten B die Übertragungsleistung eines Signals, das zur UE übertragen wird, steuert.

[0021] Wie in Bezug auf die **Fig.** 2 und 3 beschrieben wurde, so wird im NB-TDD Kommunikationssystem ein zugewiesener Kanal zwischen dem Knoten B und der UE durch den Zeitschlitz, den Kanalzuweisungkode und den Funkrahmen zugewiesen, und der TPC-Befehl wird in einer Unterrahmeneinheit übertragen. Im NB-TDD-Kommunikationssystem beträgt, wenn die Kanäle in Aufwärtsrichtung/Abwärtsrichtung zwischen der UE und dem Knoten B in jedem Unterrahmen errichtet sind, die maximale Frequenz der Übertragung der TPC-Befehle in Aufwärtsrichtung/Abwärtsrichtung 200 Hz; wenn die Kanäle in Aufwärtsrichtung/Abwärtsrichtung zwischen der UE und dem Knoten B in jedem Funkrahmen errichtet sind, so beträgt die maximale Frequenz der Übertragung 100 Hz; und wenn die Kanäle in Aufwärtsrichtung/Abwärtsrichtung zwischen der UE und dem Knoten B alle 10 Funkrahmen errichtet werden, so beträgt die maximale Frequenz der Übertragungen 10 Hz. Weiter kann es sein, daß im NB-TDD Kommunikationssystem die Kanäle in Aufwärtsrichtung/Abwärtsrichtung zwischen der UE und dem Knoten B nicht gleichmäßig errichtet werden: die Frequenz der Errichtung des Übertragungszeitschlitzes in Aufwärtsrichtung wird erhöht, wenn eine größere Menge der Übertragungsdaten in Aufwärtsrichtung vorliegen, und die Frequenz der Errichtung des Übertragungsschlitzes in Abwärtsrichtung wird erhöht, wenn eine größere Menge von Übertragungsdaten in Abwärtsrichtung vorhanden sind. Somit kann es sein, daß die Frequenz der Übertragung des TPC-Befehls in Aufwärtsrichtung nicht gleich der Frequenz der Übertragung des TPC-Befehls in Abwärtsrichtung ist.

[0022] Somit ist das NB-TDD Kommunikationssystem, das nur das Leistungssteuerverfahren mit geschlossener Schleife für die Übertragungsleistungssteuerung der DPCH verwendet, bei der passenden Einstellung der Übertragungsleistung in Aufwärtsrichtung/Abwärtsrichtung im oben angegeben Zustand, das heißt in einer Situation, bei der die Kanäle in Aufwärtsrichtung/Abwärtsrichtung für die Übertragungen in Aufwärtsrichtung/Abwärtsrichtung zwischen der UE und dem Knoten B ungleichmäßig errichtet oder diskontinuierlich errichtet werden, ineffizient, was eine glatte Übertragung der TPC-Befehle stört.

[0023] Zusätzlich liefert das NB-TDD Kommunikationssystem einen gemeinsamen Kanal zusätzlich zum DPCH als einen Kanal für das Übertragen von Benutzerdaten oder Signalisierinformation einer oberen Lage, und der gemeinsame Kanal ist gleich dem DPCH in einer physikalischen Struktur und einem Übertragungsleistungssteuerverfahren. Der gemeinsame Kanal wird in einen gemeinsamen Kanal in Abwärtsrichtung (DSCH) und einen gemeinsamen Kanal in Aufwärtsrichtung (USCH) klassifiziert. Insbesondere kann der gemeinsame Kanal wirksam für einen Paketdatendienst verwendet werden. Im Gegensatz zum zugewiesenen Kanal wird der gemeinsame Kanal durch eine Vielzahl von UEs durch das gemeinsame Nutzen der Funkressourcen (beispielsweise dem Kanalzuteilungskode, dem Zeitschlitz und der Mitambel) genutzt. Die Paketdaten werden auf einer Impulsfolgenbasis (in Form einer Impulsfolge) unter Berücksichtigung ihrer Eigenschaft erzeugt, und die Paketdaten können diskontinuierlich unter Verwendung des gemeinsamen Kanals übertragen werden, da er gegen eine Übertragungszeitverzögerung nicht empfindlich ist. Somit kann es sein, daß in dem Fall, bei dem die Übertragungsleistung des gemeinsamen Kanals im Leistungssteuerverfahren mit der geschlossenen Schleife wie beim DPCH gesteuert wird, eine Periode für das Übertragen des TPC-Signals nicht während einer langen Zeit existiert, wenn eine Periode zwischen den Datenblöcken, während derer keine Übertragung erfolgt, erhöht wird, so daß es sein kann, daß die Daten nicht normal übertragen werden.

ZUSAMMENFASSUNG DER ERFINDUNG

[0024] Eine Aufgabe der vorliegenden Erfindung besteht somit darin, eine Vorrichtung und ein Verfahren für das Steuern der Übertragungsleistung eines zugewiesenen physikalischen Kanals in einem NB-TDD-Kommunikationssystem bereit zu stellen.

[0025] Eine andere Aufgabe der vorliegenden Erfindung besteht darin, eine Vorrichtung und ein Verfahren für das Steuern der Übertragungsleistung eines gemeinsamen Kanals in einem NB-TDD-Kommunikationssystem bereit zu stellen.

[0026] Eine weitere Aufgabe der vorliegenden Erfindung besteht darin, eine Vorrichtung und ein Verfahren für das Steuern der Übertragungsleistung in Aufwärtsrichtung/Abwärtsrichtung nach dem Auftreten einer Übertragungspause, in der keine Daten übertragen werden, bereit zu stellen.

[0027] Eine nochmals andere Aufgabe der vorliegenden Erfindung besteht darin, eine Vorrichtung und ein Verfahren für das Steuern der Übertragungsleistung eines zugewiesenen Kanals und eines gemeinsamen Kanals unter Verwendung eines Leistungssteuerverfahrens mit geschlossener Schleife in einem NB-TDD Kommunikationssystem bereit zu stellen.

[0028] Eine nochmals andere Aufgabe der vorliegenden Erfindung besteht darin, eine Vorrichtung und ein Verfahren für das Steuern der Übertragungsleistung eines zugewiesenen Kanals und eines gemeinsamen Kanals unter Verwendung eines Leistungssteuerverfahrens mit offener Schleife zusammen mit einem Leistungssteuerverfahren mit einer geschlossener Schleife in einem NB-TDD Kommunikationssystem bereit zu stellen.

[0029] Eine nochmals andere Aufgabe der vorliegenden Erfindung besteht darin, eine Vorrichtung und ein Verfahren für das Steuern der Übertragungsleistung eines zugewiesenen physikalischen Kanals unter Verwendung eines Steuerverfahrens mit geschlossener Schleife in einem NB-TDD Kommunikationssystem unter Verwendung einer Strahlformungstechnik bereit zu stellen.

[0030] Eine nochmals andere Aufgabe der vorliegenden Erfindung besteht darin, eine Vorrichtung und ein Verfahren für das Steuern der Übertragungsleistung eines zugewiesenen physikalischen Kanals und eines gemeinsamen physikalischen Kanals unter Verwendung eines Leistungssteuerverfahrens mit offener Schleife zusammen mit einem Leistungssteuerverfahren mit geschlossener Schleife in einem NB-TDD Kommunikationssystem, das eine Strahlformungstechnik unterstützt, bereit zu stellen.

[0031] Um die obigen Aufgaben und andere Aufgaben zu lösen, wird eine Übertragungsleistungssteuervorrichtung in einer UE für ein TDD CDMA Kommunikationssystem, das einen Strom von Rahmen von einem Knoten B zur UE überträgt, wobei jeder der Rahmen ein Feld, das die Leistungspegelinformation, die vom Knoten B übertragen wird, anzeigt, und ein Zeitschlitzfeld für das zuweisen eines TPC-Befehls und von Übertragungsdaten vom Knoten B zur UE einschließt, wobei die UE Daten empfängt, die vom Knoten B übertragen werden, die einem Zeitschlitzfeld in einem folgenden Rahmen nach einer Übertragungspausenzeitdauer, in der keine Daten in den Zeitschlitzfeldern existieren, in speziellen Rahmen unter dem Strom von Rahmen, der vom Knoten B zur UE übertragen wird, zugewiesen werden. Nach dem Auftreten einer Übertragungspause eines speziel-

len Kanalsignals, das vom Knoten B empfangen wird, mißt eine Übertragungsleistungssteuervorrichtung für die Aufwärtsrichtung einen Ausbreitungsverlust zwischen dem Knoten B und der UE auf der Basis der Leistungspegelinformation, die im speziellen Zeitschlitz in der Übertragungspausenzeitdauer empfangen wird, detektiert ein Interferenzrauschen des Knotens B vom spezifischen Kanalsignal, und bestimmt eine Übertragungsleistung in Aufwärtsrichtung durch das Aufsummieren (i) von Werten, die durch das Anlegen eines Gewichts, basierend auf der Länge der Übertragungspausenzeitdauer, auf den aktuell gemessenen Ausbreitungsverlust und einen mittleren Ausbreitungsverlust zwischen dem Knoten B und der UE während der Übertragungspausenzeitdauer bestimmt werden, (ii) eines vorbestimmten Ziel-SIR, und (iii) eines Versatzes für das Kompensieren des Ausbreitungsverlustfehlers. Ein TPC-Befehlsgenerator für die Abwärtsrichtung erzeugt einen TPC-Befehl für die Abwärtsrichtung für das Steuern der Übertragungsleistung in Abwärtsrichtung, die vom Knoten B im folgenden Rahmen übertragen werden soll, durch das Empfangen der Übertragungsleistung in Aufwärtsrichtung, die durch die Übertragungsleistungssteuervorrichtung in Aufwärtsrichtung bestimmt wird. Ein Multiplexer multiplext den TPC-Befehl für die Abwärtsrichtung, die Benutzerdaten, die zum Knoten B übertragen werden sollen, und einen TFCI, der einen Typ und eine Datenrate der Benutzerdaten anzeigt. Ein Multiplizierer multipliziert das Kanalsignal in Aufwärtsrichtung mit einer Kanalverstärkung, basierend auf der bestimmten Übertragungsleistung in Aufwärtsrichtung.

[0032] Um weiter die obige Aufgabe und andere Aufgaben zu lösen, wird ein Übertragungsleistungssteuerverfahren in einer UE für ein TDD CDMA Kommunikationssystem, das einen Strom von Rahmen von einem Knoten B zur UE überträgt, wobei jeder der Rahmen ein Feld, das die Leistungspegelinformation, die vom Knoten B übertragen wird, und ein Zeitschlitzfeld für das Zuweisen eines TPC-Befehls und von Übertragungsdaten vom Knoten B zur UE einschließt, worin die UE Daten empfängt, die vom Knoten B übertragen werden, die einem Zeitschlitzfeld im folgenden Rahmen nach einer Übertragungspausenzeitdauer, bei der keine Übertragungsdaten in den Zeitschlitzfeldern in speziellen Rahmen unter dem Strom der Rahmen, die vom Knoten B zur UE übertragen werden, zugewiesen sind, bereit gestellt. Das Verfahren umfaßt das Messen eines Ausbreitungsverlusts zwischen dem Knoten B und der UE durch das Empfangen der Leistungspegelinformation in einem spezifischen Zeitschlitz in der Übertragungspausenzeitdauer, das Messen eines Interferenzrauschens des Knotens B durch das Empfangen eines spezifischen Kanalsignals, das durch den Knoten B übertragen wird, und das Bestimmen einer Übertragungsleistung in Aufwärtsrichtung durch das Summieren von (i) Werten, die durch das Anwenden eines Gewichts, basierend auf einer Länge der Übertragungspausenzeitdauer, auf den aktuell gemessenen Ausbreitungsverlust und einen mittleren Ausbreitungsverlust zwischen dem Knoten B und der UE während der Übertragungspausenzeitdauer, bestimmt werden, (ii) eines vorbestimmten Ziel-Signal-zu-Interferenz-Verhältnisses (SIR), und (iii) eines Versatzes für das Kompensieren des Ausbreitungsverlustfehlers, und das Übertragen eines TPC-Befehls, der der bestimmten Übertragungsleistung in Aufwärtsrichtung entspricht, an den Knoten B.

KURZE BESCHREIBUNG DER ZEICHNUNGEN

[0033] Die obige und andere Aufgaben, Merkmale und Vorteile der vorliegenden Erfindung werden aus der folgenden detaillierten Beschreibung in Verbindung mit den begleitenden Zeichnungen deutlicher.

[0034] **Fig.** 1 zeigt eine Struktur eines Unterrahmens eines NB-TDD Kommunikationssystems;

[0035] **Fig.** 2 zeigt ein Verfahren für das Zuweisen von Kanälen in Aufwärtsrichtung/Abwärtsrichtung an UEs durch einen Knoten B im NB-TDD Kommunikationssystem;

[0036] **Fig.** 3 zeigt eine typische Struktur eines Zeitschlitzes im Unterrahmen;

[0037] **Fig.** 4 zeigt eine Struktur eines UE-Transceivers gemäß einer Ausführungsform der vorliegenden Erfindung;

[0038] **Fig.** 5 zeigt eine Struktur eines Transceivers des Knotens B gemäß einer Ausführungsform der vorliegenden Erfindung;

[0039] **Fig.** 6 zeigt ein Betriebsverfahren der UE gemäß einer Ausführungsform der vorliegenden Erfindung; und

[0040] **Fig.** 7 zeigt ein Betriebsverfahren des Knotens B gemäß einer Ausführungsform der vorliegenden Erfindung.

DETAILLIERTE BESCHREIBUNG DER BEVORZUGTEN AUSFÜHRUNGSFORM

[0041] Eine bevorzugte Ausführungsform der vorliegenden Erfindung wird nachfolgend unter Bezug auf die begleitenden Zeichnungen beschrieben. In der folgenden Beschreibung werden wohl bekannte Funktionen oder Konstruktionen nicht im Detail beschrieben, das sie die Erfindung durch unnötige Details verdecken würden.

[0042] In der folgenden Beschreibung werden die Inhalte, die sich nicht direkt auf Wesentliches der vorliegenden Erfindung beziehen, weggelassen. Für ein besseres Verständnis der vorliegenden Erfindung wird jedoch Bezug genommen auf die Inhalte, die von der 3GPP (3rd Generation Partnership Projekt) angenommen oder vorgelegt wurden. Obwohl die vorliegende Erfindung in Bezug auf ein NB-TDD Kommunikationssystem beschrieben wird, kann die Erfindung auch auf andere Kommunikationssysteme angewandt werden, die die Übertragungsleistung mit nur einem Leistungssteuerverfahren mit geschlossener Schleife nicht glatt steuern können, wie auf ein NB-TDD Kommunikationssystem. Ausführungsformen der vorliegenden Erfindung werden in Bezug auf einen ersten Fall, bei dem eine lange Übertragungspause in Abwärtsrichtung auftritt, einen zweiten Fall, bei dem lange Übertragungspausen sowohl in Abwärtsrichtung als auch in Aufwärtsrichtung auftreten, und einen dritten Fall, bei dem eine Strahlformungstechnik für die Übertragung in Abwärtsrichtung verwendet wird, beschrieben.

I. Übertragungspause in Abwärtsrichtung ist länger als Übertragungspause in Aufwärtsrichtung

[0043] Wenn eine lange Übertragungspause in Abwärtsrichtung zwischen der UE und dem Knoten B existiert, oder wenn die Übertragungspause in Abwärtsrichtung beachtlich länger als die Übertragung in Aufwärtsrichtung ist, treten die folgenden Probleme auf. Hier bezieht sich der Ausdruck "Pause" auf eine Periode, bei der tatsächlich keine Daten übertragen werden. Da eine lange Übertragungspause in Abwärtsrichtung vom Knoten B zur UE vorhanden ist, wird ein TPC-Befehl für das Steuern der Übertragungsleistung in Aufwärtsrichtung einer UE, der über einen physikalischen Kanal in Abwärtsrichtung oder einen gemeinsamen Kanal in Abwärtsrichtung empfangen werden soll, während der Übertragungspause in Abwärtsrichtung nicht übertragen. Somit ist es für die UE nicht möglich, eine Übertragungsleistung in Aufwärtsrichtung unter Verwendung des TPC-Befehls zu bestimmen. Da ferner kein zugewiesener physikali-

scher Kanal (DPCH) oder ein gemeinsamer Kanal vom Knoten B übertragen wird, kann die UE keinen TPC-Befehl für das Steuern der Übertragungsleistung des zugewiesenen Kanals in Abwärtsrichtung, der nach der Übertragungspause in Abwärtsrichtung übertragen wird, bestimmen. Um somit die Probleme zu lösen, die auftreten, wenn eine Übertragungspause in Abwärtsrichtung existiert, besteht eine Notwendigkeit eines Leistungssteuerverfahrens, in welchem die UE ihre Übertragungsleistung in Aufwärtsrichtung selbst während der Übertragungspause in Abwärtsrichtung bestimmt, und in dem sie ihre anfängliche Übertragungsleistung des Knotens B in Abwärtsrichtung nach der Übertragungspause in Abwärtsrichtung steuert. Dieses Leistungssteuerverfahren wird in Bezug auf erste und zweite Ausführungsformen beschrieben.

Erste Ausführungsform

[0044] Da kein zugewiesener Kanal in Abwärtsrichtung oder ein gemeinsamer Kanal in Abwärtsrichtung, der vom Knoten B übertragen wird, existiert, mißt die UE einen Ausbreitungsverlust zwischen dem Knoten B und der UE durch das Empfangen eines primären gemeinsamen physikalischen Steuerkanals (P-CCPCH), der vom Knoten B in einem ersten Zeitschlitz (TSO **101** der **Fig. 1**) jedes Unterrahmens oder Funkrahmens übertragen wird.

[0045] Die UE bestimmt die Übertragungsleistung in Aufwärtsrichtung durch das Durchführen einer Übertragungsleistungssteuerung mit offener Schleife auf der Basis des gemessenen Ausbreitungsverlusts, bestimmt einen TPC-Befehl für das Steuern einer Übertragungsleistung in Abwärtsrichtung unter Verwendung des Werts des Ausbreitungsverlusts, und überträgt den bestimmten TPC-Befehl an den Knoten B. Der Knoten B verwendet dann den TPC-Befehl, den er von der UE empfangen hat, beim Einstellen der anfänglichen Übertragungsleistung des Kanals in Abwärtsrichtung, der nach der Übertragungspause in Abwärtsrichtung übertragen werden soll. Ein Verfahren für das Durchführen der Leistungssteuerung mit offener Schleife durch das Messen eines Ausbreitungsverlusts des P-CCPCH wird dargestellt durch:

$$P_{up} = \alpha L_{P\text{-}CCPCH} + (1-\alpha)L_a + I_{BTS} + SIR_{target} + C \quad (1)$$

[0046] In der Gleichung (1) stellt P_{up} eine Übertragungsleistung eines Kanals in Aufwärtsrichtung, der von der UE zum Knoten B in einem spezifischen Zeitschlitz übertragen wird, dar; L_a stellt einen Mittelwert des P-CCPCH Ausbreitungsverlustes, der von der UE gemessen wird, dar; $L_{P\text{-}CCPCH}$ stellt einen aktuell gemessenen P-CCPCH Ausbreitungsverlust dar, und α ist ein Wichtungswert für den mittleren Ausbreitungsverlust und den aktuell gemessenen Ausbreitungsverlust. Hier wird, wenn der Wert α größer ist, die Übertragungsleistung der UE auf der Basis des aktuell gemessenen Ausbreitungsverlustes statt des mittleren Ausbreitungsverlustes bestimmt. Der Wert α steht in Beziehung zu einer Länge und einer Maßeinheit der Übertragungspause in Abwärtsrichtung. Wenn die Maßeinheit der Übertragungspause ein Zeitschlitz ist, wenn die Übertragungspause einen Zeitschlitz beträgt, so wird die Übertragungsleistung der UE unter ausschließlicher Verwendung des aktuell gemessenen Ausbreitungsverlustes von P-CCPCH bestimmt. Wenn die Übertragungspause länger wird, so wird die Übertragungsleistung der UE durch das Anwenden eines Wichtungswertes auf den mittleren Ausbreitungsverlust des P-CCPCH bestimmt. Wenn ferner die Maßeinheit der Übertragungspause ein Rahmen beträgt, das heißt, wenn die Übertragungspause 1 Rahmen lang ist, so kann die Übertragungsleistung der UE unter ausschließlicher Verwendung des aktuell gemessenen Ausbreitungsverlustes der P-CCPCH bestimmt werden. Zusätzlich kann die Übertragungsleistung der UE, wenn die Übertragungspause länger wird, unter Verwendung des mittleren Ausbreitungsverlustes der P-CCPCH bestimmt werden.

[0047] Die L_a und die $L_{P\text{-}CCPH}$ werden in Dezibel (dB) gemessen, und ein Übertragungsleistungspegel der P-CCPCH des Knotens B wird zu den UEs im Knoten B zusammen mit der Systeminformation (SI) eines Übertragungskanals, der über den P-CCPCH übertragen wurde, übertragen. I_{BTS} stellt ein Interferenzrauschen des Knotens B, das vom Knoten B in jedem Zeitschlitz gemessen wird, dar, und der Wert I_{BTS} wird auch zu den UEs durch den Übertragungskanal übertragen. SIR_{target}, ein vorbestimmtes Signal-zu-Interferenz-Zielverhältnis, wird gemäß einer Datenrate und dem Typ der Daten, die über den zugewiesenen Kanal übertragen werden, bestimmt. C, eine Konstante, ist ein Übertragungsleistungsversatz, der vom Knoten B an die UE geliefert wird. Im Übertragungsleistungssteuerverfahren mit offener Schleife korrigiert die UE einen Fehler des gemessenen Ausbreitungsverlusts des P-CCPCH durch die Addition eines spezifischen Übertragungsleistungsversatzes.

[0048] Hier kann das α der Gleichung (1) berechnet werden zu:

$$\alpha = 1 - [(D-1)/k] \quad (2)$$

[0049] In Gleichung (2) stellt D eine Übertragungspause dar, und ihr Ausdruck wird gemäß der Maßeinheit geändert. Das heißt, wenn D = 5 ist, wenn die Maßeinheit ein Zeitschlitz beträgt, so zeigt D eine Übertragungspause der fünffachen Schlitzlänge an; wenn die Maßeinheit ein Unterrahmen ist, so zeigt D eine Übertragungspause der fünffachen Unterrahmenlänge an; und wenn die Maßeinheit ein Rahmen ist, so zeigt D eine Übertragungspause der fünffachen Rahmenlänge an. In Gleichung (2) stellt k weiter die maximale Übertragungspause, für die ein α durch eine Formel berechnet werden kann, dar. Es kann ein beliebiger Wert für k verwendet werden, und der Wert k weist dieselbe Maßeinheit wie D auf. Das heißt, wenn D eine Zeitschlitzeinheit ist, so ist auch k eine Zeitschlitzeinheit; wenn D eine Unterrahmeneinheit ist, so ist auch k eine Unterrahmeneinheit; und wenn D eine Rahmeneinheit ist, so ist auch k eine Rahmeneinheit.

[0050] In der ersten Ausführungsform bestimmt der Knoten B die anfängliche Übertragungsleistung eines DPCH in Abwärtsrichtung oder eines DPCH in Aufwärtsrichtung, der nach dem Ende der Übertragungspause übertragen werden soll, unter Verwendung eines TPC-Befehls, der von der UE übertragen wird, in folgender Weise.

[0051] Der Knoten B kann die Übertragungsleistung des Transportkanals in Abwärtsrichtung durch das Hinzufügen oder Abziehen eines spezifischen Leistungspegels gemäß dem TPC-Befehl, der von der UE empfangen wurde, auf der Basis der Übertragungsleistung des Transportkanals in Abwärtsrichtung, der gerade vor der Übertragungspause in Abwärtsrichtung übertragen wurde, neu festsetzen. Das Verfahren für das neue Festsetzen der Übertragungsleistung des Transportkanals in Abwärtsrichtung wird dargestellt durch

$$P_{DL}[k] = P_{DL}[k-1] + \Delta TPC \times TPC \quad (3)$$

[0052] Vor einer Beschreibung der Gleichung (3) kann das NB-TDD Kommunikationssystem einen Übertragungsleistungssteuerschritt in jedem Zeitschlitz steuern, und 1, 2 und 3 dB sind für den Übertragungsleistungssteuerschritt verfügbar. In Gleichung (3) kann der ΔTPC-Wert in Abhängig-

keit vom Interferenzrauschen I_{BTS}, das durch einen Empfänger des Knotens B im entsprechenden Zeitschlitz gemessen wird, bestimmt werden. Das heißt, ΔTPC stellt den Übertragungsleistungssteuerschritt dar, der auf den k-ten Zeitschlitz angewandt werden soll, und TPC stellt einen TPC-Befehl in Abwärtsrichtung, der von der UE übertragen wird, dar. Der Knoten B kann den Kanal in Abwärtsrichtung zur UE, die den TPC-Befehl übertragen hat, unter Verwendung des TPC-Befehls, der von der UE übertragen wird, und der Gleichung (3) so wieder errichten, jedes Mal dann, wenn der TPC-Befehl von der UE empfangen wird, und wenn die Übertragungsdaten in Abwärtsrichtung erzeugt werden, so überträgt der Knoten B die Übertragungsdaten in Abwärtsrichtung unter Verwendung der neu errichteten Übertragungsleistung.

Zweite Ausführungsform

[0053] Die erste Ausführungsform wurde in Bezug auf das Übertragungsleistungssteuerverfahren in Aufwärtsrichtung/Abwärtsrichtung für den Fall, bei dem eine Übertragungspause in Abwärtsrichtung existiert, beschrieben. Ein anderes Übertragungsleistungssteuerverfahren für den Fall, bei dem eine Übertragungspause in Abwärtsrichtung existiert, wird in ein Verfahren für das Steuern der Übertragungsleistung in Aufwärtsrichtung aufgeteilt.

[0054] Zuerst wird das Übertragungsleistungssteuerverfahren in Aufwärtsrichtung gemäß der zweiten Ausführungsform der Erfindung dargestellt durch

$$P_{up} = P_{up}[0] + L_1 - L_0 + TPC_{offset} \quad (4)$$

[0055] In der Gleichung (4) stellt P_{up} die Übertragungsleistung in Aufwärtsrichtung der UE dar, die durch die UE als Übertragungsleistung in Aufwärtsrichtung gerade vor dem Start der Übertragungspause in Abwärtsrichtung verwendet wird; L_1 stellt einen Ausbreitungsverlust vom Knoten B zur UE dar, der von der UE in einem Zeitschlitz direkt vor dem Start der Übertragung in Aufwärtsrichtung der UE gemessen wird; und L_0 stellt einen Ausbreitungsverlust vom Knoten B zur UE dar, der durch die UE direkt vor der Start der Übertragungspause in Abwärtsrichtung des Knotens B gemessen wird. Weiter kann der Wert TPC_{offset} unter Berücksichtigung des TPC-Befehls, der durch die UE vor dem Start der Übertragungspause in Abwärtsrichtung und einer Änderung in der Kanalumgebung zwischen der UE und dem Knoten B empfangen wurde, bestimmt werden, und als Ergebnis wird TPCoffset durch eine Konstante dargestellt. Hier bezieht sich der Ausdruck "Kanalumgebung" auf eine Änderung im Ausbreitungsverlust vom Knoten B zur UE, gemessen durch die UE. Der Grund der Kompensation des Ausbreitungsverlusts zusätzlich zu L_1 und L_0 besteht darin, daß eine bloße Kompensation einer Differenz $L_1 - L_0$ ein Fehlen von Übertragungsleistung der UE verursachen kann, wenn der Ausbreitungsverlust eine abrupte Änderung erfährt.

[0056] Als zweites wird das Übertragungsleistungssteuerverfahren in Aufwärtsrichtung gemäß der zweiten Ausführungsform der vorliegenden Erfindung dargestellt durch:

$$P_{up} = P_{up}[0] + L_1 - L_0 + TPC_{offset}\, I_{BTS1} - I_{BTS0} \quad (5)$$

[0057] Ein Unterschied zwischen der Gleichung (4) und der Gleichung (5) besteht darin, daß die Interferenz der Empfängers des Knotens B, die durch den Empfänger des Knotens B gemessen wird, für die Übertragung in Aufwärtsrichtung der UE verwendet wird, nach der Übertragungspause in Abwärtsrichtung, wenn die Übertragungsleistung der UE bestimmt wird. In Gleichung (5) ist I_{BTS1} die Signalinterferenz des Empfängers des Knotens B, die vom Knoten B direkt vor dem Übertragungspunkt in Aufwärtsrichtung gemessen wird, und die zur UE durch den Übertragungskanal, der über den P-CCPCH übertragen wird, übertragen wird, und I_{BTS0} ist die Signalinterferenz des Empfängers des Knotens B in einem Zeitschlitz direkt vor dem Start der Übertragungspause in Aufwärtsrichtung.

[0058] Die Übertragungsleistungssteuerverfahren gemäß den ersten und zweiten Ausführungsformen der vorliegenden Erfindung wurden unter Bezug auf den Fall beschrieben, bei dem die Übertragungspause in Abwärtsrichtung existiert, oder bei dem die Übertragungspause in Abwärtsrichtung länger als die Übertragungspause in Aufwärtsrichtung ist. Als nächstes wird die Erfindung in Bezug auf den Fall beschrieben, bei dem die Übertragungspause in Aufwärtsrichtung und die Übertragungspause in Abwärtsrichtung beide lang sind.

II. Die Übertragungspause in Abwärtsrichtung und die Übertragungspause in Aufwärtsrichtung sind beide lang

[0059] Wenn sowohl die Übertragungspause in Abwärtsrichtung als auch die Übertragungspause in Aufwärtsrichtung lang sind, so wird der TPC-Befehl in der Übertragungspause in Aufwärtsrichtung und der Übertragungspause in Abwärtsrichtung zwischen dem Knoten B und der UE nicht übertragen, was es schwierig macht, die Leistungssteuerung mit geschlossener Schleife durchzuführen. Insbesondere weist, wenn sowohl die Übertragungspause in Aufwärtsrichtung als auch die Übertragungspause in Abwärtsrichtung beide lang sind, der Knoten B eine hohe Fehlerwahrscheinlichkeit auf, wenn er die anfängliche Übertragungsleistung in Abwärtsrichtung nach dem Ende der Übertragungspause in Abwärtsrichtung bestimmt, und wenn er die anfängliche Übertragungsleistung in Aufwärtsrichtung nach dem Ende der Übertragungspause in Aufwärtsrichtung bestimmt. Um dieses Problem zu lösen, liefert die vorliegende Erfindung die folgenden drei Verfahren zur Einstellung der anfänglichen Übertragungsleistung in Aufwärtsrichtung der UE nach dem Ende der Übertragungspause in Aufwärtsrichtung.

[0060] Das erste Verfahren besteht darin, das Verfahren zur Einstellung der Übertragungsleistung in Aufwärtsrichtung, das in der ersten Ausführungsform beschrieben wurde, zu verwenden. Das zweite Verfahren besteht darin, das Verfahren zur Einstellung der Übertragungsleistung in Aufwärtsrichtung, das in der zweiten Ausführungsform der vorliegenden Erfindung beschrieben wurde, zu verwenden. Das dritte Verfahren besteht darin, das erste Verfahren zusammen mit dem zweiten Verfahren zu verwenden. Das erste Verfahren, das heißt, die erste Ausführungsform, bestimmt die Übertragungsleistung in Aufwärtsrichtung der UE unter Verwendung des Leistungssteuerverfahrens mit offener Schleife, und das zweite Verfahren, das heißt die zweite Ausführungsform, bestimmt die Übertragungsleistung in Aufwärtsrichtung der UE unter Verwendung eines modifizierten Leistungssteuerverfahrens mit geschlossener Schleife. Das dritte Verfahren ergänzt das Leistungssteuerverfahren mit geschlossener Schleife und das Leistungssteuerverfahren mit offener Schleife, um eine Kompensation von Fehlern zu erreichen, die in den ersten und zweiten Verfahren auftreten können. Das dritte Verfahren kann folgendermaßen dargestellt werden:

$$P_{up} = f(n) \times P_{UL1} + (1 - f(n))\, P_{UL2} \quad (6)$$

[0061] In Gleichung (6) ist P_{UL1} gleich P_{up} der Gleichung (1), und P_{UL2} ist gleich P_{PL} der Gleichung (3). Weiter ist f(n)

eine Funktion einer Übertragungspause "n", und eine Einheit ist ein Funkrahmen oder ein Unterrahmen. Wenn die Übertragungspause länger ist, so hat f(n) die Eigenschaft, ein Gewicht der anfänglichen Übertragungsleistung in Aufwärtsrichtung, die im Leistungssteuerverfahren mit offener Schleife bestimmt wurde, zu erhöhen. Beispielsweise wird f(n) durch eine Funktion fn = 1/n dargestellt.

III. Strahlformungsübertragungstechnik die für eine Übertragung in Abwärtsrichtung verwendet wird

[0062] Im NB-TDD Kommunikationssystem wird, wenn eine Übertragungspause während einer Übertragung in Aufwärtsrichtung/Abwärtsrichtung unter einer Bedingung auftaucht, bei der eine spezielle Technik, wie eine Strahlformung verwendet wird, das gemeinsame Leistungsteuerverfahren mit geschlossener Schleife verwendet, da es schwierig ist, das gemeinsame Leistungssteuerverfahren mit offener Schleife zu verwenden. Der Grund für die Verwendung des Leistungssteuerverfahrens mit geschlossener Schleife statt des Leistungssteuerverfahrens mit offener Schleife besteht darin, daß der P-CCPCH, der für das Messen eines Ausbreitungsverlusts im Leistungssteuerverfahren mit offener Schleife verwendet wird, kein Subjekt der Strahlformung ist, während der DPCH oder der gemeinsame Kanal, der vom Knoten B zur UE übertragen wird, der Strahlformung unterliegt, so daß ein Ausbreitungsverlust, den der DPCH und der gemeinsame physikalische Kanal erfahren, sich von einem Ausbreitungsverlust, den der P-CCPCH erfährt, unterscheidet.

[0063] Die Strahlformungstechnik steuert eine Übertragungsrichtung eines Übertragungsstrahls und eine Richtung einer Empfangsantenne in einem Knoten B, so daß die UE das zugewiesene Kanalsignal, das vom Knoten B übertragen wird, effizienter empfangen kann, oder so daß der Knoten B das Signal, das durch die UE übertragen wird, effizienter empfangen kann. Im allgemeinen ist der Ausbreitungsverlust proportional zum Kehrwert der vierten Potenz der Distanz zwischen dem Knoten B und der UE. Wenn jedoch die Strahlformungstechnik angewandt wird, so ist der Ausbreitungsverlust proportional zum Kehrwert der zweiten Potenz der Distanz zwischen dem Knoten B und der UE.

[0064] Somit liefert die vorliegende Erfindung einen Übertragungsleistungssteueralgorithmus, der für das Einstellen einer Übertragungsleistung in Aufwärtsrichtung der UE in dem NB-TDD Kommunikationssystem, das die Strahlformungstechnik verwendet, verwendet wird. Die Übertragungsleistung der UE, die in dem Fall anwendbar ist, bei dem die Strahlformungstechnik verwendet wird, kann dargestellt werden zu:

$$P_{up} = P_{up}[0] + \beta(L_1 - L_0) + TPC_{offset} \quad (7)$$

$$P_{up} = P_{up}[0] + \beta(L_1 - L_0) + TPC_{offset} + I_{DTS1} - I_{DTS0} \quad (8)$$

[0065] Die Gleichungen (7) und (8) sind bis auf den Parameter β ähnlich den Gleichungen (4) beziehungsweise (5). Der Parameter β in Gleichung (7) ist derselbe Parameter wie der in Gleichung (8). Der Parameter b ist ein Wert für das Korrigieren eines Unterschieds zwischen einem Ausbreitungsverlust des DPCH oder des gemeinsamen physikalischen Kanals, die einer Strahlformung unterworfen werden, und eines Ausbreitungsverlusts des P-CCPCH, der keiner Strahlformung unterworfen ist. Der Grund dafür, daß der Parameter β benötigt wird, ist der, daß die UE ihre Übertragungsleistung durch das Empfangen eines TPC-Befehls, der über den zugewiesenen Kanal in Abwärtsrichtung oder den gemeinsamen physikalischen Kanal in Abwärtsrichtung vor der Übertragungspause in Abwärtsrichtung übertragen wird, steuert, aber sie den TPC-Befehl während der Übertragungspause in Abwärtsrichtung nicht empfangen kann, so daß die Übertragungsleistung unter Verwendung eines anderen Verfahrens eingestellt werden muß. Als ein Verfahren für das Einstellen der Übertragungsleistung war es für die UE möglich, einen Ausbreitungsverlust des P-CCPCH zu messen und die Gleichungen (4) und (5) zu verwenden. Wie oben angegeben wurde, wird jedoch, da sich eine Ausbreitungsverzögerung des DPCH oder des gemeinsamen Kanals von der des P-CCPCH durch die Strahlformung unterscheidet, die Differenz zwischen der Ausbreitungsverzögerung des gemessenen Kanals und der Ausbreitungsverzögerung des tatsächlich übertragenen Kanals unter Verwendung des Parameters β korrigiert. Der Parameter β wird dargestellt durch:

$$L_{DPCH} : L_{P\text{-}CCPCH} = (A/r^2) : (A/r^4) \quad (9)$$

wobei A die Übertragungsleistung des Knotens B darstellt.

[0066] Die Gleichung (9) berechnet ein Verhältnis des Ausbreitungsverlusts des P-CCPCH zu einem Ausbreitungsverlust des DPCH oder des gemeinsamen Kanals gemäß der Distanz zwischen der UE und dem Knoten B, und der Parameter β wird durch das berechnete Verhältnis bestimmt. In Gleichung (9) zeigt r die Distanz zwischen dem Knoten B und der UE an. Da der DPCH oder der gemeinsame Kanal einer Strahlformung unterworfen wird, steht sein Ausbreitungsverlust im inversen proportionalen Verhältnis zur zweiten Leistung der Distanz r zwischen dem Knoten B und der UE. Da jedoch der P-CCPCH keiner Strahlformung unterworfen wird, steht sein Ausbreitungsverlust im inversen Verhältnis zur vierten Potenz der Distanz r zwischen dem Knoten B und der UE.

[0067] Als nächstes wird eine Transceiverstruktur der UE und des Knotens B in Bezug auf die **Fig.** 4 und 5 beschrieben, wobei man annimmt, daß eine i-te UE Signale mit dem Knoten B austauscht.

[0068] **Fig.** 4 zeigt eine Struktur eines Transceivers einer UE gemäß einer Ausführungsform der vorliegenden Erfindung. Betrachtet man **Fig.** 4, so müssen, da das NB-TDD Kommunikationssystem dasselbe Frequenzband für die Übertragungen in Aufwärtsrichtung und Abwärtsrichtung zu verschiedenen Zeiten verwendet, ein Sender und ein Empfänger durch einen Schalter **420** geschaltet werden. Ein Kodierer **402** empfängt die Daten **401** des i-ten Benutzers, die zu einem Knoten B durch die UE zu übertragen sind, und Kanalkodes der empfangenen Benutzerdaten **401** in einem Faltungskode oder einem anderen Kanalzuteilungskode. Eine Verschachtelungsvorrichtung **403** verschachtelt die Daten, die vom Kodierer **402** ausgegeben werden, gemäß einer vorbestimmten Regel und liefert die verschachtelten Daten an einen Multiplexer **406**. Die Verschachtelung ordnet die Daten des i-ten Benutzers, die vom Kodierer **402** ausgegeben werden, gemäß der vorbestimmten Regel, um somit die mögliche schmalbandige Interferenz nach dem Entschachteln zu spreizen, um den Einfluß der schmalbandigen Interferenz zu minimieren.

[0069] Der Multiplexer **406** multiplext die Daten des i-ten Benutzers, die von der Verschachtelungsvorrichtung **403**, dem TPC **405**, dem TFCI **404** und der SS **460** ausgegeben werden, in einen Zeitschlitz (hier nachfolgend als "Datenteil des i-ten Benutzers" bezeichnet), der vom NB-TDD Kommunikationssystem verwendet wird, und liefert den Datenteil des i-ten Benutzers an eine Spreizvorrichtung **407**.

[0070] Der TPC **405**, ein Übertragungsleistungssteuerbefehl für das Steuern der Übertragungsleistung in Abwärtsrichtung vom Knoten B zur UE, wird durch einen Generator

490 für einen TPC-Befehl für die Abwärtsrichtung erzeugt. Wenn keine Übertragungspause in Abwärtsrichtung existiert, so vergleicht der Generator 490 des TPC-Befehls für die Abwärtsrichtung ein Signal-zu-Interferenzverhältnis (SIR), das durch einen zugewiesenen Kanal des i-ten Benutzers oder einen gemeinsamen physikalischen Kanal gemessen wird und von einer Entspreizvorrichtung 436 ausgegeben wird, mit einem Ziel-SIR (SIR_{target}). Wenn das gemessene SIR größer oder gleich dem Ziel-SIR ist, so erzeugt der TPC-Befehlsgenerator 490 in Abwärtsrichtung einen Leistungsabsenkbefehl in Abwärtsrichtung, ansonsten erzeugt, wenn das gemessene SIR kleiner als das Ziel-SIR ist, der TPC-Befehlsgenerator 490 in Abwärtsrichtung einen Leistungserhöhungsbefehl in Abwärtsrichtung.

[0071] Nach dem Auftreten einer Übertragungspause in Abwärtsrichtung erzeugt der TPC-Befehlsgenerator 490 in Abwärtsrichtung jedoch einen TPC-Befehl durch das Messen eines Ausbreitungsverlusts des P-CCPCH in einem gemeinsamen Kanal in Abwärtsrichtung (DSCH) 437, der von der Entspreizvorrichtung 436 ausgegeben wird. Der TPC-Befehl 405 wird zum Knoten B übertragen, so daß der Knoten B die Übertragungsleistung in Abwärtsrichtung, die nach dem Ende der Übertragungspause in Abwärtsrichtung verwendet werden soll, sogar während der Übertragungspause in Abwärtsrichtung neu einstellen kann. Weiterhin ist der TFCI 404 ein Kodewort, das verwendet wird, um Datenraten einer Vielzahl von Daten, die mit den Daten des i-ten Benutzers, die durch die UE übertragen werden, gemischt sind, zu bezeichnen. Die SS 460 stellt einen Befehl dar, um die Synchronisation eines Signals in Abwärtsrichtung zu steuern.

[0072] Die Spreizvorrichtung 407 empfängt den Datenteil des i-ten Benutzers, der durch den Multiplexer 406 geschaffen wird, spreizt den Datenteil des i-ten Benutzers, indem es ihn mit dem Kanalzuteilungskode multipliziert, und liefert ihr Ausgangssignal an einen Multiplizierer 408. Hier wird ein OVSF-Kode für den Kanalzuteilungskode, der im NB-TDD Kommunikationssystem verwendet wird, verwendet, und der OVSF-Kode ist ein orthogonaler Kode, wobei seine Länge gemäß einer Datenrate bestimmt wird. Der Kanalzuteilungskode dient dazu, den Kanal in Aufwärtsrichtung jeder UE zu unterscheiden, wenn eine Vielzahl von UEs gleichzeitig Daten im NB-TDD Kommunikationssystem übertragen, und er spreizt auch ein Übertragungsband der Benutzerdaten gemäß ihrer Länge.

[0073] Der Multiplizierer 408 multipliziert ein Signal, das von der Spreizvorrichtung 407 ausgegeben wird, mit einem Kanalverstärkungsparameter und liefert sein Ausgangssignal an einen Multiplizierer 409. Hier wird der Kanalverstärkungsparameter durch eine Übertragungsleistungssteuervorrichtung in Aufwärtsrichtung 480 geschaffen, um einen Übertragungsparameter des Kanals in Aufwärtsrichtung des i-ten Benutzers zu bestimmen. Wenn keine Übertragungspause in Abwärtsrichtung vorhanden ist, so wird der Kanalverstärkungsparameter in Abhängigkeit von Typ der Daten, die durch den Datenteil des i-ten Benutzers übertragen werden, und von einem TPC-Befehl, der vom Knoten B übertragen wird, geschaffen. Beim Auftreten einer Übertragungspause in Abwärtsrichtung wird der Kanalverstärkungsparameter jedoch durch die Gleichungen (1), (4) und (5) bestimmt. Wenn keine Übertragungspause in Abwärtsrichtung vorhanden ist, so erzeugt die Übertragungsleistungssteuerung 480 in Aufwärtsrichtung den Kanalverstärkungsparameter auf der Basis eines TPC-Befehls 439, der von einem Demultiplexer 438 ausgegeben wird. Nach dem Auftreten der Übertragungspause in Abwärtsrichtung erzeugt jedoch die Übertragungsleistungssteuervorrichtung 480 in Aufwärtsrichtung den Kanalverstärkungsparameter unter Verwendung eines Ausbreitungsverlusts des P-CCPCH im gemeinsamen Kanal (DSCH) 437 in Abwärtsrichtung, der von der Entspreizvorrichtung 436 ausgegeben wird.

[0074] Der Multiplexer 409 verwürfelt ein Signal, das vom Multiplizierer 408 ausgegeben wird, indem er es mit einem Verwürfelungskode $C_{scramble}$ multipliziert, und er liefert sein Ausgangssignal an einen Multiplexer 411. Hier wird der Verwürfelungskode $C_{scramble}$ für die Identifikation des Knotens B und der UE und eine Reduktion der Kreuzkorrelation der Mehrwegesignale verwendet. Im NB-TDD Kommunikationssystem wird der Verwürfelungskode nur für die Identifikation des Knotens B und die Reduktion in der Kreuzkorrelation verwendet. Im NB-TDD Kommunikationssystem verwendet jeder Knoten B seinen eigenen eindeutigen Verwürfelungskode, und der Verwürfelungskode wird sowohl für die Übertragung in Aufwärtsrichtung als auch die Übertragung in Abwärtsrichtung verwendet. Der Multiplexer 411 multiplext ein Signal, das vom Multiplizierer 409 ausgegeben wird, und eine Mitambel 410 in einen Kanal des iten Benutzers in Aufwärtsrichtung, wobei eine Basisübertragungseinheit dieses Kanals ein Zeitschlitz beträgt. Der Kanal des i-ten Benutzers in Aufwärtsrichtung besteht aus den Benutzerdaten 401, dem TPC 405, TFCI 404, der Mitambel 410 und einer GP (Schutzperiode). Die Mitambel 410 wird für eine Kanalschätzung und eine Mehrfachbenutzerdetektion, die durch das NB-TDD Kommunikationssystem unterstützt wird, verwendet, und die GP ist eine Periode, die geschaffen wurde, um ein Interferenzrauschen zwischen den übertragungssignalen in Aufwärtsrichtung und Abwärtsrichtung, die durch eine Überlappung eines Zeitschlitzes in Aufwärtsrichtung und eines Zeitschlitzes in Abwärtsrichtung im NB-TDD Kommunikationssystem verursacht wird, zu verhindern. In der Schutzperiode werden tatsächlich keine Daten übertragen.

[0075] Ein Modulator 412 moduliert den Kanal des i-ten Benutzers in Aufwärtsrichtung, der vom Multiplexer 411 ausgegeben wird, in einem vorbestimmten Modulationmodus, und liefert sein Ausgangssignal an den Schalter 420. Hier umfaßt die Modulationstechnik QPSK (Quadratur-Phasen-Verschiebungs-Verschlüsselung), 8PSK (8-fach Phasenumtastung) und QAM (Quadraturamplitudenmodulation). Der Schalter 420 wird in die eingeschaltete Stellung geschaltet, um den Kanal des i-ten Benutzers in Aufwärtsrichtung, der vom Modulator 412 ausgegeben wird, zum Knoten B in einem Zeitschlitz zu übertragen, in dem der Kanal des iten Benutzers in Aufwärtsrichtung zu übertragen ist. Der Schalter 420 wird durch eine Steuervorrichtung 421 gesteuert, die einen Übertragungspunkt des Kanals in Aufwärtsrichtung steuert. Auf der Basis der Unterrahmenstruktur des NB-TDD Kommunikationssystems steuert die Steuervorrichtung 421 einen Übertragungspunkt eines Pilotzeitschlitzes in Aufwärtsrichtung (UpPTS), einen Übertragungspunkt eines Pilotzeitschlitzes in Abwärtsrichtung (DwPTS), und einen Ankunftspunkt eines Kanals in Abwärtsrichtung vom Knoten B zur UE.

[0076] Hier wird der UpPTS durch einen UpPTS-Generator 430 erzeugt. Der PuPTS wird übertragen, wenn die UE einen Kanal vom Knoten B zugewiesen bracht, oder in einem Übergangszustand, und der UpPTS wird durch den Knoten B beim Steuern eines Kriteriums für das Bestimmen der Übertragungsleistung in Aufwärtsrichtung der UE oder zur Steuerung der Übertragungssynchronisation in Aufwärtsrichtung verwendet. Die UE empfängt den DwPTS während ihrer anfänglichen Suche nach dem Knoten B, und der DwPTS bezeichnet eine Position des P-CCPCHs, wo der Übertragungskanal mit der Systeminformation übertragen wird, und eine Position in einer Mehrrahmenstruktur, wo die

UE aktuell einen Rahmen in Abwärtsrichtung empfängt. Im NB-TDD Kommunikationssystem lenkt für einen Datenaustausch der Knoten B eine vorbestimmte Anzahl von 10 ms Funkrahmen, und typischerweise bilden 64 oder 72 Funkrahmen eine Mehrrahmenstruktur. Der Kanal in Aufwärtsrichtung, der vom Schalter **420** ausgegeben wird, wird auf ein Trägerfrequenzband in der Frequenz durch einen RF-Prozessor **422** verschoben und dann zum Knoten B durch eine Antenne **423** übertragen.

[0077] Bis hierher wurde ein Verfahren für das Übertragen eines Kanals in Aufwärtsrichtung von der UE zum Knoten B beschrieben. Als nächstes wird ein Verfahren für das Empfangen eines Abwärtsverbindungskanals vom Knoten B beschrieben.

[0078] Ein Signal eines Kanals in Abwärtsrichtung, das durch die Antenne **423** empfangen wird, wird durch den RF-Prozessor **422** von der Frequenz des Trägerbands zur Frequenz des Basisbands in der Frequenz verschoben und dann dem Schalter **420** angeboten. Der Schalter **420** schaltet das Signal, das vom RF-Prozessor **422** ausgegeben wird, an und liefert sein Ausgangssignal unter der Steuerung der Steuervorrichtung **421** an den Demodulator **432** an einem Punkt, an dem ein Signal eines Kanals in Aufwärtsrichtung empfangen werden soll. Das Signal, das an der i-ten UE vom Knoten B empfangen wird, kann den DwPTS einschließen, und der Schalter **420** wird in Richtung einer DwPTS-Analysevorrichtung **431** an einem Ankunftspunkt des DwPTS geschaltet, um eine empfangene DwPTS an die DwPTS-Analysevorrichtung **431** zu liefern. Die DwPTS-Analysevorrichtung **431** analysiert den empfangenen DwPTS, so daß die UE eine Position eines Übertragungskanals und eine Position des aktuell empfangenen Rahmens in Abwärtsrichtung in der Mehrrahmenstruktur erkennen kann. Der Demodulator **432** demoduliert das empfangene Signal des Kanals in Abwärtsrichtung in der Modulationsart, die vom Knoten B verwendet wird, und liefert das demodulierte Signal an einen Demultiplexer **433**. Der Demultiplexer **433** demultiplext das Signal des Kanals in Abwärtsrichtung in eine Mitambel **434** und einen Benutzerdatenteil in Abwärtsrichtung. Die Mitambel **434**, die vom Demultiplexer **433** ausgegeben wird, dient dazu, einen Empfangsleistungspegel des Signals des Kanals in Abwärtsrichtung, das vom Knoten B übertragen wurde, zu messen, und es ermöglicht der UE, den Typ der Kanals in Abwärtsrichtung, der vom Knoten B übertragen wird, zu erkennen. Somit ist es durch eine einfache Analyse der Mitambel **434** möglich, zu erkennen, ob Daten zur UE übertragen werden.

[0079] Ein Multiplizierer **435** entwürfelt den Benutzerdatenteil in Abwärtsrichtung, der vom Demultiplexer **433** ausgegeben wird, indem er ihn mit demselben Verwürfelungskode $C_{scramble}$, wie er vom Knoten B verwendet wird, multipliziert, und er liefert sein Ausgangssignal an die Entspreizvorrichtung **436**. Die Entspreizvorrichtung **436** entspreizt die gespreizten Benutzerdaten und den gemeinsamen Kanal in Abwärtsrichtung durch das Multiplizieren eines Signals, das vom Multiplizierer **435** ausgegeben wird, mit dem Kanalzuteilungskode, einem OVSF-Kode, der im Knoten B verwendet wird, um somit die Benutzerdaten in Abwärtsrichtung und den gemeinsamen Kanal **437** in Abwärtsrichtung für die Übertragung der Systeminformation des Knotens B oder der UE-Steuerinformation zu extrahieren. Wenn eine Übertragungspause in Abwärtsrichtung im gemeinsamen Kanal **437** in Abwärtsrichtung existiert, so wird der P-CCPCH verwendet, um die Übertragungsleistung in Aufwärtsrichtung festzulegen.

[0080] Die i-ten Benutzerdaten, die von der Entspreizvorrichtung **436** ausgegeben werden, werden durch einen Demultiplexer **438** in TPC **439**, TFCI **440**, SS **470** und reine Benutzerdaten demultiplext. Der TPC_Befehl **439** wird verwendet, um die Übertragungsleistung des Kanals in Aufwärtsrichtung, die durch die UE des i-ten Benutzers übertragen werden soll, zu steuern, der TFCI **440** wird verwendet, um den Typ der Daten, die vom Knoten B zum i-ten Benutzer übertragen werden, zu analysieren, und die SS **470** wird vom Knoten B als ein Befehl für das Anfordern der Synchronisationssteuerung des Kanals in Aufwärtsrichtung, der durch die UE übertragen wird, verwendet. Die i-ten Benutzerdaten, die vom Demultiplexer **438** ausgegeben werden, werden durch eine Entschachtelungsvorrichtung **441** entschachtelt und dann durch einen Dekodierer **442** als die Daten **443** des i-ten Benutzers dekodiert.

[0081] **Fig.** 5 zeigt eine Struktur eines Transceivers des Knotens B gemäß einer Ausführungsform der vorliegenden Erfindung.

[0082] Zuerst wird ein Verfahren für das Übertragen von Kanälen in Abwärtsrichtung vom Knoten B zu den UEs unter Bezug auf **Fig.** 5 beschrieben. Ein Kodierer **502** führt eine Kanalkodierung der Daten **501** des i-ten Benutzers, die zum i-ten Benutzer übertragen werden sollen, durch und liefert sein Ausgangssignal an eine Verschachtelungsvorrichtung **503**. Die Verschachtelungsvorrichtung **503** verschachtelt ein Signal, das vom Kodierer **502** ausgegeben wird, gemäß einer vorbestimmten Regel und liefert ihr Ausgangssignal an einen Multiplexer **506**. Der Multiplexer **506** multiplext die Daten des i-ten Benutzers, die von der Verschachtelungsvorrichtung **503** ausgegeben werden, und einen TPC-Befehl **505** für das Steuern, der Übertragungsleistung in Aufwärtsrichtung des i-ten Benutzers, eine TFCI **504**, die ein Transportformat anzeigt, das für die Daten des i-ten Benutzers verwendet wird, und eine SS **560** für das Anfordern einer Synchronisationssteuerung auf dem Transportkanal in Aufwärtsrichtung vom UE, um den Datenteil des i-ten Benutzers zu erzeugen, und sie liefert dann den erzeugten Datenteil des i-ten Benutzers an eine Spreizvorrichtung **507**. Hier wird der TPC **505** durch einen TPC-Befehlsgenerator **590** für die Aufwärtsrichtung durch das Messen des SIR eines Transportkanals in Aufwärtsrichtung des i-ten Benutzers, der von einer Entspreizvorrichtung **535** ausgegeben wird, geschaffen.

[0083] Die Spreizvorrichtung **507** führt eine Kanalspreizung des Datenteils des i-ten Benutzers mit dem OVSF-Kode, der für den Kanal in Abwärtsrichtung des i-ten Benutzers verwendet wird, durch, und liefert ihr Ausgangssignal an einen Multiplizierer **508**. Der Multiplizierer **508** multipliziert ein Signal, das von der Spreizvorrichtung **507** ausgegeben wird, mit einer Kanalverstärkung für die Übertragungsleistung des Kanals in Abwärtsrichtung, der zum i-ten Benutzer übertragen werden soll, und liefert sein Ausgangssignal an einen Summierer **511**. Hier wird die Kanalverstärkung durch einen Übertragungsleistungssteuervorrichtung **580** in Abwärtsrichtung auf der Basis eines TPC-Befehls **537** der Abwärtsrichtung, der vom Demultiplexer **536** ausgegeben wird, geschaffen. Nach dem Auftreten einer Übertragungspause in der Abwärtsrichtung stellt die Übertragungsleistungssteuerung **580** in Abwärtsrichtung die Übertragungsleistung in Abwärtsrichtung, die am Endpunkt der Übertragungspause in Abwärtsrichtung verwendet werden soll, unter Verwendung von Gleichung (3) ein.

[0084] Der Summierer **511** summiert einen gemeinsamen Kanal **510** in Abwärtsrichtung, bei dem es sich nicht um die Kanäle **509** in Abwärtsrichtung des Benutzers handelt, und den Kanal des i-ten Benutzers vom Multiplexer **508**, wobei die Kanäle mit verschiedenen OVSF-Kodes einer Kanalspreizung unterzogen werden, so daß die Kanäle keine Interferenz mit den anderen Kanälen der Benutzers, die zusammen mit ihnen aufsummiert wurden, bilden können. Ein

Multiplizierer **512** verwürfelt die Kanalsignale in Abwärtsrichtung, die vom Summierer **511** ausgegeben werden, mit dem Verwürfelungskode, der vom Knoten B verwendet wird, und er liefert sein Ausgangssignal an einen Multiplexer **514**. Der Multiplexer **514** multiplext die Kanalsignale in Abwärtsrichtung und eine eingegebene Mitambel **513** in einen Zeitschlitz eines Kanals in Abwärtsrichtung. Die Mitambel **513** kann durch die UE beim Messen eines Übertragungsleistungspegels des Knotens B verwendet werden, und sie kann auch bei der Bestimmung der Kanäle, die über den Zeitschlitz des Kanals in Übertragungsrichtung übertragen werden, die durch den Multiplexer **514** gemultiplext wurden, verwendet werden.

[0085] Ein Modulator **515** moduliert die Signale des Kanals in Abwärtsrichtung, die vom Multiplexer **514** ausgegeben werden, in einer Modulationsart, wie BPSK (Binäre Phasenlagenverschlüsselung), QPSK, 8PSK oder QUAM. Die modulierten Signale des Kanals in Abwärtsrichtung, die vom Modulator **515** ausgegeben werden, werden einem Schalter **520** geliefert, der zum Modulator **515** an einem Übertragungspunkt des Kanalschlitzes in Abwärtsrichtung unter der Steuerung einer Steuervorrichtung **521** weiterleitet. Das Signal, das vom Schalter **520** ausgegeben wird, wird an einen RF-Prozessor **522** geliefert. Ferner wird der Schalter **520** zu einem DwPTS-Generator **516** unter der Steuerung der Steuervorrichtung **521** geschaltet, um die DwPTS an einem Übertragungspunkt der DwPTS zu übertragen. Die DwPTS wird durch die UE verwendet, um eine Position eines Übertragungskanals mit der Information des Knotens B, einen Pegel eines Signals des Knotens B und eine Position eines aktuell empfangen Rahmens in der Mehrrahmenstruktur während einer anfänglichen Suche nach dem Knoten B zu schätzen. Der RF-Prozessor **522** führt eine Frequenzverschiebung des Zeitschlitzes des Kanals in Abwärtsrichtung auf ein Trägerfrequenzband durch, und er überträgt seine Ausgangssignale an die UEs im Knoten B durch eine Antenne **523**.

[0086] Als nächstes wird ein Verfahren für das Empfangen von Signalen in Aufwärtsrichtung von den UEs im Knoten B unter Bezug auf **Fig. 5** beschrieben. Der RF-Prozessor **522** führt eine Frequenzverschiebung von Signalen in Aufwärtsrichtung, die durch die Antenne **523** empfangen werden, in ein Basisband durch, und er liefert sein Ausgangssignal dann an den Schalter **520**. Der Schalter **520** schaltet unter der Steuerung der Steuervorrichtung **521** die Signale in Aufwärtsrichtung, die von den UEs empfangen werden, zu einem Demodulator **531** zu einer spezifizierten Zeit. Die Steuervorrichtung **521** steuert den Schalter **520** durch das Analysieren der Punkte, an denen die UEs im Knoten B die Signale des Kanals in Aufwärtsrichtung übertragen haben, und sie schaltet auch den Schalter **520** (oder verbindet ihn) mit einer UpPTS-Analysevorrichtung **530** an einem Ankunftspunkt der UpPTS, um so die UpPTSs, die von den jeweiligen UEs übertragen werden, zu analysieren. Der Demodulator **531** demoduliert das empfangene Signal in Aufwärtsrichtung und liefert sein Ausgangssignal an einen Demultiplexer **532**. Der Demultiplexer **532** demultiplext das empfangene Signal in Aufwärtsrichtung, das vom Demodulator **531** ausgegeben wird, in eine Mitambel **533** und einen Signaldatenteil in Aufwärtsrichtung. Die Mitambel **533** wird bei der Detektion der Benutzer, dem Schätzen der Kanalumgebung zwischen den UEs und dem Knoten B und dem Schätzen eines Pegels der Übertragungssignale von den UEs verwendet. Der Datenteil des Signals in Aufwärtsrichtung, der vom Demultiplexer **532** ausgegeben wird, wird durch einen Multiplizierer mit demselben Verwürfelungskode, wie er im UE-Transceiver der **Fig. 4** verwendet wurde, entwürfelt. Der entwürfelte Datenteil des Signals in Aufwärtsrichtung wird durch die Entspreizvorrichtung **535** in Datenteile des Signals in Aufwärtsrichtung der entsprechenden Benutzer entspreizt, und der Datenteil des Signals in Aufwärtsrichtung des i-ten Benutzers wird an einen Demultiplexer **536** geliefert. Der Demultiplexer **536** demultiplext den Datenteil des Signals in Aufwärtsrichtung des i-ten Benutzers in TPC **537**, TFCI **538**, SS **570** und die i-ten Benutzerdaten. Der TPC **537** wird der Übertragungsleistungssteuerung **580** in Abwärtsrichtung geliefert und verwendet, um die Übertragungssignalleistung der Abwärtsverbindung des i-ten Benutzers zu steuern. Der TFCI **538** wird bei einer Analyse eines Transportformats, das für den Datenteil des i-ten Benutzers verwendet wird, verwendet, und die SS **570** wird bei der Steuerung eines Übertragungspunkts des Kanals in Abwärtsrichtung zur UE verwendet. Die i-ten Benutzerdaten, die vom Demultiplexer **536** ausgegeben werden, werden durch eine Entschachtelungsvorrichtung **539** entschachtelt, und dann durch einen Dekodierer **540** in die Daten **541** des i-ten Benutzers dekodiert. Die anderen Kanäle **550** in Aufwärtsrichtung der anderen Benutzers, die von der Entspreizvorrichtung **535** ausgeben werden, werden auch am Knoten B im selben Verfahren, wie es mit den Daten des i-ten Benutzers durchgeführt wurde, empfangen.

[0087] **Fig. 6** zeigt ein Betriebsverfahren der UE gemäß einer Ausführungsform der vorliegenden Erfindung. Betrachtet man **Fig. 6**, so führt in Schritt **601** die UE eine normale Übertragungsleistungssteuerung in Aufwärtsrichtung/Abwärtsrichtung durch, wobei sie typischerweise das Leistungssteuerverfahren mit geschlossener Schleife im NB-TDD Kommunikationssystem verwendet. Wenn die UE eine Übertragungspause in Abwärtsrichtung in Schritt **602** während der Leistungssteuerung mit geschlossener Schleife erkennt, so geht die UE zur Schritt **603** weiter. Hier kann die UE die Übertragungspause in Abwärtsrichtung durch das Analysieren einer Signalisierungsnachricht einer oberen Lage, die vom Knoten B übertragen wird, detektieren, oder sie kann die Übertragungspause in Abwärtsrichtung nach der mißlungenen Detektion einer Mitambel, die der UE in einem Mitambelteil des Kanals in Abwärtsrichtung, der vom Knoten B übertragen wurde, zugeordnet wurde, erkennen.

[0088] Nach dem Erkennen der Übertragungspause in Abwärtsrichtung mißt die UE einen Ausbreitungsverlust des P-CCPCH, der vom Knoten B übertragen wird, im Schritt **603** und geht dann zum Schritt **604** weiter. Natürlich kann die UE auch den Ausbreitungsverlust des P-CCPCH in Schritt **601** messen. Nach dem Messen des Ausbreitungsverlusts des P-CCPCH bestimmt die UE in Schritt **604**, ob eine Übertragungspause in Aufwärtsrichtung aufgetreten ist, da die UE in zwei unterschiedlichen Betriebsarten arbeitet, in Abhängigkeit davon, ob Übertragungsdaten in Aufwärtsrichtung existieren. Nach dem Auftreten der Übertragungspause in Aufwärtsrichtung in Schritt **604** stellt die UE die Übertragungsleistung in Aufwärtsrichtung unter Verwendung des Ausbreitungsverlusts des P-CCPCH, der Interferenzrauschens I_{BTS} des Knotens B und der Übertragungsleistung des Übertragungszeitschlitzes in Aufwärtsrichtung direkt vor dem Start der Übertragungspause in Abwärtsrichtung in **611** neu ein und geht dann zu Schritt **612** weiter. Hier wird das Verfahren der Neueinstellung der Übertragungsleistung in Aufwärtsrichtung in derselben Art, wie es in den Ausführungsformen der vorliegenden Erfindung beschrieben wurde, durchgeführt. In Schritt **612** bestimmt die UE, ob Übertragungsdaten in Aufwärtsrichtung existieren. Wenn keine Übertragungsdaten in Aufwärtsrichtung existieren, so kehrt die UE zum Schritt **611** zurück. Ansonsten geht die UE zum Schritt **606** weiter.

[0089] Wenn in Schritt **604** Übertragungsdaten in Aufwärtsrichtung existieren, so geht die UE zum Schritt **605** weiter, wo sie die Übertragungsleistung in Aufwärtsrichtung bestimmt und einen TPC-Befehl in Abwärtsrichtung bildet. Hier wird der TPC-Befehl in Abwärtsrichtung von der UE zum Knoten B übertragen und dann vom Knoten B bei der Bestimmung der Übertragungsleistung des Kanals in Abwärtsrichtung, der direkt nach der Übertragungspause in Abwärtsrichtung verwendet werden soll, das heißt, beim Einstellen der anfänglichen Übertragungsleistung des Kanals in Abwärtsrichtung, verwendet. Im Schritt **606** überträgt die UE den TPC-Befehl in Abwärtsrichtung, der im Schritt **605** oder **611** bestimmt wurde, und die Benutzerdaten zum Knoten B mit der bestimmten Übertragungsleistung in Aufwärtsrichtung. Im Schritt **607** bestimmt die UE, ob ein zugewiesener Kanal in Abwärtsrichtung oder ein gemeinsamer Kanal in Abwärtsrichtung vom Knoten B empfangen wird. Als Ergebnis der Bestimmung kehrt die UE, wenn kein zugewiesener Kanal in Abwärtsrichtung oder kein gemeinsamer Kanal in Abwärtsrichtung vom Knoten B empfangen wird, zum Schritt **603** zurück. Wenn jedoch der zugewiesene Kanal in Abwärtsrichtung oder der gemeinsame Kanal vom Knoten B empfangen wird, so steuert die UE in Schritt **608** die Übertragungsleistung der Abwärtsverbindung in einer normalen Leistungssteuerbetriebsart, das heißt einer Leistungssteuerbetriebsart mit geschlossener Schleife.

[0090] **Fig.** 7 zeigt ein Betriebsverfahren des Knotens B gemäß einer Ausführungsform der vorliegenden Erfindung. Betrachtet man **Fig.** 7, so steuert der Knoten B in Schritt **701** die Übertragungsleistung in Aufwärtsrichtung/Abwärtsrichtung in einer normalen Leistungssteuerbetriebsart, das heißt in der Leistungssteuerbetriebsart mit geschlossener Schleife, einer typischen Leistungssteuerbetriebsart im NB-TDD Kommunikationssystem. Da der Knoten B in zwei unterschiedlichen Betriebsarten in Abhängigkeit davon, ob einer Übertragungspause in Abwärtsrichtung während der normalen Übertragungsleistungssteueroperation in Aufwärtsrichtung/Abwärtsrichtung auftritt, arbeitet, bestimmt der Knoten B in Schritt **702**, ob einer Übertragungspause in Abwärtsrichtung auftritt. Bei Auftreten der Übertragungspause in Abwärtsrichtung stellt der Knoten B die Übertragungsleistung in Abwärtsrichtung unter Verwendung eines TPC-Befehl, der von der UE empfangen wird, in Schritt **703** neu ein, und geht dann weiter zu Schritt **704**. Wenn jedoch keine Übertragungspause in Abwärtsrichtung im Schritt **702** auftaucht, so kehrt der Knoten B zum Schritt **701** zurück. Der Knoten B bestimmt im Schritt **704**, ob es Übertragungsdaten in Abwärtsrichtung gibt. Als Ergebnis der Bestimmung kehrt der Knoten B, wenn keine Übertragungsdaten in Abwärtsrichtung vorhanden sind, zum Schritt **703** zurück, und ansonsten geht der Knoten B, wenn Übertragungsdaten in Abwärtsrichtung vorhanden sind, zum Schritt **705** weiter. Im Schritt **705** erzeugt der Knoten einen TPC-Befehl in Aufwärtsrichtung durch das Messen eines Leistungspegels eines Signals, das von der UE empfangen wird, und überträgt den TPC-Befehl in Aufwärtsrichtung und die Benutzerdaten zur UE mit der Übertragungsleistung, die in Schritt **703** bestimmt wurde. Danach steuert in Schritt **706** der Knoten B die Übertragungsleistung in Aufwärtsrichtung/Abwärtsrichtung wieder in der normalen Übertragungsleistungssteuerbetriebsart.

[0091] Wie oben beschrieben wurde, verwendet das NB-TDD Kommunikationssystem gemäß der vorliegenden Erfindung das Leistungssteuerverfahren mit geschlossener Schleife zusammen mit dem Leistungssteuerverfahren mit offener Schleife für eine Übertragungsleistungssteuerung in Aufwärtsrichtung nach dem Auftreten einer Übertragungspause in Aufwärtsrichtung/Abwärtsrichtung, um somit eine effiziente Leistungssteuerung durchzuführen. Zusätzlich kann, wenn eine spezielle Technik des Empfangs/des Sendens, wie eine Strahlungsformung angewandt wird, das NT-TDD Kommunikationssystem wirksam die Übertragungsleistung in Aufwärtsrichtung/Abwärtsrichtung unter Berücksichtigung der Unterschiede in den Eigenschaften zwischen den Kanälen, die einer Strahlformung unterworfen wurden, und den Kanälen, die keiner Strahlformung unterworfen wurden, steuern, um es für den Knoten B und die UE möglich zu machen, ihre passende anfängliche Übertragungsleistung am Ende der Übertragungspause einzustellen.

[0092] Während die Erfindung unter Bezug auf gewisse bevorzugte Ausführungsformen gezeigt und beschrieben wurde, werden Fachleute verstehen, daß verschiedene Änderungen in der Form und den Details vorgenommen werden können, ohne von der Idee und dem Umfang der Erfindung, wie sie durch die angefügten Ansprüche definiert ist, abzuweichen.

Patentansprüche

1. Übertragungsleistungssteuerverfahren in einer UE (Benutzerausrüstung) für ein TDD (Zeitduplex) CDMA (Vielfachzugriff durch Kodetrennung) Kommunikationssystem, das einen Strom von Rahmen von einem Knoten B zur UE überträgt, wobei jeder der Rahmen ein Feld, das den Leistungspegel der Information, die vom Knoten B übertragen wird, angibt, und einen Zeitschlitz für das Zuweisen eines TPC-(Übertragungsleistungssteuerungs)-Befehls und der Übertragungsdaten vom Knoten B an die UE umfaßt, wobei die UE die Daten, die vom Knoten B übertragen werden, empfängt, wobei sie einem Zeitschlitzfeld im folgenden Rahmen nach einer Übertragungspausenzeitdauer, bei der keine Übertragungsdaten im Zeitschlitzfeld im speziellen Rahmen existieren, unter dem Strom von Rahmen, die vom Knoten B zur UE übertragen werden, zugewiesen sind, wobei das Verfahren die folgenden Schritte umfaßt:

Messen eines Ausbreitungsverlusts zwischen dem Knoten B und der UE durch das Empfangen der Leistungspegelinformation in einem spezifischen Zeitschlitz in der Übertragungspausenzeitdauer;

Messen eines Interferenzrauschens des Knotens B durch das Empfangen einer speziellen Kanalsignals, das durch den Knoten B übertragen wird;

Bestimmen einer Übertragungsleistung in Aufwärtsrichtung durch das Summieren (i) von Werten, die durch das Anlegen eines Gewichts, basierend auf der Länge der Übertragungspausenzeitdauer, auf den aktuell gemessenen Ausbreitungsverlust und einen mittleren Ausbreitungsverlust zwischen dem Knoten B und der UE während der Übertragungspausenzeitdauer bestimmt werden, (ii) eines vorbestimmten Ziel-Signal-zu-Interferenz-Verhältnisses (SIR), (iii) des gemessenen Interferenzrauschens des Knotens B und (iv) eines Versatzes für das Kompensieren des Ausbreitungsverlustfehlers; und

Übertragen eines TPC-Befehls, der der bestimmten Übertragungsleistung in Aufwärtsrichtung entspricht, zum Knoten B.

2. Übertragungsleistungssteuerverfahren nach Anspruch 1, wobei es weiter den Schritt der Bestimmung einer Übertragungsleistung in Abwärtsrichtung durch den Knoten B nach dem Empfang des TPC-Befehls umfaßt, wobei (i) eine Übertragungsleistung in Abwärtsrichtung, die in einem Zeitschlitz direkt vor der Übertragungspausenzeitdauer im folgenden Rahmen

übertragen wird, (ii) der empfangene TPC-Befehl und (iii) ein Leistungssteuerschritt, der auf einen entsprechenden Zeitschlitz im folgenden Rahmen angewandt werden soll, berücksichtigt werden.

3. Übertragungsleistungssteuerverfahren nach Anspruch 1, wobei der spezifische Kanal ein Funkübertragungskanal ist.

4. Übertragungsleistungssteuerverfahren in einer UE für ein TDD CDMA Kommunikationssystem, das einen Strom von Rahmen von einem Knoten B zur UE überträgt, wobei jeder der Rahmen ein Feld, das die Leistungspegelinformation, die vom Knoten B übertragen wird, anzeigt, und ein Zeitschlitzfeld für das Zuweisen eines TPC-Befehls und Übertragungsdaten vom Knoten B zur UE einschließt, wobei die UE Daten empfängt, die vom Knoten B übertragen wurden, diese einem Zeitschlitzfeld in einem folgenden Rahmen nach einer Übertragungspausenzeitdauer, bei der keine Übertragungsdaten in den Zeitschlitzfeldern in speziellen Rahmen unter dem Strom der Rahmen, die vom Knoten B zur UE übertragen werden, existieren, zugewiesen werden, wobei das Verfahren die folgenden Schritte aufweist:

Messen eines ersten Ausbreitungsverlusts zwischen dem Knoten B und der UE durch das Empfangen der Leistungspegelinformation an einem spezifischen Zeitschlitz in der Übertragungspausenzeitdauer;

Detektieren eines Versatzes, der unter Berücksichtigung (i) der Übertragungsleistung in Aufwärtsrichtung, die im Zeitschlitz direkt vor der Übertragungspausenzeitdauer verwendet wird, (ii) eines zweiten Ausbreitungsverlusts zwischen dem Knoten B und der UE im Zeitschlitz direkt vor der Übertragungspausenzeitdauer, (iii) eines TPC-Befehls, der vom Knoten B im Zeitschlitz direkt vor der Übertragungspausenzeitdauer in Abwärtsrichtung empfangen wurde, und (iv) einer Änderung in der Kanalumgebung zwischen dem Knoten B und der UE bestimmt wird; und

Bestimmen einer ersten Übertragungsleistung in Aufwärtsrichtung durch das Summieren (a) der Übertragungsleistung in Aufwärtsrichtung, die im Zeitschlitz direkt vor der Übertragungspausenzeitdauer verwendet wird, (b) eines Werts, der durch das Subtrahieren des zweiten Ausbreitungsverlusts vom ersten Ausbreitungsverlust bestimmt wurde, und (c) des Versatzes.

5. Übertragungsleistungssteuerverfahren nach Anspruch 4, wobei es weiter folgende Schritte umfaßt:

Messen eines ersten Interferenzrauschens des Knotens B durch das Empfangen eines speziellen Kanalsignals, das vom Knoten B in einem spezifischen Zeitschlitz übertragen wird, während der erste Ausbreitungsverlust gemessen wird;

Messen eines zweiten Interferenzrauschens am Knoten B direkt vor der Übertragungspausenzeitdauer, nach dem Messen des ersten Interferenzrauschens; und

Bestimmen einer zweiten Übertragungsleistung in Aufwärtsrichtung durch das Summieren (i) der Übertragungsleistung in Aufwärtsrichtung, (ii) des Werts, der durch das Subtrahieren des zweiten Ausbreitungsverlusts vom ersten Ausbreitungsverlust bestimmt wird, (iii) des Versatzes, und (iv) eines Werts, der durch das Subtrahieren des zweiten Interferenzrauschens vom ersten Interferenzrauschen bestimmt wird.

6. Übertragungsleistungssteuerverfahren nach Anspruch 4, wobei es weiter die folgenden Schritte umfaßt:

Messen eines Interferenzrauschens am Knoten B durch das Empfangen eines speziellen Kanalsignals, das vom Knoten B im spezifischen Zeitschlitz übertragen wird; und

Bestimmen einer dritten Übertragungsleistung in Aufwärtsrichtung unter Berücksichtigung eines Werts, der durch das Summieren von (i) Werten, die durch das Anwenden eines Gewichts auf der Basis einer Länge der Übertragungspausenzeitdauer auf den aktuell gemessenen ersten Ausbreitungsverlust und eines mittleren Ausbreitungsverlusts zwischen dem Knoten B und der UE während der Übertragungspausenzeitdauer bestimmt werden, (ii) eines vorbestimmten Ziel-SIR, und (iii) einem Versatz für das Kompensieren des Ausbreitungsverlustfehlers und auch einer Berücksichtigung eines anderen Gewichts auf der Basis der Länge der Übertragungspausenzeitdauer für die erste Übertragungsleistung in Aufwärtsrichtung.

7. Übertragungsleistungssteuerverfahren nach Anspruch 4, wobei es weiter, wenn nur ein Zeitschlitz, der die Daten überträgt, einer Strahlformung unterworfen wird, den Schritt der Bestimmung einer vierten Übertragungsleistung in Aufwärtsrichtung durch das Summieren (i) einer Übertragungsleistung in Aufwärtsrichtung, die im Zeitschlitz direkt vor der Übertragungspausenzeitdauer übertragen wird, (ii) eines Werts, der unter Berücksichtigung der Kompensation einer Ausbreitungsverlustdifferenz zwischen einem Zeitschlitzfeld, das einer Strahlformung unterworfen wird, und eines Zeitschlitzfeldes, das keiner Strahlformung unterworfen wird, und eines Werts, der durch das Subtrahieren des zweiten Ausbreitungsverlusts vom ersten Ausbreitungsverlust bestimmt wird, bestimmt wird, und (iv) des Versatzes umfaßt.

8. Übertragungsleistungssteuerverfahren nach Anspruch 5, wobei es weiter die folgenden Schritte umfaßt:

Messen eines Interferenzrauschens des Knotens B durch das Empfangen eines speziellen Kanalsignals, das vom Knoten B im spezifischen Zeitschlitz übertragen wird; und

Bestimmen einer fünften Übertragungsleistung in Aufwärtsrichtung unter Berücksichtigung eines Werts, der durch das Aufsummieren von (i) Werten, die durch das Anwenden eines Gewichts, das auf der Länge der Übertragungspausenzeitdauer basiert, auf den aktuell gemessenen ersten Ausbreitungsverlust und einen mittleren Ausbreitungsverlust zwischen dem Knoten B und der UE während der Übertragungspausenzeitdauer bestimmt werden, (ii) eines vorbestimmten Ziel-SIR, und (iii) eines Versatzes für das Kompensieren des Ausbreitungsverlustfehlers, und auch unter Berücksichtigung eines anderen Gewichts, das auf der Länge der Übertragungspause der zweiten Übertragungsleistung in Aufwärtsrichtung basiert, bestimmt wird.

9. Übertragungsleistungssteuerverfahren nach Anspruch 5, wobei es weiter, wenn nur ein Zeitschlitz, der die Daten überträgt, einer Strahlformung unterworfen wird, den Schritt der Bestimmung einer sechsten Übertragungsleistung in Aufwärtsrichtung durch das Summieren (i) einer Übertragungsleistung in Aufwärtsrichtung, die im Zeitschlitz direkt vor der Übertragungspausenzeitdauer übertragen wird, (ii) eines Werts, der unter Berücksichtigung der Kompensation einer Ausbreitungsverlustdifferenz zwischen einem Zeitschlitzfeld, das einer Strahlformung unterworfen wird, und eines Zeitschlitzfeldes, das keiner Strahlformung unterworfen wird, und eines Werts, der durch das Subtrahieren des zweiten Ausbreitungsverlusts vom ersten Ausbreitungsverlust bestimmt wird, bestimmt wird, (iii)

des Versatzes, und (iv) eines Werts, der durch das Subtrahieren des zweiten Interferenzrauschens vom ersten Interferenzrauschen bestimmt wird, umfaßt.

10. Übertragungsleistungssteuerverfahren nach Anspruch 6, wobei der spezielle Kanal ein Funkübertragungskanal ist.

11. Übertragungsleistungssteuervorrichtung in einer UE für ein TDD CDMA Kommunikationssystem, das einen Strom von Rahmen von einem Knoten B zur UE überträgt, wobei jeder der Rahmen ein Feld, das den Leistungspegel der Information, die vom Knoten B übertragen wird, angibt, und einen Zeitschlitzfeld für das Zuweisen eines TPC-Befehls und der Übertragungsdaten vom Knoten B an die UE umfaßt, wobei die UE die Daten, die vom Knoten B übertragen werden, empfängt, wobei diese einem Zeitschlitzfeld in einem folgenden Rahmen nach einer Übertragungspausenzeitdauer, bei der keine Übertragungsdaten in den Zeitschlitzfeldern im speziellen Rahmen existieren, unter dem Strom von Rahmen, die vom Knoten B zur UE übertragen werden, zugewiesen sind, umfassend:

eine Übertragungsleistungssteuervorrichtung in Aufwärtsrichtung für das Messen eines Ausbreitungsverlusts zwischen dem Knoten B und der UE durch das Empfangen der Leistungspegelinformation, die in einem spezifischen Zeitschlitz in der Übertragungspausenzeitdauer empfangen wird, wenn eine Übertragungspause eines spezifischen Kanalsignals, das vom Knoten B empfangen wird, auftritt, das Detektieren eines Interferenzrauschens des Knotens B aus dem spezifischen Kanalsignal, und das Bestimmen einer Übertragungsleistung in Aufwärtsrichtung durch das Summieren von (i) Werten, die durch das Anlegen eines Gewichts, das auf der Länge der Übertragungspausenzeitdauer basiert, auf den aktuell gemessenen Ausbreitungsverlust und einen mittleren Ausbreitungsverlust zwischen dem Knoten B und der UE während der Übertragungspausenzeitdauer bestimmt werden, (ii) eines vorbestimmten Ziel-SIR, und (iii) eines Versatzes für das Kompensieren des Ausbreitungsverlustfehlers;

einen TPC-Befehlsgenerator für die Abwärtsrichtung für das Erzeugen eines TPC-Befehls für das Steuern der Übertragungsleistung in Abwärtsrichtung, die durch den Knoten B im folgenden Rahmen übertragen werden soll, durch das Empfangen der Übertragungsleistung in Aufwärtsrichtung, die durch die Übertragungsleistungssteuervorrichtung für die Aufwärtsrichtung bestimmt wird;

einen Multiplexer für das Multiplexen des TPC-Befehls in Abwärtsrichtung, von Benutzerdaten, die zum Knoten B übertragen werden sollen, und eines TFCI (Transport Format Combination Indicator, Transportformatkombinationsanzeigers), der einen Typ und eine Datenrate der Benutzerdaten bezeichnet;

und

einen Multiplizierer für das Multiplizieren des Kanalsignals in Aufwärtsrichtung mit einer Kanalverstärkung, basierend auf der bestimmten Übertragungsleistung in Aufwärtsrichtung.

12. Übertragungsleistungssteuervorrichtung nach Anspruch 11, wobei die Übertragungsleistungssteuervorrichtung für die Aufwärtsrichtung die Übertragungsleistung in Aufwärtsrichtung durch das Messen eines ersten Ausbreitungsverlusts zwischen dem Knoten B und der UE auf der Basis der Leistungspegelinformation, basierend auf einer Leistungspegelinformation, die in einem speziellen Zeitschlitz während der Übertragungspausenzeitdauer empfangen wird, Bestimmen eines Versatzes, basierend auf der Übertragungsleistung in Aufwärtsrichtung, die im Zeitschlitz direkt vor der Übertragungspausenzeitdauer verwendet wird, eines zweiten Ausbreitungsverlusts zwischen dem Knoten B und der UE im Zeitschlitz direkt vor der Übertragungspausenzeitdauer, und eines TPC-Befehls, der vom Knoten B im Zeitschlitz direkt vor der Übertragungspausenzeitdauer empfangen wird, und einer Änderung in der Kanalumgebung zwischen dem Knoten B und der UE, und dem Summieren von (i) der Übertragungsleistung in Aufwärtsrichtung, die im Zeitschlitz direkt vor der Übertragungspausenzeitdauer verwendet wird, (ii) eines Werts, der durch das Subtrahieren des zweiten Ausbreitungsverlusts vom ersten Ausbreitungsverlust bestimmt wird, und (iii) des Versatzes, bestimmt.

13. Übertragungsleistungssteuervorrichtung eines Knotens B in einer UE für ein TDD CDMA Kommunikationssystem, das einen Strom von Rahmen von einem Knoten B zur UE überträgt, wobei jeder Rahmen ein Feld, das die Leistungspegelinformation, die vom Knoten B übertragen wird, anzeigt, und ein Zeitschlitzfeld für das Zuweisen eines TPC-Befehls und von Übertragungsdaten vom Knoten B zur UE einschließt, wobei der Knoten B Daten zur UE in einem folgenden Rahmen nach einer Übertragungspausenzeitdauer, bei der keine Übertragungsdaten in den Zeitschlitzfeldern in speziellen Rahmen existieren, unter dem Strom von Rahmen, die vom Knoten B zur UE übertragen werden, überträgt, umfassend:

einen Demultiplexer für das Demultiplexen eines Kanalsignals in Aufwärtsrichtung, das von der UE empfangen wird, in einen TPC-Befehl für die Abwärtsrichtung, der Benutzerdaten von der UE, und eines TFCI, der einen Typ und eine Datenrate der Benutzerdaten anzeigt;

eine Übertragungsleistungssteuervorrichtung für die Abwärtsrichtung für das Bestimmen der Übertragungsleistung in Abwärtsrichtung für die UE auf der Basis des TPC-Befehls für die Abwärtsrichtung, nach dem Auftreten einer Übertragungspause;

einen TPC-Generator für die Aufwärtsrichtung für das Erzeugen eines TPC-Befehls für die Aufwärtsrichtung für das Steuern der Übertragungsleistung in Aufwärtsrichtung, die zur UE im folgenden Rahmen übertragen werden soll, durch das Empfangen der Übertragungsleistung in Aufwärtsrichtung, die durch die Übertragungsleistungssteuervorrichtung für die Abwärtsrichtung bestimmt wurde;

einen Multiplexer für das Multiplexen des erzeugten TPC-Befehls, der Benutzerdaten, die zur UE übertragen werden sollen, und der TFCI, der einen Typ und eine Datenrate der Benutzerdaten anzeigt; und

einen Multiplizierer für das Multiplizieren des Kanalsignals in Abwärtsrichtung mit einer Verstärkung auf der Basis der bestimmten Übertragungsleistung in Abwärtsrichtung.

Hierzu 7 Seite(n) Zeichnungen

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Int. Cl.[7]: H 04 J 3/16
Offenlegungstag: 8. August 2002

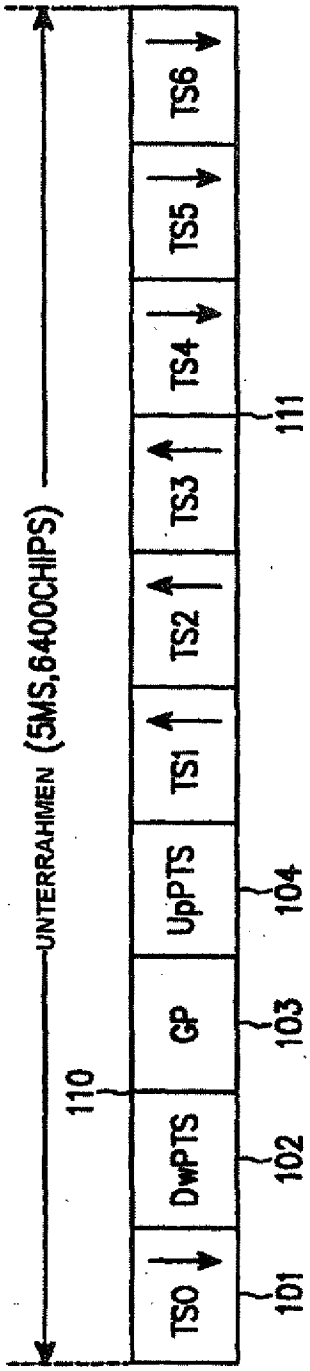


FIG. 1
STAND DER TECHNIK

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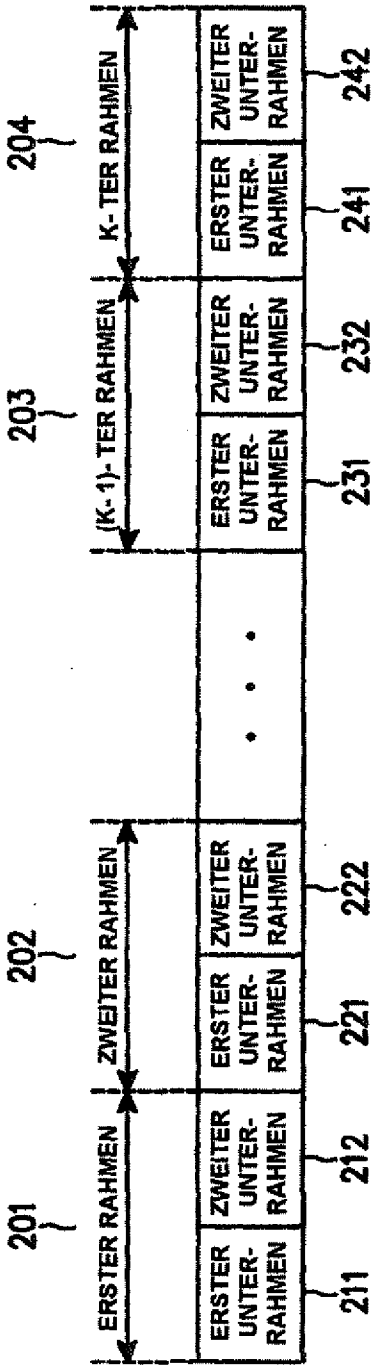


FIG.2
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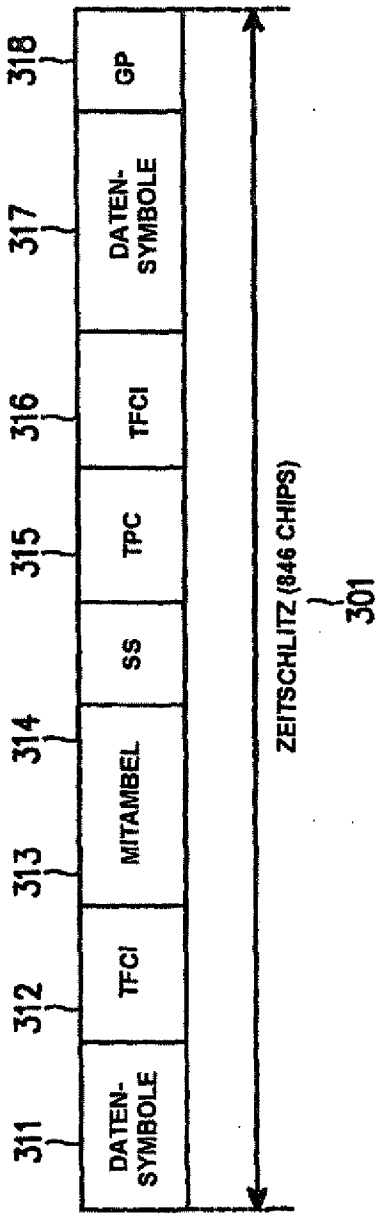


FIG.3
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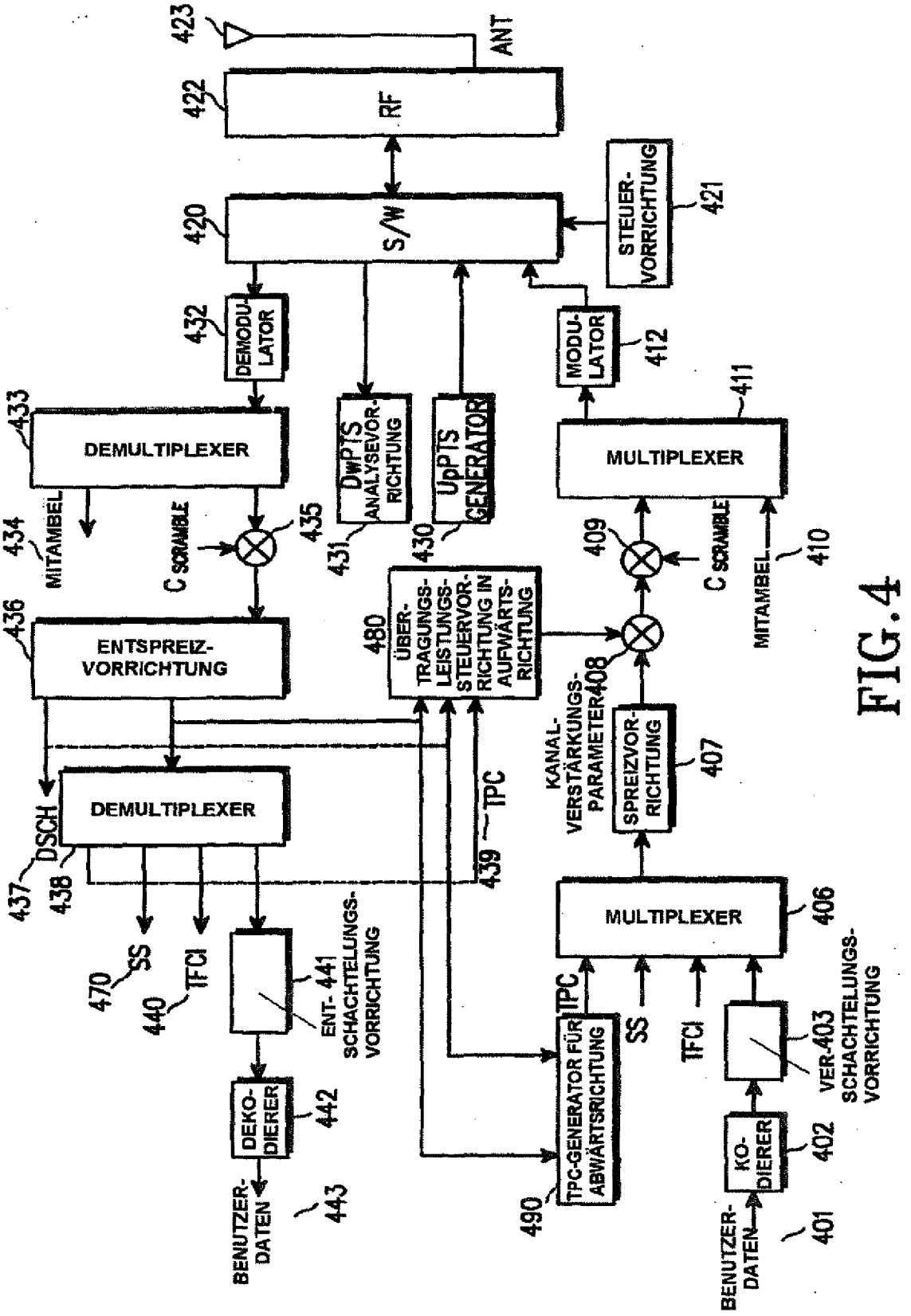


FIG. 4

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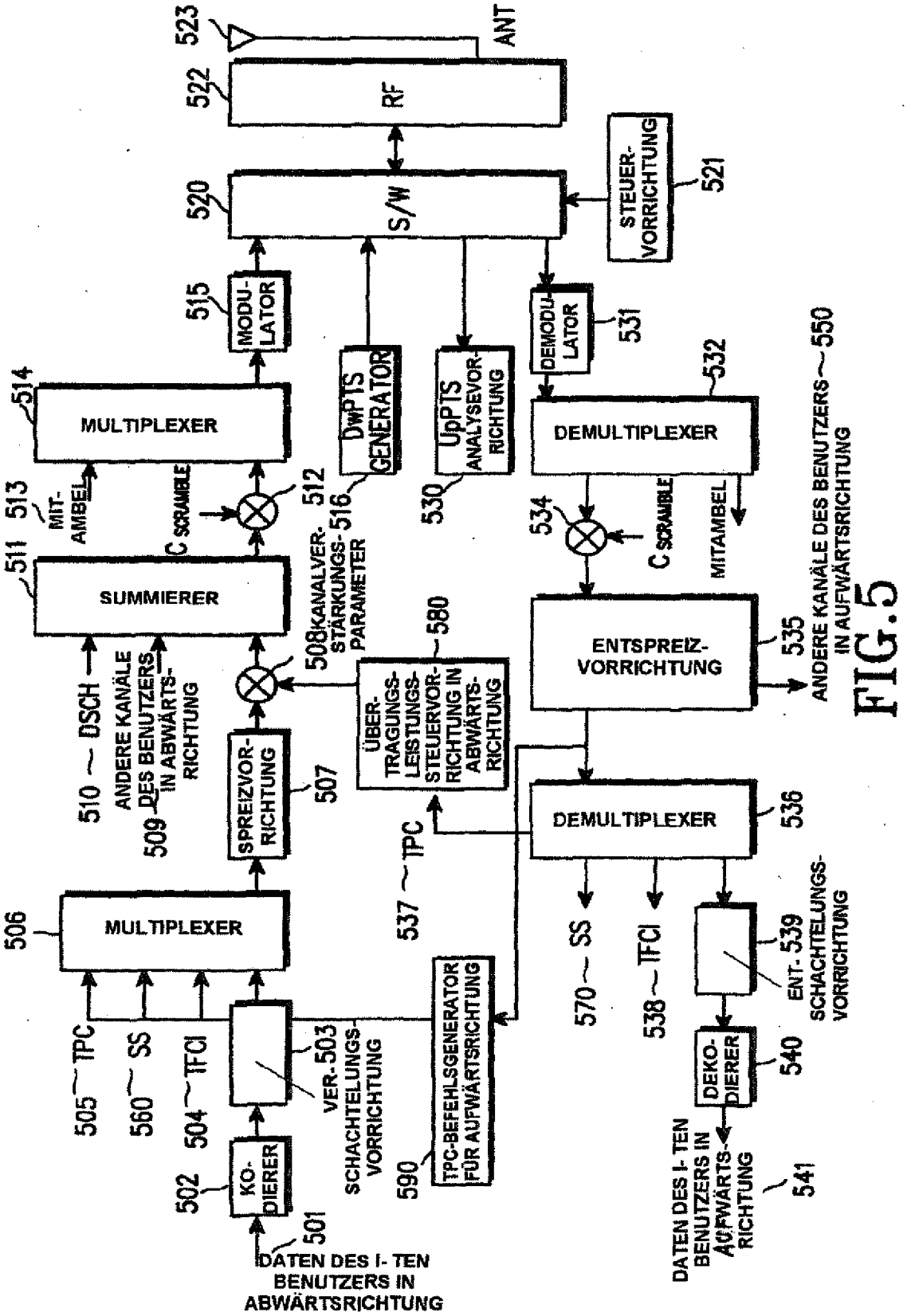


FIG.5

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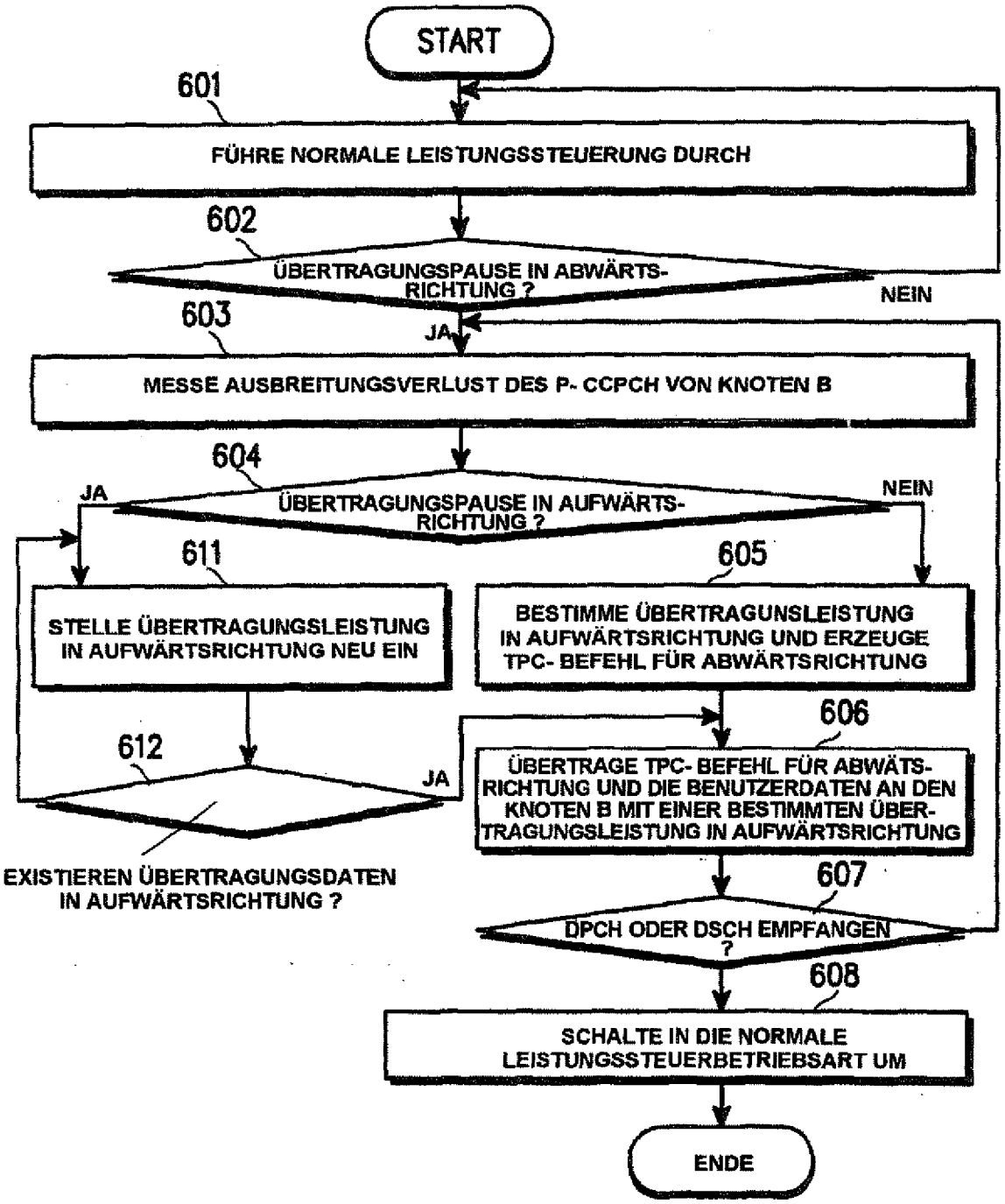


FIG. 6

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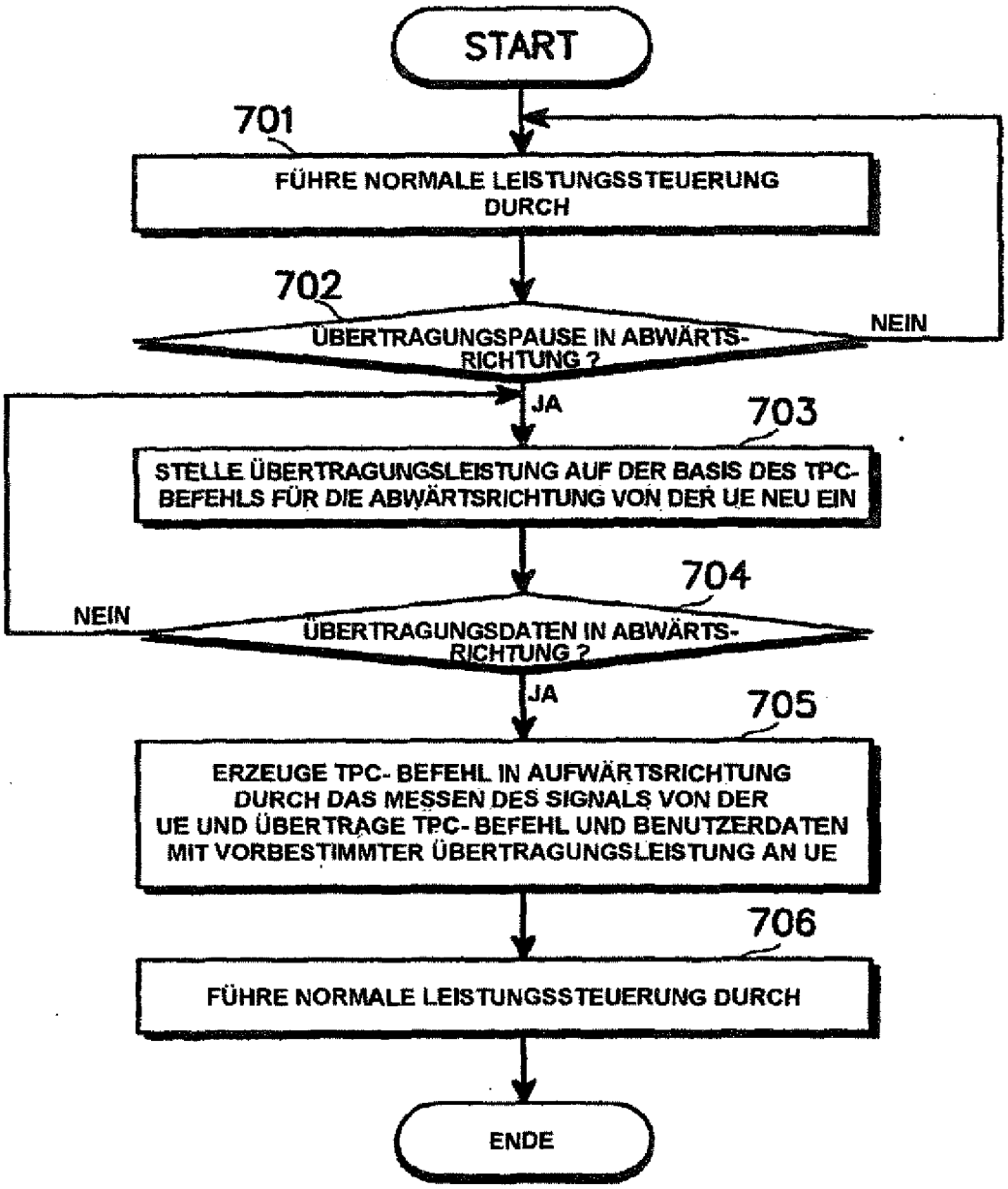


FIG. 7

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(54) Method for synchronization in a mobile radio terminal

(57) A method for synchronizing measurements in a mobile communication apparatus having a first active radio access means (100) adapted to communicate according to a first radio access technology (RAT) and at least a second passive radio access means (200) adapted to communicate according to a second RAT. A time reference common to the first and the second access means (100) is generated. At least one time schedule is obtained, said schedule indicating at least one time gap wherein the second access means (200) is allowed to be active. The activation time of the schedule is based on the common time reference. An arrangement adapted to generate the common time reference and the time schedule is also disclosed.

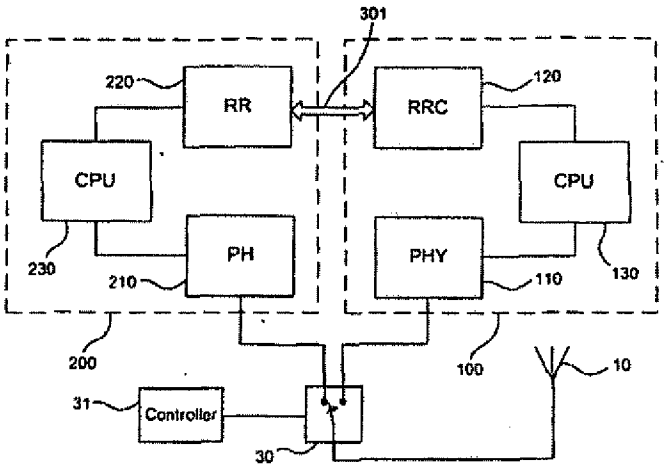


Fig. 2a

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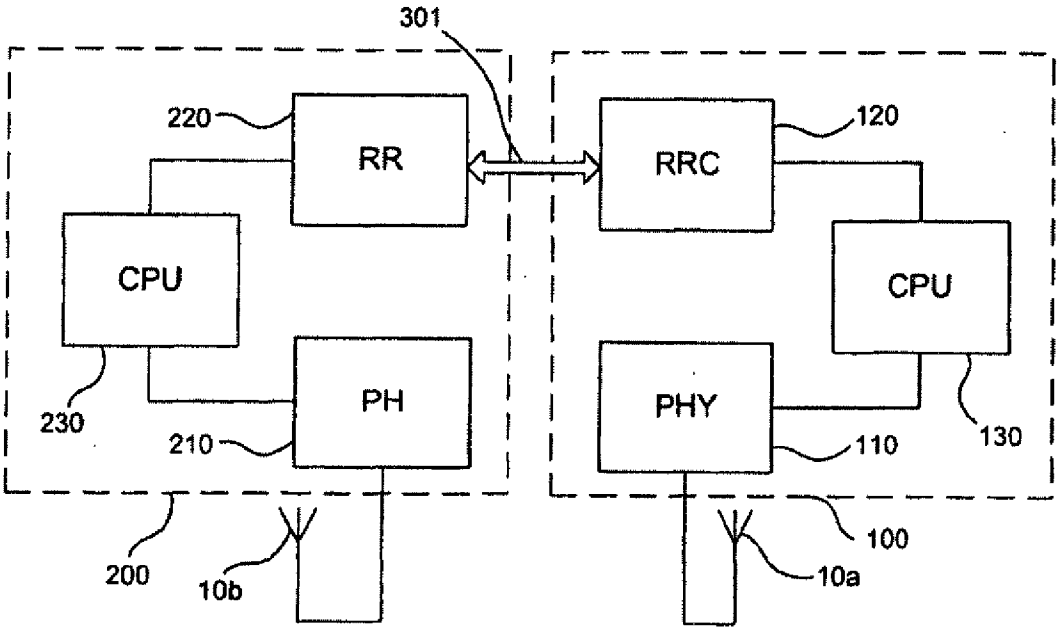


Fig. 2b

Description

Technical Field of the Invention

[0001] The present invention relates to a method for a mobile radio terminal having dual radio access technology (RAT) capabilities, and more specifically to a method for providing a common time event, from which the start time of measurements required according to respective RAT is determined, and a communication apparatus having such synchronization capabilities.

Description of Related Art

[0002] Different telecommunication systems using different technologies are available. GSM (Global System for Mobile communications) considered as a second-generation communication system is one of the most common and is based on TDMA (Time Division Multiple Access) radio access technology (RAT). GPRS (General Packet Radio Service) and EDGE (Enhanced Data for GSM Evolution) are data communication techniques for GSM systems, which are also based on TDMA technology. UMTS (Universal Mobile Telecommunication System) is considered a third-generation communication system and is based on WCDMA (Wideband Code Division Multiple Access) RAT. The WCDMA technology may be used as a stand-alone RAT. 3GPP (third Generation Partnership Project) specifications suggests a dual RAT communication system, which shall allow mobile terminals to handle both WCDMA and a second RAT, such as GSM. An important feature in dual RAT systems is the possibility to do handover between RATs and to select cell in the RAT that has the best radio environment quality. In order to achieve this, a dual RAT mobile terminal needs to execute cell measurements on both RAT systems in addition to receive/transmit using one of the RATS. When the terminal is connected to one system being active, measurements on the passive system have to be supported. This is a problem in case the passive system can not carry out measurements while the active system is receiving/transmitting. Simultaneous activities of the systems are problematic when the systems utilize common radio resources, such as a common antenna. Furthermore, simultaneous activities may also be problematic when two parallel RAT systems having separate radio resources are provided. A first of the parallel systems may interfere with the second RAT system to such an extent that the second RAT system is unable to provide measurements. In both these cases, the measurements on the passive system could be carried out when there are gaps in the reception/transmission of the active system. The occasions that can be utilized by the passive system are either determined by the active system or given by the radio access network of the active system.

[0003] There is a problem with providing measurements in a passive or slave system when it may not be active simultaneously with the active system, as the time gaps when the active system is not receiving/transmitting are very short. The passive system has to execute its measurements during such gaps. Furthermore, the two systems are not synchronized and may not use the same time format. Different time formats cause further problems, as is the case for GSM/GPRS/EDGE and WCDMA. According to GSM requirements, cell measurements have to be provided during pre-specified occasions that are determined in the GSM time format. It is not required that the cell measurements according to WCDMA RAT are executed during a specific time. WCDMA cell measurements may be executed at practically any time and do not have to be planned in advance, as is the case for GSM measurements. The time formats of GSM and WCDMA are different. Therefore, the WCDMA system cannot simply indicate in its own time format to the GSM system when the GSM system is allowed to be active and provide cell measurements, as the GSM system is not capable of interpreting the given gaps.

Summary of the Invention

[0004] One object of the present invention is to provide a method for providing a time schedule for cell measurements on an active radio access network utilizing a first radio access technology (RAT) and on a passive radio access network utilizing a second RAT, for facilitating e.g. handover and cell selection when the access means may not transmit/receive simultaneously.

[0005] According to a first aspect of the invention, this object is achieved by a method providing synchronization of the time used for cell measurements of a first communication network executed by a first radio access means and the time used for cell measurements of a second network executed by a second radio access means. The first access means utilizes a first RAT, such as WCDMA, whereas the second access means utilizes a second RAT, such as GSM. The first and the second access means may have one radio resource in common, which requires that the first and the second access means are not active simultaneously. Alternatively, the first and second access means have no radio resource in common, but are not allowed to transmit/receive simultaneously. According to the invention, the first access means is normally active and facilitates both communication and measurements, whereas the second access means acts as a slave access means, which only provides cell measurements until handover is made. According to the in-

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vention, a time reference common to the first and the second access means is generated. A time schedule common to the first and second access means is obtained, which indicates at least one time gap wherein the first access means is not receiving/transmitting and wherein the second access means is allowed to be active (receive/transmit). The schedule is determined based on the common time reference.

[0006] The common time reference may be generated in response to a time event (CTE) common to the first and second access means. In response to said CTE, the values of counters of the first and second access means, respectively, will be stored in counter value registers connected to the counters. The values of the registers will serve as the values of the time reference, which are expressed in the time format of the respective RAT.

[0007] The first access means will determine a measurement gap schedule (MGS) comprising a time schedule defining the duration and location of the gaps with respect to the CTE. The second access means is allowed to be active during said gaps. The MGS will comprise an activation time of the schedule, which is determined in the time format of the first access means and which may be determined based on the time distance from the CTE. When the second access means receives the MGS it may translate it and use the time reference of its registers to determine the activation time in its own time format.

[0008] Another object of the invention is to provide an arrangement adapted to provide cell measurements on an active radio access network utilizing a first radio access technology (RAT) and measurements on a passive radio access network utilizing a second RAT.

[0009] According to a second aspect of the invention, this object is achieved by an arrangement comprising a first radio access means and a second radio access means. The first access means is adapted to communicate with a first communication network according to a first RAT, whereas the second access means is adapted to communicate with a second communication network according to a second RAT. The arrangement further comprises a time reference generating means for generating a time reference common to the first and the second access means. A time schedule generating means for obtaining at least one time schedule being common to the first and second access means is adapted to generate a time schedule, which indicates at least one time gap wherein the first access means is not receiving/transmitting and wherein the second access means is allowed to be active. The time schedule generating means is further adapted to determine an activation time of the schedule, which is determined based on the time distance to the common time reference.

[0010] The first and second access means may have at least one common radio resource, such as an antenna.

[0011] The arrangement may further comprise in each access means a counter for generating counter values, a counter value register for registering counter values, and a counter synchronize mechanism. Either of the mechanisms may be adapted to generate a CTE, in response to which the counter values will be registered in the respective registers. The counter values are expressed in the time format of the respective access means.

[0012] The time schedule generating means may further be adapted to incorporate into the time schedule parameters identifying the time gaps, wherein the second access means is allowed to be active, and the activation time of the schedule. The second access means is adapted to translate the MGS to its own time format and determine the activation time by means of the counter values stored in its register.

[0013] According to a third aspect of the invention, a computer program product directly loadable into a memory of a mobile terminal having computer capabilities, such as a central processing unit for executing computer software code portions is disclosed. The product comprises software code portions for performing the method according to the invention when said product is run by said terminal.

[0014] According to a fourth aspect of the invention, the inventive arrangement is used in a wireless communication apparatus. The apparatus may be a mobile radio terminal, a mobile telephone, a pager, or a communicator, i.e. a personal digital assistant or a smartphone.

[0015] One advantage of the invention is that it gives a robust method that can be applied in all different states to transfer occasions for measurements from the active radio access means to the passive access means.

[0016] Further embodiments of the invention are defined in the dependent claims.

[0017] It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Brief Description of the Drawings

[0018] Further objects, features, and advantages of the invention will appear from the following description of several embodiments of the invention, wherein various aspects of the invention will be described in more detail with reference to the accompanying drawings, in which:

Fig.1 is a schematic front view of a mobile telephone and the environment in which it operates;
Fig. 2a is a block diagram of access means for a first and a second radio access technology having common radio

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resources;

Fig. 2b is a block diagram of access means for a first and a second radio access technology having separate antennas;

Fig. 3 is a more detailed block diagram of the access means of Fig. 2a and 2b;

Fig. 4 is a structure diagram showing a compressed mode pattern structure;

Fig. 5 is a timing diagram showing the relationship between the common time event, the activation request and the activation time of the compressed mode pattern of Fig. 4;

Fig. 6 is a flowchart of the steps of a method for the common time event;

Fig. 7 is a flowchart of a first embodiment of the steps of a method for the measurement gap schedule; and

Fig. 8 is a flowchart of a second embodiment of the steps of the method for the measurement gap schedule.

Detailed Description of Embodiments

[0019] Fig. 1 illustrates a mobile telephone 1 as a schematic front view and the environment in which it operates. The mobile telephone 1 comprises an antenna 10 mounted on the housing of the apparatus. Alternatively, the mobile telephone 1 may have an internal antenna mounted within the housing of the apparatus. The antenna 10 is electrically connected to a printed circuit board of the mobile telephone 1 through an antenna switch, as will be further described below. The mobile telephone further comprises a display 11, a keypad 12, a loudspeaker 13, and a microphone 14, which together provide a man-machine interface for operating the mobile telephone 1.

[0020] The mobile telephone 1 may alternatively have two separate internal or external antennas (se Fig. 2b) antennas, which are adapted to the radio access technology for which they are utilized, as will be discussed below.

[0021] The mobile telephone 1 is adapted to establish a first wireless link 15 to a radio station (base station) 16a of a first mobile telecommunication network 17. The mobile telephone 1 is also adapted to establish a second wireless link 18 to a radio station (base station) 19a of a second mobile telecommunication network 20. Each base station 16a, 19a serves one or several cells. The first system 17 utilizes a first radio access technology (RAT), such as WCDMA (Wideband Code Division Multiple Access) or cdma2000 (Code Division Multiple Access 2000), for communicating with the mobile telephone 1. The second system 20 utilizes a second radio access technology (RAT) other than the first RAT for communicating with the mobile telephone, such as GSM (Global System for Mobile communications).

[0022] The mobile telephone 1 is further adapted to select whether to utilize the first or the second communication network 17, 20 for providing communication of e.g. speech and data depending on the quality of the link 15, 18 between the base stations 16a, 19a and the mobile terminal 1. Thus, the mobile telephone has to provide cell measurements of neighboring cells. As is illustrated in Fig. 1, the first and the second network comprise several base stations 16b, 16c, and 19b, 19c, respectively, each serving one or several cells. As the position of the mobile telephone may change it may come into the vicinity of another cell, in which better link quality is provided compared to the one in which the mobile telephone 1 is located. Either the first or the second network 17, 20 is the active network, whereas the other is the passive or the slave system. When the mobile telephone 1 experiences superior link quality from a base station 16a-c, 19a-c, serving a specific cell not belonging to the active network 17, 20, the network may do handover to the other network. Also, the mobile may provide cell selection between neighboring cells within the same network. Handover and cell selection require that the mobile telephone provides cell measurements of both the active and the passive network, 17, 20.

[0023] The present invention provides a method for synchronizing the cell measurements of the active and the passive network when said networks are not utilizing the same time format. In WCDMA, frame, slot and chip are used as the time format, whereas the time format of GSM is multiframe and quarter bit.

[0024] The mobile telephone 1 may utilize common radio resources for communication according to the first and the second RAT. Thus, the antenna 10 is adapted to communicate signals in a first frequency band when the first network 17 is active and communicate signals in a second frequency band when the second network 20 is active. Communication using the WCDMA RAT is provided in the 2 GHz frequency range, whereas communication using the GSM RAT is provided in the 900, 1800, and/or 1900 frequency ranges.

[0025] As can be seen in Fig. 2a, the antenna 10 is connected to an antenna switch 30 for connection to either access means 100 of the first RAT or access means 200 of the second RAT, which may be provided as ASIC's (Application Specific Integrated Circuit) on separate chips. The switch 30 is controlled by a controller 31, which may be provided as an integrated circuit integral with the switch 30, or by any central processing unit (CPU) of the mobile telephone 1, as will be discussed below.

[0026] Alternatively, each access means 100, 200 has its own antenna, as can be seen in Fig. 2b. Corresponding components of Figs. 2a and 2b are denoted with the same reference numerals. In the embodiment of Fig. 2b, the first access means 100 is connected to a first antenna 10a, which is adapted to provide signals in at least a first frequency band, such as in the WCDMA frequency band. The second access means 200 is connected to a second antenna 10b, which is adapted to provide signals in at least a second frequency band, such as a GSM frequency band.

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[0027] The access means 100, 200, comprise circuitry for communicating according to their respective technologies. Each access means 100, 200 comprises an air interface stack having a physical layer implemented using hardware, and higher layer implemented with software for controlling the communication. The access means is generally known in the art and is therefore not further disclosed here, except when the invention departs from what is generally known.

[0028] For convenience, in the following the access means 100 adapted according to WCDMA RAT will be denoted WCDMA RAT 100 and the access means 200 adapted according to GSM RAT will be denoted GSM RAT 200. However, this should not be taken as limiting the scope of the invention, but is only for exemplifying purposes. The first communication may alternatively be a cdma2000 network and the second network may alternatively be a PCS network.

[0029] The switch 30 is in a first position operatively connected to a physical layer 110 of the air interface access stack of the WCDMA RAT 100. The WCDMA physical layer 110 is controlled by a radio resource controller (RRC) block 120, which may also control the switch 30. The RRC block 120 may establish and terminate a connection to the WCDMA system, as well as initiating cell measurements required according to system requirements and do handover. In a second position, the switch is operatively connected to the physical layer 210 of the air interface access stack of the GSM RAT 200. The GSM physical layer 210 is controlled by a management physical layer or radio resource (RR) block 220. The RR block 220 may establish and terminate a connection to the GSM system, as well as initiating cell measurements required according to system requirements and do handover. The RR block 220 may control the switch 30 instead of the RRC block 120. The circuits of the physical layer of the respective RAT's are connected via a first connection 300 (see Fig. 3) for purposes that will be described below. Also, a second connection 301 is provided between the higher layers (layer 2 and layer 3) of the access stacks of the respective RATs 100, 200, for providing high level communication, as will be further described below. Each RAT 100, 200 comprises a central processing unit 130, 230 for executing the functionality of the software that implements the higher layers of the access stacks.

[0030] Fig. 3 illustrates a more detailed block diagram of the mobile telephone 1 and components of the two RATs 100, 200. The WCDMA physical layer 110 comprises a transceiver 150 for transmitting and receiving signals according to WCDMA technology when connected to the antenna 10 via the switch 30. A timing generator 155, for providing a time reference generating means, is adapted to generate a time reference in response to a time event in the time format of the WCDMA RAT. The timing generator 155 may be implemented as an integrated circuit of the ASIC. The timing generator 155 comprises a counter synchronize mechanism 156, which is adapted to generate a synchronization signal, common time event (CTE), which will synchronize a counter 158 of the WCDMA RAT, as will be described below. When the CTE is generated by the counter synchronize mechanism 156 the timing generator 155 will store counter values specific to the WCDMA RAT in a counter value register 157. The register 157 is readable from software executed in a CPU 130, which is specific to the WCDMA RAT 100. A synchronize mechanism 161, e.g. implemented by software instructions run on the CPU 130 or a separate processor (not shown), is adapted to generate a real time event shared between the RATs 100, 200, which indicates that an activation request to initiate measurements has been issued. This function will generate maskable interrupts in both RATs, which will synchronize the measurement initiation and activate the scheduling of the measurements. A high speed serial link (HSSL) interface 162 for communicating data between the WCDMA RAT 100 and the GSM RAT 200 is connected to the CPU 130. Parameters for a measurement gap schedule (MGS) defining the time schedule will be transmitted via the HSSL 162 over a connection 301a, which may be implemented as a serial connection. A memory 153 is connected to the CPU 130, and may be provided as a combined random access memory (RAM) and read only memory (ROM) integrated on the ASIC. The memory 153 may comprise software code portions for providing computer readable instructions for carrying out software implemented features of the invention when run by the mobile telephone 1. The CPU 130 may serve as a means for carrying out said instructions.

[0031] The GSM physical layer 210 comprises transceiver circuitry 250 for exchanging data with the antenna 10 when the switch 30 is in a second position. Similar to the WCDMA RAT 100, the GSM RAT 200 comprises a timing generator 255, for providing a time reference generating means, according to the same principles as the WCDMA timing generator 155. The timing generator 255 comprises a counter synchronize mechanism 256, a counter value register 257, and a counter 258. The counter synchronize mechanism 256 is connected to the counter synchronize mechanism 156 of the WCDMA RAT. A CPU 230, which is specific to the GSM RAT is connected to the timing generator 255 and the transceiver circuitry 250. The transceiver circuitry is adapted to provide communication according to GSM RAT. A synchronize mechanism 261 is adapted to provide synchronization for the measurement activation and may be implemented by computer readable software instructions executable by the CPU 230 or a separate processor. The synchronize mechanisms 161, 261 of the respective RAT 100, 200 may exchange data, which is indicated by a connection 301b. A HSSL interface 262 connected to the GSM CPU 230 is adapted to exchange data with the HSSL interface 162 of the WCDMA RAT 100 over the connection 301a. A memory 253 is connected to the CPU 230, and may be provided as a combined random access memory (RAM) and read only memory (ROM). The memory 253 may comprise software code portions for providing computer readable instructions for carrying out software implemented features of the invention when run by the mobile telephone 1. The CPU 230 may serve as a means for carrying out said instructions.

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[0032] Each RAT 100, 200 is in operation required to provide cell measurements on its respective communication network 17, 20. The measurement requirements of the WCDMA RAT 100 when it is active may be measurements on neighboring cells, inter-frequency measurement, received signal code power, received signal code power after radio link combination, SIR (Signal-to-Interference Ratio), RSSI (Received Signal Strength Indicator), etc. Similarly, there are requirements that the GSM RAT 200 in operation should provide cell measurements, although it is the passive slave RAT. Such measurements comprise e.g. RSSI for a number of different neighboring cells, identification measurement, and reconfirmation measurement. Whenever a cell having superior radio link quality is found, handover from the active to the passive network may be made.

[0033] Interrupts for GSM measurements can be provided in three different categories; interrupt during compressed mode; interrupt during measurement occasions; and interrupt during measurement DRX cycle. Here, interrupt means a temporary suspension of an ongoing process caused by an event outside that process. A number of MGS schedules, as e.g. illustrated in Fig. 4, can be run in parallel. A request to activate each schedule may be issued separately. The activation time of each schedule may be determined with regard to one and the same CTE as illustrated in Fig. 5. Alternatively, each time schedule will have an activation time that is determined with regard to a specific CTE, which is independent of the CTE connected to any other time schedule.

[0034] The MGS according to the invention is a mechanism comprising time schedule parameters for synchronizing the required WCDMA and GSM measurements when the GSM RAT is passive. The available time gaps, wherein the WCDMA RAT is not receiving/transmitting, are determined and indicated by the WCDMA RAT 100. The WCDMA RAT may be in two different RRC (Radio Resource Control) protocol statuses: Idle mode and UTRAN connected mode. In idle mode, measurements are provided according to the discontinuous reception (DRX) cycle. The UTRAN connected mode comprises Cell_PCH, Cell_FACH, Cell_DCH and URA_PCH.

[0035] In Cell_DCH, a DPCH (Dedicated Physical Channel) is assigned to the user equipment (UE), which may be a mobile telephone 1. The UE has identified the cell level by the current Active Set, which is a procedure for updating the active set of communication parameters of the connection between the UE and the UTRAN. The dedicated transport channel, the downlink-shared transport channel and the combination thereof have also been identified.

[0036] In Cell_FACH no DPCH is assigned to the UE. In this state, the UE receives FACH (Forward Access Channel) messages in the downlink, and in the uplink it can use a common channel that can execute transmission from time to time according to access procedures of each transport channel. UTRAN is aware of the location of the UE at cell level (the cell updated by UE most recently).

[0037] In Cell_PCH, URA_PCH and Idle mode, no dedicated channel is assigned to the UE. In the downlink, the UE receives PCH messages via PICH (Paging Indication Channel) by DRX. In the uplink, the UE is not engaged in anything. UTRAN is aware of the location of the UE at UTRAN registration level (the URA (User Registration Area) assigned most recently to the UE during URA Update in Cell_FACH state).

[0038] When the WCDMA RAT is in idle state the DRX cycle will control how often and how much the GSM RAT 200 is allowed to operate. In Cell_FACH the gaps are called measurement occasions in the downlink and some of them are allocated for GSM use. In the uplink, the mobile telephone 1 may itself determine when to transmit. These gaps will never be shorter than 1 WCDMA frame and thereby clearly exceed the 14 WCDMA slot maximum gap allocated in compressed mode. It is required that the GSM system manage to measure RSSI for 16 different neighboring cells in 10ms, which gives 652 µs for each carrier that e.g. can be split into one measure part that is 59 ps (16 GSM symbols) and a tuning part that is 566 µs.

[0039] In Fig. 4, wherein the compressed mode pattern structure is illustrated, the following abbreviations are used:

TGSN	Transmission Gap Starting Slot Number;
TGL1	Transmission Gap Length 1, duration of the first transmission gap within the TGP (Transmission Gap Pattern) expressed in slots;
TGL2	Transmission Gap Length 2, duration of the second transmission gap within the TGP (Transmission Gap Pattern) expressed in slots; if not used in a pattern TGL2=TGL1;
TGD	Transmission Gap start Distance, which is the duration between the starting slots of two consecutive transmission gaps within a TGP expressed in slots. If only one TGL is used, this will not be used;
TGPL1	Transmission Gap Pattern Length 1 is the duration of transmission gap pattern length 1 expressed in number of frames;
TGPL2	Transmission Gap Pattern Length 2 is the duration of transmission gap pattern length 2, if used, expressed in number of frames;
TGPRC	Transmission Gap Pattern Repetition Count is the number of transmission gap patterns within the transmission gap pattern sequence

(continued)

TGCFN	Transmission Gap Connection Frame Number (TGCFN) is the Connection Frame Number (CFN) of the first pattern 1 within the transmission gap pattern sequence.

[0040] Fig. 4 illustrates the compressed mode pattern structure wherein reception/transmission gaps may occur. Compressed mode is based on that the radio transmission and reception of the WCDMA signals are turned off during small intervals to allow measurements on GSM neighboring cells. The transmission gaps in the compressed mode structure are referenced to the WCDMA frame and slot structure. When the WCDMA RAT 100 uses compressed mode it will raise the hardest requirements on the GSM radio, as it provides the shortest gaps. The transmission gap length (TGL) can be 3, 4, 5, 7, 10, and 14 WCDMA slots where 3 and 4 are only used for RSSI measurements, 5 is used only when the GSM cell's timing is known, and 7, 10, or 14 are used for previously not identified cells. Corresponding patterns may be provided for measurement occasion and DRX cycle having gaps wherein the WCDMA RAT 100 is not receiving/transmitting.

[0041] The transmission gap can be placed in one frame. Alternatively the transmission gap crosses the frame boarder. In order to allow efficient measurements, several intervals may be placed within a transmission gap pattern (TGP).

[0042] There are three different measurement patterns for GSM with three different purposes, GSM RSSI measurements, and GSM BSIC identification and reconfirmation. Each pattern has specific requirements. Therefore, the RR block 220 needs information of the available gaps to be able to plan the future measurements. Once the gaps are known the RR block 220 may plan the measurements based on the available gaps.

[0043] The effective transmission gap may be smaller than the TGL due to two factors: the power mask for the uplink (UL) and the timing offset between the UL and downlink (DL). The WCDMA transmitter power mask surrounding the compressed mode gap introduces a margin at the start of the gap and the end of the gap. Since the start of the transmission gap will be used for radio tuning, the margin at the start will not affect the dual RAT operation but the margin at the end will disable the last portion of the transmission gap to be used for dual RAT operation. The most rigid requirement on the GSM radio tuning is the case with TGL 14 and GSM RSSI measurements. In order to get some margin it is preferred to require a radio settling time for the GSM radio. The margin has to be evaluated and tested for each particular case.

[0044] The WCDMA RAT 100 first determines the specific transmission gaps that are required for its own measurements. Any remaining transmission gap may be allocated for measurements made by the GSM RAT 200. Alternatively, the gaps that should be handed over are pre-specified, wherein the WCDMA RAT 100 has to adapt its measurements. The WCDMA RAT 100 provides to the GSM RAT 100 the position of the gaps having reference to the CTE, and a specified activation time. The basic idea is that the activation time of the transmission gap pattern is related to the latest CTE. Considering that an activation start of the pattern is related to the CFN (connection frame number), the request to activate the measurement pattern needs to be sent down from RRC block 120 to the timing generator 155 of the WCDMA physical layer 110 no more than one CFN period in advance of the activation start time. One CFN period corresponds to 25*10 ms. The request to activate the pattern may serve as the event that initiates the generation of the CTE and the MGS. Due to that the CTE could be placed at any chip position, the following parameters need to be registered in the counter value register 157 of the WCDMA RAT 100 at the time of the CTE:

- The current connection frame number: $CFN_{CTE} \in \{0 \ldots 255\}$
- The current slot: $Slot_{CTE} \in \{0 \ldots 14\}$
- The current chip: $Chip_{CTE} \in \{0 \ldots 2559\}$

The CFN is not valid in idle mode, wherein the SFN (cell System Frame Number) has to be used to calculate the correct gaps.

[0045] A measurement activation request may cause a request for a CTE signal to be sent between the timing generators 155, 255, wherein the counter values will be stored in their counter registers 157, 257, as will be discussed below. The values of the WCDMA counter 158 and the GSM counter 258 will be stored approximately simultaneously, i.e. sufficiently simultaneous for providing a common time reference, as the RATs 100, 200 may run on asynchronous clocks. The parameters registered in the GSM RAT 200 are:

- The current frame number (FN) in the GSM multiframe structure $\in \{0 \ldots 51\}$;
- The position within the current frame $\in \{0 \ldots 4999\}$ [GSM quarter bit (QB)].

Alternatively, the complete representation of the frame number in the GSM stack is registered, which is in the range of [0...2715647].

[0046] In total, three different GSM related compressed mode patterns, or any other pattern where appropriate,

should be able to be configured to take care of the different GSM measurement requirements. This requires that the activation start of all three patterns need to refer to the same CTE. The relationship between the CTE, the measurement activation request and the activation time of the compressed mode patterns is illustrated in Fig. 5. Similar patterns may be specified for any other possible pattern, such as Idle mode and measurement occasion patterns. The configuration of activation time can be done for all patterns at once or pattern by pattern. The distance between the CTE and each activation time is denoted as $Chip_{CTE\_active\#\_delta}$, wherein #=1..3 in Fig. 5. The $Chip_{CTE\_active\#\_delta}$ is based on the sum of the distance between the CTE and the CFN when the activation is requested, (CFN_{req}), and the remaining distance between the CFN_{req} and the TGCFN.

[0047] Due to the time delay, which is caused by path drift of the received signals compared to the internal clock of the WCDMA RAT 100, between the channel timing and the counter 158 of the WCDMA RAT 100 a delay term T_{CTE_ALIGN} expressed in chips may be introduced to improve the accuracy of the time schedule, where:

$$T_{CTE\_ALIGN}=T_{channel\_delay}+T_{CTE}\ [chip];$$
$$T_{CTE}=Chip_{CTE}-Slot_{CTE}*2560\ [chip];\ and$$
$$T_{channel\_delay}=path\ delay \in \{0...38399\}\ [chip].$$

[0048] Path delay is the chip timing reference for the downlink DCH. $Chip_{CTE}$ and $Slot_{CTE}$ are the chip and slot, respectively, in which the CTE is executed.

[0049] Each of the distances from the CTE to the activation time expressed in chip may be calculated as:

$$Chip_{CTE\_req\#\_delta}= T_{CTE\_ALIGN}+ (REP_{256}+mod_{CFN} (CFN_{req}-CFN_{CTE}, 256)) *15*2560;$$
$$Chip_{req\_active\#\_delta}=mod_{CFN} (TGCFN- CFN_{req}, 256)) *15*2560$$
$$Chip_{CTE\_active\#\_delta}=Chip_{CTE\_req\#\_delta}$$
$$+Chip_{req\_active\#\_delta}+TGSN*2560;$$

where mod_{CFN} is a modulo 256 function and REP_{256} is the counter 158 of the WCDMA RAT 100 that starts at 0 and is updated each time the CFN is equal to the CFN_{CTE}. As the first activation request is made before the CTE, the CFN_{req} shall be set to CFN_{CTE} for the calculation of the first distance $Chip_{CTE\_activ1\_delta}$.

[0050] The counter parameters in the WCDMA RAT 100 are expressed in WCDMA time format, whereas the counter parameters in the GSM RAT 200 are expressed in GSM time format. The WCDMA RAT 200 is the active RAT, and therefore all arithmetic operations should be made in chips to avoid summation and truncation errors. Therefore, it is necessary for the GSM RAT 200 to convert the values of the parameters determined by the WCDMA RAT 200 into QB, which is made by multiplying each parameter with the quota 325/1152.

[0051] The parameters of the MGS will define a common time schedule for providing the GSM and WCDMA measurements, and may comprise:

Schedule ID (SI) ∈ {1...6}:

[0052] This parameter identifies the schedule, which will be needed in those situations when more than one schedule are active simultaneously. The value for this parameter is given by the Transmission Gap Pattern Sequence Identifier (TGPSI ∈ {1...6} in compressed mode). In other states there will only be one schedule running at the same time, i.e. one value for the SI.

Schedule Start Time (SST) ∈ {0...2^{32}-1} [chip]:

[0053] This parameter sets the activation time for a schedule in relation to the common time reference that is shared between the WCDMA RAT 100 and the GSM RAT 100 as a common time event (CTE). SST is pointing at the first gap occurrence, as is indicated in Fig. 4. The 32-bit range permits a time range up to 18 minutes and 38 seconds. This range is, however, for exemplification and has to be tested and evaluated in each particular case.

Schedule Transmission Gap Pattern Length 1 and 2 (STGPL1 and STGPL2) ∈ {0...19660800} [chip]:

[0054] STGPL1 sets the distance between the starting point of TG1 in pattern 1 and pattern 2 (or STGPL1 in the next pattern if no pattern 2 is defined). STGPL2 sets the distance between the starting point of TG1 in pattern 2 and pattern 1. The sum of these two parameters is the cyclic length of the schedule. If STGPL2 is assigned 0, there is only one pattern that is repeated. The values for these parameters are given by the TGPL in compressed mode (1...144 WCDMA frames). The distance between two measurement occasions that are assigned for GSM measurements called measurement period (80...640 ms if there are no inter-frequency neighbors and 160...1280 ms if there are inter-fre-

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quency neighbors) and inter RAT measurement periods during the DRX cycle (80 ms to 5.12 s) is calculated by WCDMA physical layer 110 in Idle, Cell_PCH and URA_PCH. This gives a range from 0 to 19660800 chip (DRX 5.12 s has to serve as upper limit - twice the length can be achieved if combining STGPL1 and STGPL2).

Schedule Transmission Gap Length 1 and 2 (STGL1 and STGL2) ∈ {0 ... 19660800} [chip] :

[0055] These parameters set the length of the gaps given by the schedule for GSM to measure in. The values for the parameters are given by the transmission gap lengths (TGL) in compressed mode (3, 4, 5, 7, 10 and 14 WCDMA slots), the length of the measurement occasions (1, 2, 4, and 8 WCDMA frames) or the inter RAT measurement periods during the DRX cycle (80 ms to 5.12 s) calculated by WCDMA physical layer 110 in Idle Cell_PCH and URA_PCH. This gives a range from 0 chips to 19660800 chips (DRX 5.12 s serves as upper limit since a complete DRX cycle will never be handed over to GSM). If STGL is assigned 0, a gap does not exist, which may be the case for STGL2.

Schedule Transmission Gap start Distance (STGD) ∈ {0...19660800} [chip] :

[0056] This parameter sets the distance between the starting points for STGL1 and STGL2. The parameter is only valid if STGL2 is greater than 0. The value for this parameter is given in compressed mode by the parameter TGD that is in the range 15...269 WCDMA slots. In measurement occasions and in the inter RAT measurement periods during the DRX cycle maximum STGPL will serve as upper limit, i.e. 19660800 chips. If there is only one gap during the pattern defined by STGPL, then STGD is set to 0.

[0057] The values of the MGS when the WCDMA RAT 100 is in Cell_DCH may be determined as:

SI	TGPSI ∈ {1..6} (Transmission Gap Pattern Sequence Identifier;
SST	$Chip_{CTE\_active\_delta}$+1024 (adjustment for UL-DL time difference);
STGPL1	TGPL1*2560;
STGPL2	TGPL2*2560;
STGL1	TGL1*2560-2048 (adjustment for receiver-transmitter timing difference and UL-DL time difference; adjustment is not necessary in e.g. downlink compressed mode);
STGL2	TGL2*2560-2048 (adjustment for receiver-transmitter timing difference and UL-DL time difference; adjustment is not necessary in e.g. downlink compressed mode); and
STGD	TGD*2560.

[0058] In Cell_FACH the corresponding MGS parameters may be determined as:

SI	1 [no unit] (constant value since only one schedule will be active at the same time in this state);
SST	$Chip_{CTE\_active\_delta}$;
STGPL1	0;
STGPL2	0;
STGL1	N*2560*15;
STGL2	0; and
STGD	0.

[0059] Finally, in idle state the MGS parameters can be determined as:

SI	1 [no unit] (constant value since only one schedule will be active at the same time in this state;
SST	Distance from CTE to first occasion of the MGS schedule;
STGPL1	According to the periods given by the DRX periods
STGPL2	0 (can be used (i.e. not zero) if several gaps need to be defined during one cycle in the schedule);
STGL1	According to planning (based on the DRX periods) performed by the active RAT;
STGL2	0 (can be used (i.e. not zero) if several gaps need to be defined during one cycle in the schedule); and
STGD	0 (can be used (i.e. not zero) if several gaps need to be defined during one cycle in the schedule).

[0060] The CTE which is used to synchronize common time reference of the MGS may be provided by a hardware supported interrupt, i.e. an event caused by an external device which interrupts the ongoing process in the active RAT. The interrupt will call for the counter values to be stored in the counter value registers 157, 257.

[0061] Fig. 6 illustrates the steps according to one embodiment of the invention for providing the interrupt by issuing the CTE and storing the counter values in response thereto, which provides a common time reference. In a first step 400, it is detected by the controller 130 of the WCDMA physical layer 100 that there is a need for synchronization, i. e. a CTE is needed. An activation request to start a specific measurement pattern from the network may initiate the CTE procedure. Alternatively, the RRC block 120 may (on its own request, e.g. according to instructions which control the operation of said RRC block 120) initiate an activation of the synchronization. The need may be initialized by software run by the controller 130, which will transmit a request for a CTE to the synchronize mechanism 161 of the WCDMA 100. Said synchronize mechanism 161 will then in step 401 issue a synchronization request, which is transmitted to the GSM synchronize mechanism 261. If the GSM access means is run on an internal clock, in a clock evaluation/reconfiguration step 402 a request for an external clock reference will be issued. The external clock reference is necessary if it is required that the timing generator 255 of the GSM RAT 200 have to clock the counter 258 and the counter value register 257 from an external clock to achieve sufficient accuracy and not store erroneous values. An external clock (not shown), such as an voltage controlled oscillator, may serve as the external clock reference, which will clock the counter 258 and register 257 of the GSM RAT 200, and the WCDMA RAT 100 whenever appropriate. Step 402 may be omitted in alternative embodiments of the invention, wherein the external clock reference is not required. In step 403 the CTE is generated by the counter synchronize mechanism 256 of the GSM RAT 200. The CTE is e.g. generated by writing a bit in the HW interface between the GSM RAT 100 and the WCDMA RAT 100. The CTE is in step 404 communicated e.g. over line 300. In step 405 the CTE is received by the counter synchronize mechanism 156 of the WCDMA RAT 100, wherein the CTE interrupt is served in that the counter values are registered. The values are registered approximately simultaneously and stored in the respective counter value registers 157, 257, thus generating the common time reference.

[0062] In an alternative embodiment, the WCDMA timing generator 155 will generate the CTE. If it is not required that either of the RATs 100, 200, are clocked from an external clock reference, it is not necessary to involve the synchronize mechanisms 161, 261. Either of the timing generators 150, 250 may then issue the CTE.

[0063] Step 402 provides the possibility for the GSM RAT to wake up and reconfigure its internal clocks against the external clock reference whenever needed.

[0064] Fig. 7 illustrates the steps carried out according to the invention when interrupts are provided during compressed mode or measurement occasions, i.e. when the WCDMA RAT is in Cell_DCH or Cell_FACH. The MGS is utilized, as the GSM RAT 100 has to plan measurements in advance. Then, the GSM RAT 100 is able to start the correct measurement as soon as the GSM radio is switched on and the WCDMA transceiver 150 is switched off. The synchronization procedure will e.g. start at power on if the WCDMA stack is active. Alternatively, the procedure starts if the active state of the WCDMA RAT 100 is changing or in response to a resynchronization request from the RRC block 120. The start of the procedure will establish measurement synchronization between the GSM and WCDMA RAT 100, 200 and possibly initiate CTE generation. The procedure will be ended when the WCDMA access stack enters into a passive state or into a power off state, or the state is changed.

[0065] The method of Fig. 7 is started in step 500, wherein a measurement configuration request is received by the mobile telephone 1 from the WCDMA telecommunication network 17, to which the WCDMA RAT presently is connected. The configuration request comprises any information necessary to determine the MGS, such as which gaps that may be used by the WCDMA RAT 100 and the GSM RAT 200, respectively. The measurement configuration data, i.e. compressed mode pattern or FACH measurement occasion is stored in step 501, and may be retrieved by the RRC block 120, which will plan the measurements of the WCDMA RAT 100. In step 502 the activation time of the time schedule is determined. The activation time is in Cell_DCH set by the WCDMA telecommunication network 17, whereas the activation time in Cell_FACH is obtained by the WCDMA physical layer 110, e.g. by the CPU 130, based on information received from the UTRAN. In step 503 the transmission gaps, which may be utilized by the GSM RAT 200, are determined. The gaps, which may be utilized by the GSM RAT 200, are in compressed mode given in the measurement configuration data. In Cell_FACH measurement occasions the transmission gaps are divided between the WCDMA RAT 100 and the GSM RAT 200, e.g. according to the 3GPP specification. The CPU 130 determines based on the received information, which gaps should be utilized for WCDMA RAT measurements, such as inter-frequency measurements, and which gaps should be utilized for GSM measurements. In step 504, the parameters of the MGS are obtained. The activation time and the parameters that will be handed over to the GSM RAT 100 are translated into MGS parameters. The parameters of the time schedule are determined based on the common time event CTE, which is issued in response to the activation request of the time schedule prepared in the current step. The MGS parameters including the activation time are forwarded to the GSM RAT in step 505. The GSM RAT 200 receives the MGS parameters in step 506, and translates said parameters into GSM time reference in step 507. In step 508 the planning of the GSM measurements commences, which is also the end of the procedure. The GSM measurements executed by GSM physical layer 210 may now start according to the activation time given in the MGS schedule and is e.g. controlled by the RR block 220 using said schedule.

[0066] Fig. 8 illustrates an alternative embodiment of the steps carried out according to the method of the invention

when interrupts are provided during DRX measurement cycle, i.e. when the WCDMA RAT is in idle, in Cell_PCH, or URA_PCH state. The procedure is started at power on of the mobile telephone 1 if the WCDMA access stack is active, if any WCDMA active state is changing, or if a resynchronization is requested. The WCDMA physical layer 110 may initiate the synchronization procedure for the MGS method in order to establish synchronization. In a first step 600, the RRC block 120 receives information from the WCDMA network 17 to be able to plan the measurements, such as DRX cycle length and any setup/reconfiguration message. In step 601 the WCDMA physical layer 110 plans for the DRX measurement cycle, i.e. determines which gaps should be utilized for WCDMA RAT and GSM RAT measurements, respectively. A requested activation time is also determined. In step 602 the parameters determined in step 601 are translated into MGS format having reference to a specific CTE. Inter RAT measurement rules, which are known to the WCDMA RAT 100 and which were taken into account when the MGS schedule was obtained, determine when GSM measurements are to commence. In step 603 the RRC block 120 checks whether the GSM RAT 200 shall measure within a predetermined time limit. If so, the MGS schedule is forwarded to the GSM RAT in step 604. Otherwise, the procedure waits in step 603 until a GSM measurement is to commence or the procedure is ended. Alternatively, the time schedule is directly handed over to the GSM RAT 200 as soon as it is obtained. The GSM RAT 200 receives the MGS parameters including a start time for the schedule in step 605. The MGS parameters are translated into GSM reference time in step 606. The RR block 220 may start planning for the GSM measurements in step 607, wherein the WCDMA RAT 100 and the GSM RAT 100 have knowledge of when to execute measurements according to the obtained MGS.

[0067] One difference for the common timing between the idle mode and Cell_DCH or Cell_FACH is that the time references for the different RATs 100, 200 are not locked to each other. This requires that the MGS has to be resynchronized continuously.

[0068] The WCDMA physical layer 110 will start the execution of the measurement patterns, i.e. compressed mode patterns, FACH measurement occasions, or DRX measurement cycle, and may handle the common radio resources, such as the switch 30 and the antenna 10, according to the MGS schedule. The GSM physical layer 210 executes its measurements according to the MGS schedule and will have control over the common radio resources during these measurements when the WCDMA transceiver 150 is temporarily inactive. Alternatively, when separate antennas 10a, 10b are provided no control over the radio resources is necessary, but simultaneous activation (transmission/reception) of the WCDMA RAT 100 and the GSM RAT 200 is avoided by means of the WCDMA and GSM physical layer 110, 210 having knowledge of the MGS schedule.

[0069] The RR block 220 will control the measurements at GSM physical layer 210 using MGS schedule. The measurements are scheduled according to the starting time given by the MGS schedule. In idle state the source of the MGS is DRX measurement. The RRC block 120 will request input information for the MGS schedule from WCDMA physical layer 110, since the WCDMA physical layer 110 is executing the planning of the activities during the cycle to be able to control the measurements.

[0070] The GSM radio transceiver 250 may be active immediately when the WCDMA radio transceiver 150 has been switched off. To ensure that the WCDMA transceiver has been completely switched off before the GSM transceiver 250 is activated a first time margin may be added after the WCDMA transceiver 150 is switched off. Similarly, a second time margin may be added when the GSM transceiver 250 is switched off and the WCDMA transceiver is activated. During the first time margin, the switch 30 may be controlled to switch from the first to the second position. The WCDMA CPU 130 may e.g. control the switching of the switch 30 from the first position, wherein the WCDMA transceiver 150 is connected to the antenna 10, to the second position when the WCDMA transceiver 150 is properly switched off. Similarly, the GSM CPU 230 may control the switch 30 to switch from the second to the first position when the GSM transceiver 250 is properly switched off.

[0071] The WCDMA physical layer 110 is adapted to detect a number of situations wherein the GSM RAT measurements are to be interrupted, which creates a MGS exception. Such exceptions are e.g. during altering state (leaving Cell_FACH), RACH (Random Access CHannel) procedure, BCH (Broadcast CHannel) reading due to paging, SFN (cell System Frame Number), (BCH) reading on neighbors in Cell_FACH and Cell_DCH, compressed mode patterns ends (TGPRC parameter in compressed mode, colliding compressed mode patterns, and state transition, i.e. transition between idle, Cell_PCH, and Cell_FACH). The exceptions are preferably detected by the WCDMA RAT 100, as it is the active RAT requiring the exceptions. In all exceptions, the GSM RAT 100 is notified by an exception interrupt signal, which indicates that GSM measurements should be discontinued, wherein all ongoing measurements are stopped. As soon as the exception is taken care of by the WCDMA RAT 100, the GSM RAT 200 may be informed that GSM measurements may be resumed. In such a case, stored MGS parameters may be utilized for the resumed measurements. The stored parameters may have to be evaluated to secure their validity. The time range for the MGS may have expired, wherein a resynchronization has to be provided. Alternatively, a resynchronization of the RATs 100, 200 is always executed after an exception has been taken care of.

[0072] The MGS procedure according to any of the above embodiments is completely stopped when the WCDMA access stack e.g. enters into a passive state, or is switched off.

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[0073] The present invention has been described above with reference to a mobile telephone. However, the invention may be provided in any portable radio communication equipment, such as a mobile radio terminal, a pager, or a communicator, i.e. an electronic organizer, smartphone or the like having dual RAT capabilities.

[0074] The present invention has been described above with reference to specific embodiments. However, other embodiments than the above described are equally possible within the scope of the invention. Different method steps than those described above, performing the method by hardware or software, may be provided within the scope of the invention. The different features and steps of the invention may be combined in other combinations than those described. The invention is only limited by the appended patent claims

Claims

1. A method for synchronizing measurements in a mobile communication apparatus having a first active radio access means (100) adapted to communicate according to a first radio access technology and a second passive radio access means (200) adapted to communicate according to a second radio access technology, **characterized by:**

   generating a time reference common to the first and the second access means (100, 200);
   obtaining at least one time schedule, said schedule indicating a time gap during which the second access means (200) is allowed to be active; and
   determining an activation time of the time schedule based on the common time reference.

2. The method according to claim 1, wherein, when activation of the time schedule is requested, said request initiates a common time event (CTE), in response to which the time reference is generated in the first and the second access means (100, 200).

3. The method according to claim 2, wherein the CTE is a hardware supported interrupt.

4. The method according to claim 2 or 3, wherein counter values of first and second counters (158, 258) provided in the first and the second access means (100, 200), respectively, are registered in response to the CTE.

5. The method according to claim 4, wherein the current connection frame number, current slot, and current chip are registered by the first access means (100) in response to the CTE.

6. The method according to claim 4 or 5, wherein the current frame number in a GSM multiframe structure, and the position within said frame is registered by the second access means (200) in response to the CTE.

7. The method according to any of the previous claims, wherein the time schedule is obtained based on information received from a first communication network (17) to which the first access means (100) is connected.

8. The method according to claim 7, wherein the received information comprises configuration data specifying gaps, in which the second access means (200) is allowed to be active.

9. The method according to claim 7, wherein the received information comprises setup or reconfiguration information, and the first access means (100) obtains the gaps based on stored and received data.

10. The method according to any of the previous claims, wherein the duration of said gap, and the distance between the common time reference and said gap, are given in the time schedule.

11. The method according to any of the previous claims, wherein several time gaps are determined in the time schedule, and the distance between said gaps is specified in the schedule.

12. The method according to claim 4, wherein a delay between channel timing and the counter (158) of the first access means (100) is taken into account when determining the activation time of the time schedule.

13. The method according to any of the previous claims, wherein the time schedule, which is obtained by the first access means (100), is determined in the time format of a first RAT.

14. The method according to claim 13, wherein the time schedule is translated into the time format of a second RAT

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by the second access means (200).

15. The method according to any of the previous claims, wherein the time schedule is utilized by the second access means (200) to provide cell measurements.

16. An arrangement for synchronizing measurements in a mobile communication apparatus, comprising

a first active radio access means (100) comprising a first transceiver means (150) for communicating with a first communication network (17), said first transceiver means being adapted to communicate according to a first radio access technology;
a second passive radio access means (200) comprising a second transceiver means (250) for communicating with a second communication network (20), said second transceiver means being adapted to communicate according to a second radio access technology;

characterized by:

a time reference generating means (155, 255) for generating a time reference common to the first and the second access means (100, 200);
a time schedule generating means (130) for obtaining at least one time schedule, said schedule indicating at least one time gap, during which the second access means (200) is allowed to be active; and
said time schedule generating means (130) being adapted to determine the activation time of the schedule based on the common time reference.

17. The arrangement according to claim 16, wherein the time reference generating means (155, 255) is adapted to generate a common time event (CTE), and to generate the time reference in response to the CTE in the first and the second access means (100, 200).

18. The arrangement according to claim 17, wherein the time reference generating means (155, 255) comprises first and second counter synchronize mechanisms (156, 157) provided in the first and second access means (100, 200), respectively, one of said mechanisms being adapted to generate an interrupt being the CTE, which the other mechanism is adapted to receive.

19. The arrangement according to claim 18, wherein either or both of the counter synchronize mechanisms (156, 157) are adapted to write a bit onto a connection to the other, said bit being said interrupt.

20. The arrangement according to any of the claims 17 to 19, wherein the time reference generating means comprises first and second counter means (158, 258), and first and second counter value register means (157, 258) provided in the first and second access means (100, 200), respectively.

21. The arrangement according to claim 20, wherein the counter (158) of the first access means (100), in operation, is adapted to generate current connection frame number, current slot, and current chip, which the time reference generating means (155, 255) is adapted to store in the first counter value register means (158) in response to the CTE.

22. The arrangement according to claim 20, wherein the counter (258) of the second access means (200) is adapted to generate the current frame number in GSM multiframe structure, and the position within said frame, which the time reference generating means is adapted to store in the second counter value register means (258) in response to the CTE.

23. The arrangement according to any of the claims 16-22, wherein the time schedule generating means (130) is adapted to obtain the time schedule based on stored information and data received from the first network (17) during operation.

24. The arrangement according to any of the claims 16 to 23, wherein the time schedule generating means (130) is adapted to incorporate into the time schedule parameters that identify the duration of the gap, and the distance between the common time reference and the at least one gap.

25. The arrangement according to any of the claims 16 to 24, wherein the time schedule generating means (130) is

adapted to incorporate into the time schedule several time gaps, and to specify the distance between said gaps in the schedule.

26. The arrangement according to any of the claims 16 to 25, wherein the time schedule generating means (130) is adapted to in operation determine the time schedule in the time format of the first access technology.

27. The arrangement according to claim 26, wherein a processor means (230) of the second access means (200) is adapted to in operation translate the time schedule into the time format of the second access technology.

28. The arrangement according to any of the claims 16 to 27, wherein the second access means (200) is adapted to provide cell measurements during the gaps given in the time schedule, and wherein the first access means (100) is adapted to be passive.

29. The arrangement according to any of the claims 16 to 28, wherein the first radio access technology is WCDMA (Wideband Code Division Multiple Access).

30. The arrangement according to any of the claims 16 to 29, wherein the second access technology is GSM (Global System for Mobile communication).

31. The arrangement according to any of the claims 16 to 30, wherein said first and second access means (100, 200) have at least one common radio resource (10, 30).

32. The arrangement according to claim 31, wherein the common radio resource is an antenna (10).

33. A computer program product directly loadable into a memory (153, 253) of a mobile terminal (1) having digital computer capabilities, comprising software code portions for performing the steps of claim 1 when said product is run by said mobile terminal (1).

34. Use of an arrangement according to any of the claims 16 to 32 in a wireless communication apparatus (1).

35. The use of the arrangement according to claim 34, wherein the apparatus is a mobile radio terminal, a mobile telephone (1), a pager or a communicator.

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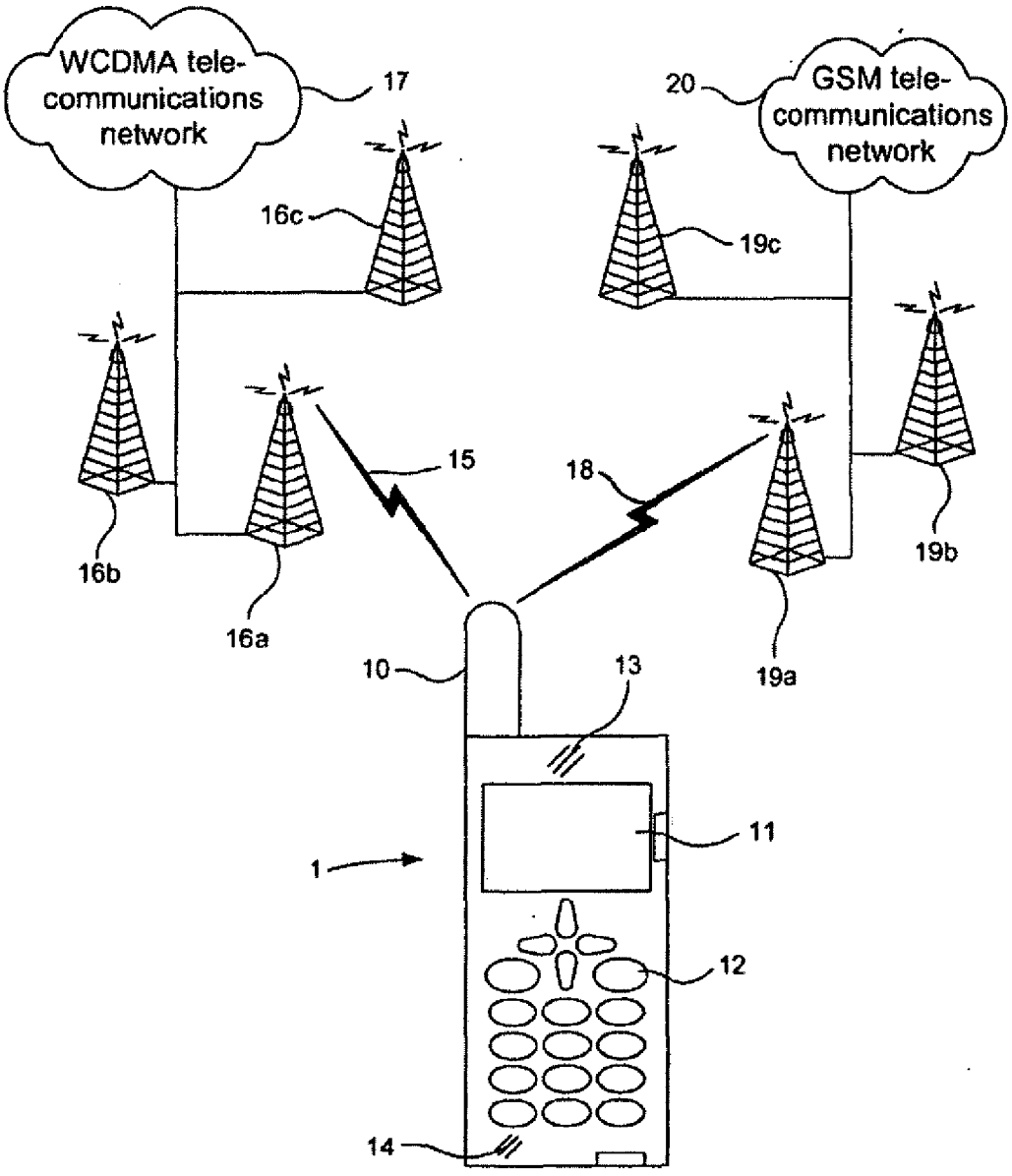

WCDMA tele-communications network
17
20
GSM tele-communications network
16c
19c
16b
15
18
19b
16a
19a
10
13
11
1
12
14

Fig. 1

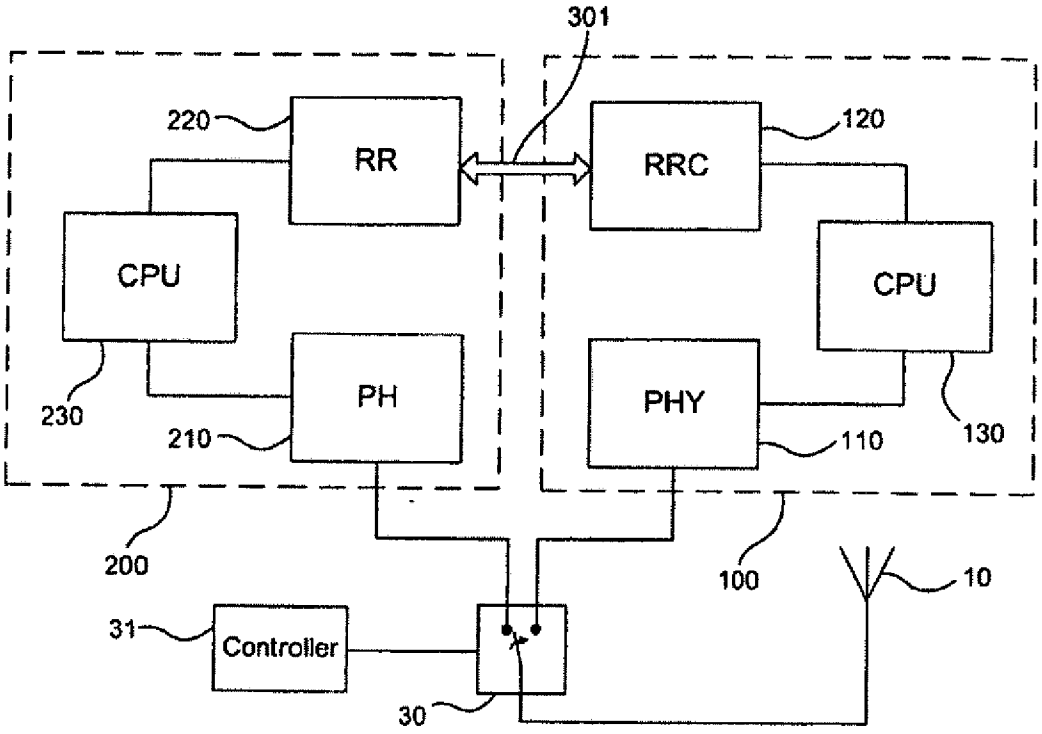

301
220
RR
RRC
120
CPU
CPU
230
PH
PHY
210
110
130
200
100
10
31
Controller
30

Fig. 2a

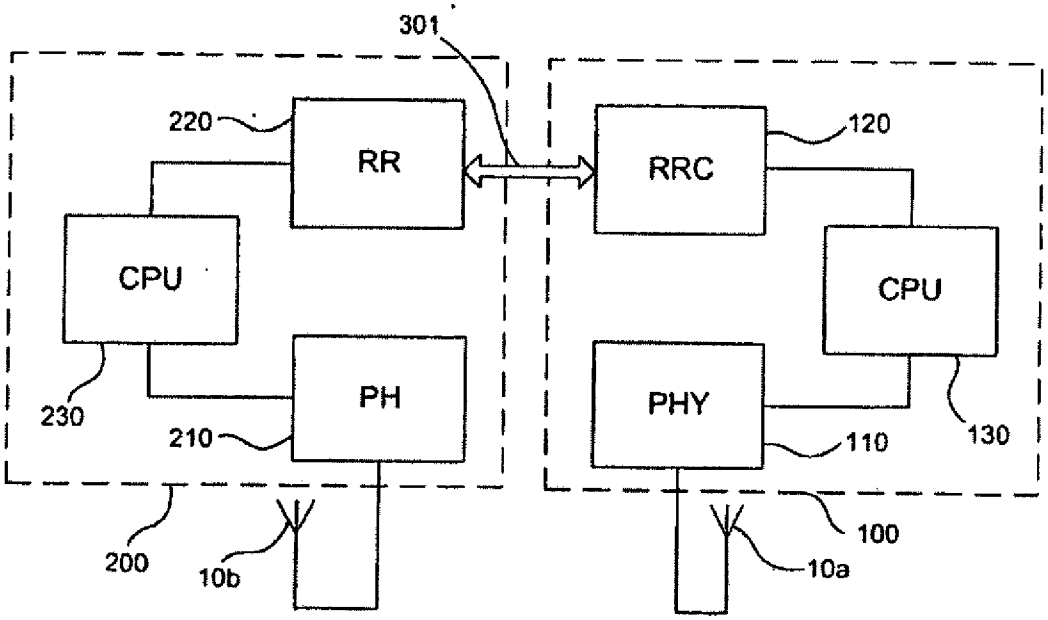

301
220
RR
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120
CPU
CPU
230
PH
PHY
210
110
130
200
100
10b
10a

Fig. 2b

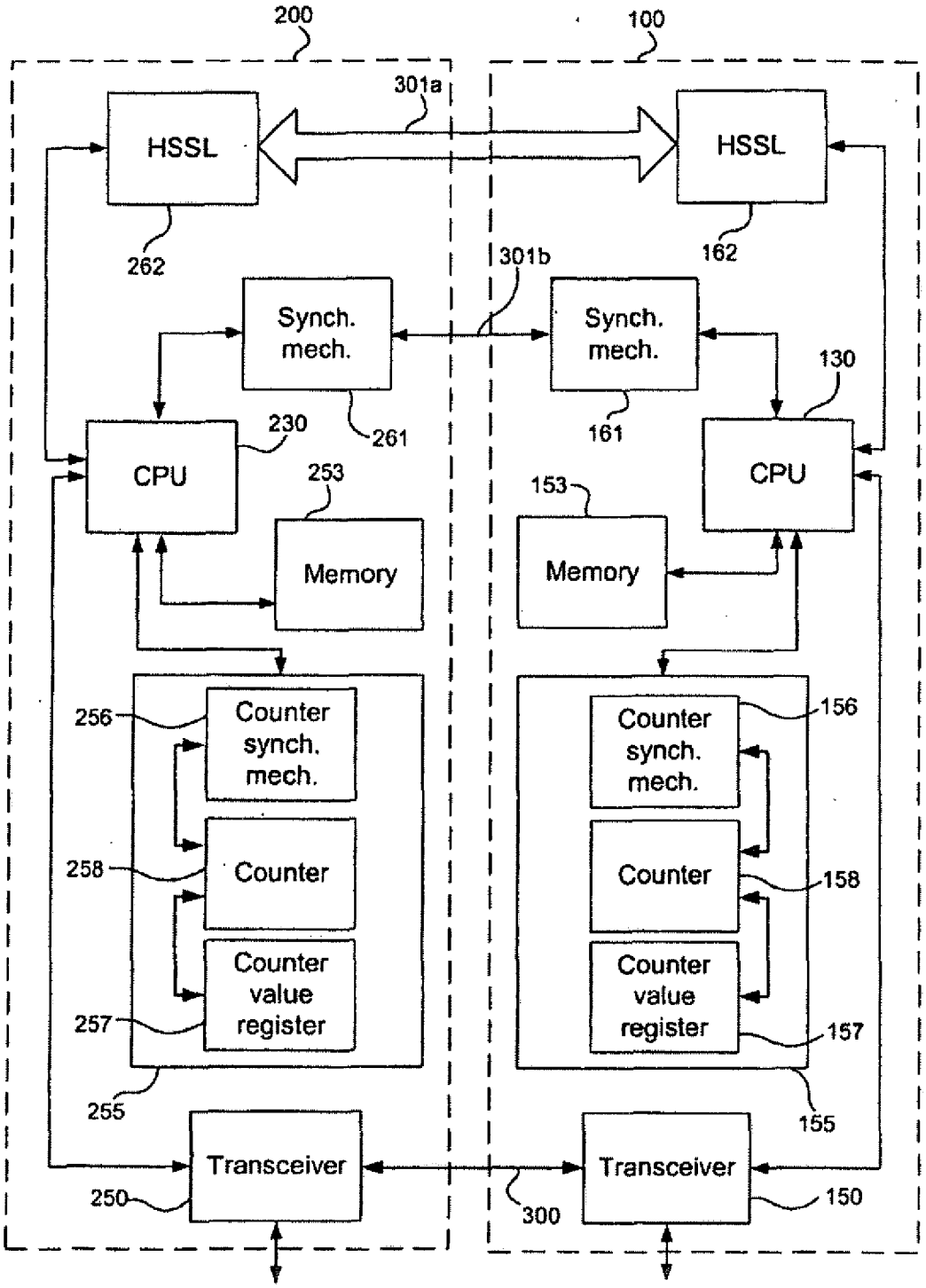

200
100
301a
HSSL
HSSL
262
162
301b
Synch. mech.
Synch. mech.
130
230
261
161
CPU
CPU
253
153
Memory
Memory
256
Counter synch. mech.
156
Counter synch. mech.
258
Counter
Counter
158
Counter value register
Counter value register
257
157
255
155
Transceiver
Transceiver
250
300
150

Fig. 3

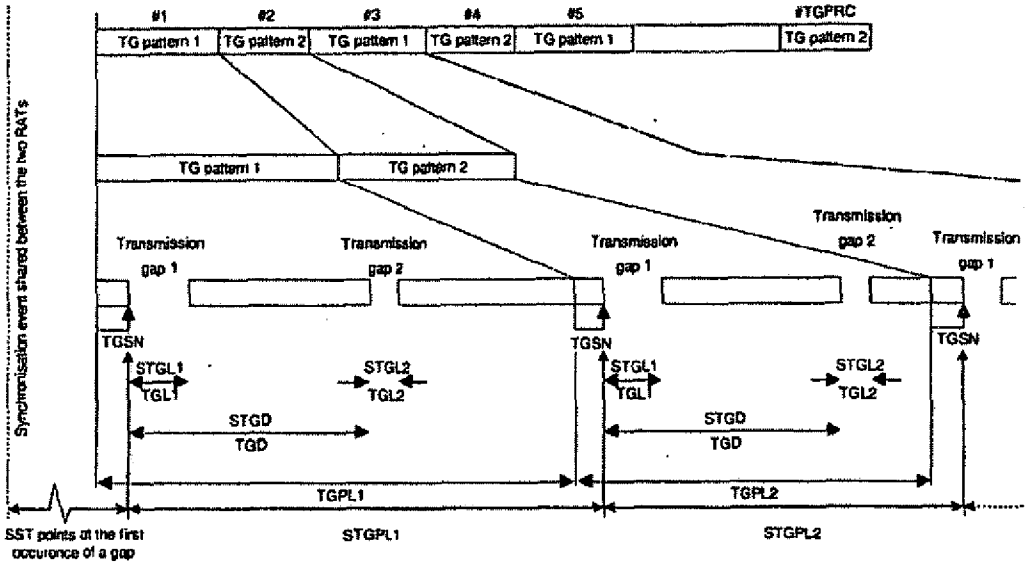

#1
#2
#3
#4
#5
#TGPRC
TG pattern 1
TG pattern 2
TG pattern 1
TG pattern 2
TG pattern 1
TG pattern 2
TG pattern 1
TG pattern 2
Transmission gap 1
Transmission gap 2
Transmission gap 1
Transmission gap 2
Transmission gap 1
TGSN
TGSN
TGSN
STGL1
TGL1
STGL2
TGL2
STGL1
TGL1
STGL2
TGL2
STGD
TGD
STGD
TGD
TGPL1
TGPL2
Synchronisation event shared between the two RATs
SST points at the first occurence of a gap
STGPL1
STGPL2

Fig. 4

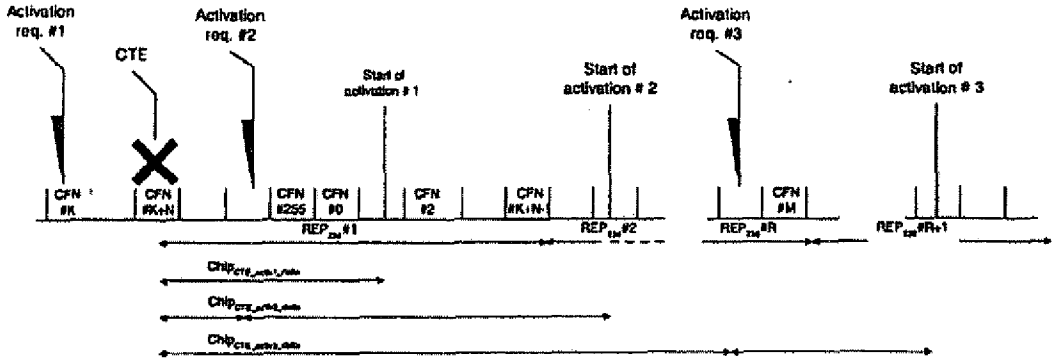

Activation req. #1
CTE
Activation req. #2
Start of activation # 1
Start of activation # 2
Activation req. #3
Start of activation # 3
CFN #K
CFN #K+N
CFN #255
CFN #0
CFN #2
CFN #K+N'
CFN #M
REP#1
REP#2
REP#R
REP#R+1

Fig. 5

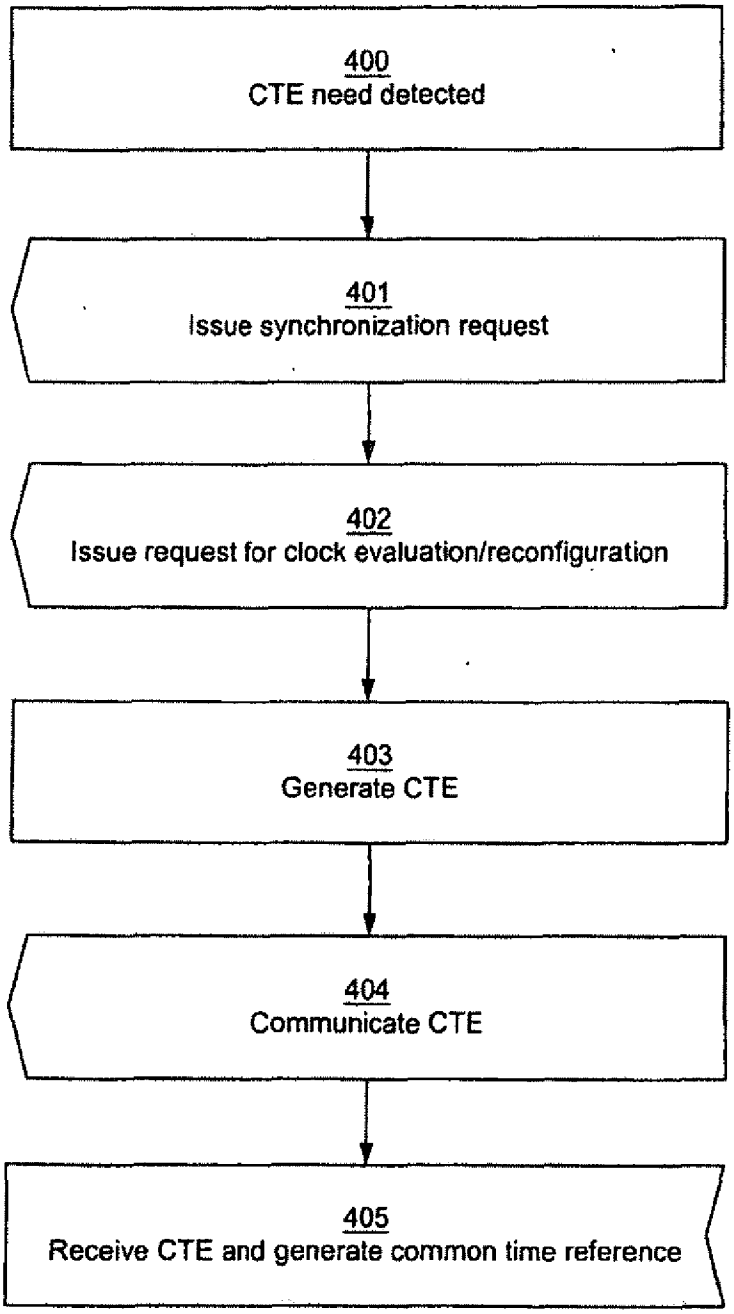

400
CTE need detected
401
Issue synchronization request
402
Issue request for clock evaluation/reconfiguration
403
Generate CTE
404
Communicate CTE
405
Receive CTE and generate common time reference

Fig. 6

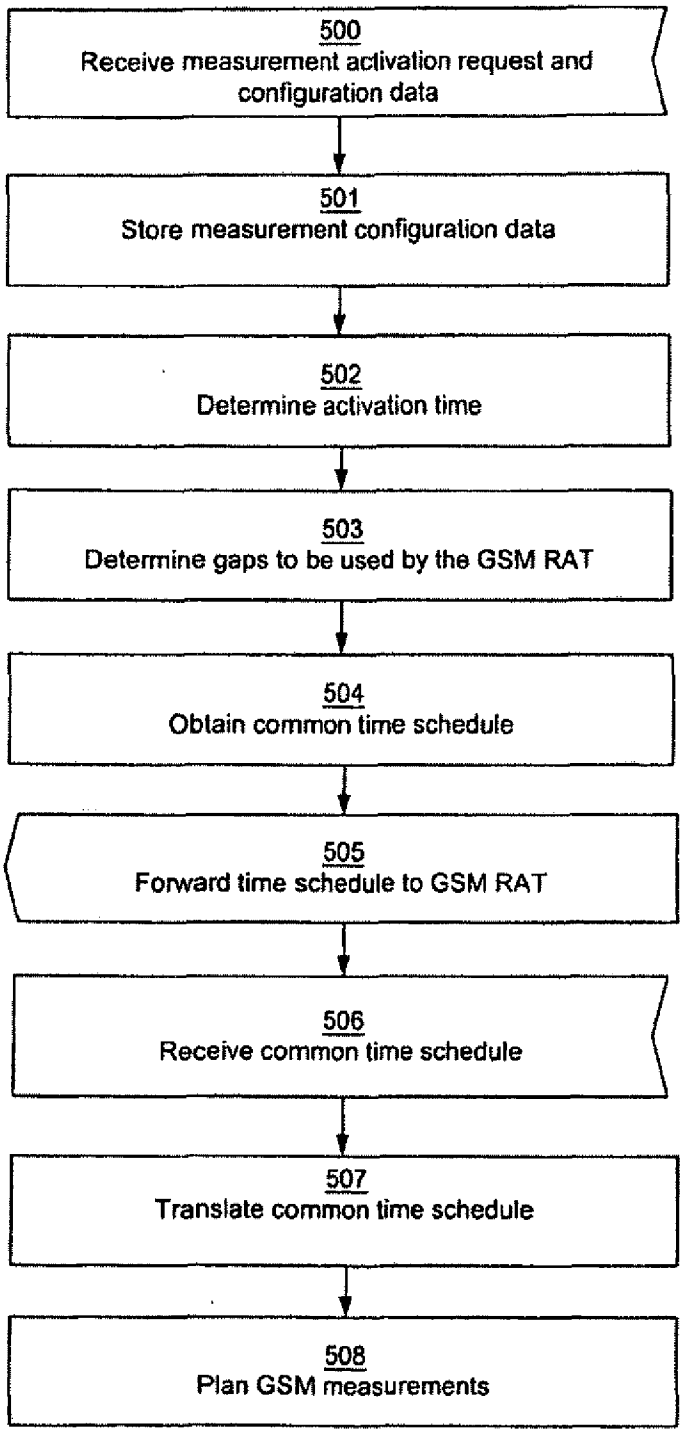


Fig. 7

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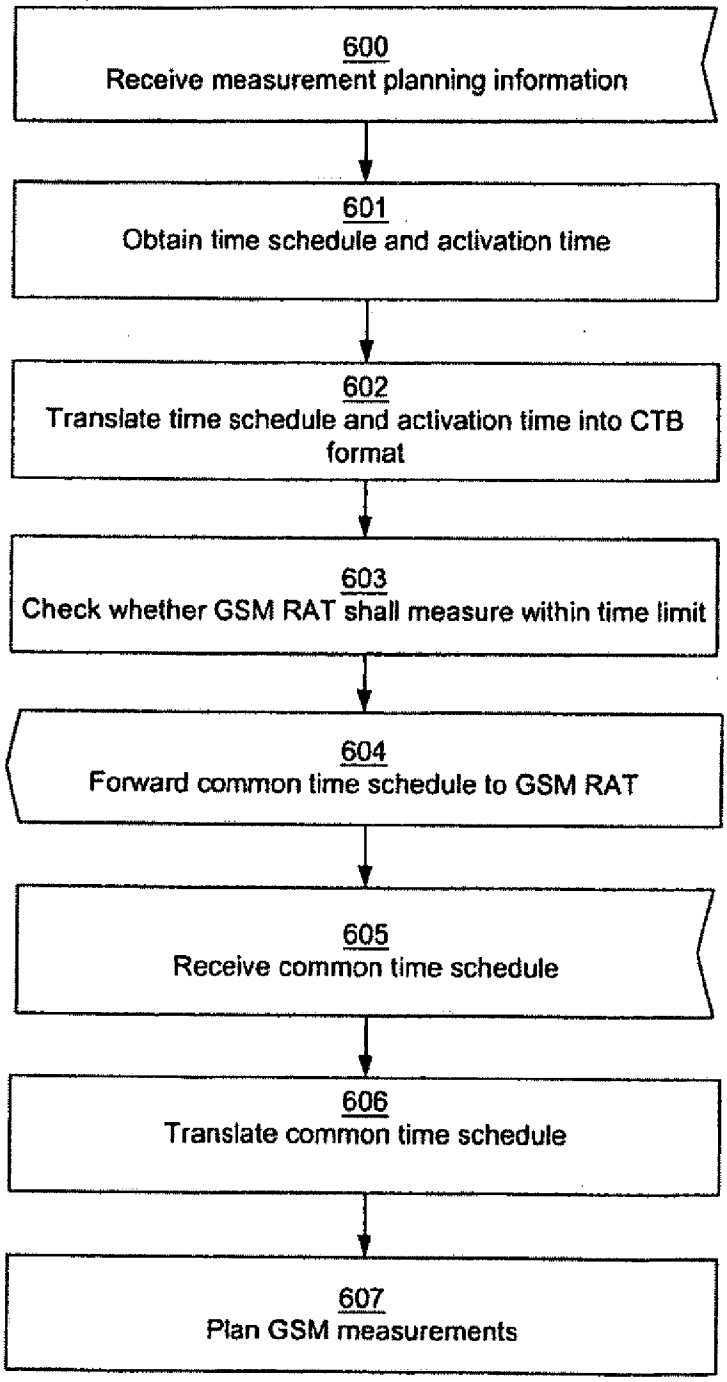


Fig. 8

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 00 8440

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	WO 02 39758 A (SCHNIEDENHARN JOERG ;BREUER VOLKER (DE); SIEMENS AG (DE); WEGNER F) 16 May 2002 (2002-05-16) * abstract * * page 1, line 34 - page 5, line 14 * * page 6, line 14 - page 8, line 22 * * page 10, line 5-18 * * claims * ---	1-35	H04Q7/32 H04Q7/38
A	EP 1 030 477 A (NOKIA MOBILE PHONES LTD) 23 August 2000 (2000-08-23) * abstract * * column 1, line 3-12 * * column 3, line 23 - column 4, line 57 * * column 6, line 6 - column 7, line 26 * * column 9, line 13 - column 10, line 26 * * claims * ---	1-35	
A	US 2003/003951 A1 (LEPRIEUR PHILIPPE ET AL) 2 January 2003 (2003-01-02) * the whole document * -----	1-35	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
H04Q
H04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 August 2003	Dejonghe, O

CATEGORY OF CITED DOCUMENTS
X : particularly relevant if taken alone
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A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 03 00 8440

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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15-08-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0239758 A	16-05-2002	AU 2155902 A	21-05-2002
		WO 0239758 A2	16-05-2002
		EP 1334632 A2	13-08-2003
EP 1030477 A	23-08-2000	FI 990361 A	20-08-2000
		EP 1030477 A2	23-08-2000
		JP 2000252968 A	14-09-2000
US 2003003951 A1	02-01-2003	FR 2826825 A1	03-01-2003
		CN 1400835 A	05-03-2003
		EP 1271977 A1	02-01-2003
		JP 2003032756 A	31-01-2003

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

(19) Europäisches Patentamt
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(11) EP 1 615 384 A1

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03781524.8 / 1 582 032

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Remarks:
This application was filed on 09 - 09 - 2005 as a divisional application to the application mentioned under INID code 62.

(54) Mimo wlan system

(57) A method and apparatus in a multiple-access MIMO WLAN system that employs MIMO, OFDM, and TDD for processing data for transmission. The data is processed by coding a data frame in accordance with a coding scheme to obtain a coded data frame, partitioning the coded data frame into a plurality of coded data subframes, one coded data subframe for each of a plurality of spatial channels, and interleaving each coded data subframe in accordance with an interleaving scheme to obtain a corresponding interleaved data subframe, where a plurality of interleaved data subframes are obtained for the plurality of spatial channels. Each interleaved data subframe is modulated to obtain a corresponding stream of modulation symbols, where a plurality of modulation symbol streams are obtained for the plurality of spatial channels.

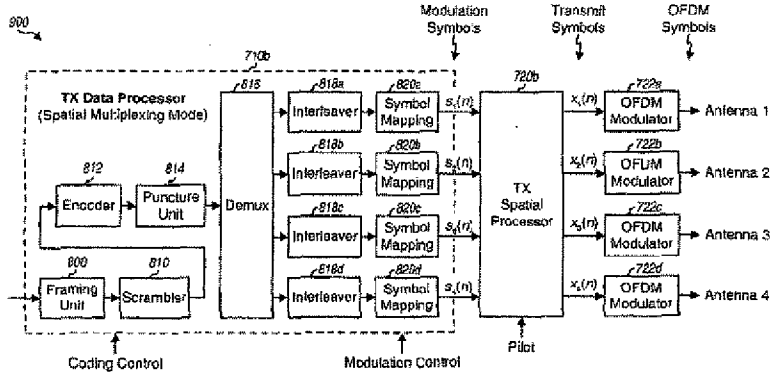


FIG. 9A

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Description

Claim of Priority under 35 U.S.C. §119

[0001] This application claims the benefit of provisional U.S. Application Serial No. 60/421,309, entitled, "MIMO WLAN System," filed on October 25, 2002.

BACKGROUND

Field

[0002] The present invention relates generally to data communication, and more specifically to a multiple-input multiple-output (MIMO) wireless local area network (WLAN) communication system.

Background

[0003] Wireless communication systems are widely deployed to provide various types of communication such as voice, packet data, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users sequentially or simultaneously by sharing the available system resources. Examples of multiple-access systems include Code Division Multiple Access (CDMA) systems, Time Division Multiple Access (TDMA) systems, and Frequency Division Multiple Access (FDMA) systems.

[0004] Wireless local area networks (WLANs) are also widely deployed to enable communication among wireless electronic devices (e.g., computers) via wireless link. A WLAN may employ access points (or base stations) that act like hubs and provide connectivity for the wireless devices. The access points may also connect (or "bridge") the WLAN to wired LANs, thus allowing the wireless devices access to LAN resources.

[0005] In a wireless communication system, a radio frequency (RF) modulated signal from a transmitter unit may reach a receiver unit via a number of propagation paths. The characteristics of the propagation paths typically vary over time due to a number of factors, such as fading and multipath. To provide diversity against deleterious path effects and improve performance, multiple transmit and receive antennas may be used. If the propagation paths between the transmit and receive antennas are linearly independent (i.e., a transmission on one path is not formed as a linear combination of the transmissions on the other paths), which is generally true to at least an extent, then the likelihood of correctly receiving a data transmission increases as the number of antennas increases. Generally, diversity increases and performance improves as the number of transmit and receive antennas increases.

[0006] A MIMO system employs multiple (N_T) transmit antennas and multiple (N_R) receive antennas for data transmission. A MIMO channel formed by the N_T transmit and N_R receive antennas may be decomposed into N_S spatial channels, with $N_S \leq \min\{N_T, N_R\}$. Each of the N_S spatial channels corresponds to a dimension. The MIMO system can provide improved performance (e.g., increased transmission capacity and/or greater reliability) if the additional dimensionalities created by the multiple transmit and receive antennas are utilized.

[0007] The resources for a given communication system are typically limited by various regulatory constraints and requirements and by other practical considerations. However, the system may be required to support a number of terminals, provide various services, achieve certain performance goals, and so on.

[0008] There is, therefore, a need in the art for a MIMO WLAN system capable of supporting multiple users and providing high system performance.

SUMMARY

[0009] A multiple-access MIMO WLAN system having various capabilities and able to achieve high performance is described herein. In an embodiment, the system employs MIMO and orthogonal frequency division multiplexing (OFDM) to attain high throughput, combat deleterious path effects, and provide other benefits. Each access point in the system can support multiple user terminals. The allocation of downlink and uplink resources is dependent on the requirements of the user terminals, the channel conditions, and other factors.

[0010] A channel structure supporting efficient downlink and uplink transmissions is also provided herein. The channel structure comprises a number of transport channels that may be used for a number of functions, such as signaling of system parameters and resource assignments, downlink and uplink data transmissions, random access of the system, and so on. Various attributes of these transport channels are configurable, which allows the system to easily adapt to changing channel and loading conditions.

[0011] Multiple rates and transmission modes are supported by the MIMO WLAN system to attain high throughput when supported by the channel conditions and the capabilities of the user terminals. The rates are configurable based

on estimates of the channel conditions and may be independently selected for the downlink and uplink. Different transmission modes may also be used, depending on the number of antennas at the user terminals and the channel conditions. Each transmission mode is associated with different spatial processing at the transmitter and receiver and may be selected for use under different operating conditions. The spatial processing facilitates data transmission from multiple transmit antennas and/or data reception with multiple receive antennas for higher throughput and/or diversity.

[0012] In an embodiment, the MIMO WLAN system uses a single frequency band for both the downlink and uplink, which share the same operating band using time division duplexing (TDD). For a TDD system, the downlink and uplink channel responses are reciprocal. Calibration techniques are provided herein to determine and account for differences in the frequency responses of the transmit/receive chains at the access point and user terminals. Techniques are also described herein to simplify the spatial processing at the access point and user terminals by taking advantage of the reciprocal nature of the downlink and uplink and the calibration.

[0013] A pilot structure with several types of pilot used for different functions is also provided. For example, a beacon pilot may be used for frequency and system acquisition, a MIMO pilot may be used for channel estimation, a steered reference (i.e., a steered pilot) may be used for improved channel estimation, and a carrier pilot may be used for phase tracking.

[0014] Various control loops for proper system operation are also provided. Rate control may be exercised independently on the downlink and uplink. Power control may be exercised for certain transmissions (e.g., fixed-rate services). Timing control may be used for uplink transmissions to account for different propagation delays of user terminals located throughout the system.

[0015] Random access techniques to allow user terminals to access the system are also provided. These techniques support system access by multiple user terminals, fast acknowledgment of system access attempts, and quick assignment of downlink/uplink resources.

[0016] The various aspects and embodiments of the invention are described in further detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The features and nature of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

[0018] FIG. 1 shows a MIMO WLAN system;

[0019] FIG. 2 shows a layer structure for the MIMO WLAN system;

[0020] FIGS. 3A, 3B and 3C show a TDD-TDM frame structure, an FDD-TDM frame structure, and an FDD-CDM frame structure, respectively;

[0021] FIG. 4 shows the TDD-TDM frame structure with five transport channels - BCH, FCCH, FCH, RCH, and RACH;

[0022] FIGS. 5A through 5G show various protocol data unit (PDU) formats for the five transport channels;

[0023] FIG. 6 shows a structure for an FCH/RCH packet;

[0024] FIG. 7 shows an access point and two user terminals;

[0025] FIGS. 8A, 9A, and 10A show three transmitter units for the diversity, spatial multiplexing, and beam-steering modes, respectively;

[0026] FIGS. 8B, 9B, and 10B show three TX diversity processors for the diversity, spatial multiplexing, and beam-steering modes, respectively,

[0027] FIG. 8C shows an OFDM modulator;

[0028] FIG. 8D shows an OFDM symbol;

[0029] FIG. 11A shows a framing unit and a scrambler within a TX data processor;

[0030] FIG. 11B shows an encoder and a repeat/puncture unit within the TX data processor;

[0031] FIG. 11C shows another TX data processor that may be used for the spatial multiplexing mode;

[0032] FIGS. 12A and 12B show a state diagram for operation of a user terminal;

[0033] FIG. 13 shows a timeline for the RACH;

[0034] FIGS. 14A and 14B show processes for controlling the rates of downlink and uplink transmissions, respectively;

[0035] FIG. 15 shows the operation of a power control loop; and

[0036] FIG. 16 shows a process for adjusting the uplink timing of a user terminal.

DETAILED DESCRIPTION

[0037] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment or design described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments or designs.

I. Overall System

[0038] **FIG. 1** shows a MIMO WLAN system 100 that supports a number of users and is capable of implementing various aspects and embodiments of the invention. MIMO WLAN system 100 includes a number of access points (APs) 110 that support communication for a number of user terminals (UTs) 120. For simplicity, only two access points 110 are shown in FIG. 1. An access point is generally a fixed station that is used for communicating with the user terminals. An access point may also be referred to as a base station or some other terminology.

[0039] User terminals 120 may be dispersed throughout the system. Each user terminal may be a fixed or mobile terminal that can communicate with the access point. A user terminal may also be referred to as a mobile station, a remote station, an access terminal, a user equipment (UE), a wireless device, or some other terminology. Each user terminal may communicate with one or possibly multiple access points on the downlink and/or uplink at any given moment. The downlink (i.e., forward link) refers to transmission from the access point to the user terminal, and the uplink (i.e., reverse link) refers to transmission from the user terminal to the access point.

[0040] In FIG. 1, access point 110a communicates with user terminals 120a through 120f, and access point 110b communicates with user terminals 120f through 120k. Depending on the specific design of system 100, an access point may communicate with multiple user terminals simultaneously (e.g., via multiple code channels or subbands) or sequentially (e.g., via multiple time slots). At any given moment, a user terminal may receive downlink transmissions from one or multiple access points. The downlink transmission from each access point may include overhead data intended to be received by multiple user terminals, user-specific data intended to be received by specific user terminals, other types of data, or any combination thereof. The overhead data may include pilot, page and broadcast messages, system parameters, and so on.

[0041] The MIMO WLAN system is based on a centralized controller network architecture. Thus, a system controller 130 couples to access points 110 and may further couple to other systems and networks. For example, system controller 130 may couple to a packet data network (PDN), a wired local area network (LAN), a wide area network (WAN), the Internet, a public switched telephone network (PSTN), a cellular communication network, and so on. System controller 130 may be designed to perform a number of functions such as (1) coordination and control for the access points coupled to it, (2) routing of data among these access points, (3) access and control of communication with the user terminals served by these access points, and so on.

[0042] The MIMO WLAN system may be able to provide high throughput with significantly greater coverage capability than conventional WLAN systems. The MIMO WLAN system can support synchronous, asynchronous, and isochronous data/voice services. The MIMO WLAN system may be designed to provide the following features:

- High service reliability
- Guaranteed quality of service (QoS)
- High instantaneous data rates
- High spectral efficiency
- Extended coverage range.

[0043] The MIMO WLAN system may be operated in various frequency bands (e.g., the 2.4 GHz and 5.x GHz U-NII bands), subject to the bandwidth and emission constraints specific to the selected operating band. The system is designed to support both indoor and outdoor deployments, with typical maximum cell size of 1 km or less. The system supports fixed terminal applications, although some operating modes also support portable and limited mobility operation.

1. MIMO, MISO, and SIMO

[0044] In a specific embodiment and as described throughout the specification, each access point is equipped with four transmit and receive antennas for data transmission and reception, where the same four antennas are used to transmit and to receive. The system also supports the case where the transmit and receive antennas of the device (e.g. access point, user terminal) are not shared, even though this configuration normally provides lower performance than when the antennas are shared. The MIMO WLAN system may also be designed such that each access point is equipped with some other number of transmit/receive antennas. Each user terminal may be equipped with a single transmit/receive antenna or multiple transmit/receive antennas for data transmission and reception. The number of antennas employed by each user terminal type may be dependent on various factors such as, for example, the services to be supported by the user terminal (e.g., voice, data, or both), cost considerations, regulatory constraints, safety issues, and so on.

[0045] For a given pairing of multi-antenna access point and multi-antenna user terminal, a MIMO channel is formed by the N_T transmit antennas and N_R receive antennas available for use for data transmission. Different MIMO channels are formed between the access point and different multi-antenna user terminals. Each MIMO channel may be decomposed into N_S spatial channels, with $N_S \leq \min\{N_T, N_R\}$. N_S data streams may be transmitted on the N_S spatial channels.

Spatial processing is required at a receiver and may or may not be performed at a transmitter in order to transmit multiple data streams on the N_S spatial channels.

[0046] The N_S spatial channels may or may not be orthogonal to one another. This depends on various factors such as (1) whether or not spatial processing was performed at the transmitter to obtain orthogonal spatial channels and (2) whether or not the spatial processing at both the transmitter and the receiver was successful in orthogonalizing the spatial channels. If no spatial processing is performed at the transmitter, then the N_S spatial channels may be formed with N_S transmit antennas and are unlikely to be orthogonal to one another.

[0047] The N_S spatial channels may be orthogonalized by performing decomposition on a channel response matrix for the MIMO channel, as described below. Each spatial channel is referred to as an eigenmode of the MIMO channel if the N_S spatial channels are orthogonalized using decomposition, which requires spatial processing at both the transmitter and the receiver, as described below. In this case, N_S data streams may be transmitted orthogonally on the N_S eigenmodes. However, an eigenmode normally refers to a theoretical construct. The N_S spatial channels are typically not completely orthogonal to one another due to various reasons. For example, the spatial channels would not be orthogonal if (1) the transmitter has no knowledge of the MIMO channel or (2) the transmitter and/or receiver have imperfect estimate of the MIMO channel. For simplicity, in the following description, the term "eigenmode" is used to denote the case where an attempt is made to orthogonalize the spatial channels using decomposition, even though the attempt may not be fully successful due to, for example, an imperfect channel estimate.

[0048] For a given number of (e.g., four) antennas at the access point, the number of spatial channels available for each user terminal is dependent on the number of antennas employed by that user terminal and the characteristics of the wireless MIMO channel that couples the access point antennas and the user terminal antennas. If a user terminal is equipped with one antenna, then the four antennas at the access point and the single antenna at the user terminal form a multiple-input single-output (MISO) channel for the downlink and a single-input multiple-output (SIMO) channel for the uplink.

[0049] The MIMO WLAN system may be designed to support a number of transmission modes. Table 1 lists the transmission modes supported by an exemplary design of the MIMO WLAN system.

Table 1

Transmission modes	Description
SIMO	Data is transmitted from a single antenna but may be received by multiple antennas for receive diversity.
Diversity	Data is redundantly transmitted from multiple transmit antennas and/or multiple subbands to provide diversity.
Beam-steering	Data is transmitted on a single (best) spatial channel at full power using phase steering information for the principal eigenmode of the MIMO channel.
Spatial multiplexing	Data is transmitted on multiple spatial channels to achieve higher spectral efficiency.

For simplicity, the term "diversity" refers to transmit diversity in the following description, unless noted otherwise.

[0050] The transmission modes available for use for the downlink and uplink for each user terminal are dependent on the number of antennas employed at the user terminal. Table 2 lists the transmission modes available for different terminal types for the downlink and uplink, assuming multiple (e.g., four) antennas at the access point.

Table 2

Transmission modes	Downlink		Uplink	
	Single-antenna user terminal	Multi-antenna user terminal	Single-antenna user terminal	Multi-antenna user terminal
MISO (on downlink)/ SIMO (on uplink)	X	X	X	X
Diversity	X	X		X
Beam-steering	X	X		X
Spatial multiplexing		X		X

For the downlink, all of the transmission modes except for the spatial multiplexing mode may be used for single-antenna

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user terminals, and all transmission modes may be used for multi-antenna user terminals. For the uplink, all transmission modes may be used by multi-antenna user terminals, while single-antenna user terminals use the SIMO mode to transmit data from the one available antenna. Receive diversity (i.e., receiving a data transmission with multiple receive antennas) may be used for the SIMO, diversity, and beam-steering modes.

[0051] The MIMO WLAN system may also be designed to support various other transmission modes, and this is within the scope of the invention. For example, a beam-forming mode may be used to transmit data on a single eigenmode using both the amplitude and phase information for the eigenmode (instead of only the phase information, which is all that is used by the beam-steering mode). As another example, a "non-steered" spatial multiplexing mode can be defined whereby the transmitter simply transmits multiple data streams from multiple transmit antennas (without any spatial processing) and the receiver performs the necessary spatial processing to isolate and recover the data streams sent from the multiple transmit antennas. As yet another example, a "multi-user" spatial multiplexing mode can be defined whereby the access point transmits multiple data streams from multiple transmit antennas (with spatial processing) to multiple user terminals concurrently on the downlink. As yet another example, a spatial multiplexing mode can be defined whereby the transmitter performs spatial processing to attempt to orthogonalize the multiple data streams sent on the multiple transmit antennas (but may not be completely successful because of an imperfect channel estimate) and the receiver performs the necessary spatial processing to isolate and recover the data streams sent from the multiple transmit antennas. Thus, the spatial processing to transmit multiple data streams via multiple spatial channels may be performed (1) at both the transmitter and receiver, (2) at only the receiver, or (3) at only the transmitter. Different spatial multiplexing modes may be used depending on, for example, the capabilities of the access point and the user terminals, the available channel state information, system requirements, and so on.

[0052] In general, the access points and user terminals may be designed with any number of transmit and receive antennas. For clarity, specific embodiments and designs are described below whereby each access point is equipped with four transmit/receive antennas, and each user terminal is equipped with four or less transmit/receive antennas.

2. OFDM

[0053] In an embodiment, the MIMO WLAN system employs OFDM to effectively partition the overall system bandwidth into a number of (N_F) orthogonal subbands. These subbands are also referred to as tones, bins, or frequency channels. With OFDM, each subband is associated with a respective subcarrier that may be modulated with data. For a MIMO system that utilizes OFDM, each spatial channel of each subband may be viewed as an independent transmission channel where the complex gain associated with each subband is effectively constant across the subband bandwidth.

[0054] In an embodiment, the system bandwidth is partitioned into 64 orthogonal subbands (i.e., $N_F = 64$), which are assigned indices of -32 to +31. Of these 64 subbands, 48 subbands (e.g., with indices of $\pm\{1, \ldots, 6, 8, \ldots, 20, 22, \ldots, 26\}$) are used for data, 4 subbands (e.g., with indices of $\pm\{7, 21\}$) are used for pilot and possibly signaling, the DC subband (with index of 0) is not used, and the remaining subbands are also not used and serve as guard subbands. This OFDM subband structure is described in further detail in a document for IEEE Standard 802.11a and entitled "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: High-speed Physical Layer in the 5 GHz Band," September 1999, which is publicly available and incorporated herein by reference. Different numbers of subbands and various other OFDM subband structures may also be implemented for the MIMO WLAN system, and this is within the scope of the invention. For example, all 53 subbands with indices from -26 to +26 may be used for data transmission. As another example, a 128-subband structure, a 256-subband structure, or a subband structure with some other number of subbands may be used. For clarity, the MIMO WLAN system is described below with the 64-subband structure described above.

[0055] For OFDM, the data to be transmitted on each subband is first modulated (i.e., symbol mapped) using a particular modulation scheme selected for use for that subband. Zeros are provided for the unused subbands. For each symbol period, the modulation symbols and zeros for all N_F subbands are transformed to the time domain using an inverse fast Fourier transform (IFFT) to obtain a transformed symbol that contains N_F time-domain samples. The duration of each transformed symbol is inversely related to the bandwidth of each subband. In one specific design for the MIMO WLAN system, the system bandwidth is 20 MHz, $N_F = 64$, the bandwidth of each subband is 312.5 KHz, and the duration of each transformed symbol is 3.2 μsec.

[0056] OFDM can provide certain advantages, such as the ability to combat frequency selective fading, which is characterized by different channel gains at different frequencies of the overall system bandwidth. It is well known that frequency selective fading causes inter-symbol interference (ISI), which is a phenomenon whereby each symbol in a received signal acts as distortion to subsequent symbols in the received signal. The ISI distortion degrades performance by impacting the ability to correctly detect the received symbols. Frequency selective fading can be conveniently combated with OFDM by repeating a portion of (or appending a cyclic prefix to) each transformed symbol to form a corresponding OFDM symbol, which is then transmitted.

[0057] The length of the cyclic prefix (i.e., the amount to repeat) for each OFDM symbol is dependent on the delay

spread of the wireless channel. In particular, to effectively combat ISI, the cyclic prefix should be longer than the maximum expected delay spread for the system.

[0058] In an embodiment, cyclic prefixes of different lengths may be used for the OFDM symbols, depending on the expected delay spread. For the specific MIMO WLAN system described above, a cyclic prefix of 400 nsec (8 samples) or 800 nsec (16 samples) may be selected for use for the OFDM symbols. A "short" OFDM symbol uses the 400 nsec cyclic prefix and has a duration of 3.6 μsec. A "long" OFDM symbol uses the 800 nsec cyclic prefix and has a duration of 4.0 μsec. Short OFDM symbols may be used if the maximum expected delay spread is 400 nsec or less, and long OFDM symbols may be used if the delay spread is greater than 400 nsec. Different cyclic prefixes may be selected for use for different transport channels, and the cyclic prefix may also be dynamically selectable, as described below. Higher system throughput may be achieved by using the shorter cyclic prefix when possible, since more OFDM symbols of shorter duration can be transmitted over a given fixed time interval.

[0059] The MIMO WLAN system may also be designed to not utilize OFDM, and this is within the scope of the invention.

3. Layer Structure

[0060] **FIG. 2** illustrates a layer structure 200 that may be used for the MIMO WLAN system. Layer structure 200 includes (1) applications and upper layer protocols that approximately correspond to Layer 3 and higher of the ISO/OSI reference model (upper layers), (2) protocols and services that correspond to Layer 2 (the link layer), and (3) protocols and services that correspond to Layer 1 (the physical layer).

[0061] The upper layers includes various applications and protocols, such as signaling services 212, data services 214, voice services 216, circuit data applications, and so on. Signaling is typically provided as messages and data is typically provided as packets. The services and applications in the upper layers originate and terminate messages and packets according to the semantics and timing of the communication protocol between the access point and the user terminal. The upper layers utilize the services provided by Layer 2.

[0062] Layer 2 supports the delivery of messages and packets generated by the upper layers. In the embodiment shown in FIG. 2, Layer 2 includes a Link Access Control (LAC) sublayer 220 and a Medium Access Control (MAC) sublayer 230. The LAC sublayer implements a data link protocol that provides for the correct transport and delivery of messages generated by the upper layers. The LAC sublayer utilizes the services provided by the MAC sublayer and Layer 1. The MAC sublayer is responsible for transporting messages and packets using the services provided by Layer 1. The MAC sublayer controls the access to Layer 1 resources by the applications and services in the upper layers. The MAC sublayer may include a Radio Link Protocol (RLP) 232, which is a retransmission mechanism that may be used to provide higher reliability for packet data. Layer 2 provides protocol data units (PDUs) to Layer 1.

[0063] Layer 1 comprises physical layer 240 and supports the transmission and reception of radio signals between the access point and user terminal. The physical layer performs coding, interleaving, modulation, and spatial processing for various transport channels used to send messages and packets generated by the upper layers. In this embodiment, the physical layer includes a multiplexing sublayer 242 that multiplexes processed PDUs for various transport channels into the proper frame format. Layer 1 provides data in units of frames.

[0064] FIG. 2 shows a specific embodiment of a layer structure that may be used for the MIMO WLAN system. Various other suitable layer structures may also be designed and used for the MIMO WLAN system, and this is within the scope of the invention. The functions performed by each layer are described in further detail below where appropriate.

4. Transport Channels

[0065] A number of services and applications may be supported by the MIMO WLAN system. Moreover, other data required for proper system operation may need to be sent by the access point or exchanged between the access point and user terminals. A number of transport channels may be defined for the MIMO WLAN system to carry various types of data. Table 3 lists an exemplary set of transport channels and also provides a brief description for each transport channel.

Table 3

Transport channels		Description
Broadcast channel	BCH	Used by the access point to transmit pilot and system parameters to the user terminals.
Forward control channel	FCCH	Used by the access point to allocate resources on the downlink and uplink. The resource allocation may be performed on a frame-by-frame basis. Also used to provide acknowledgment for messages received on the RACH.

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Table continued

Transport channels		Description
Forward channel	FCH	Used by the access point to transmit user-specific data to the user terminals and possibly a reference (pilot) used by the user terminals for channel estimation. May also be used in a broadcast mode to send page and broadcast messages to multiple user terminals.
Random access channel	RACH	Used by the user terminals to gain access to the system and send short messages to the access point.
Reverse channel	RCH	Used by the user terminals to transmit data to the access
		point. May also carry a reference used by the access point for channel estimation.

[0066] As shown in Table 3, the downlink transport channels used by the access point includes the BCH, FCCH, and FCH. The uplink transport channels used by the user terminals include the RACH and RCH. Each of these transport channels is described in further detail below.

[0067] The transport channels listed in Table 3 represent a specific embodiment of a channel structure that may be used for the MIMO WLAN system. Fewer, additional, and/or different transport channels may also be defined for use for the MIMO WLAN system. For example, certain functions may be supported by function-specific transport channels (e.g., pilot, paging, power control, and sync channel channels). Thus, other channel structures with different sets of transport channels may be defined and used for the MIMO WLAN system, and this is within the scope of the invention.

5. Frame Structures

[0068] A number of frame structures may be defined for the transport channels. The specific frame structure to use for the MIMO WLAN system is dependent on various factors such as, for example, (1) whether the same or different frequency bands are used for the downlink and uplink and (2) the multiplexing scheme used to multiplex the transport channels together.

[0069] If only one frequency band is available, then the downlink and uplink may be transmitted on different phases of a frame using time division duplexing (TDD), as described below. If two frequency bands are available, then the downlink and uplink may be transmitted on different frequency bands using frequency division duplexing (FDD).

[0070] For both TDD and FDD, the transport channels may be multiplexed together using time division multiplexing (TDM), code division multiplexing (CDM), frequency division multiplexing (FDM), and so on. For TDM, each transport channel is assigned to a different portion of a frame. For CDM, the transport channels are transmitted concurrently but each transport channel is channelized by a different channelization code, similar to that performed in a code division multiple access (CDMA) system. For FDM, each transport channel is assigned a different portion of the frequency band for the link.

[0071] Table 4 lists the various frame structures that may be used to carry the transport channels. Each of these frame structures is described in further detail below. For clarity, the frame structures are described for the set of transport channels listed in Table 3.

Table 4

	Shared frequency band for downlink and uplink	Separate frequency bands for downlink and uplink
Time division	TDD-TDM frame structure	FDD-TDM frame structure
Code division	TDD-CDM frame structure	FDD-CDM frame structure

[0072] **FIG. 3A** illustrates an embodiment of a TDD-TDM frame structure 300a that may be used if a single frequency band is used for both the downlink and uplink. Data transmission occurs in units of TDD frames. Each TDD frame may be defined to span a particular time duration. The frame duration may be selected based on various factors such as, for example, (1) the bandwidth of the operating band, (2) the expected sizes of the PDUs for the transport channels, and so on. In general, a shorter frame duration may provide reduced delays. However, a longer frame duration may be more efficient since header and overhead may represent a smaller fraction of the frame. In a specific embodiment, each TDD frame has a duration of 2 msec.

[0073] Each TDD frame is partitioned into a downlink phase and an uplink phase. The downlink phase is further partitioned into three segments for the three downlink transport channels - the BCH, FCCH, and FCH. The uplink phase is further partitioned into two segments for the two uplink transport channels - the RCH and RACH.

[0074] The segment for each transport channel may be defined to have either a fixed duration or a variable duration that can change from frame to frame. In an embodiment, the BCH segment is defined to have a fixed duration, and the FCCH, FCH, RCH, and RACH segments are defined to have variable durations.

[0075] The segment for each transport channel may be used to carry one or more protocol data units (PDUs) for that transport channel. In the specific embodiment shown in FIG. 3A, a BCH PDU is transmitted in a first segment 310, an FCCH PDU is transmitted in a second segment 320, and one or more FCH PDUs are transmitted in a third segment 330 of the downlink phase. On the uplink phase, one or more RCH PDUs are transmitted in a fourth segment 340 and one or more RACH PDUs are transmitted in a fifth segment 350 of the TDD frame.

[0076] Frame structure 300a represents a specific arrangement of the various transport channels within a TDD frame. This arrangement can provide certain benefits such as reduced delays for data transmission on the downlink and uplink. The BCH is transmitted first in the TDD frame since it carries system parameters that may be used for the PDUs of the other transport channels within the same TDD frame. The FCCH is transmitted next since it carries channel assignment information indicative of which user terminal(s) are designated to receive downlink data on the FCH and which user terminal(s) are designated to transmit uplink data on the RCH within the current TDD frame. Other TDD-TDM frame structures may also be defined and used for the MIMO WLAN system, and this is within the scope of the invention.

[0077] **FIG. 3B** illustrates an embodiment of an FDD-TDM frame structure 300b that may be used if the downlink and uplink are transmitted using two separate frequency bands. Downlink data is transmitted in a downlink frame 302a, and uplink data is transmitted in an uplink frame 302b. Each downlink and uplink frame may he defined to span a particular time duration (e.g., 2 msec). For simplicity, the downlink and uplink frames may be defined to have the same duration and may further be defined to be aligned at the frame boundaries. However, different frame durations and/or non-aligned (i.e., offset) frame boundaries may also be used for the downlink and uplink.

[0078] As shown in FIG. 3B, the downlink frame is partitioned into three segments for the three downlink transport channels. The uplink frame is partitioned into two segments for the two uplink transport channels. The segment for each transport channel may be defined to have a fixed or variable duration, and may be used to carry one or more PDUs for that transport channel.

[0079] In the specific embodiment shown in FIG. 3B, the downlink frame carries a BCH PDU, an FCCH PDU, and one or more FCH PDUs in segments 310, 320, and 330, respectively. The uplink frame carries one or more RCH PDUs and one or more RACH PDUs in segments 340 and 350, respectively. This specific arrangement may provide the benefits described above (e.g., reduced delays for data transmission). The transport channels may have different PDU formats, as described below. Other FDD-TDM frame structures may also be defined and used for the MIMO WLAN system, and this is within the scope of the invention.

[0080] **FIG. 3C** illustrates an embodiment of an FDD-CDM/FDM frame structure 300c that may also be used if the downlink and uplink are transmitted using separate frequency bands. Downlink data may be transmitted in a downlink frame 304a, and uplink data may be transmitted in an uplink frame 304b. The downlink and uplink frames may be defined to have the same duration (e.g., 2 msec) and aligned at the frame boundaries.

[0081] As shown in FIG. 3C, the three downlink transport channels are transmitted concurrently in the downlink frame, and the two uplink transport channels are transmitted concurrently in the uplink frame. For CDM, the transport channels for each link are "channelized" with different channelization codes, which may be Walsh codes, orthogonal variable spreading factor (OVSF) codes, quasi-orthogonal functions (QOF), and so on. For FDM, the transport channels for each link are assigned different portions of the frequency band for the link. Different amounts of transmit power may also be used for different transport channels in each link.

[0082] Other frame structures may also be defined for the downlink and uplink transport channels, and this is within the scope of the invention. Moreover, it is possible to use different types of frame structure for the downlink and uplink. For example, a TDM-based frame structure may be used for the downlink and a CDM-based frame structure may be used for the uplink.

[0083] In the following description, the MIMO WLAN system is assumed to use one frequency band for both downlink and uplink transmissions. For clarity, the TDD-TDM frame structure shown in FIG. 3A is used for the MIMO WLAN system. For clarity, a specific implementation of the TDD-TDM frame structure is described throughout the specification. For this implementation, the duration of each TDD frame is fixed at 2 msec, and the number of OFDM symbols per TDD frame is a function of the length of the cyclic prefix used for the OFDM symbols. The BCH has a fixed duration of 80 μsec and uses the 800 nsec cyclic prefix for the OFDM symbols transmitted. The remainder of the TDD frame contains 480 OFDM symbols if the 800 nsec cyclic prefix is used, and 533 OFDM symbols plus 1.2 μsec of excess time if the 400 nsec cyclic prefix is used. The excess time can be added to the guard interval at the end of the RACH segment. Other frame structures and other implementations may also be used, and this is within the scope of the invention.

II. Transport Channels

[0084] The transport channels are used to send various types of data and may be categorized into two groups: common transport channels and dedicated transport channels. Because the common and dedicated transport channels are used for different purposes, different processing may be used for these two groups of transport channels, as described in further detail below.

[0085] **Common Transport Channels.** The common transport channels include the BCH, FCCH, and RACH. These transport channels are used to send data to or receive data from multiple user terminals. For improved reliability, the BCH and FCCH are transmitted by the access point using the diversity mode. On the uplink, the RACH is transmitted by the user terminals using the beam-steering mode (if supported by the user terminal). The BCH is operated at a known fixed rate so that the user terminals can receive and process the BCH without any additional information. The FCCH and RACH support multiple rates to allow for greater efficiency. As used herein, each "rate" or "rate set" is associated with a particular code rate (or coding scheme) and a particular modulation scheme.

[0086] **Dedicated Transport Channels.** The dedicated transport channels include the FCH and RCH. These transport channels are normally used to send user-specific data to or by specific user terminals. The FCH and RCH may be dynamically allocated to the user terminals as necessary and as available. The FCH may also be used in a broadcast mode to send overhead, page, and broadcast messages to the user terminals. In general, the overhead, page, and broadcast messages are transmitted prior to any user-specific data on the FCH.

[0087] **FIG. 4** illustrates an exemplary transmission on the BCH, FCCH, FCH, RCH, and RACH based on TDD-TDM frame structure 300a. In this embodiment, one BCH PDU 410 and one FCCH PDU 420 are transmitted in BCH segment 310 and FCCH segment 320, respectively. FCH segment 330 may be used to send one or more FCH PDUs 430, each of which may be intended for a specific user terminal or multiple user terminals. Similarly, one or more RCH PDUs 440 may be sent by one or more user terminals in RCH segment 340. The start of each FCH/RCH PDU is indicated by an FCH/RCH offset from the end of the preceding segment. A number of RACH PDUs 450 may be sent in RACH segment 350 by a number of user terminals to access the system and/or to send short messages, as described below.

[0088] For clarity, the transport channels are described for the specific TDD-TDM frame structure shown in FIGS. 3A and 4.

1. Broadcast Channel (BCH) - Downlink

[0089] The BCH is used by the access point to transmit a beacon pilot, a MIMO pilot, and system parameters to the user terminals. The beacon pilot is used by the user terminals to acquire system timing and frequency. The MIMO pilot is used by the user terminals to estimate the MIMO channel formed by the access point antennas and their own antennas. The beacon and MIMO pilots are described in further detail below. The system parameters specify various attributes of the downlink and uplink transmissions. For example, since the durations of the FCCH, FCH, RACH, and RCH segments are variable, the system parameters that specify the length of each of these segments for the current TDD frame are sent in the BCH.

[0090] **FIG. 5A** illustrates an embodiment of BCH PDU 410. In this embodiment, BCH PDU 410 includes a preamble portion 510 and a message portion 516. Preamble portion 510 further includes a beacon pilot portion 512 and a MIMO pilot portion 514. Portion 512 carries a beacon pilot and has a fixed duration of $T_{CP} = 8\mu sec$. Portion 514 carries a MIMO pilot and has a fixed duration of $T_{MP} = 32\mu sec$. Portion 516 carries a BCH message and has a fixed duration of $T_{BM} = 40\mu sec$. The duration of the BCH PDU is fixed at $T_{CP} + T_{MP} + T_{BM} = 80\mu sec$.

[0091] A preamble may be used to send one or more types of pilot and/or other information. A beacon pilot comprises a specific set of modulation symbols that is transmitted from all transmit antennas. A MIMO pilot comprises a specific set of modulation symbols that is transmitted from all transmit antennas with different orthogonal codes, which then allows the receivers to recover the pilot transmitted from each antenna. Different sets of modulation symbols may be used for the beacon and MIMO pilots. The generation of the beacon and MIMO pilots is described in further detail below.

[0092] The BCH message carries system configuration information. Table 5 lists the various fields for an exemplary BCH message format.

Table 5 - BCH Message

Fields/ Parameter Names	Length(bits)	Description
Frame Counter	4	TDD frame counter
Net ID	10	Network identifier (ID)
AP ID	6	Access point ID

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Table continued

Fields/ Parameter Names	Length(bits)	Description
AP Tx Lvl	4	Access point transmit level
AP Rx Lvl	3	Access point receive level
FCCH Length	6	Duration of FCCH (in units of OFDM symbols)
FCCH Rate	2	Physical layer rate of FCCH
FCH Length	9	Duration of FCH (in units of OFDM symbols)
RCH Length	9	Duration of RCH (in units of OFDM symbols)
RACH Length	5	Duration of RACH (in units of RACH slots)
RACH Slot Size	2	Duration of each RACH slot (in units of OFDM symbols)
RACH Guard Interval	2	Guard interval at the end of RACH
Cyclic Prefix Duration	1	Cyclic prefix duration
Page Bit	1	"0" = page message sent on FCH "1" = no page message sent
Broadcast Bit	1	"0" = broadcast message sent on FCH "1" = no broadcast message sent
RACH Acknowledgment Bit	1	"0" = RACH acknowledgment sent on FCH "1" = no RACH acknowledgment sent
CRC	16	CRC value for the BCH message
Tail Bits	6	Tail bits for convolutional encoder
Reserved	32	Reserved for future use

[0093] The Frame Counter value may be used to synchronize various processes at the access point and user terminals (e.g., the pilot, scrambling codes, cover code, and so on). A frame counter may be implemented with a 4-bit counter that wraps around. This counter is incremented at the start of each TDD frame, and the counter value is included in the Frame Counter field. The Net ID field indicates the identifier (ID) of the network to which the access point belongs. The AP ID field indicates the ID of the access point within the network ID. The AP Tx Lvl and AP Rx Lvl fields indicate the maximum transmit power level and the desired receive power level at the access point, respectively. The desired receive power level may be used by the user terminal to determine the initial uplink transmit power.

[0094] The FCCH Length, FCH Length, and RCH Length fields indicate the lengths of the FCCH, FCH, and RCH segments, respectively, for the current TDD frame. The lengths of these segments are given in units of OFDM symbols. The OFDM symbol duration for the BCH is fixed at 4.0 μsec. The OFDM symbol duration for all other transport channels (i.e., the FCCH, FCH, RACH, and RCH) is variable and depends on the selected cyclic prefix, which is specified by the Cyclic Prefix Duration field. The FCCH Rate field indicates the rate used for the FCCH for the current TDD frame.

[0095] The RACH Length field indicates the length of the RACH segment, which is given in units of RACH slots. The duration of each RACH slot is given by the RACH Slot Size field, in units of OFDM symbols. The RACH Guard Interval field indicates the amount of time between the last RACH slot and the start of the BCH segment for the next TDD frame. These various fields for the RACH are described in further detail below.

[0096] The Page Bit and Broadcast Bit indicate whether or not page messages and broadcast messages, respectively, are being sent on the FCH in the current TDD frame. These two bits may be set independently for each TDD frame. The RACH Acknowledgment Bit indicates whether or not acknowledgments for PDUs sent on the RACH in prior TDD frames are being sent on the FCCH in the current TDD frame.

[0097] The CRC field includes a CRC value for the entire BCH message. This CRC value may be used by the user terminals to determine whether the received BCH message is decoded correctly (i.e., good) or in error (i.e., erased). The Tail Bits field includes a group of zeros used to reset the convolutional encoder to a known state at the end of the BCH message.

[0098] As shown in Table 5, the BCH message includes a total of 120 bits. These 120 bits may be transmitted with 10 OFDM symbols using the processing described in detail below.

[0099] Table 5 shows a specific embodiment of the format for the BCH message. Other BCH message formats with fewer, additional, and/or different fields may also be defined and used, and this is within the scope of the invention.

2. Forward Control Channel (FCCH) - Downlink

[0100] In an embodiment, the access point is able to allocate resources for the FCH and RCH on a per frame basis. The FCCH is used by the access point to convey the resource allocation for the FCH and RCH (i.e., the channel assignments).

[0101] **FIG. 5B** illustrates an embodiment of FCCH PDU 420. In this embodiment, the FCCH PDU includes only a portion 520 for an FCCH message. The FCCH message has a variable duration that can change from frame to frame, depending on the amount of scheduling information being carried on the FCCH for that frame. The FCCH message duration is in even number of OFDM symbols and given by the FCCH Length field on the BCH message. The duration of messages sent using the diversity mode (e.g., BCH and FCCH messages) is given in even number of OFDM symbols because the diversity mode transmits OFDM symbols in pairs, as described below.

[0102] In an embodiment, the FCCH can be transmitted using four possible rates. The specific rate used for the FCCH PDU in each TDD frame is indicated by the FCCH Phy Mode field in the BCH message. Each FCCH rate corresponds to a particular code rate and a particular modulation scheme and is further associated with a particular transmission mode, as shown in Table 26.

[0103] An FCCH message may include zero, one, or multiple information elements (IEs). Each information element may be associated with a specific user terminal and may be used to provide information indicative of the assignment of FCH/RCH resources for that user terminal. Table 6 lists the various fields for an exemplary FCCH message format.

Table 6 - FCCH Message

Fields/ Parameter Names	Length (bits)	Description
N_IE	6	Number of IEs included in the FCCH message
N_IE information elements, each including:		
IE Type	4	IE type
MAC ID	10	ID assigned to the user terminal
Control Fields	48 or 72	Control fields for channel assignment
Padding Bits	Variable	Pad bits to achieve even number of OFDM symbols in the FCCH message
CRC	16	CRC value for the FCCH message
Tail Bits	6	Tail bits for convolutional encoder

[0104] The N_IE field indicates the number of information elements included in the FCCH message sent in the current TDD frame. For each information element (IE) included in the FCCH message, the IE Type field indicates the particular type of this IE. A number of IE types are defined for use to allocate resources for different types of transmissions, as described below.

[0105] The MAC ID field identifies the specific user terminal for which the information element is intended. Each user terminal registers with the access point at the start of a communication session and is assigned a unique MAC ID by the access point. This MAC ID is used to identify the user terminal during the session.

[0106] The Control Fields are used to convey channel assignment information for the user terminal and are described in detail below. The Padding Bits field includes a sufficient number of padding bits so that the overall length of the FCCH message is an even number of OFDM symbols. The FCCH CRC field includes a CRC value that may be used by the user terminals to determine whether the received FCCH message is decoded correctly or in error. The Tail Bits field includes zeros used to reset the convolutional encoder to a known state at the end of the FCCH message. Some of these fields are described in further detail below.

[0107] A number of transmission modes are supported by the MIMO WLAN system for the FCH and RCH, as indicated in Table 1. Moreover, a user terminal may be active or idle during a connection. Thus, a number of types of IE are defined for use to allocate FCH/RCH resources for different types of transmissions. Table 7 lists an exemplary set of IE types.

Table 7 - FCCH IE Types

IE Type	IE Size (bits)	IE Type	Description
0	48	Diversity Mode	Diversity mode only
1	72	Spatial Multiplexing Mode	Spatial multiplexing mode - variable rate services

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Table continued

IE Type	IE Size (bits)	IE Type	Description
2	48	Idle Mode	Idle state - variable rate services
3	48	RACH Acknowledgment	RACH acknowledgment - diversity mode
4		Beam Steering Mode	Beam steering mode
5-15	-	Reserved	Reserved for future use

[0108] For IE types 0, 1 and 4, resources are allocated to a specific user terminal for both the FCH and RCH (i.e., in channel pairs). For IE type 2, minimal resources are allocated to the user terminal on the FCH and RCH to maintain up-to-date estimate of the link: An exemplary format for each IE type is described below. In general, the rates and durations for the FCH and RCH can be independently assigned to the user terminals.

A. IE Type 0, 4 - Diversity/Beam-Steering Mode

[0109] IE type 0 and 4 are used to allocate FCH/RCH resources for the diversity and beam-steering modes, respectively. For fixed low-rate services (e.g., voice), the rate remains fixed for the duration of the call. For variable rate services, the rate may be selected independently for the FCH and RCH. The FCCH IE indicates the location of the FCH and RCH PDUs assigned to the user terminal. Table 8 lists the various fields of an exemplary IE Type 0 and 4 information element.

Table 8 - FCCH IE Type 0 and 4

Fields/Parameter Names	Length (bits)	Description
IE Type	4	IE type
MAC ID	10	Temporary ID assigned to the user terminal
FCH Offset	9	FCH offset from start of the TDD frame (in OFDM symbols)
FCH Preamble Type	2	FCH preamble size (in OFDM symbols)
FCH Rate	4	Rate for the FCH
RCH Offset	9	RCH offset from start of the TDD frame (in OFDM symbols)
RCH Preamble Type	2	RCH preamble size (in OFDM symbols)
RCH Rate	4	Rate for the RCH
RCH Timing Adjustment	2	Timing adjustment parameter for RCH
RCH Power Control	2	Power control bits for RCH

[0110] The FCH and RCH Offset fields indicate the time offset from the beginning of the current TDD frame to the start of the FCH and RCH PDUs, respectively, assigned by the information element. The FCH and RCH Rate fields indicate the rates for the FCH and RCH, respectively.

[0111] The FCH and RCH Preamble Type fields indicate the size of the preamble in the FCH and RCH PDUs, respectively. Table 9 lists the values for the FCH and RCH Preamble Type fields and the associated preamble sizes.

Table 9 - Preamble Type

Type	Bits	Preamble Size
0	00	0 OFDM symbol
1	01	1 OFDM symbol
2	10	4 OFDM symbols
3	11	8 OFDM symbols

[0112] The RCH Timing Adjustment field includes two bits used to adjust the timing of the uplink transmission from the user terminal identified by the MAC ID field. This timing adjustment is used to reduce interference in a TDD-based

frame structure (such as the one shown in FIG. 3A) where the downlink and uplink transmissions are time division duplexed. Table 10 lists the values for the RCH Timing Adjustment field and the associated actions.

Table 10 - RCH Timing Adjustment

Bits	Description
00	Maintain current timing
01	Advance uplink transmit timing by 1 sample
10	Delay uplink transmit timing by 1 sample
11	Not used

[0113] The RCH Power Control field includes two bits used to adjust the transmit power of the uplink transmission from the identified user terminal. This power control is used to reduce interference on the uplink. Table 11 lists the values for the RCH Power Control field and the associated actions.

Table 11 - RCH Power Control

Bits	Description
00	Maintain current transmit power
01	Increase uplink transmit power by δ dB, where δ is a system parameter.
10	Decrease uplink transmit power by δ dB, where δ is a system parameter.
11	Not used

[0114] The channel assignment for the identified user terminal may be provided in various manners. In an embodiment, the user terminal is assigned FCH/RCH resources for only the current TDD frame. In another embodiment, the FCH/RCH resources are assigned to the terminal for each TDD frame until canceled. In yet another embodiment, the FCH/RCH resources are assigned to the user terminal for every *n*-th TDD frame, which is referred to as "decimated" scheduling of TDD frames. The different types of assignment may be indicated by an Assignment Type field in the FCCH information element.

B. IE Type 1 - Spatial Multiplexing Mode

[0115] IE type 1 is used to allocate FCH/RCH resources to user terminals using the spatial multiplexing mode. The rate for these user terminals is variable, and may be selected independently for the FCH and RCH. Table 12 lists the various fields of an exemplary IE type 1 information element.

Table 12 - FCCH IE Type 1

Fields/ Parameter Names	Length (bits)	Description
IE Type	4	IE type
MAC ID	10	Temporary ID assigned to the user terminal
FCH Offset	9	FCH offset from end of FCCH (in OFDM symbols)
FCH Preamble Type	2	FCH preamble size (in OFDM symbols)
FCH Spatial Channel 1 Rate	4	Rate for the FCH for spatial channel 1
FCH Spatial Channel 2 Rate	4	Rate for the FCH for spatial channel 2
FCH Spatial Channel 3 Rate	4	Rate for the FCH for spatial channel 3
FCH Spatial Channel 4 Rate	4	Rate for the FCH for spatial channel 4
RCH Offset	9	RCH offset from end of FCH (in OFDM symbols)
RCH Preamble Type	2	RCH preamble size (in OFDM symbols)
RCH Spatial Channel 1 Rate	4	Rate for the RCH for spatial channel 1

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Table continued

Fields/ Parameter Names	Length (bits)	Description
RCH Spatial Channel 2 Rate	4	Rate for the RCH for spatial channel 2
RCH Spatial Channel 3 Tate	4	Rate for the RCH for spatial channel 3
RCH Spatial Channel 4 Rate	4	Rate for the RCH for spatial channel 4
RCH Timing Adjustment	2	Timing adjustment parameter for RCH
Reserved	2	Reserved for future use

[0116] For IE type 1, the rate for each spatial channel may be selected independently on the FCH and RCH. The interpretation of the rates for the spatial multiplexing mode is general in that it can specify the rate per spatial channel (e.g., for up to four spatial channels for the embodiment shown in Table 12). The rate is given per eigenmode if the transmitter performs spatial processing to transmit data on the eigenmodes. The rate is given per antenna if the transmitter simply transmits data from the transmit antennas and the receiver performs the spatial processing to isolate and recover the data (for the non-steered spatial multiplexing mode).

[0117] The information element includes the rates for all enabled spatial channels and zeros for the ones not enabled. User terminals with less than four transmit antennas set the unused FCH/RCH Spatial Channel Rate fields to zero. Since the access point is equipped with four transmit/receive antennas, user terminals with more than four transmit antennas may use them to transmit up to four independent data streams.

C. IE Type 2 - Idle Mode

[0118] IE type 2 is used to provide control information for user terminals operating in an *Idle* state (described below). In an embodiment, when a user terminal is in the *Idle* state, steering vectors used by the access point and user terminal for spatial processing are continually updated so that data transmission can start quickly if and when resumed. Table 13 lists the various fields of an exemplary IE type 2 information element.

Table 13 - FCCH IE Type 2

Fields/Parameter Names	Length (bits)	Description
IE Type	4	IE type
MAC ID	10	Temporary ID assigned to the user terminal
FCH Offset	9	FCH offset from end of FCCH (in OFDM symbols)
FCH Preamble Type	2	FCH preamble size (in OFDM symbols)
RCH Offset	9	RCH offset from end of FCH (in OFDM symbols)
RCH Preamble Type	2	RCH preamble size (in OFDM symbols)
Reserved	12	Reserved for future use

D. IE Type 3 - RACH Quick Acknowledgment

[0119] IE type 3 is used to provide quick acknowledgment for user terminals attempting to access the system via the RACH. To gain access to the system or to send a short message to the access point, a user terminal may transmit an RACH PDU on the uplink. After the user terminal sends the RACH PDU, it monitors the BCH to determine if the RACH Acknowledgement Bit is set. This bit is set by the access point if any user terminal was successful in accessing the system and an acknowledgment is being sent for at least one user terminal on the FCCH. If this bit is set, then the user terminal processes the FCCH for acknowledgment sent on the FCCH. IE Type 3 information elements are sent if the access point desires to acknowledge that it correctly decoded the RACH PDUs from the user terminals without assigning resources. Table 14 lists the various fields of an exemplary IE Type 3 information element.

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Table 14 - FCCH IE Type 3

Fields/ Parameter Names	Length (bits)	Description
IE Type	4	IE type
MAC ID	10	Temporary ID assigned to user terminal
Reserved	34	Reserved for future use

[0120] A single or multiple types of acknowledgment may be defined and sent on the FCCH. For example, a quick acknowledgment and an assignment-based acknowledgment may be defined. A quick acknowledgment may be used to simply acknowledge that the RACH PDU has been received by the access point but that no FCH/RCH resources have been assigned to the user terminal. An assignment-based acknowledgment includes assignments for the FCH and/or RCH for the current TDD frame.

[0121] The FCCH may be implemented in other manners and may also be transmitted in various ways. In one embodiment, the FCCH is transmitted at a single rate that is signaled in the BCH message. This rate may be selected, for example, based on the lowest signal-to-noise-and-interference ratios (SNRs) of all user terminals for which the FCCH is being sent in the current TDD frame. Different rates may be used for different TDD frames depending on the channel conditions of the recipient user terminals in each TDD frame.

[0122] In another embodiment, the FCCH is implemented with multiple (e.g., four) FCCH subchannels. Each FCCH subchannel is transmitted at a different rate and is associated with a different required SNR in order to recover the subchannel. The FCCH subchannels are transmitted in order from lowest rate to highest rate. Each FCCH subchannel may or may not be transmitted in a given TDD frame. The first FCCH subchannel (with the lowest rate) is transmitted first and can be received by all user terminals. This FCCH subchannel can indicate whether or not each of the remaining FCCH subchannels will be transmitted in the current TDD frame. Each user terminal can process the transmitted FCCH subchannels to obtain its FCCH information element. Each user terminal can terminate processing of the FCCH if any of the following occurs: (1) failure to decode the current FCCH subchannel, (2) reception of its FCCH information element in the current FCCH subchannel, or (3) all transmitted FCCH subchannels have been processed. A user terminal can terminate processing of the FCCH as soon as it encounters FCCH decoding failure because the FCCH subchannels are transmitted at ascending rates and the user terminal is unlikely to be able to decode subsequent FCCH subchannels transmitted at higher rates.

3. Random Access Channel (RACH) - Uplink

[0123] The RACH is used by the user terminals to gain access to the system and to send short messages to the access point. The operation of the RACH is based on a slotted Aloha random access protocol, which is described below.

[0124] **FIG. 5C** illustrates an embodiment of RACH PDU 450. In this embodiment, the RACH PDU includes a preamble portion 552 and a message portion 554. Preamble portion 552 may be used to send a steered reference (i.e., a steered pilot), if the user terminal is equipped with multiple antennas. The steered reference is a pilot comprised of a specific set of modulation symbols that is subjected to spatial processing prior to transmission on the uplink. The spatial processing allows the pilot to be transmitted on a specific eigenmode of the MIMO channel. The processing for the steered reference is described in further detail below. Preamble portion 552 has a fixed duration of at least 2 OFDM symbols. Message portion 554 carries an RACH message and has a variable duration. The duration of the RACH PDU is thus variable.

[0125] In an embodiment, four different rates are supported for the RACH. The specific rate used for each RACH message is indicated by a 2-bit RACH data rate indicator (DRI), which is embedded in the preamble portion of the RACH PDU, as shown in FIG. 5C. In an embodiment, four different message sizes are also supported for the RACH. The size of each RACH message is indicated by a Message Duration field included in the RACH message. Each RACH rate supports 1, 2, 3 or all 4 message sizes. Table 15 lists the four RACH rates, their associated coding and modulation parameters, and the message sizes supported by these RACH rates.

Table 15

RACH Rates				RACH Message Sizes (in bits and OFDM symbols)			
bps/Hz	Code Rate	Modulation	DRI	96 bits	192 bits	384 bits	768 bits
0.25	0.25	BPSK	(1,1)	8	n/a	n/a	n/a
0.5	0.5	BPSK	(1,-1)	4	8	n/a	n/a
1	0.5	QPSK	(-1, 1)	2	4	8	n/a

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Table continued

RACH Rates				RACH Message Sizes (in bits and OFDM symbols)			
bps/Hz	Code Rate	Modulation	DRI	96 bits	192 bits	384 bits	768 bits
2	0.5	16 QAM	(-1, -1)	1	2	4	8

[0126] The RACH message carries short messages and access requests from the user terminal. Table 16 lists the various fields of an exemplary RACH message format and the size of each field for each of the four different message sizes.

Table 16

Fields/Parameter Names	RACH Message Sizes				Description
	96 bits	192 bits	384 bits	768 bits	
Message Duration	2	2	2	2	Duration of message
MAC PDU Type	4	4	4	4	RACH message type
MAC ID	10	10	10	10	MAC ID
Slot ID	6	6	6	6	Tx Slot ID
Payload	44	140	332	716	Info bits
CRC	24	24	24	24	CRC value for the RACH message
Tail Bits	6	6	6	6	Tail bits

[0127] The Message Duration field indicates the size of the RACH message. The MAC PDU Type field indicates the RACH message type. The MAC ID field contains the MAC ID that uniquely identifies the user terminal sending the RACH message. During initial system access, a unique MAC ID has not been assigned to the user terminal. In this case, a registration MAC ID (e.g., a specific value reserved for registration purpose) may be included in the MAC ID field. The Slot ID field indicates the starting RACH slot on which the RACH PDU was sent (the RACH timing and transmission is described below). The Payload field includes the information bits for the RACH message. The CRC field contains a CRC value for the RACH message, and the Tail Bits field is used to reset the convolutional encoder for the RACH. The operation of the RACH in conjunction with the BCH and FCCH for system access is described in further detail below.

[0128] The RACH may also be implemented with a "fast" RACH (F-RACH) and a "slow" RACH (S-RACH). The F-RACH and S-RACH can be designed to efficiently support user terminals in different operating states. For example, the F-RACH may be used by user terminals that (1) have registered with the system, (2) can compensate for their round trip delays (RTDs) by properly advancing their transmit timing, and (3) achieve the required SNR for operation on the F-RACH. The S-RACH may be used by user terminals that cannot use the F-RACH for any reasons.

[0129] Different designs may be used for the F-RACH and S-RACH to facilitate rapid access to the system whenever possible and to minimize the amount of system resources needed to implement random access. For example, the F-RACH can use a shorter PDU, employ a weaker coding scheme, require F-RACH PDUs to arrive approximately time-aligned at the access point, and utilize a slotted Aloha random access scheme. The S-RACH can use a longer PDU, employ a stronger coding scheme, allow S-RACH PDUs to arrive non-aligned in time at the access point, and utilize an unslotted Aloha random access scheme.

[0130] For simplicity, the following description assumes that a single RACH is used for the MIMO WLAN system.

4. Forward Channel (FCH) - Downlink

[0131] The FCH is used by the access point to transmit user-specific data to specific user terminals and page/broadcast messages to multiple user terminals. The FCH may also be used to transmit pilot to user terminals. The FCH can be allocated on a per frame basis. A number of FCH PDU types are provided to accommodate different uses of the FCH. Table 17 lists an exemplary set of FCH PDU types.

Table 17 - FCH PDU Types

Code	FCH PDU Type	Description
0	Message Only	FCH broadcast/page service/user message

Table continued

Code	FCH PDU Type	Description
1	Message and Preamble	FCH user message
2	Preamble Only	FCH *Idle* state

[0132] FCH PDU Type 0 is used to send page/broadcast messages and user messages/packets on the FCH and only includes the message/packet. (Data for a specific user terminal may be sent as a message or a packet, and these two terms are used interchangeably herein.) FCH PDU Type 1 is used to send user packets and includes a preamble. FCH PDU Type 2 includes only the preamble and no message/packet, and is associated with *Idle* state FCH traffic.

[0133] **FIG. 5D** illustrates an embodiment of an FCH PDU 430a for FCH PDU Type 0. In this embodiment, FCH PDU 430a includes only a message portion 534a for a page/broadcast message or a user packet. The message/packet can have variable length, which is given by the FCH Message Length field in the FCH PDU. The message length is given in integer number of PHY frames (described below). The rate and transmission mode for the page/broadcast message are specified and described below. The rate and transmission mode for the user packet are specified in the associated FCCH information element.

[0134] **FIG. 5E** illustrates an embodiment of an FCH PDU 430b for FCH PDU Type 1. In this embodiment, FCH PDU 430b includes a preamble portion 532b and a message/packet portion 534b. Preamble portion 532b is used to send a MIMO pilot or a steered reference and has a variable length, which is given by the FCH Preamble Type field in the associated FCCH information element. Portion 534b is used to send an FCH packet and also has a variable length (in integer number of PHY frames), which is given by the FCH Message Length field in the FCH PDU. The FCH packet is sent using the rate and transmission mode specified by the associated FCCH information element.

[0135] **FIG. 5F** illustrates an embodiment of an FCH PDU 430c for FCH PDU Type 2. In this embodiment, FCH PDU 430c includes only a preamble portion 532c and no message portion. The length of the preamble portion is indicated by the FCCH IE. The FCH PDU Type 2 may be used to allow the user terminal to update its channel estimate while in the *Idle* state.

[0136] A number of FCH Message types are provided to accommodate different uses of the FCH. Table 18 lists an exemplary set of FCH Message types.

Table 18 - FCH Message Types

Code	FCH Message Type	Description
0	Page Message	Page message - diversity mode, rate = 0.25 bps/Hz
1	Broadcast Message	Broadcast message - diversity mode, rate = 0.25 bps/Hz
2	User Packet	Dedicated channel operation - user terminal specific PDU, rate specified in the FCCH
3-15	Reserved	Reserved for future use

[0137] A page message may be used to page multiple user terminals and is sent using FCH PDU Type 0. If the Page Bit in the BCH message is set, then one or more FCH PDUs with page messages (or "Page PDUs") are sent first on the FCH. Multiple Page PDUs may be sent in the same frame. Page PDUs are transmitted using the diversity mode and the lowest rate of 0.25 bps/Hz to increase the likelihood of correct reception by the user terminals.

[0138] A broadcast message may be used to send information to multiple user terminals and is sent using FCH PDU Type 0. If the Broadcast Bit in the BCH message is set, then one or more FCH PDUs with broadcast messages (or "Broadcast PDUs") are sent on the FCH immediately following any Page PDUs sent on the FCH. The Broadcast PDUs are also transmitted using the diversity mode and the lowest rate of 0.25 bps/Hz to increase the likelihood of correct reception.

[0139] A user packet may be used to send user-specific data, and may be sent using FCH PDU Type 1 or 2. User PDUs of Type 1 and 2 are sent on the FCH following any Page and Broadcast PDUs sent on the FCH. Each User PDU may be transmitted using the diversity, beam-steering, or spatial multiplexing mode. The FCCH information element specifies the rate and transmission mode used for each User PDU sent on the FCH.

[0140] A message or packet sent on the FCH comprises an integer number of PHY frames. In an embodiment and as described below, each PHY frame may include a CRC value that permits individual PHY frames in an FCH PDU to be checked and retransmitted if necessary. For asynchronous services, the RLP may be employed for segmentation, retransmission, and reassembly of PHY frames within a given FCH PDU. In another embodiment, a CRC value is provided for each message or packet, instead of each PHY frame.

[0141] **FIG. 6** illustrates an embodiment of the structure for an FCH packet 534. The FCH packet comprises an integer number of PHY frames 610. Each PHY frame includes a payload field 622, a CRC field 624, and a tail bit field 626. The first PHY frame for the FCH packet further includes a header field 620, which indicates the message type and duration. The last PHY frame in the FCH packet further includes a pad bit field 628, which contains zero padding bits at the end of the payload in order to fill the last PHY frame. In an embodiment, each PHY frame comprises 6 OFDM symbols. The number of bits included in each PHY frame is dependent on the rate used for that PHY frame.

[0142] Table 19 lists the various fields for an exemplary FCH PDU format for FCH PDU Types 0 and 1.

Table 19 - FCH PDU Format

	Fields/Parameter Names	Length (bits)	Description
First PHY frame	FCH Message Type	4	FCH message type
	FCH Message Length	16	Number of bytes in FCH PDU
	Payload	Variable	Payload bits
	CRC	16	CRC value for PHY frame (optional)
	Tail Bits	6	Tail bits for convolutional encoder
Each Middle PHY frame	Payload	Variable	Payload bits
	CRC	16	CRC value for PHY frame (optional)
	Tail Bits	6	Tail bits for convolutional encoder
Last PHY frame	Payload	Variable	Payload bits
	Pad bits	Variable	Pad bits to fill out PHY frame
	CRC	16	CRC value for PHY frame (optional)
	Tail Bits	6	Tail bits for convolutional encoder

[0143] The FCH Message Type and FCH Message Length fields are sent in the header of the first PHY frame of the FCH PDU. The payload, CRC, and tail bits fields are included in each PHY frame. The payload portion of each FCH PDU carries the information bits for the page/broadcast message or user-specific packet. Pad bits are used to fill the last PHY frame of the FCH PDU, if required.

[0144] A PHY frame may also be defined to comprise some other number of OFDM symbols (e.g., one, two, four, eight, and so on). The PHY frame may be defined with even number of OFDM symbols because OFDM symbols are transmitted in pairs for the diversity mode, which may be used for the FCH and RCH. The PHY frame size may be selected based on the expected traffic such that inefficiency is minimized. In particular, if the frame size is too large, then inefficiency results from using a large PHY frame to send a small amount of data. Alternatively, if the frame size is too small, then the overhead represents a larger fraction of the frame.

5. Reverse Channel (RCH) - Uplink

[0145] The RCH is used by the user terminals to transmit uplink data and pilot to the access point. The RCH may be allocated on a per TDD frame basis. One or more user terminals may be designated to transmit on the RCH in any given TDD frame. A number of RCH PDU types are provided to accommodate different operating modes on the RCH. Table 20 lists an exemplary set of RCH PDU types.

Table 20 - RCH PDU Types

Code	RCH PDU Type	Description
0	Message Only	RCH user message, no preamble
1	Message and Preamble, not Idle	RCH user message, with preamble
2	Message and Preamble, Idle	RCH idle state message with preamble

[0146] RCH PDU Type 0 is used to send a message/packet on the RCH and does not include a preamble. RCH PDU Type 1 is used to send a message/packet and includes a preamble. RCH PDU Type 2 includes a preamble and a short

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message, and is associated with *Idle* state RCH traffic.

[0147] **FIG. 5D** illustrates an embodiment of an RCH PDU for RCH PDU Type 0. In this embodiment, the RCH PDU includes only a message portion 534a for a variable-length RCH packet, which is given in integer number of PHY frames by the RCH Message Length field in the RCH PDU. The rate and transmission mode for the RCH packet are specified in the associated FCCH information element.

[0148] **FIG. 5E** illustrates an embodiment of an RCH PDU for RCH PDU Type 1. In this embodiment, the RCH PDU includes a preamble portion 532b and a packet portion 534b. Preamble portion 532b is used to send a reference (e.g., a MIMO pilot or a steered reference) and has a variable length, which is given by the RCH Preamble Type field in the associated FCCH information element. Portion 534b is used to send an RCH packet and also has a variable length, which is given by the RCH Message Length field in the RCH PDU. The RCH packet is sent using the rate and transmission mode specified in the associated FCCH information element.

[0149] **FIG. 5G** illustrates an embodiment of an RCH PDU 350d for RCH PDU Type 2. In this embodiment, the RCH PDU includes a preamble portion 532d and a message portion 536d. Preamble portion 532d is used to send a reference and has a length of 1, 4 or 8 OFDM symbols. Portion 536d is used to send a short RCH message and has a fixed length of one OFDM symbol. The short RCH message is sent using a specific rate and transmission mode (e.g., rate 1/2 or rate 1/4 and BPSK modulation).

[0150] A packet sent on the RCH (for PDU Types 0 and 1) comprises an integer number of PHY frames. The structure for an RCH packet (for PDU Types 0 and 1) is shown in FIG. 6, and is the same as for the FCH packet. The RCH packet comprises an integer number of PHY frames 610. Each PHY frame includes payload field 622, an optional CRC field 624, and tail bit field 626. The first PHY frame in the RCH packet further includes header field 620, and the last PHY frame in the packet further includes pad bit field 628.

[0151] Table 21 lists the various fields for an exemplary RCH PDU format for RCH PDU Types 0 and 1.

Table 21 - RCH PDU Format (PDU Types 0 and 1)

	Fields/Parameter Names	**Length** (bits)	**Description**
First PHY frame	RCH Message Type	4	RCH message type
	RCH Message Length	16	Number of bytes in RCH PDU
	FCH Rate Indicator	16	Indicate maximum rate for each spatial channel on FCH
	Payload	Variable	Payload bits
	CRC	16	CRC value for PHY frame (optional)
	Tail Bits	6	Tail bits for convolutional encoder
Each Middle PHY frame	Payload	Variable	Payload bits
	CRC	16	CRC value for PHY frame (optional)
	Tail Bits	6	Tail bits for convolutional encoder
Last PHY frame	Payload	Variable	Payload bits
	Pad bits	Variable	Pad bits to fill out PHY frame
	CRC	16	CRC value for PHY frame (optional)
	Tail Bits	6	Tail bits for convolutional encoder

[0152] The RCH Message Type, RCH Message Length, and FCH Rate Indicator fields are sent in the header of the first PHY frame of the RCH PDU. The FCH Rate Indicator field is used to convey FCH rate information (e.g., the maximum rates supported by each of the spatial channels) to the access point.

[0153] Table 22 lists the various fields for an exemplary RCH PDU format for RCH PDU Type 2.

Table 22 - RCH Message for RCH PDU Type 2

Fields/Parameter Names	**Length** (bits)	**Description**
FCH Rate Indicator	16	Indicate maximum rate for each spatial channel on FCH
RCH Request	1	User terminal request to send additional data

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Table continued

Fields/Parameter Names	Length (bits)	Description
Reserved	1	Reserved for future use
Tail Bits	6	Tail bits for convolutional encoder

The RCH Request field is used by the user terminal to request additional capacity on the uplink. This short RCH message does not include a CRC and is transmitted in a single OFDM symbol.

6. Dedicated Channel Activity

[0154] Data transmission on the FCH and RCH can occur independently. Depending on the transmission modes selected for use for the FCH and RCH, one or multiple spatial channels (for the beam-steering and diversity modes) may be active and used for data transmission for each dedicated transport channel. Each spatial channel may be associated with a specific rate.

[0155] When only the FCH or only the RCH has all four rates set to zero, the user terminal is idle on that link. The idle terminal still transmits an idle PDU on the RCH. When both the FCH and RCH have all four rates set to zero, both the access point and user terminal are off and not transmitting. User terminals with less than four transmit antennas set the unused rate fields to zero. User terminals with more than four transmit antennas use no more than four spatial channels to transmit data. Table 23 shows the transmission state and channel activity when the rates on all four spatial channels of either the FCH or RCH (or both) are set to zero.

Table 23

FCH Rates	RCH Rates	Channel Activity	Transmission State
At least one rate on FCH ≠ 0	At least one rate on RCH ≠ 0	FCH and RCH are active	FCH and/or RCH are transmitting
At least one rate on FCH ≠ 0	All rates on RCH = 0	FCH active, RCH idle	
All rates on FCH = 0	At least one rate on RCH ≠ 0	FCH idle, RCH active	
All rates on FCH = 0	All rates on RCH = 0	FCH and RCH are OFF	No transmissions

[0156] There may also be a situation where both the RCH and FCH are idle (i.e., not transmitting data) but still transmitting preamble. This is referred to as the *Idle* state. The control fields used to support a user terminal in the *Idle* state are provided in an FCCH IE Type 2 information element, which is shown in Table 13.

7. Alternative Designs

[0157] For clarity, specific PDU types, PDU structures, message formats, and so on, have been described for an exemplary design. Fewer, additional, and/or different types, structures, and formats may also be defined for use, and this is within the scope of the invention.

III. OFDM Subband Structures

[0158] In the above description, the same OFDM subband structure is used for all of the transport channels. Improved efficiency may be achieved by using different OFDM subband structures for different transport channels. For example, a 64-subband structure may be used for some transport channels, a 256-subband structure may be used for some other transport channels, and so on. Moreover, multiple OFDM subband structures may be used for a given transport channel.

[0159] For a given system bandwidth of W, the duration of an OFDM symbol is dependent on the number of total subbands. If the total number of subbands is N, then the duration of each transformed symbol (without a cyclic prefix) is N/W μsec (if W is given in MHz). A cyclic prefix is added to each transformed symbol to form a corresponding OFDM symbol. The length of the cyclic prefix is determined by the expected delay spread of the system. The cyclic prefix represents overhead, which is needed for each OFDM symbol in order to combat a frequency selective channel. This overhead represents a larger percentage of the OFDM symbol if the symbol is short and a smaller percentage if the symbol is long.

[0160] Since different transport channels may be associated with different types of traffic data, a suitable OFDM subband structure may be selected for use for each transport channel to match the expected traffic data type. If a large

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amount of data is expected to be transmitted on a given transport channel, then a larger subband structure may be defined for use for the transport channel. In this case, the cyclic prefix would represent a smaller percentage of the OFDM symbol and greater efficiency may be achieved. Conversely, if a small amount of data is expected to be transmitted on a given transport channel, than a smaller subband structure may be defined for use for the transport channel. In this case, even though the cyclic prefix represents a larger percentage of the OFDM symbol, greater efficiency may still be achieved by reducing the amount of excess capacity by using a smaller size OFDM symbol. The OFDM symbol may thus be viewed as a "box car" that is used to send data, and the proper size "box car" may be selected for each transport channel depending on the amount of data expected to be sent.

[0161] For example, for the embodiment described above, the data on the FCH and RCH is sent in PHY frames, each of which comprises 6 OFDM symbols. In this case, another OFDM structure may be defined for use for the FCH and RCH. For example, a 256-subband structure may be defined for the FCH and RCH. A "large" OFDM symbol for the 256-subband structure would be approximately four times the duration of a "small" OFDM symbol for the 64-subband structure but would have four times the data-carrying capacity. However, only one cyclic prefix is needed for one large OFDM symbol, whereas four cyclic prefixes are needed for the equivalent four small OFDM symbols. Thus, the amount of overhead for the cyclic prefixes may be reduced by 75% by the use of the larger 256-subband structure.

[0162] This concept may be extended so that different OFDM subband structures may be used for the same transport channel. For example, the RCH supports different PDU types, each of which may be associated with a certain size. In this case, a larger subband structure may be used for a larger-size RCH PDU type, and a smaller subband structure may be used for a smaller-size RCH PDU type. A combination of different subband structures may also be used for a given PDU. For example, if one long OFDM symbol is equivalent to four short OFDM symbols, then a PDU may be sent using N_{large} large OFDM symbols and N_{small} small OFDM symbols, where $N_{large} \geq 0$ and $3 \geq N_{small} \geq 0$.

[0163] Different OFDM subband structures are associated with OFDM symbols of different lengths. Thus, if different OFDM subband structures are used for different transport channels (and/or for the same transport channel), then the FCH and RCH offsets for the FCH and RCH PDUs would need to be specified with the proper time resolution, which is smaller than an OFDM symbol period. In particular, the time increment for the FCH and RCH PDUs may be given in integer numbers of cyclic prefix length, instead of OFDM symbol period.

IV. Rates and Transmission Modes

[0164] The transport channels described above are used to send various types of data for various services and functions. Each transport channel may be designed to support one or more rates and one or more transmission modes.

1. Transmission Modes

[0165] A number of transmission modes are supported for the transport channels. Each transmission mode is associated with specific spatial processing at the transmitter and receiver, as described below. Table 24 lists the transmission mode(s) supported by each of the transport channels.

Table 24

Transport Channels	Transmission Modes			
	SIMO	Tx Diversity	Beam-Steering	Spatial Multiplexing
BCH	-	X		-
FCCH	-	X	-	-
RACH	X	-	X	-
FCH	-	X	X	X
RCH	X	X	X	X

For the diversity mode, each data symbol is transmitted redundantly over multiple transmit antennas, multiple subbands, multiple symbol periods, or a combination thereof to achieve spatial, frequency, and/or time diversity. For the beam-steering mode, a single spatial channel is used for data transmission (typically the best spatial channel), and each data symbol is transmitted on the single spatial channel using full transmit power available for the transmit antennas. For the spatial multiplexing mode, multiple spatial channels are used for data transmission, and each data symbol is transmitted on one spatial channel, where a spatial channel may correspond to an eigenmode, a transmit antenna, and so on. The beam-steering mode may be viewed as a special case of the spatial multiplexing mode whereby only one spatial channel

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is used for data transmission.

[0166] The diversity mode may be used for the common transport channels (BCH and FCCH) for the downlink from the access point to the user terminals. The diversity mode may also be used for the dedicated transport channels (FCH and RCH). The use of the diversity mode on the FCH and RCH may be negotiated at call setup. The diversity mode transmits data on one "spatial mode" using a pair of antennas for each subband.

[0167] The beam-steering mode may be employed on the RACH by user terminals with multiple transmit antennas. A user terminal can estimate the MIMO channel based on the MIMO pilot sent on the BCH. This channel estimate may then be used to perform beam-steering on the RACH for system accesses. The beam-steering mode may also be used for the dedicated transport channels (FCH and RCH). The beam-steering mode may be able to achieve higher received signal-to-noise-and-interference ratio (SNR) at the receiver than the diversity mode by exploiting the gain of the antenna array at the transmitter. In addition, the preamble portion of the PDU may be reduced since the steered reference only includes symbols for a single "steered" antenna. The diversity mode may also be used for the RACH.

[0168] The spatial multiplexing mode may be used for the FCH and RCH to achieve greater throughput, when supported by the channel conditions. The spatial multiplexing and beam-steering modes are reference driven and require closed-loop control for proper operation. As such, a user terminal is allocated resources on both the FCH and RCH to support the spatial multiplexing mode. Up to four spatial channels may be supported on the FCH and RCH (limited by the number of antennas at the access point).

2. Coding and Modulation

[0169] A number of different rates are supported for the transport channels. Each rate is associated with a particular code rate and a particular modulation scheme, which collectively results in a particular spectral efficiency (or data rate). Table 25 lists the various rates supported by the system.

Table 25

Rate Word	Spectral Efficiency (bps/Hz)	Code Rate	Modulation Scheme	Info bits/ OFDM symbol	Code bits/ OFDM symbol
0000	0.0	-	off	-	-
0001	0.25	1/4	BPSK	12	48
0010	0.5	1/2	BPSK	24	48
0011	1.0	1/2	QPSK	48	96
0100	1.5	3/4	QPSK	72	96
0101	2.0	1/2	16 QAM	96	192
0110	2.5	5/8	16 QAM	120	192
0111	3.0	3/4	16 QAM	144	192
1000	3.5	7/12	64 QAM	168	288
1001	4.0	2/3	64 QAM	192	288
1010	4.5	3/4	64 QAM	216	288
1011	5.0	5/6	64 QAM	240	288
1100	5.5	11/16	256 QAM	264	384
1101	6.0	3/4	256 QAM	288	384
1110	6.5	13/16	256 QAM	312	384
1111	7.0	7/8	256 QAM	336	384

[0170] Each common transport channel supports one or more rates and one transmission mode (or possibly more, as may be the case for the RACH). The BCH is transmitted at a fixed rate using the diversity mode. The FCCH may be transmitted at one of four possible rates, as indicated by the FCCH Phy Mode field in the BCH message, using the diversity mode. In one embodiment, the RACH may be transmitted at one of four possible rates, as indicated by the RACH DRI embedded in the preamble of the RACH PDU, and each RACH message is one of four possible sizes. In

another embodiment, the RACH is transmitted at a single rate. Table 26 lists the coding, modulation, and transmission parameters and the message sizes supported by each common transport channel.

Table 26 - Parameters for Common Transport Channels

Transport Channel	Spectral Efficiency (bps/Hz)	Code Rate	Modulation Scheme	Transmission Mode	Message Size	
					bits	OFDM symbols
BCH	0.25	1/4	BPSK	Diversity	120	10
FCCH	0.25	1/4	BPSK	Diversity	variable	variable
"	0.5	1/2	BPSK	Diversity	variable	variable
"	1.0	1/2	QPSK	Diversity	variable	variable
"	2.0	1/2	16 QAM	Diversity	variable	variable
RACH	0.25	1/4	BPSK	Beam-Steering	96	8
"	0.5	1/2	BPSK	Beam-Steering	96, 192	4,8
"	1.0	1/2	QPSK	Beam-Steering	96, 192, 384	2, 4, 8
"	2.0	1/2	16 QAM	Beam-Steering	96, 192, 384, 768	1, 2, 4, 8

The FCCH message is variable in size and given in even number of OFDM symbols.

[0171] The FCH and RCH support all of the rates listed in Table 25. Table 27 lists the coding, modulation, and transmission parameters and the message sizes supported by the FCH and RCH.

Table 27 - Parameters for FCH and RCH

					PHY Frame Size		
					code bits	mod symbols	OFDM symbols
0.25 [A]	1/4	BPSK	72	72	144	288	6
0.5	1/2	BPSK	144	144	288	288	6
1.0	1/2	QPSK	288	288	576	288	6
1.5	3/4	QPSK	432	144	576	288	6
2.0	1/2	16 QAM	576	576	1152	288	6
2.5	5/8	16 QAM	720	432	1152	288	6
3.0	3/4	16 QAM	864	288	1152	288	6
3.5	7/12	64 QAM	1008	720	1728	288	6
4.0	2/3	64 QAM	1152	576	1728	288	6
4.5	3/4	64 QAM	1296	432	1728	288	6
5.0	5/6	64 QAM	1440	288	1728	288	6
5.5	11/16	256 QAM	1584	720	2304	288	6
6.0	3/4	256 QAM	1728	576	2304	288	6
6.5	13/16	256 QAM	1872	432	2304	288	6
7.0	7/8	256 QAM	2016	288	2304	288	6

Note A: each rate 1/2 code bit is repeated on two subbands to obtain an effective code rate of 1/4. The parity bits represent redundancy bits introduced by the coding and are used for error correction by the receiver.

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[0172] The PHY frame size in Table 27 indicates the number of code bits, modulation symbols, and OFDM symbols for each PHY frame. If 48 data subbands are used for data transmission, then each OFDM symbol includes 48 modulation symbols. For the diversity and beam-steering modes, one symbol stream is transmitted and the PHY frame size corresponds to the single rate employed for this symbol stream. For the spatial multiplexing mode, multiple symbol streams may be sent on multiple spatial channels, and the overall PHY frame size is determined by the sum of the PHY frame sizes for the individual spatial channels. The PHY frame size for each spatial channel is determined by the rate employed for that spatial channel.

[0173] As an example, suppose the MIMO channel is capable of supporting four spatial channels operating at spectral efficiencies of 0.5, 1.5, 4.5, and 5.5 bps/Hz. The four rates selected for the four spatial channels would then be as shown in Table 28.

Table 28 - Example Spatial Multiplexing Transmission

Spatial channel Index	Spectral Efficiency (bps/Hz)	Code Rate	Modulation Scheme	Payload (bits/ PHY frame)	PHY Frame Size		
					code bits	mod symbols	OFDM symbols
1	0.5	1/2	BPSK	144	288	288	6
2	1.5	3/4	QPSK	432	576	288	6
3	4.5	3/4	64 QAM	1296	1728	288	6
4	5.5	11/16	256 QAM	1584	2304	288	6

The overall PHY frame size is then 144 + 432 + 1296 + 1584 = 3456 information bits or 288+576+1728+2304=4896 code bits. Even though each of the four spatial channels supports a different number of payload bits, the overall PHY frame can be transmitted in 6 OFDM symbols (e.g., 24 μsec, assuming 4 μsec/OFDM symbol).

V. Physical Layer Processing

[0174] **FIG. 7** shows a block diagram of an embodiment of an access point 110x and two user terminals 120x and 120y within the MIMO WLAN system.

[0175] On the downlink, at access point 110x, a transmit (TX) data processor 710 receives traffic data (i.e., information bits) from a data source 708 and signaling and other information from a controller 730 and possibly a scheduler 734. These various types of data may be sent on different transport channels. TX data processor 710 "frames" the data (if necessary), scrambles the framed/unframed data, encodes the scrambled data, interleaves (i.e., reorders) the coded data, and maps the interleaved data into modulation symbols. For simplicity, a "data symbol" refers to a modulation symbol for traffic data, and a "pilot symbol" refers to a modulation symbol for pilot. The scrambling randomizes the data bits. The encoding increases the reliability of the data transmission. The interleaving provides time, frequency, and/or spatial diversity for the code bits. The scrambling, coding, and modulation may be performed based on control signals provided by controller 730 and are described in further detail below. TX data processor 710 provides a stream of modulation symbols for each spatial channel used for data transmission.

[0176] A TX spatial processor 720 receives one or more modulation symbol streams from TX data processor 710 and performs spatial processing on the modulation symbols to provide four streams of transmit symbols, one stream for each transmit antenna. The spatial processing is described in further detail below.

[0177] Each modulator (MOD) 722 receives and processes a respective transmit symbol stream to provide a corresponding stream of OFDM symbols. Each OFDM symbol stream is further processed to provide a corresponding downlink modulated signal. The four downlink modulated signals from modulator 722a through 722d are then transmitted from four antennas 724a through 724d, respectively.

[0178] At each user terminal 120, one or multiple antennas 752 receive the transmitted downlink modulated signals, and each receive antenna provides a received signal to a respective demodulator (DEMOD) 754. Each demodulator 754 performs processing complementary to that performed at modulator 722 and provides received symbols. A receive (RX) spatial processor 760 then performs spatial processing on the received symbols from all demodulators 754 to provide recovered symbols, which are estimates of the modulation symbols sent by the access point.

[0179] An RX data processor 770 receives and demultiplexes the recovered symbols into their respective transport channels. The recovered symbols for each transport channel may be symbol demapped, deinterleaved, decoded, and descrambled to provide decoded data for that transport channel. The decoded data for each transport channel may include recovered packet data, messages, signaling, and so on, which are provided to a data sink 772 for storage and/or

a controller 780 for further processing.

[0180] The processing by access point 110 and terminal 120 for the downlink is described in further detail below. The processing for the uplink may be the same or different from the processing for the downlink.

[0181] For the downlink, at each active user terminal 120, RX spatial processor 760 further estimates the downlink to obtain channel state information (CSI). The CSI may include channel response estimates, received SNRs, and so on. RX data processor 770 may also provide the status of each packet/frame received on the downlink. A controller 780 receives the channel state information and the packet/frame status and determines the feedback information to be sent back to the access point. The feedback information is processed by a TX data processor 790 and a TX spatial processor 792 (if present), conditioned by one or more modulators 754, and transmitted via one or more antennas 752 back to the access point.

[0182] At access point 110, the transmitted uplink signal(s) are received by antennas 724, demodulated by demodulators 722, and processed by an RX spatial processor 740 and an RX data processor 742 in a complementary manner to that performed at the user terminal. The recovered feedback information is then provided to controller 730 and a scheduler 734.

[0183] Scheduler 734 uses the feedback information to perform a number of functions such as (1) selecting a set of user terminals for data transmission on the downlink and uplink, (2) selecting the transmission rate(s) and the transmission mode for each selected user terminal, and (3) assigning the available FCH/RCH resources to the selected terminals. Scheduler 734 and/or controller 730 further uses information (e.g., steering vectors) obtained from the uplink transmission for the processing of the downlink transmission, as described in further detail below.

[0184] A number of transmission modes are supported for data transmission on the downlink and uplink. The processing for each of these transmission modes is described in further detail below.

1. Diversity Mode - Transmit Processing

[0185] **FIG. 8A** shows a block diagram of an embodiment of a transmitter unit 800 capable of performing the transmit processing for the diversity mode. Transmitter unit 800 may be used for transmitter portion of the access point and the user terminal.

[0186] Within a TX data processor 710a, a framing unit 808 frames the data for each packet to be transmitted on the FCH or RCH. The framing need not be performed for the other transport channels. The framing may be performed as illustrated in FIG. 6 to generate one or more PHY frames for each user packet. A scrambler 810 then scrambles the framed/unframed data for each transport channel to randomize the data.

[0187] An encoder 812 receives and codes the scrambled data in accordance with a selected coding scheme to provide code bits. A repeat/puncture unit 814 then repeats or punctures (i.e., deletes) some of the code bits to obtain the desired code rate. In an embodiment, encoder 812 is a rate 1/2, constraint length 7, binary convolutional encoder. A code rate of 1/4 may be obtained by repeating each code bit once. Code rates greater than 1/2 may be obtained by deleting some of the code bits from encoder 812. A specific design for framing unit 808, scrambler 810, encoder 812, and repeat/puncture unit 814 is described below.

[0188] An interleaver 818 then interleaves (i.e., reorders) the code bits from unit 814 based on a selected interleaving scheme. In an embodiment, each group of 48 consecutive code bits to be transmitted on a given spatial channel is spread over the 48 data-carrying subbands (or simply, data subbands) to provide frequency diversity. The interleaving is described in further detail below.

[0189] A symbol mapping unit 820 then maps the interleaved data in accordance with a particular modulation scheme to provide modulation symbols. As shown in Table 26, BPSK, 4 QAM, or 16 QAM may be used for the diversity mode, depending on the selected rate. In the diversity mode, the same modulation scheme is used for all data subbands. The symbol mapping may be achieved by (1) grouping sets of B bits to form B-bit values, where $B \geq 1$, and (2) mapping each B-bit value to a point in a signal constellation corresponding to the selected modulation scheme. Each mapped signal point is a complex value and corresponds to a modulation symbol. Symbol mapping unit 820 provides a stream of modulation symbols to a TX diversity processor 720a.

[0190] In an embodiment, the diversity mode utilizes space-time transmit diversity (STTD) for dual transmit diversity on a per subband basis. STTD supports simultaneous transmission of independent symbol streams on two transmit antennas while maintaining orthogonality at the receiver.

[0191] The STTD scheme operates as follows. Suppose that two modulation symbols, denoted as s_1 and s_2, are to be transmitted on a given subband. The transmitter generates two vectors, $\underline{\mathbf{x}}_1 = [s_1 \; s_2]^T$ and $\underline{\mathbf{x}}_2 = [s_2^* \; -s_1^*]^T$, where "*" denotes the complex conjugate and "^{T}" denotes the transpose. Each vector includes two elements that are to be transmitted from two transmit antennas in one symbol period (i.e., vector $\underline{\mathbf{x}}_1$ is transmitted from two antennas in the first symbol period, and vector $\underline{\mathbf{x}}_2$ is transmitted from two antennas in the next symbol period).

[0192] If the receiver is equipped with a single receive antenna, then the received symbols may be expressed as:

$$r_1 = h_1 s_1 + h_2 s_2 + n_1 \quad , \text{ and} \quad \text{Eq (1)}$$

$$r_2 = h_1 s_2^* - h_2 s_1^* + n_2 \quad ,$$

where r_1 and r_2 are two symbols received in two consecutive symbol periods at the receiver;
h_1 and h_2 are the path gains from the two transmit antennas to the receive antenna for the subband under consideration, where the path gains are assumed to be constant over the subband and static over the 2-symbol period; and
n_1 and n_2 are the noise associated with the two received symbols r_1 and r_2, respectively.

[0193] The receiver may then derive estimates of the two transmitted symbols, s_1 and s_2, as follows:

$$\hat{s}_1 = \frac{h_1^* r_1 - h_2 r_2^*}{|h_1|^2 + |h_2|^2} = s_1 + \frac{h_1^* n_1 - h_2 n_2^*}{|h_1|^2 + |h_2|^2} \quad , \text{ and} \quad \text{Eq (2)}$$

$$\hat{s}_2 = \frac{h_2^* r_1 + h_1 r_2^*}{|h_1|^2 + |h_2|^2} = s_2 + \frac{h_2^* n_1 + h_1 n_2^*}{|h_1|^2 + |h_2|^2} \quad .$$

[0194] Alternatively, the transmitter may generate two vectors $\underline{\mathbf{x}}_1 = [s_1 \quad -s_2^*]^T$ and $\underline{\mathbf{x}}_2 = [s_2 \quad s_1^*]^T$ and transmit the two vectors sequentially in two symbol periods from two transmit antennas. The received symbols may then be expressed as:

$$r_1 = h_1 s_1 - h_2 s_2^* + n_1 \quad ,$$

and

$$r_2 = h_1 s_2 + h_2 s_1^* + n_2 \quad .$$

The receiver may then derive estimates of the two transmitted symbols as follows:

$$\hat{s}_1 = \frac{h_1^* r_1 + h_2 r_2^*}{|h_1|^2 + |h_2|^2} = s_1 + \frac{h_1^* n_1 + h_2 n_2}{|h_1|^2 + |h_2|^2} \quad ,$$

and

$$\hat{s}_2 = \frac{-h_2 r_1^* + h_1^* r_2}{|h_1|^2 + |h_2|^2} = s_2 + \frac{h_1^* n_2 - h_2 n_1}{|h_1|^2 + |h_2|^2} \quad .$$

[0195] The above description may be extended for a MIMO-OFDM system with two or more transmit antennas, N_R receive antennas, and multiple subbands. Two transmit antennas are used for any given subband. Suppose that two modulation symbols, denoted as $s_1(k)$ and $s_2(k)$, are to be transmitted on a given subband k. The transmitter generates two vectors $\underline{\mathbf{x}}_1(k)=[s_1(k) \quad s_2(k)]^T$ and $\underline{\mathbf{x}}_2(k) = [s_2^*(k) \quad -s_1^*(k)]^T$ or equivalently two symbol sets $\{x_i(k)\} = \{s_1(k) \quad s_2^*(k)\}$ and $\{x_j(k)\} = \{s_2(k) \quad -s_1^*(k)\}$. Each symbol set includes two elements that are to be transmitted sequentially in two symbol periods from a respective transmit antenna on subband k (i.e., symbol set $\{x_i(k)\}$ is transmitted on subband k from antenna i in two symbol periods, and symbol set $\{x_j(k)\}$ is transmitted on subband

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k from antenna j in the same 2-symbol period).

[0196] The vectors of received symbols at the receive antennas in the two symbol periods may be expressed as:

$$\underline{\mathbf{r}}_1(k) = \underline{\mathbf{h}}_i(k)s_1(k) + \underline{\mathbf{h}}_j(k)s_2(k) + \underline{\mathbf{n}}_1(k) \quad ,$$

and

$$\underline{\mathbf{r}}_2(k) = \underline{\mathbf{h}}_i(k)s_2^*(k) - \underline{\mathbf{h}}_j(k)s_1^*(k) + \underline{\mathbf{n}}_2(k) \quad ,$$

where $\underline{\mathbf{r}}_1(k)$ and $\underline{\mathbf{r}}_2(k)$ are two symbol vectors received in two consecutive symbol periods on subband k at the receiver, with each vector including N_R received symbols for N_R receive antennas;
$\underline{\mathbf{h}}_i(k)$ and $\underline{\mathbf{h}}_j(k)$ are the vectors of path gains from the two transmit antennas i and j to the N_R receive antennas for subband k, with each vector including the channel gains from the associated transmit antenna to each of the N_R receive antennas, where the path gains are assumed to be constant over the subband and static over the 2-symbol period; and
$\underline{\mathbf{n}}_1(k)$ and $\underline{\mathbf{n}}_2(k)$ are noise vectors associated with the two received vectors $\underline{\mathbf{r}}_1(k)$ and $\underline{\mathbf{r}}_2(k)$, respectively.

[0197] The receiver may then derive estimates of the two transmitted symbols, $s_1(k)$ and $s_2(k)$, as follows:

$$\hat{s}_1(k) = \frac{\hat{\underline{\mathbf{h}}}_i^H(k)\underline{\mathbf{r}}_1(k) - \underline{\mathbf{r}}_2^H(k)\hat{\underline{\mathbf{h}}}_j(k)}{\|\hat{\underline{\mathbf{h}}}_i(k)\|^2 + \|\hat{\underline{\mathbf{h}}}_j(k)\|^2} = s_1(k) + \frac{\hat{\underline{\mathbf{h}}}_i^H(k)\underline{\mathbf{n}}_1(k) - \underline{\mathbf{n}}_2^H(k)\hat{\underline{\mathbf{h}}}_j(k)}{\|\hat{\underline{\mathbf{h}}}_i(k)\|^2 + \|\hat{\underline{\mathbf{h}}}_j(k)\|^2} \quad ,$$

and

$$\hat{s}_2(k) = \frac{\hat{\underline{\mathbf{h}}}_j^H(k)\underline{\mathbf{r}}_1(k) + \underline{\mathbf{r}}_2^H(k)\hat{\underline{\mathbf{h}}}_i(k)}{\|\hat{\underline{\mathbf{h}}}_i(k)\|^2 + \|\hat{\underline{\mathbf{h}}}_j(k)\|^2} = s_2(k) + \frac{\hat{\underline{\mathbf{h}}}_j^H(k)\underline{\mathbf{n}}_1(k) + \underline{\mathbf{n}}_2^H(k)\hat{\underline{\mathbf{h}}}_i(k)}{\|\hat{\underline{\mathbf{h}}}_i(k)\|^2 + \|\hat{\underline{\mathbf{h}}}_j(k)\|^2} \quad .$$

[0198] Alternatively, the transmitter may generate two symbol sets $\{x_i(k)\} = \{s_1(k) \;\; s_2(k)\}$ and $\{x_j(k)\} = \{-s_2^*(k) \;\; s_1^*(k)\}$ and transmit these two symbol sets from two transmit antennas i and j. The vectors of received symbols may then be expressed as:

$$\underline{\mathbf{r}}_1(k) = \underline{\mathbf{h}}_i(k)s_1(k) - \underline{\mathbf{h}}_j(k)s_2^*(k) + \underline{\mathbf{n}}_1(k) \quad ,$$

and

$$\underline{\mathbf{r}}_2(k) = \underline{\mathbf{h}}_i(k)s_2(k) + \underline{\mathbf{h}}_j(k)s_1^*(k) + \underline{\mathbf{n}}_2(k) \quad .$$

The receiver may then derive estimates of the two transmitted symbols as follows:

$$\hat{s}_1(k) = \frac{\hat{\underline{\mathbf{h}}}_i^H(k)\underline{\mathbf{r}}_1(k) + \underline{\mathbf{r}}_2^H(k)\hat{\underline{\mathbf{h}}}_j(k)}{\|\hat{\underline{\mathbf{h}}}_i(k)\|^2 + \|\hat{\underline{\mathbf{h}}}_j(k)\|^2} = s_1(k) + \frac{\hat{\underline{\mathbf{h}}}_i^H(k)\underline{\mathbf{n}}_1(k) + \underline{\mathbf{n}}_2^H(k)\hat{\underline{\mathbf{h}}}_j(k)}{\|\hat{\underline{\mathbf{h}}}_i(k)\|^2 + \|\hat{\underline{\mathbf{h}}}_j(k)\|^2} \quad ,$$

and

$$\hat{s}_2(k) = \frac{\hat{\underline{h}}_i^H(k)\underline{r}_2(k) - \underline{r}_1^H(k)\hat{\underline{h}}_j(k)}{\|\hat{\underline{h}}_i(k)\|^2 + \|\hat{\underline{h}}_j(k)\|^2} = s_2(k) + \frac{\hat{\underline{h}}_i^H(k)\underline{n}_2(k) - \underline{n}_1^H(k)\hat{\underline{h}}_j(k)}{\|\hat{\underline{h}}_i(k)\|^2 + \|\hat{\underline{h}}_j(k)\|^2} \quad .$$

[0199] The STTD scheme is described by S.M. Alamouti in a paper entitled "A Simple Transmit Diversity Technique for Wireless Communications," IEEE Journal on Selected Areas in Communications, Vol. 16, No. 8, October 1998, pgs. 1451-1458. The STTD scheme is also described in commonly assigned U.S. Patent Application Serial No. 09/737,602, entitled "Method and System for Increased Bandwidth Efficiency in Multiple Input - Multiple Output Channels," filed January 5, 2001, and U.S. Patent Application Serial No. 10/179,439, entitled "Diversity Transmission Modes for MIMO OFDM Communication Systems," filed June 24, 2002.

[0200] The STTD scheme effectively transmits one modulation symbol per subband over two transmit antennas in each symbol period. However, the STTD scheme distributes the information in each modulation symbol over two successive OFDM symbols. Thus, the symbol recovery at the receiver is performed based on two consecutive received OFDM symbols.

[0201] The STTD scheme utilizes one pair of transmit antennas for each data subband. Since the access point includes four transmit antennas, each antenna may be selected for use for half of the 48 data subbands. Table 29 lists an exemplary subband-antenna assignment scheme for the STTD scheme.

Table 29

Subband Indices	TX Ant	Bit Index	Subband Indices	TX Ant	Bit Index	Subband Indices	TX Ant	Bit Index	Subband Indices	TX Ant	Bit Index
-	-	-	-13	1,2	26	1	3,4	1	15	1,2	33
-26	1,2	0	-12	3,4	32	2	1,2	7	16	2,4	39
-25	3,4	6	-11	1,3	38	3	2,4	13	17	1,3	45
-24	1,3	12	-10	2,4	44	4	1,3	19	18	2,3	5
-23	2,4	18	-9	1,4	4	5	2,3	25	19	1,4	11
-22	1,4	24	-8	2,3	10	6	1,4	31	20	3,4	17
-21	1	P0	-7	2	P1	7	3	P2	21	4	P3
-20	2,3	30	-6	1,2	16	8	3,4	37	22	1,2	23
-19	1,2	36	-5	3,4	22	9	1,2	43	23	2,4	29
-18	3,4	42	-4	1,3	28	10	2,4	3	24	1,3	35
-17	1,3	2	-3	2,4	34	11	1,3	9	25	2,3	41
-16	2,4	8	-2	1,4	40	12	2,3	15	26	1,4	47
-15	1,4	14	-1	2,3	46	13	1,4	21	-	-	-
-14	2,3	20	0	-	-	14	3,4	27	-	-	-

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[0202] As shown in Table 29, transmit antennas 1 and 2 are used for subbands with indices -26, -19, -13, and so on, transmit antennas 2 and 4 are used for subbands with indices -25, -18, -12, and so on, transmit antennas 1 and 3 are used for subbands with indices -24, -17, -11, *and* so on. There are six different antenna pairings with four transmit antennas. Each of the six antenna pairings is used for 8 data subbands, which are spaced approximately uniformly across the 48 data subbands. The antenna pairing to subband assignment is such that different antennas are used for adjacent subbands, which may provide greater frequency and spatial diversity. For example, antennas 1 and 2 are used for subband -26, and antennas 3 and 4 are used for subband -25.

[0203] The antenna-subband assignment in Table 29 is also such that all four transmit antennas are used for each code bit for the lowest rate of 1/4, which may maximize spatial diversity. For rate 1/4, each code bit is repeated and sent on two subbands (which is also referred to as dual subband repeat coding). The two subbands used for each code bit are mapped to different antenna pairs so that all four antennas are used to transmit that code bit. For example, bit indices 0 and 1 in Table 29 correspond to the same code bit for the diversity mode, where the bit with index 0 is transmitted from antennas 1 and 2 on subband -26 and the bit with index 1 is transmitted from antennas 3 and 4 on subband 1. As another example, bit indices 2 and 3 in Table 29 correspond to the same code bit, where the bit with index 2 is transmitted from antennas 1 and 3 in subband -17 and the bit with index 3 is transmitted from antennas 2 and 4 in subband 10.

[0204] The system may support other transmit diversity schemes, and this is within the scope of the invention. For example, the system may support a space-frequency transmit diversity (SFTD) that can achieve space and frequency diversity on a per-subband-pair basis. An exemplary SFTD scheme operates as follows. Suppose that two modulation symbols, denoted as $s(k)$ and $s(k+1)$, are generated and mapped to two adjacent subbands of an OFDM symbol. For SFTD, the transmitter would transmit symbols $s(k)$ and $s(k+1)$ from two antennas on subband k and would transmit symbols $s^*(k+1)$ and $-s^*(k)$ from the same two antennas on subband $k+1$. Adjacent subbands are used for the pair of modulation symbols because the channel response is assumed to be constant for the transmission of the two pairs of symbols. The processing at the receiver to recover the modulation symbols is the same as for the STTD scheme, except that the received symbols for two subbands instead of two OFDM symbol periods are processed.

[0205] **FIG. 8B** shows a block diagram of an embodiment of a TX diversity processor 720a capable of implementing the STTD scheme for the diversity mode.

[0206] Within TX diversity processor 720a, a demultiplexer 832 receives and demultiplexes the stream of modulation symbols $s(n)$ from TX data processor 710a into 48 substreams, denoted as $s_1(n)$ through $s_K(n)$, for the 48 data subbands. Each modulation symbol substream includes one modulation symbol for each symbol period, which corresponds to a symbol rate of $(T_{OFDM})^{-1}$, where T_{OFDM} is the duration of one OFDM symbol. Each modulation symbol substream is provided to a respective TX subband diversity processor 840.

[0207] Within each TX subband diversity processor 840, a demultiplexer 842 demultiplexes the modulation symbols for the subband into two symbol sequences, with each sequence having a symbol rate of $(2T_{OFDM})^{-1}$. A space-time encoder 850 receives the two modulation symbol sequences and, for each 2-symbol period, uses two symbols s_1 and s_2 in the two sequences to form two symbol sets $\{x_i\} = \{s_1 \quad s_2^*\}$ and $\{x_j\} = \{s_2 \quad -s_1^*\}$ for two transmit antennas. Each symbol set includes two symbols, one symbol from each of the two sequences. Symbol set $\{x_i\}$ is generated by providing symbol s_1 first and symbol s_2^* next, where s_1 is obtained via a switch 856a and s_2^* is obtained by taking the conjugate of s_2 with a unit 852a and delaying the conjugated symbol by one symbol period with a delay unit 854a. Similarly, symbol set $\{x_j\}$ is generated by providing symbol s_2 first and symbol $-s_1^*$ next, where s_2 is obtained via a switch 856b and $-s_1^*$ is obtained by taking the negative conjugate of s_1 with a unit 852b and delaying the negative conjugated symbol by one symbol period with a delay unit 854b. The two symbol sets $\{x_i\}$ and $\{x_j\}$ are to be transmitted from two antennas i and j assigned to the subband, as indicated in Table 29. Space-time encoder 850 provides the first symbol set $\{x_i\} = \{s_1 \quad s_2^*\}$ to a buffer/multiplexer 870 for the first transmit antenna i and the second symbol set $\{x_j\} = \{s_2 \quad -s_1^*\}$ to another buffer/multiplexer 870 for the second transmit antenna j. The two symbols provided by space-time encoder 850 for each symbol period are referred to as STTD symbols.

[0208] Buffers/multiplexers 870a through 870d are used to buffer and multiplex the STTD symbols from all diversity processors 840. Each buffer/multiplexer 870 receives pilot symbols and STTD symbols from the appropriate TX subband diversity processors 840, as determined by Table 29. For example, buffer/multiplexer 870a receives modulation symbols for subbands -26, -24, -22, -19, and so on (i.e., all subbands mapped to antenna 1), buffer/multiplexer 870b receives modulation symbols for subbands -26, -23, -20, -19, and so on (i.e., all subbands mapped to antenna 2), buffer/multiplexer 870c receives modulation symbols for subbands -25, -24, -20, -18, and so on (i.e., all subbands mapped to antenna 3), and buffer/multiplexer 870d receives modulation symbols for subbands -25, -23, -22, -18, and so on (i.e., all subbands mapped to antenna 4).

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[0209] Each buffer/multiplexer 870 then, for each symbol period, multiplexes four pilots, 24 STTD symbols, and 36 zeros for the four pilot subbands, 24 data subbands, and 36 unused subbands, respectively, to form a sequence of 64 transmit symbols for the 64 total subbands. Although there are a total of 48 data subbands, only 24 subbands are used for each transmit antenna for the diversity mode, and the effective total number of unused subbands for each antenna is thus 36 instead of 12. Each transmit symbol is a complex value (which may be zero for an unused subband) that is sent on one subband in one symbol period. Each buffer/multiplexer 870 provides a stream of transmit symbols $x_i(n)$ for one transmit antenna. Each transmit symbol stream comprises concatenated sequences of 64 transmit symbols, one sequence for each symbol period. Referring back to FIG. 8A, TX diversity processor 720a provides four transmit symbol streams, $x_1(n)$ through $x_4(n)$, to four OFDM modulators 722a through 722d.

[0210] **FIG. 8C** shows a block diagram of an embodiment of an OFDM modulator 722x, which may be used for each of OFDM modulators 722a through 722d in FIG. 8A. Within OFDM modulator 722x, an inverse fast Fourier transform (IFFT) unit 852 receives a stream of transmit symbol, $x_i(n)$, and converts each sequence of 64 transmit symbols into its time-domain representation (which is referred to as a transformed symbol) using a 64-point inverse fast Fourier transform. Each transformed symbol comprises 64 time-domain samples corresponding to the 64 total subbands.

[0211] For each transformed symbol, cyclic prefix generator 854 repeats a portion of the transformed symbol to form a corresponding OFDM symbol. As noted above, one of two different cyclic prefix lengths may be used. The cyclic prefix for the BCH is fixed and is 800 nsec. The cyclic prefix for all other transport channels is selectable (either 400 nsec or 800 nsec) and indicated by the Cyclic Prefix Duration field of the BCH message. For a system with a bandwidth of 20 MHz, a sample period of 50 nsec, and 64 subbands, each transformed symbol has a duration of 3.2 msec (or 64x50 nsec) and each OFDM symbol has a duration of either 3.6 msec or 4.0 msec depending on whether the 400 nsec or 800 nsec cyclic prefix is used for the OFDM symbol.

[0212] **FIG. 8D** illustrates an OFDM symbol. The OFDM symbol is composed of two parts: a cyclic prefix having a duration of 400 or 800 nsec (8 or 16 samples) and a transformed symbol with a duration of 3.2 μsec (64 samples). The cyclic prefix is a copy of the last 8 or 16 samples (i.e., a cyclic continuation) of the transformed symbol and is inserted in front of the transformed symbol. The cyclic prefix ensures that the OFDM symbol retains its orthogonal property in the presence of multipath delay spread, thereby improving performance against deleterious path effects such as multipath and channel dispersion caused by frequency selective fading.

[0213] Cyclic prefix generator 854 provides a stream of OFDM symbols to a transmitter (TMTR) 856. Transmitter 856 converts the OFDM symbol stream into one or more analog signals, and further amplifies, filters, and frequency upconverts the analog signals to generate a modulated signal suitable for transmission from an associated antenna.

[0214] The baseband waveform for an OFDM symbol may be expressed as:

$$x_n(t) = \sum_{k=-N_{ST}/2, k\neq 0}^{N_{ST}/2} c_n(k)\Psi_n(k,t) \quad , \qquad \text{Eq (3)}$$

where n denotes the symbol period (i.e., the OFDM symbol index);
k denotes the subband index;
N_{ST} is the number of pilot and data subbands;
$c_n(k)$ denotes the symbol transmitted on subband k of symbol period n; and

$$\Psi_n(k,t) = \begin{cases} e^{j2\pi k\Delta f(t-T_{CP}-nT_S)} & , \text{ for } nT_S \le t \le (n+1)T_S \\ 0 & , \text{ otherwise} \end{cases} \quad , \qquad \text{Eq (4)}$$

where T_{CP} is the cyclic prefix duration;
T_S is the OFDM symbol duration; and
Δf is the bandwidth of each subband.

2. Spatial Multiplexing Mode - Transmit Processing

[0215] **FIG. 9A** shows a block diagram of a transmitter unit 900 capable of performing the transmit processing for the spatial multiplexing mode. Transmitter unit 900 is another embodiment of the transmitter portion of the access point and the user terminal. For the spatial multiplexing mode, again assuming that four transmit antennas and four receive antennas are available, data may be transmitted on up to four spatial channels. A different rate may be used for each

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spatial channel depending on its transmission capacity. Each rate is associated with a particular code rate and modulation scheme, as shown in Table 25. In the following description it is assumed that N_E spatial channels are selected for use for data transmission, where $N_E \leq N_S \leq \min\{N_T, N_R\}$.

[0216] Within a TX data processor 710b, framing unit 808 frames the data for each FCH/RCH packet to generate one or more PHY frames for the packet. Each PHY frame includes the number of data bits that may be transmitted in all N_E spatial channels within 6 OFDM symbols. Scrambler 810 scrambles the data for each transport channel. Encoder 812 receives and codes the scrambled data in accordance with a selected coding scheme to provide code bits. In an embodiment, a common coding scheme is used to code the data for all N_E spatial channels, and different code rates for different spatial channels are obtained by puncturing the code bits with different puncturing patterns. Puncture unit 814 thus punctures the code bits to obtain the desired code rate for each spatial channel. The puncturing for the spatial multiplexing mode is described in further detail below.

[0217] A demultiplexer 816 receives and demultiplexes the code bits from puncture unit 814 to provide N_E code bit streams for the N_E spatial channels selected for use. Each code bit stream is provided to a respective interleaver 818, which interleaves the code bits in the stream across the 48 data subbands. The coding and interleaving for the spatial multiplexing mode are described in further detail below. The interleaved data from each interleaver 818 is provided to a respective symbol mapping unit 820.

[0218] In the spatial multiplexing mode, up to four different rates may be used for the four spatial channels, depending on the received SNRs achieved for these spatial channels. Each rate is associated with a particular modulation scheme, as shown in Table 25. Each symbol mapping unit 820 maps the interleaved data in accordance with a particular modulation scheme selected for the associated spatial channel to provide modulation symbols. If all four spatial channels are selected for use, then symbol mapping units 820a through 820d provide four streams of modulation symbols for the four spatial channels to a TX spatial processor 720b.

[0219] TX spatial processor 720b performs spatial processing for the spatial multiplexing mode. For simplicity, the following description assumes that four transmit antennas, four receive antennas, and 48 data subbands are used for data transmission. The data subband indices are given by the set $\boldsymbol{K}$, where $K = \pm \{1, \ldots, 6, 8 \ldots, 20, 22, \ldots 26\}$ for the OFDM subband structure described above.

[0220] The model for a MIMO-OFDM system may be expressed as:

$$\underline{\mathbf{r}}(k) = \underline{\mathbf{H}}(k)\underline{\mathbf{x}}(k) + \underline{\mathbf{n}}(k) \quad , \text{ for } k \in K , \qquad \text{Eq (5)}$$

where $\underline{\mathbf{r}}(k)$ is a "receive" vector with four entries for the symbols received via the four receive antennas for subband k (i.e., $\underline{\mathbf{r}}(k) = [r_1(k)\ r_2(k)\ r_3(k)\ r_4(k)]^T$);
$\underline{\mathbf{x}}(k)$ is a "transmit" vector with four entries for the symbols transmitted from the four transmit antennas for subband k (i.e., $\underline{\mathbf{x}}(k) = [x_1(k)\ x_2(k)\ x_3(k)\ x_4(k)]^T$);
$\underline{\mathbf{H}}(k)$ is an $(N_R \times N_T)$ channel response matrix for subband k; and
$\underline{\mathbf{n}}(k)$ is a vector of additive white Gaussian noise (AWGN) for subband k.
The noise vector $\underline{\mathbf{n}}(k)$ is assumed to have components with zero mean and a covariance matrix of $\underline{\Lambda}_n = \sigma^2\underline{\mathbf{I}}$, where $\underline{\mathbf{I}}$ is the identity matrix and σ^2 is the noise variance.

[0221] The channel response matrix $\underline{\mathbf{H}}(k)$ for subband k may be expressed as:

$$\underline{\mathbf{H}}(k) = \begin{bmatrix} h_{1,1}(k) & h_{1,2}(k) & h_{1,3}(k) & h_{1,4}(k) \\ h_{2,1}(k) & h_{2,2}(k) & h_{2,3}(k) & h_{2,4}(k) \\ h_{3,1}(k) & h_{3,2}(k) & h_{3,3}(k) & h_{3,4}(k) \\ h_{4,1}(k) & h_{4,2}(k) & h_{4,3}(k) & h_{4,4}(k) \end{bmatrix} , \text{ for } k \in K , \qquad \text{Eq (6)}$$

where entry $h_{ij}(k)$, for $i \in \{1, 2, 3, 4\}$ and $j \in \{1, 2, 3, 4\}$, is the coupling (i.e., complex gain) between transmit antenna i and receive antenna j for subband k. For simplicity, it is assumed that the channel response matrices $\underline{\mathbf{H}}(k)$, for $k \in K$, are known or can be ascertained by both the transmitter and receiver.

[0222] The channel response matrix $\underline{\mathbf{H}}(k)$ for each subband may be "diagonalized" to obtain the N_S eigenmodes for that subband. This can be achieved by performing eigenvalue decomposition on the correlation matrix of $\underline{\mathbf{H}}(k)$, which is $\underline{\mathbf{R}}(k) = \underline{\mathbf{H}}^H(k)\underline{\mathbf{H}}(k)$, where $\underline{\mathbf{H}}^H(k)$ denotes the conjugate transpose of $\underline{\mathbf{H}}(k)$. The eigenvalue decomposition of the correlation matrix $\underline{\mathbf{R}}(k)$ may be expressed as:

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$$\underline{\mathbf{R}}(k) = \underline{\mathbf{V}}(k)\underline{\mathbf{D}}(k)\underline{\mathbf{V}}^{H}(k) \quad , \text{for } k \in K \, , \qquad \text{Eq (7)}$$

where $\underline{\mathbf{V}}(k)$ is an $(N_T \times N_T)$ unitary matrix whose columns are eigenvectors of $\underline{\mathbf{R}}(k)$ (i.e., $\underline{\mathbf{V}}(k)=[\underline{\mathbf{v}}_1(k)\ \underline{\mathbf{v}}_2(k)\ \underline{\mathbf{v}}_3(k)\ \underline{\mathbf{v}}_4(k)]$, where each $\underline{\mathbf{v}}_i(k)$ is an eigenvector for one eigenmode); and
$\underline{\mathbf{D}}(k)$ is an $(N_T \times N_T)$ diagonal matrix of eigenvalues of $\underline{\mathbf{R}}(k)$.
A unitary matrix is characterized by the property $\underline{\mathbf{M}}^H\underline{\mathbf{M}} = \underline{\mathbf{I}}$. Eigenvectors $\underline{\mathbf{v}}_i(k)$, for $i \in \{1, 2, 3, 4\}$, are also referred to as transmit steering vectors for each of the spatial channels.

[0223] The channel response matrix $\underline{\mathbf{H}}(k)$ may also be diagonalized using singular value decomposition, which may be expressed as:

$$\underline{\mathbf{H}}(k) = \underline{\mathbf{U}}(k)\underline{\Sigma}(k)\underline{\mathbf{V}}^{H}(k) \quad , \text{for } k \in K \, , \qquad \text{Eq (8)}$$

where $\underline{\mathbf{V}}(k)$ is a matrix whose columns are right eigenvectors of $\underline{\mathbf{H}}(k)$;
$\underline{\Sigma}(k)$ is a diagonal matrix containing singular values of $\underline{\mathbf{H}}(k)$, which are positive square roots of the diagonal elements of $\underline{\mathbf{D}}(k)$, the eigenvalues of $\underline{\mathbf{R}}(k)$; and
$\underline{\mathbf{U}}(k)$ is a matrix whose columns are left eigenvectors of $\underline{\mathbf{H}}(k)$.
Singular value decomposition is described by Gilbert Strang in a book entitled "Linear Algebra and Its Applications," Second Edition, Academic Press, 1980. As shown in equations (7) and (8), the columns of the matrix $\underline{\mathbf{V}}(k)$ are eigenvectors of $\underline{\mathbf{R}}(k)$ as well as right eigenvectors of $\underline{\mathbf{H}}(k)$. The columns of the matrix $\underline{\mathbf{U}}(k)$ are eigenvectors of $\underline{\mathbf{H}}(k)\underline{\mathbf{H}}^H(k)$ as well as left eigenvectors of $\underline{\mathbf{H}}(k)$.

[0224] The diagonal matrix $\underline{\mathbf{D}}(k)$ for each subband contains non-negative real values along the diagonal and zeros everywhere else. The eigenvalues of $\underline{\mathbf{R}}(k)$ are denoted as $\{\lambda_1(k), \lambda_2(k), \lambda_3(k), \lambda_4(k)\}$ or $\{\lambda_i(k)\}$ for $i \in \{1,2,3,4\}$.

[0225] The eigenvalue decomposition may be performed independently for the channel response matrix $\underline{\mathbf{H}}(k)$ for each of the 48 data subbands to determine the four eigenmodes for that subband (assuming that each matrix $\underline{\mathbf{H}}(k)$ is full rank). The four eigenvalues for each diagonal matrix $\underline{\mathbf{D}}(k)$ may be ordered such that $\{\lambda_1(k) \geq \lambda_2(k) \geq \lambda_3(k) \geq \lambda_4(k)\}$, where $\lambda_1(k)$ is the largest eigenvalue and $\lambda_4(k)$ is the smallest eigenvalue for subband k. When the eigenvalues for each diagonal matrix $\underline{\mathbf{D}}(k)$ are ordered, the eigenvectors (or columns) of the associated matrix $\underline{\mathbf{V}}(k)$ are also ordered correspondingly.

[0226] A "wideband" eigenmode may be defined as the set of same-order eigenmodes of all subbands after the ordering (i.e., wideband eigenmode m includes eigenmodes m of all subbands). Each wideband eigenmode is associated with a respective set of eigenvectors for all of the subbands. The "principal" wideband eigenmode is the one associated with the largest singular value in each of the matrices $\underline{\Sigma}(k)$ after the ordering.

[0227] A vector $\underline{\mathbf{d}}^m$ may then be formed to include the m-th rank eigenvalue for all 48 data subbands. This vector $\underline{\mathbf{d}}^m$ may be expressed as:

$$\underline{\mathbf{d}}^m = [\lambda_m(-26) \ \ldots \ \lambda_m(-22) \ \ldots \lambda_m(22) \ \ldots \ \lambda_m(26)] \ , \text{ for } m = \{1, 2, 3, 4\} . \qquad \text{Eq (9)}$$

The vector $\underline{\mathbf{d}}^1$ includes the eigenvalues for the best or principal wideband eigenmode. For a MIMO-OFDM system with four transmit antennas and four receive antennas (i.e., a 4×4 system), there are up four wideband eigenmodes.

[0228] If the noise variance σ^2 at the receiver is constant across the operating band and known to the transmitter, then the received SNR for each subband of each wideband eigenmode may be determined by dividing the eigenvalue $\lambda_m(k)$ by the noise variance σ^2. For simplicity, the noise variance can be assumed to be equal to one (i.e., $\sigma^2 = 1$).

[0229] For the spatial multiplexing mode, the total transmit power P_{total} available to the transmitter may be distributed to the wideband eigenmodes based on various power allocation schemes. In one scheme, the total transmit power P_{total} is distributed uniformly to all four wideband eigenmodes such that $P_m = P_{total}/4$, where P_m is the transmit power allocated to wideband eigenmode m. In another scheme, the total transmit power P_{total} is distributed to the four wideband eigenmodes using a water-filling procedure.

[0230] The water-filling procedure distributes power such that the wideband eigenmodes with higher power gains receive greater fractions of the total transmit power. The amount of transmit power allocated to a given wideband eigenmode is determined by its received SNR, which in turn is dependent on the power gains (or eigenvalues) for all of the subbands of that wideband eigenmode. The water-filling procedure may allocate zero transmit power to wideband eigenmodes with sufficiently poor received SNRs. The water-filling procedure receives $\underline{\beta}=\{\beta_1, \beta_2, \beta_3, \beta_4\}$ for the four wideband eigenmodes, where β_m is a normalization factor for wideband eigenmode m and may be expressed as:

$$\beta_m = \frac{1}{\sum_{k \in K} \lambda_m^{-1}(k)} \text{ , for } m = \{1, 2, 3, 4\} . \qquad \text{Eq (10)}$$

The normalization factor β_m keeps the transmit power allocated to wideband eigenmode m invariant after channel inversion is applied, as described below. As shown in equation (10), the normalization factor β_m can be derived based on the eigenvalues in the vector $\underline{d}^m$ and with the assumption of the noise variance being equal to one (i.e., $\sigma^2 = 1$).

[0231] The water-filling procedure then determines the fraction α_m of the total transmit power to allocate to each wideband eigenmode based on the set $\underline{\beta}$ such that spectral efficiency or some other criterion is optimized. The transmit power allocated to wideband eigenmode m by the water-filling procedure may be expressed as:

$$P_m = \alpha_m P_{total} \text{ , for } m = \{1, 2, 3, 4\} . \qquad \text{Eq (11)}$$

The power allocations for the four wideband eigenmodes may be given by $\underline{\alpha} = \{\alpha_1, \alpha_2, \alpha_3, \alpha_4\}$, where $\sum_{m=1}^{4} \alpha_m = 1$ and $\sum_{m=1}^{4} P_m = P_{total}$. The spatial multiplexing mode may be selected for use if more than one value in set $\underline{\alpha}$ is non-zero.

[0232] The procedure for performing water-filling is known in the art and not described herein. One reference that describes water-filling is "Information Theory and Reliable Communication," by Robert G. Gallager, John Wiley and Sons, 1968, which is incorporated herein by reference.

[0233] For the spatial multiplexing mode, the rate for each spatial channel or wideband eigenmode may be selected based on the received SNR achieved by that spatial channel/wideband eigenmode with its allocated transmit power of P_m. For simplicity, the following description assumes data transmission on the wideband eigenmodes. The received SNR for each wideband eigenmode may be expressed as:

$$\gamma_m = \frac{P_m \beta_m}{\sigma^2} \text{ , for } m = \{1, 2, 3, 4\} . \qquad \text{Eq (12)}$$

In one embodiment, the rate for each wideband eigenmode is determined based on a table that includes the rates supported by the system and a range of SNRs for each rate. This table may be obtained by computer simulation, empirical measurements, and so on. The particular rate to use for each wideband eigenmode is the rate in the table with a range of SNRs covering the received SNR for the wideband eigenmode. In another embodiment, the rate for each wideband eigenmode is selected based on (1) the received SNR for the wideband eigenmode, (2) an SNR offset used to account for estimation error, variability in the MIMO channel, and other factors, and (3) a table of supported rates and their required SNRs. For this embodiment, an average received SNR for each wideband eigenmode is first computed as described above or as an average of the received SNRs (in units of dBs) for all of the subbands of the wideband eigenmode. In any case, an operating SNR is next computed as the sum of the received SNR and the SNR offset (where both are given in units of dBs). The operating SNR is then compared against the required SNR for each of the rates supported by the system. The highest rate in the table with a required SNR that is less than or equal to the operating SNR is then selected for the wideband eigenmode. The rate for the transmit diversity mode and the beam-steering mode may also be determined in similar manner.

[0234] The transmit power P_m allocated for each wideband eigenmode may be distributed across the 48 data subbands of that wideband eigenmode such that the received SNRs for all subbands are approximately equal. This non-uniform allocation of power across the subbands is referred to as channel inversion. The transmit power $P_m(k)$ allocated to each subband may be expressed as:

$$P_m(k) = \frac{\beta_m P_m}{\lambda_m(k)} \text{ , for } k \in K \text{ and } m = \{1, 2, 3, 4\} , \qquad \text{Eq (13)}$$

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where β_m is given in equation (10).

[0235] As shown in equation (13), the transmit power P_m is distributed non-uniformly across the data subbands based on their channel power gains, which is given by the eigenvalues $\lambda_m(k)$, for $k \in K$. The power distribution is such that approximately equal received SNRs are achieved at the receiver for all data subbands of each wideband eigenmode. This channel inversion is performed independently for each of the four wideband eigenmodes. The channel inversion per wideband eigenmode is described in further detail in commonly assigned U.S. Patent Application Serial No. 10/229,209, entitled "Coded MIMO Systems with Selective Channel Inversion Applied Per Eigenmode," filed August 27, 2002.

[0236] The channel inversion may be performed in various manners. For full channel inversion, all data subbands are used for data transmission if a wideband eigenmode is selected for use. For selective channel inversion, all or a subset of the available data subbands may be selected for use for each wideband eigenmode. The selective channel inversion discards poor subbands with received SNR below a particular threshold and performs channel inversion on only the selected subbands. Selective channel inversion for each wideband eigenmode is also described in commonly assigned U.S. Patent Application Serial No. 10/229,209, entitled "Coded MIMO Systems with Selective Channel Inversion Applied Per Eigenmode," filed August 27, 2002. For simplicity, the following description assumes that full channel inversion is performed for each wideband eigenmode selected for use.

[0237] The gain to use for each subband of each wideband eigenmode may be determined based on the transmit power $P_m(k)$ allocated to that subband. The gain $g_m(k)$ for each data subband may be expressed as:

$$g_m(k) = \sqrt{P_m(k)} \ , \text{ for } k \in K \text{ and } m = \{1, 2, 3, 4\} . \qquad \text{Eq (14)}$$

A diagonal gain matrix $\underline{\mathbf{G}}(k)$ may be defined for each subband. This matrix $\underline{\mathbf{G}}(k)$ includes the gains for the four eigenmodes for subband k along the diagonal, and may be expressed as: $\underline{\mathbf{G}}(k) = \text{diag}[g_1(k), g_2(k), g_3(k), g_4(k)]$.

[0238] For the spatial multiplexing mode, the transmit vector $\mathbf{x}(k)$ for each data subband may be expressed as:

$$\underline{\mathbf{x}}(k) = \underline{\mathbf{V}}(k)\underline{\mathbf{G}}(k)\underline{\mathbf{s}}(k) \ , \text{for } k \in K , \qquad \text{Eq (15)}$$

where

$$\underline{\mathbf{s}}(k) = [s_1(k) \ s_2(k) \ s_3(k) \ s_4(k)]^T \ ,$$

and

$$\underline{\mathbf{x}}(k) = [x_1(k) \ x_2(k) \ x_3(k) \ x_4(k)]^T \ .$$

The vector $\underline{\mathbf{s}}(k)$ includes four modulation symbols to be transmitted on the four eigenmodes for subband k, and the vector $\underline{\mathbf{x}}(k)$ includes four transmit symbols to be transmitted from the four antennas for subband k. For simplicity, equation (15) does not include the correction factors used to account for differences between the transmit/receive chains at the access point and the user terminal, which are described in detail below.

[0239] **FIG. 9B** shows a block diagram of an embodiment of TX spatial processor 720b capable of performing spatial processing for the spatial multiplexing mode. For simplicity, the following description assumes that all four wideband eigenmodes are selected for use. However, less than four wideband eigenmodes may also be selected for use.

[0240] Within processor 720b, a demultiplexer 932 receives the four modulation symbol streams (denoted as $s_1(n)$ through $s_4(n)$) to be transmitted on the four wideband eigenmodes, demultiplexes each stream into 48 substreams for the 48 data subbands, and provides four modulation symbol substreams for each data subband to a respective TX subband spatial processor 940. Each processor 940 performs the processing shown in equation (15) for one subband.

[0241] Within each TX subband spatial processor 940, the four modulation symbol substreams (denoted as $s_1(k)$ through $s_4(k)$) are provided to four multipliers 942a through 942d, which also receive the gains $g_1(k)$, $g_2(k)$, $g_3(k)$, and $g_4(k)$ for the four eigenmodes of the associated subband. Each gain $g_m(k)$ may be determined based on the transmit power $P_m(k)$ allocated to that subband/eigenmode, as shown in equation (14). Each multiplier 942 scales its modulation

symbols with its gain $g_m(k)$ to provide scaled modulation symbols. Multipliers 942a through 942d provide four scaled modulation symbol substreams to four beam-formers 950a through 950d, respectively.

[0242] Each beam-former 950 performs beam-forming to transmit one symbol substream on one eigenmode of one subband. Each beam-former 950 receives one symbol substream $s_m(k)$ and one eigenvector $\underline{\mathbf{v}}_m(k)$ for the associated eigenmode. In particular, beam-former 950a receives eigenvector $\underline{\mathbf{v}}_1(k)$ for the first eigenmode, beam-former 950b receives eigenvector $\underline{\mathbf{v}}_2(k)$ for the second eigenmode, and so on. The beam-forming is performed using the eigenvector for the associated eigenmode.

[0243] Within each beam-former 950, the scaled modulation symbols are provided to four multipliers 952a through 952d, which also receive four elements, $v_{m,1}(k)$, $v_{m,2}(k)$, $v_{m,3}(k)$, and $v_{m,4}(k)$, of eigenvector $\underline{\mathbf{v}}_m(k)$ for the associated eigenmode. Each multiplier 952 then multiplies the scaled modulation symbols with its eigenvector value $v_{m,j}(k)$ to provide "beam-formed" symbols. Multipliers 952a through 952d provide four beam-formed symbol substreams (which are to be transmitted from four antennas) to summers 960a through 960d, respectively.

[0244] Each summer 960 receives and sums four beam-formed symbols for the four eigenmodes for each symbol period to provide a preconditioned symbol for an associated transmit antenna. Summers 960a through 960d provide four substreams of preconditioned symbols for four transmit antennas to buffers/multiplexers 970a through 970d, respectively.

[0245] Each buffer/multiplexer 970 receives pilot symbols and the preconditioned symbols from TX subband spatial processors 940a through 940k for the 48 data subbands. Each buffer/multiplexer 970 then, for each symbol period, multiplexes 4 pilot symbols, 48 preconditioned symbols, and 12 zeros for 4 pilot subbands, 48 data subbands, and 12 unused subbands, respectively, to form a sequence of 64 transmit symbols for that symbol period. Each buffer/multiplexer 970 provides a stream of transmit symbols $x_j(n)$ for one transmit antenna, where the transmit symbol stream comprises concatenated sequences of 64 transmit symbols. The transmit symbols can be scaled with correction factors to account for differences between the transmit/receive chains at the access point and the user terminal, as described below. The subsequent OFDM modulation for each transmit symbol stream is described above.

[0246] Parallel symbol streams may also be transmitted from the four transmit antennas without spatial processing at the access point using the non-steered spatial multiplexing mode. For this mode, the channel inversion process and beam-forming by beam-former 950 may be omitted. Each modulation symbol stream is further OFDM processed and transmitted from a respective transmit antenna.

[0247] The non-steered spatial multiplexing mode may be used for various situations such as if the transmitter is unable to perform the spatial processing necessary to support beam-steering based on eigenmode decomposition. This may be because the transmitter has not performed calibration procedures, is unable to generate a sufficiently good estimate of the channel, or does not have calibration and eigenmode processing capabilities at all. For the non-steered spatial multiplexing mode, spatial multiplexing is still used to increase the transmission capacity, but the spatial processing to separate out the individual symbol streams is performed by the receiver.

[0248] For the non-steered spatial multiplexing mode, the receiver performs the spatial processing to recover the transmitted symbol streams. In particular, a user terminal may implement a channel correlation matrix inversion (CCMI) technique, a minimum mean square error (MMSE) technique, a successive interference cancellation receiver processing technique, or some other receiver spatial processing technique. These techniques are described in detail in commonly assigned U.S. Patent Application Serial No. 09/993,087, entitled "Multiple-Access Multiple-Input Multiple-Output (MIMO) Communication System," filed November 6, 2001. The non-steered spatial multiplexing mode may be used for both downlink and uplink transmissions.

[0249] The multi-user spatial multiplexing mode supports data transmission to multiple user terminals simultaneously on the downlink based on the "spatial signatures" of the user terminals. The spatial signature for a user terminal is given by a channel response vector (for each subband) between the access point antennas and each user terminal antenna. The access point may obtain the spatial signatures, for example, based on the steered reference transmitted by the user terminals. The access point may process the spatial signatures for user terminals desiring data transmission to (1) select a set of user terminals for simultaneous data transmission on the downlink and (2) derive steering vectors for each of the independent data streams to be transmitted to the selected user terminals.

[0250] The steering vectors for the multi-user spatial multiplexing mode may be derived in various manners. Two exemplary schemes are described below. For simplicity, the following description is for one subband and assumes that each user terminal is equipped with a single antenna.

[0251] In a first scheme, the access point obtains the steering vectors using channel inversion. The access point may select N_{ap} single-antenna user terminals for simultaneous transmission on the downlink. The access point obtains an $1 \times N_{ap}$ channel response row vector for each selected user terminal and forms an $N_{ap} \times N_{ap}$ channel response matrix $\underline{\mathbf{H}}_{mu}$ with the N_{ap} row vectors for the N_{ap} user terminals. The access point then obtains a matrix $\underline{\mathbf{H}}_{steer}$ of N_{ap} steering vectors for the N_{ap} selected user terminals as $\underline{\mathbf{H}}_{steer} = \underline{\mathbf{H}}_{mu}^{-1}$. The access point can also transmit a steered reference

to each selected user terminal. Each user terminal processes its steered reference to estimate the channel gain and phase and coherently demodulates received symbols for its single antenna with the channel gain and phase estimates to obtain recovered symbols.

[0252] In a second scheme, the access point precodes N_{ap} symbol streams to be sent to N_{ap} user terminals such that these symbol streams experience little cross-talk at the user terminals. The access point can form the channel response matrix $\underline{\mathbf{H}}_{mu}$ for the N_{ap} selected user terminals and perform QR factorization on $\underline{\mathbf{H}}_{mu}$ such that $\underline{\mathbf{H}}_{mu} = \underline{\mathbf{F}}_{tri}\underline{\mathbf{Q}}_{mu}$, where $\underline{\mathbf{T}}_{tri}$ is a lower left triangular matrix $\underline{\mathbf{T}}_{tri}$ and $\underline{\mathbf{Q}}_{mu}$ is a unitary matrix. The access point then precodes the N_{ap} data symbol streams with the matrix $\underline{\mathbf{T}}_{tri}$ to obtain N_{ap} precoded symbol streams $\underline{\mathbf{a}}$, and further processes the precoded symbol streams with the unitary matrix $\underline{\mathbf{Q}}_{mu}$ to obtain the N_{ap} transmit symbol streams for transmission to the N_{ap} user terminals. Again, the access point can also transmit a steered reference to each user terminal. Each user terminal uses the steered reference to coherently demodulate its received symbols to obtain recovered symbols.

[0253] For the uplink in the multi-user spatial multiplexing mode, the access point can recover N_{ap} symbol streams transmitted simultaneously by N_{ap} user terminals using MMSE receiver processing, successive interference cancellation, or some other receiver processing technique. The access point can estimate the uplink channel response for each user terminal and use the channel response estimate for receiver spatial processing and for scheduling uplink transmissions. Each single-antenna user terminal can transmit an orthogonal pilot on the uplink. The uplink pilots from the N_{ap} user terminals can be orthogonal in time and/or frequency. Time orthogonality can be achieved by having each user terminal covers its uplink pilot with an orthogonal sequence assigned to the user terminal. Frequency orthogonality can be achieved by having each user terminal transmits its uplink pilot on a different set of subbands. The uplink transmissions from the user terminals should be approximately time-aligned at the access point (e.g., time-aligned to within the cyclic prefix).

3. Beam-Steering Mode - Transmit Processing

[0254] **FIG. 10A** shows a block diagram of a transmitter unit 1000 capable of performing the transmit processing for the beam-steering mode. Transmitter unit 1000 is yet another embodiment of the transmitter portion of the access point and the user terminal.

[0255] Within a TX data processor 710c, framing unit 808 frames the data for each FCH/RCH packet to generate one or more PHY frames for the packet. Scrambler 810 then scrambles the data for each transport channel. Encoder 812 next codes the framed data in accordance with a selected coding scheme to provide code bits. Puncture unit 814 then punctures the code bits to obtain the desired code rate for the wideband eigenmode used for data transmission. The code bits from puncture unit 818 are interleaved across all data subbands. Symbol mapping unit 820 then maps the interleaved data in accordance with a selected modulation scheme to provide modulation symbols. A TX spatial processor 720c then performs transmit processing on the modulation symbols for the beam-steering mode.

[0256] The beam-steering mode may be used to transmit data on one spatial channel or wideband eigenmode - typically the one associated with the largest eigenvalues for all of the data subbands. The beam-steering mode may be selected if the transmit power allocation to the wideband eigenmodes results in only one entry in the set $\underline{\alpha}$ being non-zero. Whereas the spatial multiplexing mode performs beam-forming for each of the selected eigenmodes of each subband based on its eigenvector, the beam-steering mode performs beam-steering based on a "normalized" eigenvector for the principal eigenmode of each subband to transmit data on that single eigenmode.

[0257] The four elements of each eigenvector $\underline{\mathbf{v}}_1(k)$, for $k \in K$, for the principal eigenmode may have different magnitudes. The four preconditioned symbols obtained based on the four elements of eigenvector $\underline{\mathbf{v}}_1(k)$ for each subband may then have different magnitudes. Consequently, the four per-antenna transmit vectors, each of which includes the preconditioned symbols for all data subbands for a given transmit antenna, may have different magnitudes. If the transmit power for each transmit antenna is limited (e.g., because of limitations of the power amplifiers), then the beam-forming technique may not fully use the total power available for each antenna.

[0258] The beam-steering mode uses only the phase information from eigenvectors $\underline{\mathbf{v}}_1(k)$, for $k \in K$, for the principal eigenmode and normalizes each eigenvector such that all four elements in the eigenvector have equal magnitudes. The normalized eigenvector $\underline{\tilde{\mathbf{v}}}(k)$ for subband k may be expressed as:

$$\underline{\tilde{\mathbf{v}}}(k) = [Ae^{j\theta_1(k)} \;\; Ae^{j\theta_2(k)} \;\; Ae^{j\theta_3(k)} \;\; Ae^{j\theta_4(k)}]^T \;, \qquad \text{Eq (16)}$$

where A is a constant (e.g., A = 1); and
$\theta_i(k)$ is the phase for subband k of transmit antenna i, which is given as:

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$$\theta_i(k) = \angle v_{1,i}(k) = \tan^{-1}\left(\frac{\mathrm{Im}\{v_{1,i}(k)\}}{\mathrm{Re}\{v_{1,i}(k)\}}\right) . \qquad \text{Eq (17)}$$

As shown in equation (17), the phase of each element in the vector $\underline{\tilde{v}}(k)$ is obtained from the corresponding element of eigenvector $\underline{v}_1(k)$ (i.e., $\theta_i(k)$ is obtained from $v_{1,i}(k)$, where $\underline{v}_1(k)=[v_{1,1}(k)\ v_{1,2}(k)\ v_{1,3}(k)\ v_{1,4}(k)]^T$).

[0259] Channel inversion may also be performed for the beam-steering mode so that a common rate can be used for all data subbands. The transmit power $\tilde{P}_i(k)$ allocated to each data subband for the beam-steering mode may be expressed as:

$$\tilde{P}_i(k) = \frac{\tilde{\beta}_1 \tilde{P}_1}{\tilde{\lambda}_1(k)} , \text{ for } k \in K , \qquad \text{Eq (18)}$$

where $\tilde{\beta}_1$ is a normalization factor that keeps the total transmit power invariant after channel inversion is applied;
$\tilde{P}_1$ is the transmit power allocated to each of the four antennas; and
$\tilde{\lambda}_1(k)$ is the power gain for subband k of the principal eigenmode for the beam-steering mode.
The normalization factor $\tilde{\beta}_1$ may be expressed as:

$$\tilde{\beta}_1 = \frac{1}{\sum_{k \in K} \tilde{\lambda}_1^{-1}(k)} . \qquad \text{Eq (19)}$$

The transmit power $\tilde{P}_1$ may be given as $P_1 = P_{total}/4$ (i.e., uniform allocation of the total transmit power across the four transmit antennas). The power gain $\tilde{\lambda}_1(k)$ may be expressed as:

$$\tilde{\lambda}_1(k) = \underline{\tilde{v}}^H(k)\underline{\underline{H}}^H(k)\underline{\underline{H}}(k)\underline{\tilde{v}}(k) . \qquad \text{Eq (20)}$$

[0260] The channel inversion results in power allocation of $\tilde{P}_1(k)$, for $k \in K$, for the 48 data subbands. The gain for each data subband may then be given as $\tilde{g}(k) = \sqrt{\tilde{P}_1(k)}$.

[0261] For the beam-steering mode, the transmit vector $\underline{x}(k)$ for each subband may be expressed as:

$$\underline{x}(k) = \underline{\tilde{v}}(k)\tilde{g}(k)s(k) \text{ , for } k \in K . \qquad \text{Eq (21)}$$

Again for simplicity, equation (21) does not include the correction factors used to account for differences between the transmit/receive chains at the access point and the user terminal.

[0262] As shown in equation (16), the four elements of the normalized steering vector $\underline{\tilde{v}}(k)$ for each subband have equal magnitude but possibly different phases. The beam-steering thus generates one transmit vector $\underline{x}(k)$ for each subband, with the four elements of $\underline{x}(k)$ having the same magnitude but possibly different phases.

[0263] **FIG. 10B** shows a block diagram of an embodiment of TX spatial processor 720c capable of performing the spatial processing for the beam-steering mode.

[0264] Within processor 720c, a demultiplexer 1032 receives and demultiplexes the modulation symbol stream $s(n)$ into 48 substreams for the 48 data subbands (denoted as $s(1)$ through $s(k)$). Each symbol substream is provided to a respective TX subband beam-steering processor 1040. Each processor 1040 performs the processing shown in equation (14) for one subband.

[0265] Within each TX subband beam-steering processor 1040, the modulation symbol substream is provided to a multiplier 1042, which also receives the gain $\tilde{g}(k)$ for the associated subband. Multiplier 1042 then scales the modulation symbols with the gain $\tilde{g}(k)$ to obtain scaled modulation symbols, which are then provided to a beam-steering unit 1050.

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[0266] Beam-steering unit 1050 also receives the normalized eigenvector $\underline{\tilde{v}}(k)$ for the associated subband. Within beam-steering unit 1050, the scaled modulation symbols are provided to four multipliers 1052a through 1052d, which also respectively receive the four elements, $\tilde{v}_1(k)$, $\tilde{v}_2(k)$, $\tilde{v}_3(k)$, and $\tilde{v}_4(k)$, of the normalized eigenvector $\underline{\tilde{v}}(k)$. Each multiplier 1052 multiplies its scaled modulation symbols with its normalized eigenvector value $\tilde{v}_i(k)$ to provide preconditioned symbols. Multipliers 1052a through 1052d provide four preconditioned symbol substreams to buffers/multiplexers 1070a through 1070d, respectively.

[0267] Each buffer/multiplexer 1070 receives pilot symbols and the preconditioned symbols from TX subband beam-steering processors 1040a through 1040k for the 48 data subbands, multiplexes the pilot and preconditioned symbols and zeros for each symbol period, and provides a stream of transmit symbols $x_i(n)$ for one transmit antenna. The subsequent OFDM modulation for each transmit symbol stream is described above.

[0268] The processing for the beam-steering mode is described in further detail in commonly assigned U.S. Patent Application Serial No. 10/228,393, entitled "Beam-Steering and Beam-Forming for Wideband MIMO Systems," filed August 27, 2002. The system may also be designed to support a beam-forming mode whereby a data stream is transmitted on the principal eigenmode using the eigenvector instead of the normalized eigenvector.

4. Framing for PHY frames

[0269] **FIG. 11A** shows an embodiment of framing unit 808, which is used to frame the data for each FCH/RCH packet prior to subsequent processing by the TX data processor. This framing function may be bypassed for messages sent on the BCH, FCCH, and RACH. The framing unit generates an integer number of PHY frames for each FCH/RCH packet, where each PHY frame spans 6 OFDM symbols for the embodiment described herein.

[0270] For the diversity and beam-steering modes, only one spatial channel or wideband eigenmode is used for data transmission. The rate for this mode is known, and the number of information bits that may be sent in the payload of each PHY frame may be computed. For the spatial multiplexing mode, multiple spatial channels may be used for data transmission. Since the rate of each spatial channel is known, the number of information bits that may be sent in the payload of each PHY frame for all spatial channels may be computed.

[0271] As shown in FIG. 11A, the information bits (denoted as $i_1\ i_2\ i_3\ i_4$ ...) for each FCH/RCH packet are provided to a CRC generator 1102 and a multiplexer 1104 within framing unit 808. CRC generator 1102 generates a CRC value for the bits in the header (if any) and payload fields of each PHY frame and provides CRC bits to multiplexer 1104. Multiplexer 1104 receives the information bits, CRC bits, header bits, and pad bits (e.g., zeros), and provides these bits in the proper order, as shown in FIG. 6, based on a PHY Frame Control signal. The framing function may be bypassed by providing the information bits directly through multiplexer 1104. The framed or unframed bits (denoted as $d_1\ d_2\ d_3\ d_4$ ...) are provided to scrambler 810.

5. Scrambling

[0272] In an embodiment, the data bits for each transport channel are scrambled prior to coding. The scrambling randomizes the data so that a long sequence of all ones or all zeros is not transmitted. This can reduce the variation in the peak to average power of the OFDM waveform. The scrambling may be omitted for one or more transport channels and may also be selectively enabled and disabled.

[0273] FIG. 11A also shows an embodiment of scrambler 810. In this embodiment, scrambler 810 implements a generator polynomial:

$$G(x) = x^7 + x^4 + x \quad . \qquad \text{Eq (22)}$$

Other generator polynomials may also be used, and this is within the scope of the invention.

[0274] As shown in FIG. 11A, scrambler 810 includes seven delay elements 1112a through 1112g coupled in series. For each clock cycle, an adder 1114 performs modulo-2 addition of two bits stored in delay elements 1112d and 1112g and provides a scrambling bit to delay element 1112a.

[0275] The framed/unframed bits ($d_1\ d_2\ d_3\ d_4$ ...) are provided to an adder 1116, which also receives scrambling bits from adder 1114. Adder 1116 performs modulo-2 addition of each bit d_n with a corresponding scrambling bit to provide a scrambled bit q_n. Scrambler 810 provides a sequence of scrambled bits, which is denoted as $q_1\ q_2\ q_3\ q_4$ ... .

[0276] The initial state of the scrambler (i.e., the content of delay elements 1112a through 1112g) is set to a 7-bit non-zero number at the start of each TDD frame. The three most significant bits (MSBs) (i.e., delay element 1112e through 1112f) are always set to one ('1') and the four least significant bits (LSBs) are set to the TDD frame counter, as indicated in the BCH message.

6. Encoding/Puncturing

[0277] In an embodiment, a single base code is used to code data prior to transmission. This base code generates code bits for one code rate. All other code rates supported by the system (as listed in Table 25) may be obtained by either repeating or puncturing the code bits.

[0278] **FIG. 11B** shows an embodiment of encoder 812 that implements the base code for the system. In this embodiment, the base code is a rate 1/2, constraint length 7 (K = 7), convolutional code with generators of 133 and 171 (octal).

[0279] Within encoder 812, a multiplexer 1120 receives and multiplexes the scrambled bits and tail bits (e.g., zeros). Encoder 812 further includes six delay elements 1122a through 1122f coupled in series. Four adders 1124a through 1124d are also coupled in series and used to implement the first generator (133). Similarly, four adders 1126a through 1126d are coupled in series and used to implement the second generator (171). The adders are further coupled to the delay elements in a manner to implement the two generators of 133 and 171, as shown in FIG. 11B.

[0280] The scrambled bits are provided to the first delay element 1122a and to adders 1124a and 1126a. For each clock cycle, adders 1124a through 1124d perform modulo-2 addition of the incoming bit and four prior bits stored in delay elements 1122b, 1122c, 1122e, and 1122f to provide the first code bit for that clock cycle. Similarly, adders 1126a through 1126d perform modulo-2 addition of the incoming bit and four prior bits stored in delay elements 1122a, 1122b, 1122c, and 1122f to provide the second code bit for that clock cycle. The code bits generated by the first generator are denoted as $a_1\ a_2\ a_3\ a_4$ ..., and the code bits generated by the second generator are denoted as $b_1\ b_2\ b_3\ b_4$ .... A multiplexer 1128 then receives and multiplexes the two streams of code bits from the two generators into a single stream of code bits, which is denoted as $a_1\ b_1\ a_2\ b_2\ a_3\ b_3\ a_4\ b_4$ .... For each scrambled bit q_n, two code bits a_n and b_n are generated, which results in a code rate of 1/2.

[0281] FIG. 11B also shows an embodiment of repeat/puncture unit 814 that can be used to generate other code rates based on the base code rate of 1/2. Within unit 814, the rate 1/2 code bits from encoder 812 are provided to a repeating unit 1132 and a puncturing unit 1134. Repeating unit 1132 repeats each rate 1/2 code bit once to obtain an effective code rate of 1/4. Puncturing unit 1134 deletes some of the rate 1/2 code bits based on a specific puncturing pattern to provide the desired code rate.

[0282] Table 30 lists exemplary puncturing patterns that may be used for the various code rates supported by the system. Other puncturing patterns may also be used, and this is within the scope of the invention.

Table 30

Code Rate	Puncturing Pattern
1/2	11
7/12	11111110111110
5/8	1110111011
2/3	1110
11/16	11111011111110100111100
3/4	111001
13/16	01111011111101110000101100
5/6	1110011001
7/8	11101010011001

[0283] To obtain a code rate of k/n, puncturing unit 1134 provides n code bits for each group of 2k rate 1/2 code bits received from encoder 812. Thus, $2k$-n code bits are deleted from each group of $2k$ code bits. The bits to be deleted from each group are denoted by zeros in the puncturing pattern. For example, to obtain a code rate of 7/12, two bits are deleted from each group of 14 code bits from encoder 812, with the deleted bits being the 8th and 14th code bits in the group, as denoted by the puncturing pattern of "11111110111110". No puncturing is performed if the desired code rate is 1/2.

[0284] A multiplexer 1136 receives the stream of code bits from repeating unit 1132 and the stream of code bits from puncturing unit 1134. Multiplexer 1136 then provides the code bits from repeating unit 1132 if the desired code rate is 1/4 and the code bits from puncturing unit 1134 if the desired code rate is 1/2 or higher.

[0285] Other codes and puncturing patterns besides those described above may also be used, and this is within the scope of the invention. For example, a Turbo code, a block code, some other codes, or any combination thereof may be used to code data. Also, different coding schemes may be used for different transport channels. For example,

convolutional coding may be used for the common transport channels, and Turbo coding may be used for the dedicated transport channels.

7. Interleaving

[0286] In an embodiment, the code bits to be transmitted are interleaved across the 48 data subbands. For the diversity and beam-steering modes, one stream of code bits is transmitted and interleaved across all data subbands. For the spatial multiplexing mode, up to four streams of code bits may be transmitted on up to four spatial channels. The interleaving may be performed separately for each spatial channel such that each stream of code bits is interleaved across all data subbands of the spatial channel used to transmit that stream. Table 29 shows an exemplary code bit-subband assignment that may be used for the interleaving for all transmission modes.

[0287] In one embodiment, the interleaving is performed across all 48 data subbands in each interleaving interval. For this embodiment, each group of 48 code bits in a stream is spread over the 48 data subbands to provide frequency diversity. The 48 code bits in each group may be assigned indices of 0 through 47. Each code bit index is associated with a respective subband. All code bits with a particular index are transmitted on the associated subband. For example, the first code bit (with index 0) in each group is transmitted on subband -26, the second code bit (with index 1) is transmitted on subband 1, the third code bit (with index 2) is transmitted on subband -17, and so on. This interleaving scheme may be used for the diversity, beam-steering, and spatial multiplexing modes. An alternative interleaving scheme for the spatial multiplexing mode is described below.

[0288] The interleaving may alternatively or additionally be performed over time. For example, after the interleaving across the data subbands, the code bits for each subband may further be interleaved (e.g., over one PHY frame or one PDU) to provide time diversity. For the spatial multiplexing mode, the interleaving may also be performed over multiple spatial channels.

[0289] Additionally, interleaving may be employed across the dimensions of the QAM symbols such that code bits forming QAM symbols are mapped to different bit positions of the QAM symbols.

8. Symbol Mapping

[0290] Table 31 shows the symbol mapping for various modulation schemes supported by the system. For each modulation scheme (except for BPSK), half of the bits are mapped to an inphase (I) component and the other half of the bits are mapped to a quadrature (Q) component.

[0291] In an embodiment, the signal constellation for each supported modulation scheme may be defined based on Gray mapping. With Gray mapping, neighboring points in the signal constellation (in both the I and Q components) differ by only one bit position. Gray mapping reduces the number of bit errors for more likely error events, which corresponds to a received symbol being mapped to a location near the correct location, in which case only one code bit would be received in error.

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Table 31

BPSK		
b	I	Q
0	-1	0
1	1	0

QPSK			
b_0	I	b_1	Q
0	-1	0	-1
1	1	1	1

16 QAM			
b_0b_1	I	b_2b_3	Q
00	-3	00	-3
01	-1	01	-1
11	1	11	1
10	3	10	3

64 QAM			
$b_0b_1b_2$	I	$b_3b_4b_5$	Q
000	-7	000	-7
001	-5	001	-5
011	-3	011	-3
010	-1	010	-1
110	1	110	1
111	3	111	3
101	5	101	5
100	7	100	7

256 QAM			
$b_0b_1b_2b_3$	I	$b_4b_5b_6b_7$	Q
0000	-15	0000	-15
0001	-13	0001	-13
0011	-11	0011	-11
0010	-9	0010	-9
0110	-7	0110	-7
0111	-5	0111	-5
0101	-3	0101	-3
0100	-1	0100	-1
1100	1	1100	1
1101	3	1101	3
1111	5	1111	5
1110	7	1110	7
1010	9	1010	9
1011	11	1011	11
1001	13	1001	13
1000	15	1000	15

Normalization Factor K_{norm}	
Modulation Scheme	Value
BPSK	1.0
QPSK	$1/\sqrt{2}$
16 QAM	$1/\sqrt{10}$
64 QAM	$1/\sqrt{42}$
256 QAM	$1/\sqrt{170}$

[0292] The I and Q values for each modulation scheme shown in Table 31 are scaled by a normalization factor K_{norm}

so that the average power of all signal points in the associated signal constellation is equal to unity. The normalization factor for each modulation scheme is shown in Table 31. Quantized values for the normalization factors for the supported modulation schemes may also be used. A modulation symbol s from a particular signal constellation would then have the following form:

$$s = (I + jQ) \cdot K_{norm} \quad ,$$

where I and Q are the values in Table 31 for the signal constellation.

[0293] For a given PDU, the modulation may be different across the PDU and may be different for multiple spatial channels used for data transmission. For example, for the BCH PDU, different modulation schemes may be used for the beacon pilot, the MIMO pilot, and the BCH message.

9. Processing for Spatial Multiplexing Mode

[0294] For the spatial multiplexing mode, a PDU may be transmitted over multiple spatial channels. Various schemes may be used to process data for transmission over multiple spatial channels. Two specific processing schemes for the spatial multiplexing mode are described below.

[0295] In the first processing scheme, coding and puncturing are performed on a per spatial channel basis to achieve the desired code rate for each spatial channel. The N_E spatial channels to use for data transmission are ranked from the highest to lowest received SNR. The data for the entire PDU is first coded to obtain a stream of rate 1/2 code bits. The code bits are then punctured to obtain the desired code rate for each spatial channel.

[0296] The puncturing may be performed in sequential order for the N_E spatial channels, from the best (i.e., highest SNR) to the worst (i.e., lowest SNR) spatial channel. In particular, the puncture unit first performs puncturing for the best spatial channel with the highest received SNR. When the correct number of code bits have been generated for the best spatial channel, the puncture unit then performs puncturing for the second best spatial channel with the next highest received SNR. This process continues until the code bits for all N_E spatial channels are generated. The order for puncturing is from the largest to smallest received SNR, regardless of the specific code rate used for each spatial channel.

[0297] For the example shown in Table 28, the 3456 information bits to be transmitted in the overall PHY frame are first coded with the rate 1/2 base code to obtain 6912 code bits. The first 3168 code bits are punctured using the puncturing pattern for code rate 11/16 to obtain 2304 code bits, which are provided in the PHY frame for the first spatial channel. The next 2592 code bits are then punctured using the puncturing pattern for code rate 3/4 to obtain 1728 code bits, which are provided in the PHY frame for the second spatial channel. The next 864 code bits are then punctured using the puncturing pattern for code rate 3/4 to obtain 576 code bits, which are provided in the PHY frame for the third spatial channel. The last 288 code bits for the PHY frame are then punctured using the puncturing pattern for code rate 1/2 to obtain 288 code bits, which are provided in the PHY frame for the last spatial channel. These four individual PHY frames are further processed and transmitted on the four spatial channels. The puncturing for the next overall PHY frame is then performed in similar manner. The first processing scheme may be implemented by TX data processor 710b in FIG. 9A.

[0298] In the second processing scheme, the coding and puncturing are performed for pairs of subbands. Moreover, the coding and puncturing are cycled through all selected spatial channels for each pair of subbands.

[0299] **FIG. 11C** shows a block diagram that illustrates a TX data processor 710d that implements the second processing scheme. Encoder 812 performs rate 1/2 convolutional encoding of the scrambled bits from scrambler 810. Each spatial channel is assigned a particular rate, which is associated with a specific combination of code rate and modulation scheme, as shown in Table 25. Let b_m denote the number of code bits per modulation symbol for spatial channel m (or equivalently, the number of code bits sent on each data subband of spatial channel m) and r_m denote the code rate used for spatial channel m. The value for b_m is dependent on the constellation size of the modulation scheme used for spatial channel m. In particular, $b_m = 1$, 2, 4, 6 and 8 for BPSK, QPSK, 16-QAM, 64-QAM and 256-QAM, respectively.

[0300] Encoder 812 provides a stream of rate 1/2 code bits to demultiplexer 816, which demultiplexes the received code bit stream into four substreams for the four spatial channels. The demultiplexing is such that the first $4b_1r_1$ code bits are sent to buffer 813a for spatial channel 1, the next $4b_2r_2$ code bits are sent to buffer 813b for spatial channel 2, and so on. Each buffer 813 receives $4b_mr_m$ code bits each time demultiplexer 816 cycles through all four spatial channels. A total of $b_{total} = \sum_{m=1}^{4} 4b_m r_m$ rate 1/2 code bits are provided to the four buffers 813a through 813d for each cycle. Demultiplexer 816 thus cycles through all four positions for the four spatial channels for every b_{total} code bits, which is the number of code bits that can be sent on a pair of subbands using all four spatial channels.

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[0301] Once each buffer 813 has been filled with $4b_m r_m$ code chips for the associated spatial channel, the code bits in the buffer are punctured to obtain the code rate for that spatial channel. Since $4b_m r_m$ rate 1/2 code bits span an integer number of puncturing periods for each puncturing pattern, exactly $2b_m$ code bits are provided after the puncturing for each spatial channel m. The $2b_m$ code bits for each spatial channel are then distributed (interleaved) over the data subbands.

[0302] In an embodiment, the interleaving is performed for each spatial channel in groups of 6 subbands at a time. The code bits after the puncturing for each spatial channel may be numbered sequentially as c_i, for $i = 0, 1, 2, \ldots$. A counter C_m may be maintained for each spatial channel to count every group of $6b_m$ code bits provided by the puncturing unit for that spatial channel. For example, for QPSK with $b_m = 2$, the counter would be set to $C_m = 0$ for code bits c_0 through c_{11} provided by the puncturing unit, $C_m = 1$ after code bits c_{12} through c_{23}, and so on. The counter value C_m for spatial channel m may be expressed as:

$$C_m = \lfloor i/(6b_m) \rfloor \bmod 8 \quad . \qquad \text{Eq (23)}$$

[0303] To determine the subband to which code bit c_i is assigned, the bit index for the code bit is first determined as follows:

$$\text{bit index} = (i \bmod 6) + 6 \cdot C_m \quad . \qquad \text{Eq (24)}$$

The bit index is then mapped to the corresponding subband using Table 29.

[0304] For the example above, the first group of 6 code bits c_0 through c_5 is associated with bit indices 0 through 5, respectively, the second group of 6 code bits c_6 through c_{11} is also associated with bit indices 0 through 5, respectively. Code bits c_0 and c_6 would be mapped to subband -26, code bits c_1 and c_7 would be mapped to subband 1, and so on, as shown in Table 29. The spatial processing may then commence for this first group of 6 subbands. The third group of 6 code bits c_{12} through c_{17} (with $C_m = 1$) is associated with bit indices 6 through 11, respectively, and the fourth group of 6 code bits c_{18} through c_{23} is also associated with bit indices 6 through 11, respectively. Code bits c_{12} and c_{18} would be mapped to subband -25, code bits c_{13} and c_{19} would be mapped to subband 2, and so on. The spatial processing may then commence for this next group of 6 subbands.

[0305] The number 6 in equation (24) comes from the fact that the interleaving is performed in groups of six subbands. The (mod 8) operation in equation (23) comes from the fact that there are eight interleaving groups for the 48 data subbands. Since each cycle of demultiplexer 816 shown in FIG. 11C produces enough code bits to fill two subbands for each wideband eigenmode, a total of 24 cycles are needed to provide the $48b_m$ code bits for one OFDM symbol for each spatial channel.

[0306] The interleaving in groups of 6 subbands at a time can reduce processing delays. In particular, the spatial processing can commence once each group of 6 subbands is available.

[0307] In alternative embodiments, the interleaving may be performed for each spatial channel in groups of N_B subbands at a time, where N_B may be any integer (e.g., N_B may be equal to 48 for interleaving over all 48 data subbands).

VI. Calibration

[0308] For a TDD system, the downlink and uplink share the same frequency band in a time division duplexed manner. In this case, a high degree of correlation typically exists between the downlink and uplink channel responses. This correlation may be exploited to simplify the channel estimation and spatial processing. For a TDD system, each subband of the wireless link may be assumed to be reciprocal. That is, if $\underline{\mathbf{H}}(k)$ represents the channel response matrix from antenna array A to antenna array B for subband k, then a reciprocal channel implies that the coupling from array B to array A is given by the transpose of $\underline{\mathbf{H}}(k)$, which is $\underline{\mathbf{H}}^T(k)$.

[0309] However, the responses (gain and phase) of the transmit and receive chains at the access point are typically different from the responses of the transmit and receive chains at the user terminal. Calibration may be performed to determine the difference in the frequency responses of the transmit/receive chains at the access point and user terminal, and to account for the difference, such that the calibrated downlink and uplink responses can be expressed in terms of each other. Once the transmit/receive chains have been calibrated and accounted for, a measurement for one link (e.g., the downlink) may be used to derive steering vectors for the other link (e.g., the uplink).

[0310] The "effective" downlink and uplink channel responses, $\underline{\mathbf{H}}_{dn}(k)$ and $\underline{\mathbf{H}}_{up}(k)$, which include the responses of the applicable transmit and receive chains at the access point and user terminal, may be expressed as:

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$$\underline{\mathbf{H}}_{dn}(k) = \underline{\mathbf{R}}_{ut}(k)\underline{\mathbf{H}}(k)\underline{\mathbf{T}}_{ap}(k) \ , \text{ for } k \in K, \text{ and} \qquad \text{Eq (25)}$$

$$\underline{\mathbf{H}}_{up}(k) = \underline{\mathbf{R}}_{ap}(k)\underline{\mathbf{H}}^{T}(k)\underline{\mathbf{T}}_{ut}(k) \ , \text{ for } k \in K,$$

where $\underline{T}_{ap}(k)$ and $\underline{R}_{ap}(k)$ are $N_{ap} \times N_{ap}$ diagonal matrices with entries for the complex gains associated with the transmit chain and receive chain, respectively, for the N_{ap} antennas at the access point for subband k;
$\underline{T}_{ut}(k)$ and $\underline{R}_{ut}(k)$ are $N_{ut} \times N_{ut}$ diagonal matrices with entries for the complex gains associated with the transmit chain and receive chain, respectively, for the N_{ut} antennas at the user terminal for subband k; and
$\underline{H}(k)$ is an $N_{ut} \times N_{ap}$ channel response matrix for the downlink.

[0311] Combining the two equations in equation set (25), the following relationship may be obtained:

$$\underline{\mathbf{H}}_{up}(k)\underline{\mathbf{K}}_{ut}(k) = (\underline{\mathbf{H}}_{dn}(k)\underline{\mathbf{K}}_{ap}(k))^{T} \ , \text{ for } k \in K, \qquad \text{Eq (26)}$$

where

$$\underline{\mathbf{K}}_{ut}(k) = \underline{\mathbf{T}}_{ut}^{-1}(k)\underline{\mathbf{R}}_{ut}(k) \text{ and } \underline{\mathbf{K}}_{ap}(k) = \underline{\mathbf{T}}_{ap}^{-1}(k)\underline{\mathbf{R}}_{ap}(k).$$

[0312] The left-hand side of equation (26) represents the "true" calibrated channel response on the uplink, and the right-hand side represents the transpose of the "true" calibrated channel response on the downlink. The application of the diagonal matrices $\underline{K}_{ap}(k)$ and $\underline{K}_{ut}(k)$ to the effective downlink and uplink channel responses, respectively, as shown in equation (26), allows the calibrated channel responses for the downlink and uplink to be expressed as transposes of each other. The $(N_{ap} \times N_{ap})$ diagonal matrix $\underline{K}_{ap}(k)$ for the access point is the ratio of the receive chain response $\underline{R}_{ap}(k)$ to the transmit chain response $\underline{T}_{ap}(k)$ (i.e., $\underline{\mathbf{K}}_{ap}(k) = \frac{\underline{\mathbf{R}}_{ap}(k)}{\underline{\mathbf{T}}_{ap}(k)}$), where the ratio is taken element-by-element. Similarly, the $(N_{ut} \times N_{ut})$ diagonal matrix $\underline{K}_{ut}(k)$ for the user terminal is the ratio of the receive chain response $\underline{R}_{ut}(k)$ to the transmit chain response $\underline{T}_{ut}(k)$.

[0313] The matrices $\underline{K}_{ap}(k)$ and $\underline{K}_{ut}(k)$ include values that can account for differences in the transmit/receive chains at the access point and the user terminal. This would then allow the channel response for one link to be expressed by the channel response for the other link, as shown in equation (26).

[0314] Calibration may be performed to determine the matrices $\underline{K}_{ap}(k)$ and $\underline{K}_{ut}(k)$. Typically, the true channel response $\underline{H}(k)$ and the transmit/receive chain responses are not known nor can they be exactly or easily ascertained. Instead, the effective downlink and uplink channel responses, $\underline{H}_{dn}(k)$ and $\underline{H}_{up}(k)$, may be estimated based on pilots sent on the downlink and uplink, respectively, as described below. Estimates of the matrices $\underline{K}_{ap}(k)$ and $\underline{K}_{ut}(k)$, which are referred to as correction matrices $\hat{\underline{K}}_{ap}(k)$ and $\hat{\underline{K}}_{ut}(k)$, may then be derived based on the downlink and uplink channel response estimates, $\hat{\underline{H}}_{dn}(k)$ and $\hat{\underline{H}}_{up}(k)$, as described below. The matrices $\hat{\underline{K}}_{ap}(k)$ and $\hat{\underline{K}}_{ut}(k)$ include correction factors that can account for differences in the transmit/receive chains at the access point and the user terminal.

[0315] The "calibrated" downlink and uplink channel responses observed by the user terminal and the access point, respectively, may then be expressed as:

$$\underline{\mathbf{H}}_{cdn}(k) = \underline{\mathbf{H}}_{dn}(k)\hat{\underline{\mathbf{K}}}_{ap}(k) \ , \text{ for } k \in K, \text{ and} \qquad \text{Eq (27)}$$

$$\underline{\mathbf{H}}_{cup}(k) = \underline{\mathbf{H}}_{up}(k)\hat{\underline{\mathbf{K}}}_{ut}(k) \ , \text{ for } k \in K,$$

where $\underline{\mathbf{H}}_{cdn}^{T}(k)$ and $\underline{H}_{cup}(k)$ are estimates of the "true" calibrated channel response expressions in equation (26). Combining the two equations in equation set (27) using the expression in equation (26), it can be shown that $\underline{\mathbf{H}}_{cup}(k) \approx \underline{\mathbf{H}}_{cdn}^{T}(k)$. The accuracy of the relationship $\underline{\mathbf{H}}_{cup}(k) \approx \underline{\mathbf{H}}_{cdn}^{T}(k)$ is dependent on the accuracy of the

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matrices $\hat{\underline{K}}_{ap}(k)$ and $\hat{\underline{K}}_{ut}(k)$, which in turn is typically dependent on the quality of the downlink and uplink channel response estimates, $\hat{\underline{H}}_{dn}(k)$ and $\hat{\underline{H}}_{up}(k)$.

[0316] The calibration may be performed using various schemes. For clarity, a specific calibration scheme is described below. To perform the calibration, the user terminal initially acquires the timing and frequency of the access point based on the beacon pilot transmitted on the BCH. The user terminal then sends a message on the RACH to initiate a calibration procedure with the access point. The calibration may be performed in parallel with registration/ authentication.

[0317] Since the frequency responses of the transmit/receive chains at the access point and user terminal are typically flat over most of the band of interest, the phase/gain differences of the transmit/receive chains may be characterized with a small number of subbands. The calibration may be performed for 4, 8, 16, 48 or some other number of subbands, which may be specified in the message sent to initiate the calibration. Calibration may also be performed for the pilot subbands. Calibration constants for subbands on which calibration is not explicitly performed may be computed by interpolation on calibrated subbands. For clarity, the following assumes that calibration is performed for all data subbands.

[0318] For the calibration, the access point allocates to the user terminal a sufficient amount of time on the RCH to send an uplink MIMO pilot of sufficient duration plus a message. The duration of the uplink MIMO pilot may be dependent on the number of subbands over which calibration is performed. For example, 8 OFDM symbols may be sufficient if calibration is performed for four subbands, and more (e.g., 20) OFDM symbols may be needed for more subbands. The total transmit power is typically fixed, so if the MIMO pilot is transmitted on a small number of subbands, then higher amounts of transmit power may be used for each of these subbands and the SNR for each subband is high. Conversely, if the MIMO pilot is transmitted on a large number of subbands then smaller amounts of transmit power may be used for each subband and the SNR for each subband is worse. If the SNR of each subband is not sufficiently high, then more OFDM symbols may be sent for the MIMO pilot and integrated at the receiver to obtain a higher overall SNR for the subband.

[0319] The user terminal then transmits a MIMO pilot on the RCH, which is used by the access point to derive an estimate of the effective uplink channel response, $\hat{\underline{H}}_{up}(k)$, for each of the data subbands. The uplink channel response estimates are quantized (e.g., to 12-bit complex values, with inphase (I) and quadrature (Q) components) and sent to the user terminal.

[0320] The user terminal also derives an estimate of the effective downlink channel response, $\hat{\underline{H}}_{dn}(k)$, for each of the data subbands based on the downlink MIMO pilot sent on the BCH. Upon obtaining the effective uplink and downlink channel response estimates, $\hat{\underline{H}}_{up}(k)$ and $\hat{\underline{H}}_{dn}(k)$, for all data subbands, the user terminal determines correction factors, $\hat{\underline{K}}_{ap}(k)$ and $\hat{\underline{K}}_{ut}(k)$, for each of the data subbands, which are to be used by the access point and user terminal, respectively. A correction vector $\hat{\underline{k}}_{ap}(k)$ may be defined to include only the diagonal elements of $\hat{\underline{K}}_{ap}(k)$, and a correction vector $\hat{\underline{k}}_{ut}(k)$ may be defined to include only the diagonal elements of $\hat{\underline{K}}_{ut}(k)$.

[0321] The correction factors may be derived in various manners, including by a matrix-ratio computation and an MMSE computation. Both of these computation methods are described in further detail below. Other computation methods may also be used, and this is within the scope of the invention.

1. Matrix-Ratio Computation

[0322] To determine the correction vectors $\hat{\underline{k}}_{ap}(k)$ and $\hat{\underline{k}}_{ut}(k)$ given the effective downlink and uplink channel response estimates, $\hat{\underline{H}}_{dn}(k)$ and $\hat{\underline{H}}_{up}(k)$, an $(N_{ut} \times N_{ap})$ matrix $\underline{C}(k)$ is first computed for each data subband, as follows:

$$\underline{C}(k) = \frac{\hat{\underline{H}}_{up}^{T}(k)}{\hat{\underline{H}}_{dn}(k)} \quad , \text{for } k \in K \ , \qquad \text{Eq (28)}$$

where the ratio is taken element-by-element. Each element of $\underline{C}(k)$ may thus be computed as:

$$c_{i,j}(k) = \frac{\hat{h}_{up\,i,j}(k)}{\hat{h}_{dn\,i,j}(k)} \quad , \text{ for } i = \{1 \ldots N_{ut}\} \text{ and } j = \{1 \ldots N_{ap}\} , \qquad \text{Eq (29)}$$

where $\hat{h}_{upi,j}(k)$ is the (i,j)-th (row, column) element of $\hat{\underline{H}}_{up}^{T}(k)$, $\hat{h}_{dni,j}(k)$ is the (i,j)-th element of $\hat{\underline{H}}_{dn}(k)$, and $c_{i,j}(k)$ is the (i,j)-th element of $\underline{C}(k)$.

[0323] The correction vector $\hat{\underline{k}}_{ap}(k)$ for the access point is then equal to the mean of the normalized rows of $\underline{C}(k)$. Each

row of $\underline{\mathbf{C}}(k)$ is first normalized by scaling each of the N_{ap} elements in the row with the first element in the row. Thus, if $\underline{\mathbf{c}}_i(k) = [c_{i,1}(k) \ldots c_{i,Nap}(k)]$ is the i-th row of $\underline{\mathbf{C}}(k)$, then the normalized row $\tilde{\underline{\mathbf{c}}}_i(k)$ may be expressed as:

$$\tilde{\underline{\mathbf{c}}}_i(k) = [c_{i,1}(k)/c_{i,1}(k) \ \ldots \ c_{i,j}(k)/c_{i,1}(k) \ \ldots \ c_{i,N_{ap}}(k)/c_{i,1}(k)] \ . \qquad \text{Eq (30)}$$

The mean of the normalized rows is then the sum of the N_{ut} normalized rows divided by N_{ut}, which may be expressed as:

$$\hat{\underline{\mathbf{k}}}_{ap}(k) = \frac{1}{N_{ut}} \sum_{i=1}^{N_{ut}} \tilde{\underline{\mathbf{c}}}_i(k) \ , \text{for } k \in K . \qquad \text{Eq (31)}$$

Because of the normalization, the first element of $\hat{\underline{\mathbf{k}}}_{ap}(k)$ is unity.

[0324] The correction vector $\hat{\underline{\mathbf{k}}}_{ut}(k)$ for the user terminal is equal to the mean of the inverses of the normalized columns of $\underline{\mathbf{C}}(k)$. The j-th column of $\underline{\mathbf{C}}(k)$ is first normalized by scaling each element in the column with the j-th element of the vector $\hat{\underline{\mathbf{k}}}_{ap}(k)$, which is denoted as $K_{ap,j,j}(k)$. Thus, if $\underline{\mathbf{c}}_j(k) = [c_{1,j}(k) \ldots c_{Nut,j}(k)]^T$ is the j-th column of $\underline{\mathbf{C}}(k)$, then the normalized column $\tilde{\underline{\mathbf{c}}}_j(k)$ may be expressed as:

$$\tilde{\underline{\mathbf{c}}}_j(k) = [c_{1,j}(k)/K_{ap,j,j}(k) \ \ldots \ c_{i,j}(k)/K_{ap,j,j}(k) \ \ldots \ c_{N_{ut},j}(k)/K_{ap,j,j}(k)]^T . \quad \text{Eq (32)}$$

The mean of the inverses of the normalized columns is then the sum of the inverses of the N_{ap} normalized columns divided by N_{ap}, which may be expressed as:

$$\hat{\underline{\mathbf{k}}}_{ut}(k) = \frac{1}{N_{ap}} \sum_{j=1}^{N_{ap}} \frac{1}{\tilde{\underline{\mathbf{c}}}_j(k)} \ , \text{for } k \in K , \qquad \text{Eq (33)}$$

where the inversion of the normalized columns, $\tilde{\underline{\mathbf{c}}}_j(k)$, is performed element-wise.

2. MMSE Computation

[0325] For the MMSE computation, the correction factors $\hat{\underline{\mathbf{K}}}_{ap}(k)$ and $\hat{\underline{\mathbf{K}}}_{ut}(k)$ are derived from the effective downlink and uplink channel response estimates, $\hat{\underline{\mathbf{H}}}_{dn}(k)$ and $\hat{\underline{\mathbf{H}}}_{up}(k)$, such that the mean square error (MSE) between the calibrated downlink channel response and the calibrated uplink channel response is minimized. This condition may be expressed as:

$$\min \left| (\hat{\underline{\mathbf{H}}}_{dn}(k)\hat{\underline{\mathbf{K}}}_{ap}(k))^T - (\hat{\underline{\mathbf{H}}}_{up}(k)\hat{\underline{\mathbf{K}}}_{ut}(k)) \right|^2 \ , \text{for } k \in K , \qquad \text{Eq (34)}$$

which may also be written as:

$$\min \left| \hat{\underline{\mathbf{K}}}_{ap}(k)\hat{\underline{\mathbf{H}}}_{dn}^T(k) - \hat{\underline{\mathbf{H}}}_{up}(k)\hat{\underline{\mathbf{K}}}_{ut}(k) \right|^2 \ , \text{for } k \in K ,$$

where $\hat{\underline{\mathbf{K}}}_{ap}^T(k) = \hat{\underline{\mathbf{K}}}_{ap}(k)$ since $\hat{\underline{\mathbf{K}}}_{ap}(k)$ is a diagonal matrix.

[0326] Equation (34) is subject to the constraint that the lead element of $\hat{\underline{\mathbf{K}}}_{ap}(k)$ is set equal to unity (i.e., $\hat{\underline{\mathbf{K}}}_{ap0,0}(k) = 1$). Without this constraint, the trivial solution would be obtained with all elements of the matrices $\hat{\underline{\mathbf{K}}}_{ap}(k)$ and $\hat{\underline{\mathbf{K}}}_{ut}(k)$ set equal to zero. In equation (34), a matrix $\underline{\mathbf{Y}}(k)$ is first obtained as $\underline{\mathbf{Y}}(k) = \hat{\underline{\mathbf{K}}}_{ap}(k)\hat{\underline{\mathbf{H}}}_{dn}^T(k) - \hat{\underline{\mathbf{H}}}_{up}(k)\hat{\underline{\mathbf{K}}}_{ut}(k)$. The

square of the absolute value is next obtained for each of the $N_{ap} \cdot N_{ut}$ entries of the matrix $\underline{Y}(k)$. The mean square error (or the square error, since a divide by $N_{ap} \cdot N_{ut}$ is omitted) is then equal to the sum of all $N_{ap} \cdot N_{ut}$ squared values.

[0327] The MMSE computation is performed for each designated subband to obtain the correction factors $\hat{\underline{K}}_{ap}(k)$ and $\hat{\underline{K}}_{ut}(k)$ for that subband. The MMSE computation for one subband is described below. For simplicity, the subband index, k, is omitted in the following description. Also for simplicity, the elements of the downlink channel response estimate $\hat{\underline{H}}_{dn}^{T}$ are denoted as $\{a_{ij}\}$, the elements of the uplink channel response estimate $\hat{\underline{H}}_{up}(k)$ are denoted as $\{b_{ij}\}$, the diagonal elements of the matrix $\hat{\underline{K}}_{ap}$ are denoted as $\{u_i\}$, and the diagonal elements of the matrix $\hat{\underline{K}}_{ut}$ are denoted as $\{v_j\}$, where $i = \{1 \ldots N_{ap}\}$ and $j = \{1 \ldots N_{ut}\}$.

[0328] The mean square error may be rewritten from equation (34), as follows:

$$\text{MSE} = \sum_{j=1}^{N_{ut}} \sum_{i=1}^{N_{ap}} | a_{ij} u_i - b_{ij} v_j |^2 \quad , \qquad \text{Eq (35)}$$

again subject to the constraint $u_1 = 1$. The minimum mean square error may be obtained by taking the partial derivatives of equation (35) with respect to u and v and setting the partial derivatives to zero. The results of these operations are the following equation sets:

$$\sum_{j=1}^{N_{ut}} (a_{ij} u_i - b_{ij} v_j) \cdot a_{ij}^{*} = 0 \quad , \text{for } i \in \{2 \ \ldots \ N_{ap}\} \text{, and} \qquad \text{Eq (36a)}$$

$$\sum_{i=1}^{N_{ap}} (a_{ij} u_i - b_{ij} v_j) \cdot b_{ij}^{*} = 0 \quad , \text{for } j \in \{1 \ \ldots \ N_{ut}\} . \qquad \text{Eq (36b)}$$

In equation (36a), $u_1 = 1$ so there is no partial derivative for this case, and the index i runs from 2 through N_{ap}.

[0329] The set of $(N_{ap} + N_{ut} - 1)$ equations in equation sets (36a) and (36b) may be more conveniently expressed in matrix form, as follows:

$$\underline{A}\underline{y} = \underline{z} \quad , \qquad \text{Eq (37)}$$

where

$$\underline{\mathbf{A}} = \begin{bmatrix} \sum_{j=1}^{N_{ut}} |a_{2j}|^2 & 0 & \cdots & 0 & -b_{21}a_{21}^* & \cdots & -b_{2N_{ap}}a_{2N_{ut}}^* \\ 0 & \sum_{j=1}^{N_{ut}} |a_{3j}|^2 & 0 & \cdots & \cdots & \cdots & \cdots \\ \cdots & 0 & \cdots & 0 & & & \\ 0 & \cdots & 0 & \sum_{j=1}^{N_{ut}} |a_{N_{ap}j}|^2 & -b_{N_{ap}1}a_{N_{ap}1}^* & & -b_{N_{ap}N_{ut}}a_{N_{ap}N_{ut}}^* \\ -a_{21}b_{31}^* & \cdots & & -a_{N_{ap}1}b_{N_{ap}1}^* & \sum_{i=1}^{N_{ap}} |b_{i1}|^2 & 0 & \cdots & 0 \\ \cdots & \cdots & & & 0 & \sum_{i=1}^{N_{ap}} |b_{i2}|^2 & 0 & \cdots \\ & & & & \cdots & 0 & \cdots & 0 \\ -a_{2N_{ut}}b_{2N_{ut}}^* & \cdots & & -a_{N_{ap}N_{ut}}b_{N_{ap}N_{ut}}^* & 0 & \cdots & 0 & \sum_{i=1}^{N_{ap}} |b_{iN_{ut}}|^2 \end{bmatrix}$$

$$\underline{\mathbf{y}} = \begin{bmatrix} u_2 \\ u_3 \\ \cdots \\ u_{N_{ap}} \\ v_1 \\ v_2 \\ \cdots \\ v_{N_{ut}} \end{bmatrix} \text{ and } \underline{\mathbf{z}} = \begin{bmatrix} 0 \\ 0 \\ \cdots \\ 0 \\ a_{11}b_{11}^* \\ a_{12}b_{12}^* \\ \cdots \\ a_{1N_{ut}}b_{1N_{ut}}^* \end{bmatrix}.$$

[0330] The matrix $\underline{\mathbf{A}}$ includes $(N_{ap}+N_{ut}-1)$ rows, with the first $N_{ap}-1$ rows corresponding to the $N_{ap}-1$ equations from equation set (36a) and the last N_{ut} rows corresponding to the N_{ut} equations from equation set (36b). In particular, the first row of the matrix $\underline{\mathbf{A}}$ is generated from equation set (36a) with $i=2$, the second row is generated with $i=3$, and so on. The N_{ap}-th row of the matrix $\underline{\mathbf{A}}$ is generated from equation set (36b) with $j=1$, and so on, and the last row is generated with $j = N_{ut}$. As shown above, the entries of the matrix $\underline{\mathbf{A}}$ and the entries of the vector $\underline{\mathbf{z}}$ may be obtained based on the entries in the matrices $\hat{\underline{\mathbf{H}}}_{dn}^{T}$ and $\hat{\underline{\mathbf{H}}}_{up}$.

[0331] The correction factors are included in the vector $\underline{\mathbf{y}}$, which may be obtained as:

$$\underline{\mathbf{y}} = \underline{\mathbf{A}}^{-1}\underline{\mathbf{z}} \quad . \qquad \text{Eq (38)}$$

[0332] The results of the MMSE computation are correction matrices $\hat{\underline{\mathbf{K}}}_{ap}$ and $\hat{\underline{\mathbf{K}}}_{ut}$ that minimize the mean square error in the calibrated downlink and uplink channel responses, as shown in equation (34). Since the matrices $\hat{\underline{\mathbf{K}}}_{ap}$ and $\hat{\underline{\mathbf{K}}}_{ut}$ are obtained based on the downlink and uplink channel response estimates, $\hat{\underline{\mathbf{H}}}_{dn}$ and $\hat{\underline{\mathbf{H}}}_{up}$, the quality of the correction matrices $\hat{\underline{\mathbf{K}}}_{ap}$ and $\hat{\underline{\mathbf{K}}}_{ut}$ are thus dependent on the quality of the channel estimates $\hat{\underline{\mathbf{H}}}_{dn}$ and $\hat{\underline{\mathbf{H}}}_{up}$. The MIMO pilot may be averaged at the receiver to obtain more accurate estimates for $\hat{\underline{\mathbf{H}}}_{dn}$ and $\hat{\underline{\mathbf{H}}}_{up}$.

[0333] The correction matrices, $\hat{\underline{\mathbf{K}}}_{ap}$ and $\hat{\underline{\mathbf{K}}}_{ut}$, obtained based on the MMSE computation are generally better than the correction matrices obtained based on the matrix-ratio computation. This is especially true when some of the channel

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gains are small and measurement noise can greatly degrade the channel gains.

3. Post Computation

[0334] A pair of correction vectors, $\hat{\underline{k}}_{ap}(k)$ and $\hat{\underline{k}}_{ut}(k)$, may be determined for each of the data subbands. Since adjacent subbands are likely to be correlated, the computation may be simplified. For example, the computation may be performed for every *n*-th subband instead of each subband, where *n* may be determined by the expected response of the transmit/receive chains. If the calibration is performed for fewer than all of the data and pilot subbands, then the correction factors for the "uncalibrated" subbands may be obtained by interpolating the correction factors obtained for the "calibrated" subbands.

[0335] Various other calibration schemes may also be used to derive the correction vectors, $\hat{\underline{k}}_{ap}(k)$ and $\hat{\underline{k}}_{ut}(k)$, for the access point and the user terminal, respectively. However, the scheme described above allows "compatible" correction vectors to be derived for the access point when the calibration is performed by different user terminals.

[0336] After the derivation, the user terminal sends the correction vectors $\hat{\underline{k}}_{ap}(k)$ for all data subbands back to the access point. If the access point has already been calibrated (e.g., by other user terminals), then the current correction vectors are updated with the newly received correction vectors. Thus, if the access point uses correction vectors $\hat{\underline{k}}_{ap1}(k)$ to transmit the MIMO pilot from which the user terminal determines new correction vectors $\hat{\underline{k}}_{ap2}(k)$, then the updated correction vectors are the product of the current and new correction vectors, i.e., $\hat{\underline{k}}_{ap3}(k) = \hat{\underline{k}}_{ap1}(k) \cdot \hat{\underline{k}}_{ap2}(k)$, where the multiplication is element-by-element. The updated correction vectors $\hat{\underline{k}}_{ap3}(k)$ may then be used by the access point until they are updated again.

[0337] The correction vectors $\hat{\underline{k}}_{ap1}(k)$ and $\hat{\underline{k}}_{ap2}(k)$ may be derived by the same or different user terminals. In one embodiment, the updated correction vectors are defined as $\hat{\underline{k}}_{ap3}(k) = \hat{\underline{k}}_{ap1}(k) \cdot \hat{\underline{k}}_{ap2}(k)$, where the multiplication is element-by-element. In another embodiment, the updated correction vectors may be redefined as $\hat{\underline{k}}_{ap3}(k) = \hat{\underline{k}}_{ap1}(k) \cdot \hat{\underline{k}}_{ap2}^{\alpha}(k)$, where α is a factor used to provide weighted averaging (e.g., $0<\alpha<1$). If the calibration updates are infrequent, then α close to one might perform best. If the calibration updates are frequent but noisy, then a smaller value for α is better. The updated correction vectors $\hat{\underline{k}}_{ap3}(k)$ may then be used by the access point until they are updated again.

[0338] The access point and user terminal use their respective correction vectors $\hat{\underline{k}}_{ap}(k)$ and $\hat{\underline{k}}_{ut}(k)$, or the corresponding correction matrices $\hat{\underline{K}}_{ap}(k)$ and $\hat{\underline{K}}_{ut}(k)$, for $k \in K$, to scale the modulation symbols prior to transmission, as described below. The calibrated downlink and uplink channels that the user terminal and access point observe are shown in equation (27).

VII. Spatial Processing

[0339] The spatial processing at the access point and user terminal may be simplified for a TDD system, after calibration has been performed to account for the difference in the transmit/receive chains. As noted above, the calibrated downlink channel response is $\underline{H}_{cdn}(k)=\underline{H}_{dn}(k)\hat{\underline{K}}_{ap}(k)$. The calibrated uplink channel response is $\underline{H}_{cup}(k)=\underline{H}_{up}(k)\hat{\underline{K}}_{ut}(k)\approx(\underline{H}_{dn}(k)\hat{\underline{K}}_{ap}(k))^{T}$.

1. Uplink Spatial Processing

[0340] Singular value decomposition of the calibrated uplink channel response matrix, $\underline{H}_{cup}(k)$, may be expressed as:

$$\underline{\mathbf{H}}_{cup}(k) = \underline{\mathbf{U}}_{ap}(k)\underline{\Sigma}(k)\underline{\mathbf{V}}_{ut}^{H}(k) \quad , \text{for } k \in K , \qquad \text{Eq (39)}$$

where $\underline{U}_{ap}(k)$ is an $(N_{ap} \times N_{ap})$ unitary matrix of left eigenvectors of $\underline{H}_{cup}(k)$;
$\underline{\Sigma}(k)$ is an $(N_{ap} \times N_{ut})$ diagonal matrix of singular values of $\underline{H}_{cup}(k)$, and
$\underline{V}_{ut}(k)$ is an $(N_{ut} \times N_{ut})$ unitary matrix of right eigenvectors of $\underline{H}_{cup}(k)$.

[0341] Correspondingly, singular value decomposition of the calibrated downlink channel response matrix, $\underline{H}_{cdn}(k)$, may be expressed as:

$$\underline{\mathbf{H}}_{cdn}(k) = \underline{\mathbf{V}}_{ut}^{*}(k)\underline{\Sigma}(k)\underline{\mathbf{U}}_{ap}^{T}(k) \quad , \text{for } k \in K . \qquad \text{Eq (40)}$$

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The matrices $\underline{\mathbf{V}}_{ut}^{*}(k)$ and $\underline{\mathbf{U}}_{ap}^{*}(k)$ are also matrices of left and right eigenvectors, respectively, of $\underline{H}_{cdn}(k)$. As shown in equations (39) and (40) and based on the above description, the matrices of left and right eigenvectors for one link are the complex conjugate of the matrices of right and left eigenvectors, respectively, for the other link. The matrices $\underline{\mathbf{V}}_{ut}(k)$, $\underline{\mathbf{V}}_{ut}^{*}(k)$, $\underline{\mathbf{V}}_{ut}^{T}(k)$, and $\underline{\mathbf{V}}_{ut}^{H}(k)$ are different forms of the matrix $\underline{\mathbf{V}}_{ut}(k)$, and the matrices $\underline{\mathbf{U}}_{ap}(k)$, $\underline{\mathbf{U}}_{ap}^{*}(k)$, $\underline{\mathbf{U}}_{ap}^{T}(k)$, and $\underline{\mathbf{U}}_{ap}^{H}(k)$ are also different forms of the matrix $\underline{\mathbf{U}}_{ap}(k)$. For simplicity, reference to the matrices $\underline{\mathbf{U}}_{ap}(k)$ and $\underline{\mathbf{V}}_{ut}(k)$ in the following description may also refer to their various other forms. The matrices $\underline{\mathbf{U}}_{ap}(k)$ and $\underline{\mathbf{V}}_{ut}(k)$ are used by the access point and user terminal, respectively, for spatial processing and are denoted as such by their subscripts. The eigenvectors are also often referred to as "steering" vectors.

[0342] The user terminal can estimate the calibrated downlink channel response based on the MIMO pilot sent by the access point. The user terminal can then perform the singular value decomposition of the calibrated downlink channel response estimate $\underline{\hat{H}}_{cdn}(k)$, for $k \in K$, to obtain the diagonal matrix $\underline{\hat{\Sigma}}(k)$ and the matrix $\underline{\hat{\mathbf{V}}}_{ut}^{*}(k)$ of left eigenvectors of $\underline{\hat{H}}_{cdn}(k)$. This singular value decomposition may be given as $\underline{\hat{\mathbf{H}}}_{cdn}(k) = \underline{\hat{\mathbf{V}}}_{ut}^{*}(k)\underline{\hat{\Sigma}}(k)\underline{\hat{\mathbf{U}}}_{ap}^{T}(k)$, where the hat ("^") above each matrix indicates that it is an estimate of the actual matrix.

[0343] Similarly, the access point can estimate the calibrated uplink channel response based on a MIMO pilot sent by the user terminal. The access point may then perform singular value decomposition for the calibrated uplink channel response estimate $\underline{\hat{H}}_{cup}(k)$, for $k \in K$, to obtain the diagonal matrix $\underline{\hat{\Sigma}}(k)$ and the matrix $\underline{\hat{\mathbf{U}}}_{ap}(k)$ of left eigenvectors of $\underline{\hat{H}}_{cup}(k)$. This singular value decomposition may be given as $\underline{\hat{\mathbf{H}}}_{cup}(k) = \underline{\hat{\mathbf{U}}}_{ap}(k)\underline{\hat{\Sigma}}(k)\underline{\hat{\mathbf{V}}}_{ut}^{H}(k)$.

[0344] An ($N_{ut} \times N_{ut}$) matrix $\underline{F}_{ut}(k)$ may be defined as:

$$\underline{\mathbf{F}}_{ut}(k) = \underline{\hat{\mathbf{K}}}_{ut}(k)\underline{\hat{\mathbf{V}}}_{ut}(k) \quad \text{, for } k \in K \text{.} \qquad \text{Eq (41)}$$

While it is active, the user terminal keeps a running estimate of the calibrated downlink channel $\underline{\hat{H}}_{cdn}(k)$ and the matrices $\underline{\hat{\mathbf{V}}}_{ut}(k)$ of left eigenvectors of $\underline{\hat{H}}_{cdn}(k)$, which are used to update the matrix $\underline{F}_{ut}(k)$.

[0345] The user terminal uses the matrix $\underline{F}_{ut}(k)$ for the spatial processing for the beam-steering and spatial multiplexing modes. For the spatial multiplexing mode, the transmit vector $\underline{\mathbf{x}}_{up}(k)$ for each subband may be expressed as:

$$\underline{\mathbf{x}}_{up}(k) = \underline{\mathbf{F}}_{ut}(k)\underline{\mathbf{s}}_{up}(k) \quad \text{, for } k \in K \text{,} \qquad \text{Eq (42)}$$

where $\underline{\mathbf{s}}_{up}(k)$ is a data vector with up to N_s symbols to be transmitted on the N_s eigenmodes of subband k;
$\underline{F}_{ut}(k)$ substitutes for $\underline{\mathbf{V}}(k)$ in equation (15), and the signal scaling by $\underline{\mathbf{G}}(k)$ to achieve channel inversion is omitted in equation (42) for simplicity; and
$\underline{\mathbf{x}}_{up}(k)$ is the transmit vector for the uplink for subband k.

[0346] At the access point, the received vector $\underline{\mathbf{r}}_{up}(k)$ for the uplink transmission may be expressed as:

$$\begin{aligned}
\underline{\mathbf{r}}_{up}(k) &= \underline{\mathbf{H}}_{up}(k)\underline{\mathbf{x}}_{up}(k) + \underline{\mathbf{n}}_{up}(k) \qquad \text{, for } k \in K \text{,} \quad \text{Eq (43)} \\
&= \underline{\mathbf{H}}_{up}(k)\underline{\hat{\mathbf{K}}}_{ut}(k)\underline{\hat{\mathbf{V}}}_{ut}(k)\underline{\mathbf{s}}_{up}(k) + \underline{\mathbf{n}}_{up}(k) \\
&\approx \underline{\hat{\mathbf{H}}}_{cup}(k)\underline{\hat{\mathbf{V}}}_{ut}(k)\underline{\mathbf{s}}_{up}(k) + \underline{\mathbf{n}}_{up}(k) \\
&= \underline{\hat{\mathbf{U}}}_{ap}(k)\underline{\hat{\Sigma}}(k)\underline{\hat{\mathbf{V}}}_{ut}^{H}(k)\underline{\hat{\mathbf{V}}}_{ut}(k)\underline{\mathbf{s}}_{up}(k) + \underline{\mathbf{n}}_{up}(k) \\
&= \underline{\hat{\mathbf{U}}}_{ap}(k)\underline{\hat{\Sigma}}(k)\underline{\mathbf{s}}_{up}(k) + \underline{\mathbf{n}}_{up}(k)
\end{aligned}$$

where $\underline{\mathbf{r}}_{up}(k)$ is the received vector for the uplink subband k; and
$\underline{\mathbf{n}}_{up}(k)$ is additive white Gaussian noise (AWGN) for subband k.

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Equation (43) uses the following relationships: $\underline{\mathbf{H}}_{up}(k)\hat{\underline{\mathbf{K}}}_{ut}(k)=\underline{\mathbf{H}}_{cup}(k)\approx\hat{\underline{\mathbf{H}}}_{cup}(k)$ and $\hat{\underline{\mathbf{H}}}_{cup}(k)=\hat{\underline{\mathbf{U}}}_{ap}(k)\hat{\underline{\Sigma}}(k)\hat{\underline{\mathbf{V}}}_{ut}^{H}(k)$. As shown in equation (43), at the access point, the received uplink transmission is transformed by $\hat{\underline{\mathbf{U}}}_{ap}(k)\hat{\underline{\Sigma}}(k)$, which is the matrix $\hat{\underline{\mathbf{U}}}_{ap}(k)$ of left eigenvectors of $\hat{\underline{\mathbf{H}}}_{cup}(k)$ scaled by the diagonal matrix $\hat{\underline{\Sigma}}(k)$ of singular values.

[0347] The user terminal transmits a steered reference on the uplink using the matrix $\underline{\mathbf{F}}_{ut}(k)$. The steered reference is a pilot transmission on one wideband eigenmode using either beam-steering or beam-forming, and is described in detail below. At the access point, the received uplink steered reference (in the absence of noise) is approximately $\hat{\underline{\mathbf{U}}}_{ap}(k)\hat{\underline{\Sigma}}(k)$. The access point can thus obtain an estimate of the unitary matrix $\hat{\underline{\mathbf{U}}}_{ap}(k)$ and diagonal matrix $\hat{\underline{\Sigma}}(k)$ based on the steered reference sent by the user terminal. Various estimation techniques may be used to obtain the estimate of the unitary and diagonal matrices.

[0348] In one embodiment, to obtain an estimate of $\hat{\underline{\mathbf{U}}}_{ap}(k)$, the received vector $\underline{\mathbf{r}}_m(k)$ for the steered reference for subband k of wideband eigenmode m is first multiplied with the complex conjugate of a pilot OFDM symbol, $p^*(k)$, sent for the steered reference. The generation of the steered reference and the pilot OFDM symbol are described in detail below. The result is then integrated over multiple received steered reference symbols for each wideband eigenmode to obtain an estimate of $\hat{\underline{\mathbf{u}}}_m(k)\sigma_m(k)$, which is a scaled left eigenvector of $\hat{\underline{\mathbf{H}}}_{cup}(k)$ for wideband eigenmode m. Since eigenvectors have unit power, the singular values (or $\sigma_m(k)$) in $\hat{\underline{\Sigma}}(k)$ may be estimated based on the received power of the steered reference, which can be measured for each subband of each wideband eigenmode.

[0349] In another embodiment, an MMSE technique is used to obtain an estimate of $\hat{\underline{\mathbf{u}}}_m(k)$ based on the received vector $\underline{\mathbf{r}}_m(k)$ for the steered reference.

[0350] The steered reference may be sent for one wideband eigenmode in any given symbol period, and may in turn be used to obtain an estimate of one eigenvector for each subband of that wideband eigenmode. Thus, the receiver is able to obtain an estimate of one eigenvector in a unitary matrix for any given symbol period. Since estimates of multiple eigenvectors for the unitary matrix are obtained over different symbol periods, and due to noise and other sources of degradation in the transmission path, the estimated eigenvectors for the unitary matrix are not likely be orthogonal. If the estimated eigenvectors are thereafter used for spatial processing of data transmission on the other link, then any errors in orthogonality in these estimated eigenvectors would result in cross-talk among the eigenmodes, which may degrade performance.

[0351] In an embodiment, the estimated eigenvectors for each unitary matrix are forced to be orthogonal to each other. The orthogonalization of the eigenvectors may be achieved using various techniques such as QR factorization, minimum square error computation, polar decomposition, and so on. QR factorization decomposes a matrix $\underline{\mathbf{M}}^T$ (with non-orthogonal columns) into an orthogonal matrix $\underline{\mathbf{Q}}_F$ and an upper triangle matrix $\underline{\mathbf{R}}_F$. The matrix $\underline{\mathbf{Q}}_F$ forms an orthogonal basis for the columns of $\underline{\mathbf{M}}^T$. The diagonal elements of $\underline{\mathbf{R}}_F$ give the length of the components of the columns of $\underline{\mathbf{M}}^T$ in the directions of the respective columns of $\underline{\mathbf{Q}}_F$. The matrix $\underline{\mathbf{Q}}_F$ may be used for spatial processing on the downlink. The matrices $\underline{\mathbf{Q}}_F$ and $\underline{\mathbf{R}}_F$ may be used to derive an enhanced matched filter matrix for the uplink. The QR factorization may be performed by various methods including a Gram-Schmidt procedure, a householder transformation, and so on.

[0352] Other techniques to estimate the unitary and diagonal matrices based on the steered reference may also be used, and this is within the scope of the invention.

[0353] The access point can thus estimate both $\hat{\underline{\mathbf{U}}}_{ap}(k)$ and $\hat{\underline{\Sigma}}(k)$ based on the steered reference sent by the user terminal, without having to perform singular value decomposition on $\hat{\underline{\mathbf{H}}}_{cup}(k)$.

[0354] A normalized matched filter matrix $\underline{\mathbf{M}}_{ap}(k)$ for the uplink transmission from the user terminal may be expressed as:

$$\underline{\mathbf{M}}_{ap}(k)=\hat{\underline{\Sigma}}^{-1}(k)\hat{\underline{\mathbf{U}}}_{ap}^{H}(k) \quad \text{, for } k\in K\,. \qquad \text{Eq (44)}$$

The matched filtering at the access point for the uplink transmission may then be expressed as:

$$\begin{aligned}\hat{\underline{\mathbf{s}}}_{up}(k) &= \underline{\mathbf{M}}_{ap}(k)\underline{\mathbf{r}}_{up}(k)\\ &= \hat{\underline{\Sigma}}^{-1}(k)\hat{\underline{\mathbf{U}}}_{ap}^{H}(k)(\hat{\underline{\mathbf{U}}}_{ap}(k)\hat{\underline{\Sigma}}(k)\underline{\mathbf{s}}_{up}(k)+\underline{\mathbf{n}}_{up}(k)) \quad \text{, for } k\in K\,, \quad \text{Eq (45)}\\ &= \underline{\mathbf{s}}_{up}(k)+\tilde{\underline{\mathbf{n}}}_{up}(k)\end{aligned}$$

where $\hat{\underline{\mathbf{s}}}_{up}(k)$ is an estimate of the vector of modulation symbols $\underline{\mathbf{s}}_{up}(k)$ transmitted by the user terminal for the spatial multiplexing mode. For the beam-steering mode, only one row of the matrix $\underline{\mathbf{M}}_{ap}(k)$ is used to provide one symbol estimate

$\hat{\underline{s}}(k)$ for the eigenmode used for data transmission.

2. Downlink Spatial Processing

[0355] For the downlink, the access point uses an $(N_{ap} \times N_{ap})$ matrix $\underline{F}_{ap}(k)$ for spatial processing. This matrix may be expressed as:

$$\underline{F}_{ap}(k) = \hat{\underline{K}}_{ap}(k)\hat{\underline{U}}_{ap}^{*}(k) \quad , \text{for } k \in K . \qquad \text{Eq (46)}$$

The correction matrix $\hat{\underline{K}}_{ap}(k)$ is derived by the user terminal and sent back to the access point during calibration. The matrix $\hat{\underline{U}}_{ap}(k)$ may be obtained based on the steered reference sent on the uplink by the user terminal.

[0356] For the spatial multiplexing mode, the transmit vector $\underline{x}_{dn}(k)$ for the downlink for each data subband may be expressed as:

$$\underline{x}_{dn}(k) = \underline{F}_{ap}(k)\underline{s}_{dn}(k) \quad , \text{for } k \in K , \qquad \text{Eq (47)}$$

where $\underline{x}_{dn}(k)$ is the transmit vector, $\underline{s}_{dn}(k)$ is the data vector for the downlink, and the signal scaling by $\underline{G}(k)$ to achieve channel inversion is again omitted for simplicity.

[0357] At the user terminal, the received vector $\underline{r}_{dn}(k)$ for the downlink transmission may be expressed as:

$$\begin{aligned}
\underline{r}_{dn}(k) &= \underline{H}_{dn}(k)\underline{x}_{dn}(k) + \underline{n}_{dn}(k) \\
&= \underline{H}_{dn}(k)\hat{\underline{K}}_{ap}(k)\hat{\underline{U}}_{ap}^{*}(k)\underline{s}_{dn}(k) + \underline{n}_{dn}(k) \\
&\approx \hat{\underline{H}}_{cdn}(k)\hat{\underline{U}}_{ap}^{*}(k)\underline{s}_{dn}(k) + \underline{n}_{dn}(k) \\
&= \hat{\underline{V}}_{ut}^{*}(k)\hat{\underline{\Sigma}}(k)\hat{\underline{U}}_{ap}^{T}(k)\hat{\underline{U}}_{ap}^{*}(k)\underline{s}_{dn}(k) + \underline{n}_{dn}(k)) \\
&= \hat{\underline{V}}_{ut}^{*}(k)\hat{\underline{\Sigma}}(k)\underline{s}_{dn}(k) + \underline{n}_{dn}(k) \qquad , \text{for } k \in K . \quad \text{Eq (48)}
\end{aligned}$$

As shown in equation (48), at the user terminal, the received downlink transmission is transformed by $\hat{\underline{V}}_{ut}^{*}(k)\hat{\underline{\Sigma}}(k)$, which is the matrix $\hat{\underline{V}}_{ut}(k)$ of left eigenvectors of $\hat{\underline{H}}_{cdn}(k)$ scaled by the diagonal matrix $\hat{\underline{\Sigma}}(k)$ of singular values.

[0358] A normalized matched filter matrix $\underline{M}_{ut}(k)$ for the downlink transmission from the access point may be expressed as:

$$\underline{M}_{ut}(k) = \hat{\underline{\Sigma}}^{-1}(k)\hat{\underline{V}}_{ut}^{T}(k) \quad , \text{for } k \in K . \qquad \text{Eq (49)}$$

The diagonal matrix $\hat{\underline{\Sigma}}(k)$ and matrix $\hat{\underline{V}}_{ut}(k)$ of left eigenvectors can be derived by the user terminal by performing singular value decomposition on the calibrated downlink channel response estimate $\hat{\underline{H}}_{cdn}(k)$, as described above.

[0359] The matched filtering at the user terminal for the downlink transmission may then be expressed as:

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$$\begin{aligned}\hat{\underline{s}}_{dn}(k) &= \underline{M}_{ut}(k)\underline{r}_{dn}(k) \\ &= \hat{\underline{\Sigma}}^{-1}(k)\hat{\underline{V}}_{ut}^{T}(k)(\hat{\underline{V}}_{ut}^{*}(k)\hat{\underline{\Sigma}}(k)\underline{s}_{dn}(k)+\underline{n}_{dn}(k)) \quad \text{, for } k \in K \text{.} \quad \text{Eq (50)} \\ &= \underline{s}_{dn}(k)+\tilde{\underline{n}}_{dn}(k)\end{aligned}$$

3. Access Point and User Terminal Spatial Processing

[0360] Because of the reciprocal channel for the TDD system and the calibration, the spatial processing at both the access point and the user terminal may be simplified. Table 32 summarizes the spatial processing at the access point and user terminal for data transmission and reception.

Table 32

	Uplink	Downlink
User Terminal	Transmit: $\underline{x}_{up}(k) = \hat{\underline{K}}_{ut}(k)\hat{\underline{V}}_{ut}(k)\underline{s}_{up}(k)$	Receive : $\hat{\underline{s}}_{dn}(k) = \hat{\underline{\Sigma}}^{-1}(k)\hat{\underline{V}}_{ut}^{T}(k)\underline{r}_{dn}(k)$
Access Point	Receive: $\hat{\underline{s}}_{up}(k) = \hat{\underline{\Sigma}}^{-1}(k)\hat{\underline{U}}_{ap}^{H}(k)\underline{r}_{up}(k)$	Transmit: $\underline{x}_{dn}(k) = \hat{\underline{K}}_{ap}(k)\hat{\underline{U}}_{ap}^{*}(k)\underline{s}_{dn}(k)$

The spatial processing for data reception is also commonly referred to as matched filtering.

[0361] Because of the reciprocal channel, $\hat{\underline{V}}_{ut}(k)$ is both the matrix of right eigenvectors of $\hat{\underline{H}}_{cup}(k)$ (to transmit) and left eigenvectors of $\hat{\underline{H}}_{cdn}(k)$ (to receive) for the user terminal. Similarly, $\hat{\underline{U}}_{ap}(k)$ is both the matrix of right eigenvectors of $\hat{\underline{H}}_{cdn}(k)$ (to transmit) and left eigenvectors of $\hat{\underline{H}}_{cup}(k)$ (to receive) for the access point. The singular value decomposition only needs to be performed by the user terminal for the calibrated downlink channel response estimate $\hat{\underline{H}}_{cdn}(k)$ to obtain $\hat{\underline{V}}_{ut}(k)$ and $\hat{\underline{\Sigma}}(k)$. The access point can derive $\hat{\underline{U}}_{ap}(k)$ and $\hat{\underline{\Sigma}}(k)$ based on the steered reference sent by the user terminal and does not need to perform the singular value decomposition on the uplink channel response estimate $\hat{\underline{H}}_{cup}(k)$. The access point and user terminal may have different versions of the matrix $\hat{\underline{\Sigma}}(k)$ due to the different means used by the access point and user terminal to derive $\hat{\underline{\Sigma}}(k)$. Moreover, the matrix $\hat{\underline{U}}_{ap}(k)$ derived by the access point based on the steered reference is typically different from the matrix $\hat{\underline{U}}_{ap}(k)$ derived by the user terminal using singular value decomposition. For simplicity, these differences are not shown in the above derivation.

4. Beam-Steering

[0362] For certain channel conditions, it is better to transmit data on only one wideband eigenmode - typically the best or principal wideband eigenmode. This may be the case if the received SNRs for all other wideband eigenmodes are sufficiently poor so that improved performance is achieved by using all of the available transmit power on the principal wideband eigenmode.

[0363] Data transmission on one wideband eigenmode may be achieved using either beam-forming or beam-steering. For beam-forming, the modulation symbols are spatially processed with the eigenvectors $\hat{\underline{v}}_{ut,1}(k)$ or $\hat{\underline{u}}_{ap,1}(k)$, for $k \in K$, for the principal wideband eigenmode (i.e., the first column of $\hat{\underline{V}}_{ut}(k)$ or $\hat{\underline{U}}_{ap}(k)$, after the ordering). For beam-steering, the modulation symbols are spatially processed with a set of "normalized" (or "saturated") eigenvectors $\bar{\underline{v}}_{ut}(k)$ or $\bar{\underline{u}}_{ap}(k)$, for $k \in K$, for the principal wideband eigenmode. For clarity, beam-steering is described below for the uplink.

[0364] For the uplink, the elements of each eigenvector $\hat{\underline{v}}_{ut,1}(k)$, for $k \in K$, for the principal wideband eigenmode may have different magnitudes. Thus, the preconditioned symbols for each subband, which are obtained by multiplying the modulation symbol for subband k with the elements of the eigenvector $\hat{\underline{v}}_{ut,1}(k)$ for subband k, may then have different magnitudes. Consequently, the per-antenna transmit vectors, each of which includes the preconditioned symbols for all data subbands for a given transmit antenna, may have different magnitudes. If the transmit power for each transmit antenna is limited (e.g., because of limitations of power amplifiers), then beam-forming may not fully use the total power available for each antenna.

[0365]] Beam-steering uses only the phase information from the eigenvectors $\hat{\underline{v}}_{ut,1}(k)$, for $k \in K$, for the principal wideband eigenmode and normalizes each eigenvector such that all elements in the eigenvector have equal magnitudes.

The normalized eigenvector $\underline{\tilde{\mathbf{v}}}_{ut}(k)$ for subband k may be expressed as:

$$\underline{\tilde{\mathbf{v}}}_{ut}(k) = [Ae^{j\theta_1(k)} \;\; Ae^{j\theta_2(k)} \;\; \ldots \;\; Ae^{j\theta_{N_{ut}}(k)}]^T \;, \qquad \text{Eq (51)}$$

where A is a constant (e.g., A = 1); and
$\theta_i(k)$ is the phase for subband k of transmit antenna i, which is given as:

$$\theta_i(k) = \angle \hat{v}_{ut,1,i}(k) = \tan^{-1}\left(\frac{\mathrm{Im}\{\hat{v}_{ut,1,i}(k)\}}{\mathrm{Re}\{\hat{v}_{ut,1,i}(k)\}}\right) \;. \qquad \text{Eq (52)}$$

As shown in equation (52), the phase of each element in the vector $\underline{\tilde{\mathbf{v}}}_{ut}(k)$ is obtained from the corresponding element of the eigenvector $\underline{\hat{\mathbf{v}}}_{ut,1}(k)$ (i.e., $\theta_i(k)$ is obtained from $\underline{\hat{v}}_{ut,1,i}(k)$, where $\underline{\hat{\mathbf{v}}}_{ut,1}(k) = [\underline{\hat{v}}_{ut,1,1}(k) \; \underline{\hat{v}}_{ut,1,2}(k) \; \ldots \; \underline{\hat{v}}_{ut,1,Nut}(k)]^T$).

5. Uplink Beam-Steering

[0366] The spatial processing by the user terminal for beam-steering on the uplink may be expressed as:

$$\underline{\tilde{\mathbf{x}}}_{up}(k) = \underline{\hat{\mathbf{K}}}_{ut}\,\underline{\tilde{\mathbf{v}}}_{ut}(k)s_{up}(k) \;\; , \text{for } k \in K \;, \qquad \text{Eq (53)}$$

where $s_{up}(k)$ is the modulation symbol to be transmitted on subband k; and
$\underline{\tilde{\mathbf{x}}}_{up}(k)$ is the transmit vector for subband k for beam-steering.
As shown in equation (53), the N_{ut} elements of the normalized steering vector $\underline{\tilde{\mathbf{v}}}_{ut}(k)$ for each subband have equal magnitude but possibly different phases. The beam-steering thus generates one transmit vector $\underline{\tilde{\mathbf{x}}}_{up}(k)$ for each subband, with the N_{ut} elements of $\underline{\tilde{\mathbf{x}}}_{up}(k)$ having the same magnitude but possibly different phases.

[0367] The received uplink transmission at the access point for beam-steering may be expressed as:

$$\begin{aligned}\underline{\tilde{\mathbf{r}}}_{up}(k) &= \underline{\mathbf{H}}_{up}(k)\underline{\tilde{\mathbf{x}}}_{up}(k) + \underline{\mathbf{n}}_{up}(k) \qquad \text{, for } k \in K \;, \qquad \text{Eq (54)} \\ &= \underline{\mathbf{H}}_{up}(k)\underline{\hat{\mathbf{K}}}_{ut}(k)\underline{\tilde{\mathbf{v}}}_{ut}(k)s_{up}(k) + \underline{\mathbf{n}}_{up}(k) \\ &= \underline{\mathbf{H}}_{cup}(k)\underline{\tilde{\mathbf{v}}}_{ut}(k)s_{up}(k) + \underline{\mathbf{n}}_{up}(k)\end{aligned}$$

where $\underline{\tilde{\mathbf{r}}}_{up}(k)$ is the received vector for the uplink for subband k for beam-steering.

[0368] A matched filter row vector $\underline{\tilde{\mathbf{m}}}_{ap}(k)$ for the uplink transmission using beam-steering may be expressed as:

$$\underline{\tilde{\mathbf{m}}}_{ap}(k) = (\underline{\mathbf{H}}_{cup}(k)\underline{\tilde{\mathbf{v}}}_{ut}(k))^H \;, \text{ for } k \in K \;. \qquad \text{Eq (55)}$$

The matched filter vector $\underline{\tilde{\mathbf{m}}}_{ap}(k)$ may be obtained as described below. The spatial processing (or matched filtering) at the access point for the received uplink transmission with beam-steering may be expressed as:

$$\begin{aligned}\hat{s}_{up}(k) &= \tilde{\lambda}_{up}^{-1}(k)\underline{\tilde{\mathbf{m}}}_{up}(k)\underline{\tilde{\mathbf{r}}}_{up}(k) \\ &= \tilde{\lambda}_{up}^{-1}(k)(\underline{\mathbf{H}}_{cup}(k)\underline{\tilde{\mathbf{v}}}_{ut}(k))^H(\underline{\mathbf{H}}_{cup}(k)\underline{\tilde{\mathbf{v}}}_{ut}(k)s_{up}(k) + \underline{\mathbf{n}}_{up}(k)) \;, \text{ for } k \in K \;, \qquad \text{Eq (56)} \\ &= s_{up}(k) + \tilde{n}_{up}(k)\end{aligned}$$

where $\tilde{\lambda}_{up}(k) = (\underline{\mathbf{H}}_{cup}(k)\underline{\tilde{\mathbf{v}}}_{ut}(k))^H(\underline{\mathbf{H}}_{cup}(k)\underline{\tilde{\mathbf{v}}}_{ut}(k))$ (i.e., $\tilde{\lambda}_{up}(k)$ is the inner product of

$\underline{\tilde{m}}_{ap}(k)$ and its conjugate transpose).
$\hat{s}_{up}(k)$ is an estimate of the modulation symbol $s_{up}(k)$ transmitted by the user terminal on the uplink, and
$\hat{n}_{up}(k)$ is the post-processed noise.

6. Downlink Beam-Steering

[0369] The spatial processing by the access point for beam-steering on the downlink may be expressed as:

$$\underline{\tilde{x}}_{dn}(k) = \underline{\hat{K}}_{ap}\,\underline{\tilde{u}}_{ap}(k)s_{dn}(k) \quad \text{, for } k \in K\text{,} \qquad \text{Eq (57)}$$

where $\underline{\tilde{u}}_{ap}(k)$ is the normalized eigenvector for subband k, which is generated based on the eigenvector $\underline{\hat{u}}^{*}_{ap,1}(k)$, for the principal wideband eigenmode, similar to that described above for the uplink.

[0370] A matched filter row vector $\underline{\tilde{m}}_{ut}(k)$ for the downlink transmission using beam-steering may be expressed as:

$$\underline{\tilde{m}}_{ut}(k) = (\underline{H}_{cdn}(k)\underline{\tilde{u}}_{ap}(k))^{H} \quad \text{, for } k \in K\text{.} \qquad \text{Eq (58)}$$

The spatial processing (or matched filtering) at the user terminal for the received downlink transmission may be expressed as:

$$\begin{aligned}\hat{s}_{dn}(k) &= \tilde{\lambda}^{-1}_{dn}(k)\underline{\tilde{m}}_{ut}(k)\underline{\tilde{r}}_{dn}(k) \\ &= \tilde{\lambda}^{-1}_{dn}(k)(\underline{H}_{cdn}(k)\underline{\tilde{u}}_{ap}(k))^{H}(\underline{H}_{cdn}(k)\underline{\tilde{u}}_{ap}(k)s_{up}(k) + \underline{n}_{dn}(k))\text{, for } k \in K\text{,} \qquad \text{Eq (59)} \\ &= s_{dn}(k) + \tilde{n}_{dn}(k)\end{aligned}$$

where $\tilde{\lambda}_{dn}(k) = (\underline{H}_{cdn}(k)\underline{\tilde{u}}_{ap}(k))^{H}(\underline{H}_{cdn}(k)\underline{\tilde{u}}_{ap}(k))$ (i.e., $\tilde{\lambda}_{dn}(k)$ is the inner product of $\underline{\tilde{m}}_{ut}(k)$ and its conjugate transpose).

7. Spatial Processing with Channel Inversion

[0371] For the uplink, the transmit vector $\underline{x}_{up}(k)$ for the spatial multiplexing mode may be derived by the user terminal as:

$$\underline{x}_{up}(k) = \underline{\hat{K}}_{ut}(k)\underline{\hat{V}}_{ut}(k)\underline{G}(k)\underline{s}_{up}(k) \quad \text{, for } k \in K\text{,} \qquad \text{Eq (60)}$$

where $\underline{G}(k)$ is a diagonal matrix of gains for the channel inversion described above. Equation (60) is similar to equation (15), except that $\underline{\hat{K}}_{ut}(k)\underline{\hat{V}}_{ut}(k)$ is used in place of $\underline{V}(k)$. The elements of $\underline{\hat{K}}_{ut}(k)\underline{\hat{V}}_{ut}(k)$ are provided to multipliers 952 within beam-formers 950 in FIG. 9B.

[0372] For the uplink, the transmit vector $\underline{\tilde{x}}_{up}(k)$ for the beam-steering mode may be derived by the user terminal as:

$$\underline{\tilde{x}}_{up}(k) = \underline{\hat{K}}_{ut}(k)\underline{\tilde{v}}_{ut}(k)\tilde{g}(k)s_{up}(k) \quad \text{, for } k \in K\text{,} \qquad \text{Eq (61)}$$

where $\underline{\tilde{v}}_{ut}(k)$ is a vector with four elements having equal magnitude but phases obtained based on eigenvector $\underline{\hat{v}}_{ut,1}(k)$ for the principal eigenmode. The vector $\underline{\tilde{v}}_{ut}(k)$ may be derived similar to that shown above in equations (16) and (17). The gain $\tilde{g}(k)$ achieves channel inversion and may be derived similar to that shown above in equations (18) through (20), except that $\tilde{\lambda}_1(k) = \underline{\tilde{v}}^{H}_{ut}(k)\underline{\hat{H}}^{H}_{cup}(k)\underline{\hat{H}}_{cup}(k)\underline{\tilde{v}}_{ut}(k)$ is used for equation (20). The elements of $\underline{\tilde{v}}_{ut}(k)$ are provided to multipliers 1052 within beam-steering unit 1050 in FIG. 10B.

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[0373] For the downlink, the transmit vector $\underline{x}_{dn}(k)$ for the spatial multiplexing mode may be derived by the access point as:

$$\underline{x}_{dn}(k) = \underline{\hat{K}}_{ap}(k)\underline{\hat{U}}^{*}_{ap}(k)\underline{G}(k)\underline{s}_{dn}(k) \quad , \text{for } k \in K . \qquad \text{Eq (62)}$$

Equation (62) is similar to equation (15), except that $\underline{\hat{K}}_{ap}(k)\underline{\hat{U}}^{*}_{ap}(k)$ is used in place of $\underline{V}(k)$. The elements of $\underline{\hat{K}}_{ap}(k)\underline{\hat{U}}^{*}_{ap}(k)$ may be provided to multipliers 952 within beam-formers 950 in FIG. 9B.

[0374] For the downlink, the transmit vector $\underline{\tilde{x}}_{dn}(k)$ for the beam-steering mode may be derived by the access point as:

$$\underline{\tilde{x}}_{dn}(k) = \underline{\hat{K}}_{ap}(k)\underline{\tilde{u}}_{ap}(k)\tilde{g}(k)s_{dn}(k) \quad , \text{for } k \in K , \qquad \text{Eq (63)}$$

where $\underline{\tilde{u}}_{ap}(k)$ is a vector with four elements having equal magnitude but phases obtained based on eigenvector $\underline{\hat{u}}_{ap,1}(k)$ for the principal eigenmode. The gain $\tilde{g}(k)$ achieves channel inversion and may be derived in a similar manner to that shown above in equations (18) through (20), except that $\tilde{\lambda}_1(k) = \underline{\tilde{u}}^{H}_{ap}(k)\underline{\hat{H}}^{H}_{cdn}(k)\underline{\hat{H}}_{cdn}(k)\underline{\tilde{u}}_{ap}(k)$ is used for equation (20). The elements of $\underline{\tilde{u}}_{ap}(k)$ are provided to multipliers 1052 within beam-steering unit 1050 in FIG. 10B.

VIII. Pilot Structure

[0375] A pilot structure is provided for the MIMO WLAN system to allow the access points and user terminals to perform timing and frequency acquisition, channel estimation, and other functions needed for proper system operation. Table 33 lists four types of pilot and their short description for an exemplary pilot structure. Fewer, different, and/or additional pilot types may also be used for the pilot structure.

Table 33 - Pilot Types

Pilot Type	Description
Beacon Pilot	A pilot transmitted from all transmit antennas and used for timing and frequency acquisition.
MIMO Pilot	A pilot transmitted from all transmit antennas with different orthogonal codes and used for channel estimation.
Steered Reference or Steered Pilot	A pilot transmitted on specific eigenmodes of a MIMO channel for a specific user terminal and used for channel estimation and possibly rate control.
Carrier Pilot	A pilot used for phase tracking of a carrier signal.

Steered reference and steered pilot are synonymous terms.

[0376] In an embodiment, the pilot structure includes (1) for the downlink - a beacon pilot, a MIMO pilot, a steered reference, and a carrier pilot transmitted by the access point, and (2) for the uplink - a MIMO pilot, a steered reference, and a carrier pilot transmitted by the user terminals.

[0377] The downlink beacon pilot and MIMO pilot are sent on the BCH (as shown in FIG. 5A) in each TDD frame. The beacon pilot may be used by the user terminals for timing and frequency acquisition and Doppler estimation. The MIMO pilot may be used by the user terminals to (1) obtain an estimate of the downlink MIMO channel, (2) derive the steering vectors for uplink transmission (if the beam-steering or spatial multiplexing mode is supported), and (3) derive a matched filter for downlink transmission. The downlink steered reference may also be used by a specified user terminal for channel estimation.

[0378] An uplink steered reference is transmitted by each active user terminal that supports the beam-steering or spatial multiplexing mode and may be used by the access point to (1) derive the steering vectors for the downlink transmission and (2) derive a matched filter for the uplink transmission. In general, the steered reference is only sent for/by user terminals that support the beam-steering and/or spatial multiplexing modes. The reference sent works regardless of whether or not it is steered properly (e.g., due to a poor channel estimate). That is, the reference becomes

orthogonal on a per transmit antenna basis since the steering matrix is diagonal.

[0379] If a user terminal is calibrated, then it can transmit a steered reference on the principal eigenmode on the RACH using the vector $\hat{\underline{\mathbf{K}}}_{ut}(k)\hat{\underline{\mathbf{v}}}_{ut,0}(k)$, for $k \in K$, where $\hat{\underline{\mathbf{v}}}_{ut,0}(k)$ is the column of $\hat{\underline{\mathbf{V}}}_{ut}(k)$ for the principal eigenmode. If the user terminal is not calibrated, then it can transmit a pilot on the RACH using a vector $\underline{\mathbf{v}}_{ut,p}(k)=[e^{j\theta 1(k)}\ e^{j\theta 2(k)}\ \ldots\ e^{j\theta Nut(k)}]^T$, for $k \in K$. The vector $\underline{\mathbf{v}}_{ut,p}(k)$ for each subband includes N_{ut} random steering coefficients whose phases $\theta_i(k)$, for $i \in \{1, 2, \ldots N_{ut}\}$, may be selected in accordance with a pseudo-random procedure. Since only the relative phases among the N_{ut} steering coefficients matter, the phase of the first steering coefficient may be set to zero (i.e., $\theta_1(k) = 0$). The phases of the other N_{ut}-1 steering coefficients may change for each access attempt, so that all 360° are covered by each steering coefficient in intervals of $360°/N_{\theta i}$, where $N_{\theta i}$ is a function of N_{ut}. The perturbation of the phases of the N_{ut} elements of the steering vector $\underline{\mathbf{v}}_{ut,p}(k)$ on every RACH attempt, when using the RACH in the beam-steering mode prior to calibration, is so that the user terminal does not use a bad steering vector for all access attempts. A MIMO pilot may be sent for/by user terminals that do not support beam-steering and/or spatial multiplexing modes.

[0380] The access point does not have knowledge of the channel for any user terminal until the user terminal communicates directly with the access point. When a user terminal desires to transmit data, it first estimates the channel based on the MIMO pilot transmitted by the access point. The user terminal then sends steered reference in the preamble of the RACH when it attempts to access the system. The access point uses the reference on the RACH preamble for signal detection and channel estimation.

[0381] Once the user terminal has been granted access to the system and assigned FCH/RCH resources by the access point, the user terminal sends a reference (e.g., a MIMO pilot) at the beginning of each RCH PDU it transmits. If the user terminal is using the diversity mode, then the reference is sent on the RCH without steering. If the user terminal is using the beam-steering or spatial multiplexing mode, then a steered reference is sent on the RCH to allow the access point to determine the eigenvector for the principal eigenmode (for the beam-steering mode) or the set of four eigenvectors (for the spatial multiplexing mode) for each of the 48 data subbands. The steered reference allows the access point to improve its estimate of the channel and to track the channel.

1. Beacon Pilot - Downlink

[0382] The downlink beacon pilot is included in the first portion of the BCH (as shown in FIG. 5A) and transmitted in each TDD frame. The beacon pilot includes a specific OFDM symbol (denoted as "B") that is transmitted from each of the four antennas at the access point. The same B OFDM symbol is transmitted twice in the 2-symbol duration for the beacon pilot.

[0383] In a specific embodiment, the B OFDM symbol comprises a set of 12 BPSK modulation symbols, $b(k)$, for 12 specific subbands, which is shown in Table 34.

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Table 34 - Pilot Symbols

Sub-band Index	Beacon Pilot $b(k)$	MIMO Pilot $p(k)$	Sub-band Index	Beacon Pilot $b(k)$	MIMO Pilot $p(k)$	Sub-band Index	Beacon Pilot $b(k)$	MIMO Pilot $p(k)$	Sub-band Index	Beacon Pilot $b(k)$	MIMO Pilot $p(k)$
M	0	0	-13	0	1-j	1	0	1-j	15	0	1+j
-26	0	-1-j	-12	-1-j	1-j	2	0	-1-j	16	1+j	-1+j
-25	0	-1+j	-11	0	-1-j	3	0	-1-j	17	0	-1+j
-24	1+j	-1+j	-10	0	-1-j	4	-1-j	-1-j	18	0	1-j
-23	0	-1+j	-9	0	1-j	5	0	-1+j	19	0	1+j
-22	0	1-j	-8	-1-j	-1-j	6	0	1+j	20	1+j	-1+j
-21	0	1-j	-7	0	1+j	7	0	-1-j	21	0	1+j
-20	-1-j	1+j	-6	0	-1+j	8	-1-j	-1+j	22	0	-1+j
-19	0	-1-j	-5	0	-1-j	9	0	-1-j	23	0	1+j
-18	0	-1+j	-4	1+j	-1+j	10	0	-1-j	24	1+j	-1+j
-17	0	1+j	-3	0	-1+j	11	0	1+j	25	0	1-j
-16	1+j	-1+j	-2	0	1-j	12	1+j	1-j	26	0	-1-j
-15	0	1-j	-1	0	-1+j	13	0	-1+j	N	0	0
-14	0	1+j	0	0	0	14	0	-1-j			

[0384] For the beacon pilot embodiment shown in Table 34, the B OFDM symbol comprises (1) BPSK modulation symbol $(1+j)$ for subbands -24, -16, -4, 12, 16, 20, and 24, (2) BPSK modulation symbol $-(1+j)$ for subbands -20, -12, -8, 4, and 8, and (3) signal values of zero for the remaining 52 subbands. The B OFDM symbol is specifically designed to facilitate timing and frequency acquisition by the user terminals. However, other OFDM symbols may also be used for the beacon pilot, and this is within the scope of the invention.

2. MIMO Pilot - Downlink

[0385] The downlink MIMO pilot is included in the second portion of the BCH (as shown in FIG. 5A) and also transmitted in each TDD frame. The MIMO pilot includes a specific OFDM symbol (denoted as "P") that is transmitted from each of the four antennas at the access point. The same P OFDM symbol is transmitted eight times in the 8-symbol duration for the MIMO pilot. However, the eight P OFDM symbols for each antenna are "covered" with a different 4-chip Walsh sequence assigned to that antenna. Covering is a process whereby a given pilot or data symbol (or a set of L pilot/data symbols with the same value) to be transmitted is multiplied by all L chips of an L-chip orthogonal sequence to obtain L covered symbols, which are then transmitted. Decovering is a complementary process whereby received symbols are multiplied by the L chips of the same L-chip orthogonal sequence to obtain L decovered symbols, which are then accumulated to obtain an estimate of the transmitted pilot/data symbol. The covering achieves orthogonality among the N_T pilot transmissions from the N_T transmit antennas and allows the user terminals to distinguish the individual transmit antennas. Covering may be achieved with Walsh sequences or other orthogonal sequences.

[0386] In a specific embodiment, the P OFDM symbol comprises a set of 52 QPSK modulation symbols, $p(k)$, for the 48 data subbands and 4 pilot subbands, which is shown in Table 34. Signal values of zero are transmitted on the remaining 12 subbands. The P OFDM symbol comprises a unique "word" of 52 QPSK modulation symbols that is designed to facilitate channel estimation by the user terminals. This unique word is also selected to minimize the peak-to-average variation in the transmitted MIMO pilot. This may then reduce the amount of distortion and non-linearity generated by the receiver circuitry at the user terminals, which can result in improved accuracy for the channel estimation. However, other OFDM symbols may also be used for the MIMO pilot, and this is within the scope of the invention.

[0387] In an embodiment, the four antennas at the access point are assigned 4-chip Walsh sequences of $W_1 = 1111$, $W_2 = 1010$, $W_3 = 1100$, and $W_4 = 1001$ for the MIMO pilot. For a given Walsh sequence, a value of "1" indicates that a P OFDM symbol is transmitted and a value of "0" indicates that a -P OFDM symbol is transmitted (i.e., each of the 52 modulation symbols in P is inverted).

[0388] Table 35 lists the OFDM symbols to be transmitted from each of the four antennas at the access point for the beacon pilot and MIMO pilot. The B and P OFDM symbols are as described above.

Table 35 - Beacon and MIMO Pilots

Pilot	OFDM Symbol	Antenna 1	Antenna 2	Antenna 3	Antenna 4
Beacon Pilot	1	B	B	B	B
	2	B	B	B	B
MIMO Pilot	3	+P	+P	+P	+P
	4	+P	-P	+P	-P
	5	+P	+P	-P	-P
	6	+P	-P	-P	+P
	7	+P	+P	+P	+P
	8	+P	-P	+P	-P
	9	+P	+P	-P	-P
	10	+P	-P	-P	+P

[0389] The MIMO pilot may be used by the user terminal to estimate the channel response of the downlink. In particular, to recover the pilot sent from access point antenna i and received by user terminal antenna j, the pilot received by terminal antenna j is first multiplied with the Walsh sequence assigned to access point antenna i. The eight decovered OFDM symbols for all eight symbol periods for the MIMO pilot are then accumulated, where the accumulation is performed individually for each of the 52 subbands' used to carry the MIMO pilot. The results of the accumulation is $\hat{h}_{cdn\,i,j}(k)$, for $k = \pm\{1, \ldots, 26\}$, which is an estimate of the calibrated downlink channel response from access point antenna i to user

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terminal antenna j for the 52 data and pilot subbands.

[0390] The same pilot processing may be performed by the access point to recover the pilot from each access point antenna at each user terminal antenna. The pilot transmitted from each access point antenna may be recovered by decovering with the Walsh sequence assigned to that antenna. The pilot processing provides $N_{ap} \cdot N_{ut}$ values for each of the 52 subbands, where N_{ap} denotes the number of antennas at the access point and N_{ut} denotes the number of antennas at the user terminal. The $N_{ap} \cdot N_{ut}$ values for each subband are the elements of the calibrated downlink channel response estimate $\hat{\underline{H}}_{cdn}(k)$ for that subband.

[0391] The MIMO pilot may also be transmitted on the uplink by the user terminal for calibration and in the diversity mode. The same processing described above for the user terminal to recover the MIMO pilot sent by the access point may also be performed by the access point to recover the MIMO pilot sent by the user terminal.

3. Steered Reference

[0392] A steered reference may be transmitted in the preamble portion of an RACH PDU (as shown in FIG. 5C) or an RCH PDU (as shown in FIGS. 5E and 5G) by each active user terminal. A steered reference may also be transmitted in the preamble portion of an FCH PDU (as shown in FIGS. 5E and 5F) by the access point to an active user terminal.

A. Steered Reference for Spatial Multiplexing

[0393] The steered reference comprises a specific OFDM symbol (e.g., the same P OFDM symbol used for the MIMO pilot) that is transmitted from all of the transmit antennas at the user terminal (for the uplink) or the access point (for the downlink). However, the P OFDM symbol for each symbol period is spatially processed (i.e., beam-formed) with a steering vector for one eigenmode.

[0394] The first symbol of steered reference transmitted by the user terminal in the preamble of the RACH may be expressed as:

$$\underline{x}(k) = \hat{\underline{K}}_{ut}(k) \cdot \hat{\underline{v}}_{ut,1}(k) \cdot p(k) \quad , \text{for } k \in K', \qquad \text{Eq (64)}$$

where $\underline{x}(k)$ is the transmit vector for subband k;
$\hat{\underline{K}}_{ut}(k)$ is the correction matrix for subband k for the user terminal;
$\hat{\underline{v}}_{ut,1}(k)$ is the steering vector for subband k of the principal wideband eigenmode;
$p(k)$ is the pilot symbol for subband k; and
$K' = \{-32, \ldots, 31\}$ is the set of indices for all 64 subbands.

The vector $\underline{x}(k)$ includes four transmit symbols for each value of k, which are to be transmitted from the four antennas at the user terminal. The steering vector $\hat{\underline{v}}_{ut,1}(k)$ is the first column of the matrix $\hat{\underline{V}}_{ut}(k)$ of right eigenvectors of the calibrated uplink channel response estimate $\hat{\underline{H}}_{cup}(k)$, where $\hat{\underline{V}}_{ut}(k) = [\hat{\underline{v}}_{ut,1}(k)\ \hat{\underline{v}}_{ut,2}(k)\ \hat{\underline{v}}_{ut,3}(k)\ \hat{\underline{v}}_{ut,4}(k)]$ and $\hat{\underline{v}}_{ut,i}(k)$ is the i-th column of $\hat{\underline{V}}_{ut}(k)$. The above assumes that the singular values in $\underline{\Sigma}(k)$ and the columns of $\hat{\underline{V}}_{ut}(k)$ are ordered as described above.

[0395] The second symbol of steered reference transmitted by the user terminal in the preamble of the RACH includes the data rate indicator (DRI) for the RACH PDU. The DRI indicates the rate used for the RACH message sent in the RACH PDU. The DRI is embedded in the second steered reference symbol by mapping the DRI to a specific QPSK symbol s_{dri} as shown in Table 15. The s_{dri} symbol is then multiplied with the pilot symbol $p(k)$ before performing the spatial processing. The second symbol of steered reference for the RACH may be expressed as:

$$\underline{x}(k) = \hat{\underline{K}}_{ut}(k) \cdot \hat{\underline{v}}_{ut,1}(k) \cdot s_{dri} \cdot p(k) \quad , \text{for } k \in K'. \qquad \text{Eq (65)}$$

As shown in equations (64) and (65), only eigenvector $\hat{\underline{v}}_{ut,1}(k)$ for the principal eigenmode is used for the steered reference for the RACH.

[0396] A symbol of steered reference transmitted by the user terminal in the preamble of the RCH may be expressed as:

$$\underline{x}_{up,str,m}(k) = \hat{\underline{K}}_{ut}(k) \cdot \hat{\underline{v}}_{ut,m}(k) \cdot p(k) \quad , \text{for } k \in K', \qquad \text{Eq (66)}$$

where $\underline{x}_{up,sr,m}(k)$ is the transmit vector for subband k of wideband eigenmode m; and
$\hat{\underline{v}}_{ut,m}(k)$ is the steering vector for subband k of wideband eigenmode m (i.e., the m-th column of $\hat{\underline{V}}_{ut}(k)$).

[0397] A symbol of steered reference transmitted by the access point in the preamble of the FCH may be expressed as:

$$\underline{x}_{dn,sr,m}(k) = \hat{\underline{K}}_{ap}(k) \cdot \hat{\underline{u}}^{*}_{ap,m}(k)\, p(k) \quad , \text{for } k \in K', \qquad \text{Eq (67)}$$

where $\underline{x}_{dn,sr,m}(k)$ is the transmit vector for subband k of wideband eigenmode m;
$\hat{\underline{K}}_{ap}(k)$ is the correction matrix for subband k for the access point; and
$\hat{\underline{u}}^{*}_{ap,m}(k)$ is the steering vector for subband k of wideband eigenmode m.
The steering vector $\hat{\underline{u}}_{ap,m}(k)$ is the m-th column of the matrix $\hat{\underline{U}}_{ap}(k)$ of right eigenvectors of the calibrated downlink channel response estimate $\hat{\underline{H}}_{cdn}(k)$, where $\hat{\underline{U}}_{ap}(k) = [\hat{\underline{u}}_{ap,1}(k)\ \hat{\underline{u}}_{ap,2}(k)\ \hat{\underline{u}}_{ap,3}(k)\ \hat{\underline{u}}_{ap,4}(k)]$.

[0398] The steered reference may be transmitted in various manners. In one embodiment, one or more eigenvectors are used for the steered reference for each TDD frame and are dependent on the duration of the steered reference, which is indicated by the FCH/RCH Preamble Type fields in the FCCH information element. Table 36 lists the eigenmodes used for the preamble for the FCH and RCH for various preamble sizes, for an exemplary design.

Table 36

Type	Preamble Size	Eigenmodes Used
0	0 OFDM symbol	no preamble
1	1 OFDM symbol	eigenmode m, where m = frame counter mod 4
2	4 OFDM symbols	cycle through all 4 eigenmodes in the preamble
3	8 OFDM symbols	cycle through all 4 eigenmodes twice in the preamble

[0399] As shown in Table 36, the steered reference is transmitted for all four eigenmodes within a single TDD frame when the preamble size is four or eight OFDM symbols. The steered reference transmitted by the user terminal for the n-th OFDM symbol in the preamble for the RCH may be expressed as:

$$\underline{x}_{up,sr,n}(k) = \hat{\underline{K}}_{ut}(k) \cdot \hat{\underline{v}}_{ut,n \bmod 4}(k) \cdot p(k) \quad , \text{for } k \in K' \text{ and } n = \{1, \ldots, L\}, \quad \text{Eq (68)}$$

where L is the preamble size, i.e., L = 4 for Type 2 and L = 8 for Type 3.

[0400] Similarly, the steered reference transmitted by the access point for the n-th OFDM symbol in the preamble for the FCH may be expressed as:

$$\underline{x}_{dn,sr,n}(k) = \hat{\underline{K}}_{ap}(k) \cdot \hat{\underline{u}}^{*}_{ap,n \bmod 4}(k)\, p(k) \quad , \text{for } k \in K' \text{ and } n = \{1, \ldots, L\}. \quad \text{Eq (69)}$$

As shown in equations (68) and (69), the four eigenmodes are cycled through in each 4-symbol period by the (n mod 4) operation for the steering vector. This scheme may be used if the channel changes more rapidly and/or during the early part of a connection when a good channel estimate needs to be obtained quickly for proper system operation.

[0401] In another embodiment, the steered reference is transmitted for one wideband eigenmode for each TDD frame. The steered reference for four wideband eigenmodes may be cycled through in four TDD frames. For example, the steering vectors $\hat{\underline{v}}_{ut,1}(k)$, $\hat{\underline{v}}_{ut,2}(k)$, $\hat{\underline{v}}_{ut,3}(k)$, and $\hat{\underline{v}}_{ut,4}(k)$ may be used for the first, second, third, and fourth TDD frames, respectively, by the user terminal. The particular steering vector to use may be specified by the 2 LSBs of the Frame Counter value in the BCH message. This scheme allows a shorter preamble portion to be used in the PDU but may require a longer time period to obtain a good estimate of the channel.

[0402] For both embodiments described above, the steered reference may be transmitted on all four eigenmodes that may be used for data transmission, even though fewer than four eigenmodes are currently used (e.g., because the unused eigenmodes are poor and discarded by the water-filling). The transmission of the steered reference on a currently unused eigenmode allows the receiver to determine when the eigenmode improves enough to be selected for use.

B. Steered Reference for Beam-Steering

[0403] For the beam-steering mode, the spatial processing on the transmit side is performed using a set of normalized eigenvectors for the principal wideband eigenmode. The overall transfer function with a normalized eigenvector is different from the overall transfer function with an unnormalized eigenvector (i.e., $\underline{\mathbf{H}}_{cup}(k)\hat{\underline{\mathbf{v}}}_{ut,1}(k) \neq \underline{\mathbf{H}}_{cup}(k)\tilde{\underline{\mathbf{v}}}_{ut}(k)$). A steered reference generated using the set of normalized eigenvectors for all subbands may then be sent by the transmitter and used by the receiver to derive the matched filter vectors for these subbands for the beam-steering mode.

[0404] For the uplink, the steered reference for the beam-steering mode may be expressed as:

$$\tilde{\underline{\mathbf{x}}}_{up,sr}(k) = \hat{\underline{\mathbf{K}}}_{ut}(k)\tilde{\underline{\mathbf{v}}}_{ut}(k)p(k) \quad , \text{for } k \in K . \qquad \text{Eq (70)}$$

At the access point, the receive uplink steered reference for the beam-steering mode may be expressed as:

$$\begin{aligned} \tilde{\underline{\mathbf{r}}}_{up,sr}(k) &= \underline{\mathbf{H}}_{up}(k)\underline{\mathbf{x}}_{up,sr}(k) + \underline{\mathbf{n}}_{up}(k) \qquad , \text{for } k \in K . \qquad \text{Eq (71)} \\ &= \underline{\mathbf{H}}_{up}(k)\hat{\underline{\mathbf{K}}}_{ut}(k)\tilde{\underline{\mathbf{v}}}_{ut}(k)p(k) + \underline{\mathbf{n}}_{up}(k) \\ &= \underline{\mathbf{H}}_{cup}(k)\tilde{\underline{\mathbf{v}}}_{ut}(k)p(k) + \underline{\mathbf{n}}_{up}(k) \end{aligned}$$

[0405] To obtain the matched filter row vector $\tilde{\underline{\mathbf{m}}}_{ap}(k)$ for the uplink transmission with beam-steering, the received vector $\tilde{\underline{\mathbf{r}}}_{up,sr}(k)$ for the steered reference is first multiplied with $p^*(k)$. The result is then integrated over multiple received steered reference symbols to form an estimate of $\underline{\mathbf{H}}_{cup}(k)\tilde{\underline{\mathbf{v}}}_{ut}(k)$. The vector $\tilde{\underline{\mathbf{m}}}_{ap}(k)$ is then the conjugate transpose of this estimate.

[0406] While operating in the beam-steering mode, the user terminal may transmit multiple symbols of steered reference, for example, one or more symbols using the normalized eigenvector $\tilde{\underline{\mathbf{v}}}_{ut}(k)$, one or more symbols using the eigenvector $\hat{\underline{\mathbf{v}}}_{ut,1}(k)$ for the principal wideband eigenmode, and possibly one or more symbols using the eigenvectors for the other wideband eigenmodes. The steered reference symbols generated with $\tilde{\underline{\mathbf{v}}}_{ut}(k)$ may be used by the access point to derive the matched filter vector $\tilde{\underline{\mathbf{m}}}_{ap}(k)$. The steered reference symbols generated with $\hat{\underline{\mathbf{v}}}_{ut,1}(k)$ may be used to obtain $\hat{\underline{\mathbf{u}}}_{ap,1}(k)$, which may then be used to derive the normalized eigenvector $\tilde{\underline{\mathbf{u}}}_{ap}(k)$ that is used for beam-steering on the downlink. The steered reference symbols generated with the eigenvectors $\hat{\underline{\mathbf{v}}}_{ut,2}(k)$ through $\hat{\underline{\mathbf{v}}}_{ut,Ns}(k)$ for the other eigenmodes may be used by the access point to obtain $\hat{\underline{\mathbf{u}}}_{ap,2}(k)$ through $\hat{\underline{\mathbf{u}}}_{ap,NS}(k)$ and the singular values for these other eigenmodes. This information may then be used by the access point to determine whether to use the spatial multiplexing mode or the beam-steering mode for data transmission.

[0407] For the downlink, the user terminal may derive the matched filter vector $\tilde{\underline{\mathbf{m}}}_{ut}(k)$ for the beam-steering mode based on the calibrated downlink channel response estimate $\hat{\underline{\mathbf{H}}}_{cdn}(k)$. In particular, the user terminal has $\hat{\underline{\mathbf{u}}}_{ap,1}(k)$ from the singular value decomposition of $\hat{\underline{\mathbf{H}}}_{cdn}(k)$ and can derive the normalized eigenvector $\tilde{\underline{\mathbf{u}}}_{ap}(k)$. The user terminal can then multiply $\tilde{\underline{\mathbf{u}}}_{ap}(k)$ with $\hat{\underline{\mathbf{H}}}_{cdn}(k)$ to obtain $\hat{\underline{\mathbf{H}}}_{cdn}(k)\tilde{\underline{\mathbf{u}}}_{ap}(k)$, and may then derive $\tilde{\underline{\mathbf{m}}}_{ut}(k)$ based on $\hat{\underline{\mathbf{H}}}_{cdn}(k)\tilde{\underline{\mathbf{u}}}_{ap}(k)$. Alternatively, a steered reference may be sent by the access point using the normalized eigenvector $\tilde{\underline{\mathbf{u}}}_{ap}(k)$, and this steered reference may be processed by the user terminal in the manner described above to obtain $\tilde{\underline{\mathbf{m}}}_{ut}(k)$.

4. Carrier Pilot - Uplink

[0408] The OFDM subband structure described herein includes four pilot subbands with indices of -21, -7, 7, and 21. In an embodiment, a carrier pilot is transmitted on the four pilot subbands in all OFDM symbols that are not part of a preamble. The carrier pilot may be used by the receiver to track phase changes due to drifts in the oscillators at both the transmitter and receiver. This may provide improved data demodulation performance.

[0409] The carrier pilot comprises four pilot sequences, $P_{c1}(n)$, $P_{c2}(n)$, $P_{c3}(n)$, and $P_{c4}(n)$, which are transmitted on the four pilot subbands. The pilot sequences may be defined as:

$$P_{c1}(n) = P_{c2}(n) = P_{c3}(n) = -P_{c4}(n) \quad , \text{for } n = \{1, 2, \ldots 127\} , \qquad \text{Eq (72)}$$

where n is an index for OFDM symbol period.

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[0410] The pilot sequences may be defined based on various data sequences. In an embodiment, the pilot sequence $P_{c1}(n)$ is generated based on a polynomial $G(x)=x^7+x^4+x$, where the initial state is set to all ones and the output bits are mapped to signal values as follows: $1 \Rightarrow -1$ and $0 \Rightarrow 1$. The pilot sequence $P_{c1}(n)$, for $n = \{1, 2, \ldots 127\}$, may then be expressed as:

$$P_{c1}(n) = \{1,1,1,1,-1,-1,-1,1,-1,-1,-1,-1,1,1,-1,1,-1,-1,1,1,-1,1,1,-1,1,1,1,1,1,1,-1,1,$$
$$1,1,-1,1,1,-1,-1,1,1,1,-1,1,-1,-1,-1,1,-1,1,-1,-1,1,-1,1,-1,-1,1,1,1,1,1,1,-1,-1,1,1,$$
$$-1,-1,1,-1,1,-1,1,1,-1,-1,-1,1,1,-1,-1,-1,-1,1,-1,-1,1,-1,1,1,1,1,1,-1,1,-1,1,-1,1,$$
$$-1,-1,-1,-1,-1,1,-1,1,1,-1,1,-1,1,1,1,-1,-1,1,-1,-1,-1,1,1,1,1,-1,-1,-1,-1,-1,-1,1\}.$$

The values of "1" and "-1" in the pilot sequence $P_{c1}(n)$ may be mapped to pilot symbols using a particular modulation scheme. For example, using BPSK, a "1" may be mapped to $1 + j$ and a "-1" may be mapped to $-(1+j)$. If there are more than 127 OFDM symbols, then the pilot sequence may be repeated so that $P_{c1}(n) = P_{c1}(n \bmod 127)$ for $n > 127$.

[0411] In one embodiment, the four pilot sequences are reset for each transport channel. Thus, on the downlink, the pilot sequences are reset for the first OFDM symbol of the BCH message, reset again for the first OFDM symbol of the FCCH message, and reset for the first OFDM symbol sent on the FCH. In another embodiment, the pilot sequences are reset at the start of each TDD frame and repeat as often as needed. For this embodiment, the pilot sequences may be stalled during the preamble portions of the BCH and FCH.

[0412] In the diversity mode, the four pilot sequences are mapped to four subband/antenna pairing as shown in Table 29. In particular, $P_{c1}(n)$ is used for subband -21 of antenna 1, $P_{c2}(n)$ is used for subband -7 of antenna 2, $P_{c3}(n)$ is used for subband 7 of antenna 3, and $P_{c4}(n)$ is used for subband 21 of antenna 4. Each pilot sequence is then transmitted on the associated subband and antenna.

[0413] In the spatial multiplexing mode, the four pilot sequences are transmitted on the principal eigenmode of their respective subbands. The spatial processing for the carrier pilot symbols is similar to that performed for the modulation symbols, as described above. In the beam-steering mode, the four pilot sequences are transmitted on their respective subbands using beam-steering. The beam-steering for the carrier pilot symbols is also similar to that performed for the modulation symbols.

[0414] A specific pilot structure has been described above for the MIMO WLAN system. Other pilot structures may also be used for the system, and this is within the scope of the invention.

IX. System Operation

[0415] **FIG. 12A** shows a specific embodiment of a state diagram 1200 for the operation of a user terminal. This state diagram includes four states - an *Init* state 1210, a *Dormant* state 1220, an *Access* state 1230, and a *Connected* state 1240. Each of states 1210, 1220, 1230, and 1240 may be associated with a number of substates (not shown in FIG. 12A for simplicity).

[0416] In the *Init* state, the user terminal acquires the system frequency and timing and obtains system parameters sent on the BCH. In the *Init* state, the user terminal may perform the following functions:

- System determination - the user terminal determines which carrier frequency to acquire the system on.
- Frequency/timing acquisition - the user terminal acquires the beacon pilot and adjusts its frequency and timing accordingly.
- Parameter acquisition - the user terminal processes the BCH to obtain the system parameters associated with the access point from which the downlink signal is received.

Upon completing the required functions for the *Init* state, the user terminal transitions to the *Dormant* state.

[0417] In the *Dormant* state, the user terminal periodically monitors the BCH for updated system parameters, indications of pages and broadcast messages being sent on the downlink, and so on. No radio resources are allocated to the user terminal in this state. In the *Dormant* state, the user terminal may perform the following functions:

- If a registration is warranted, the user terminal enters the *Access* state with a registration request.
- If calibration of the transmitter/receiver is warranted, the user terminal enters the *Access* state with a calibration request.
- The user terminal monitors the BCH for indication of pages and broadcast messages sent on the FCH.

- If the user terminal has data to send on the uplink, it enters the *Access* state with a resource request.
- The user terminal performs maintenance procedures such as updating the system parameters and tracking the channel.
- The user terminal may enter a slotted mode of operation for power savings, if this mode is supported by the user terminal.4

If the user terminal desires radio resources from the access point for any task, it transitions to the *Access* state. For example, the user terminal may transition to the *Access* state in response to a page or DST indicator being sent in the BCH message, for registration or request for calibration, or to request dedicated resources.

[0418] In the *Access* state, the user terminal is in the process of accessing the system. The user terminal may send short messages and/or requests for FCH/RCH resources using the RACH. The operation on the RACH is described in further detail below. If the user terminal is released by the access point, then it transitions back to the *Dormant* state. If the user terminal is assigned resources for the downlink and/or uplink, then it transitions to the *Connected* state.

[0419] In the *Connected* state, the user terminal is assigned the FCH/RCH resources, although not necessarily for every TDD frame. The user terminal may actively use the allocated resources or may be idle (while still maintaining the connection) in the *Connected* state. The user terminal remains in the *Connected* state until it is released by the access point or if it times out after no activity for a particular timeout period, in which case it transitions back to the *Dormant* state.

[0420] While in the *Dormant*, *Access*, or *Connected* state, the user terminal transitions back to the *Init* state if it is powered down or if the connection is dropped.

[0421] **FIG. 12B** shows a specific embodiment of a state diagram for *Connected* state 1240. In this embodiment, the *Connected* state includes three substates - a *Setup* substate 1260, an *Open* substate 1270, and an *Idle* substate 1280. The user terminal enters the *Setup* substate upon receiving an assignment on the FCCH.

[0422] In the *Setup* substate, the user terminal is in the process of setting up the connection and is not yet exchanging data. The connection setup may include channel estimation for the access point, rate determination, service negotiation, and so on. Upon entering the *Setup* substate, the user terminal sets a timer for a specified amount of time. If the timer expires before the user terminal leaves this substate, then it transitions back to the *Dormant* state. The user terminal transitions to the *Open* substate upon completion of the connection setup.

[0423] In the *Open* substate, the user terminal and access point exchange data on the downlink and/or uplink. While in the *Open* substate, the user terminal monitors the BCH for system parameters and indication of page/broadcast messages. If a BCH message cannot be decoded correctly within a specified number of TDD frames, then the user terminal transitions back to the *Init* state.

[0424] The user terminal also monitors the FCCH for channel assignment, rate control, RCH timing control, and power control information. The user terminal estimates the received SNR using the BCH beacon pilot and the FCH preamble and determines the maximum rate that can be sustained reliably on the FCH.

[0425] The FCH and RCH assignments for the user terminal for each TDD frame are given by the information elements in the FCCH PDU transmitted in the current (or possibly prior) TDD frame. The user terminal may not be assigned for data transmission on the FCH and/or RCH for any given TDD frame. For each TDD frame in which the user terminal is not scheduled for data transmission, it does not receive an FCH PDU on the downlink and does not transmit on the uplink.

[0426] For each TDD frame in which the user terminal is scheduled, the data transmissions on the downlink and/or uplink are performed using the rate, transmission mode, and RCH timing offset (for the uplink) indicated in the FCCH assignments (i.e., the FCCH information elements addressed to the user terminal). The user terminal receives, demodulates, and decodes FCH PDUs sent to it. The user terminal also transmits RCH PDUs, which include the preamble and FCH data rate indicator. The user terminal adjusts the rate used on the RCH according to the rate control information contained in the FCCH assignment. If power control is being applied for the uplink transmission, then the user terminal adjusts its transmit power based on the power control commands included in the FCCH assignment. The data exchange may be bursty, in which case the user terminal may enter into the *Idle* substate whenever no data is being exchanged. The user terminal enter the *Idle* substate when directed by the access point. If the access point does not assign the FCH or RCH to the user terminal within a specified number of TDD frames, then the user terminal transitions back to the *Dormant* state and retains its MAC ID.

[0427] In the *Idle* substate, both the uplink and downlink are idling. Data is not being sent in either direction. However, the links are maintained with the steered reference and control messages. In this substate, the access point periodically assigns Idle PDUs to the user terminal on the RCH and possibly the FCH (not necessarily simultaneously). The user terminal may be able to remain in the *Connected* state indefinitely, provided that the access point periodically assigns Idle PDUs on the FCH and RCH to maintain the link.

[0428] While in the *Idle* substate, the user terminal monitors the BCH. If a BCH message is not decoded correctly within a specified number of TDD frames, then the user terminal transitions back to the *Init* state. The user terminal also monitors the FCCH for channel assignment, rate control, RCH timing control, and power control information. The user terminal may also estimate the receive SNR and determine the maximum rate supported by the FCH. The user terminal

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transmits an Idle PDU on the RCH, when assigned, and sets the RCH Request bit in the Idle PDU if it has data to send. If the access point does not assign an FCH or RCH to the user terminal within a specified number of TDD frames, then the user terminal transitions back to the *Dormant* state and retains its MAC ID.

[0429] A time-out timer may be set to a particular value upon entering any of the three substates. This timer would then count down if there is no activity while in the substate. While in the *Setup, Active,* or *Idle* substate, the terminal would transition back to the *Dormant* state if the time-out timer expires and to the *Init* state if the connection is dropped. While in the *Active* or *Idle* substate, the terminal would also transition back to the *Dormant* state if the connection is released.

[0430] FIGS. 12A and 12B show a specific embodiment of a state diagram that may be used for the user terminal. Various other state diagrams with fewer, additional, and/or different states and substates may also be used for the system, and this is within the scope of the invention.

X. Random Access

[0431] In an embodiment, a random access scheme is employed to allow the user terminals to access the MIMO WLAN system. In an embodiment, the random access scheme is based on a slotted Aloha scheme whereby a user terminal transmits in a randomly selected RACH slot to attempt to gain access to the system. The user terminal may send multiple transmissions on the RACH until access is gained or the maximum number of access attempts has been reached. Various parameters for each RACH transmission may be changed to improve the likelihood of success, as described below.

[0432] **FIG. 13** illustrates a timeline for the RACH, which is partitioned into RACH slots. The number of RACH slots available for use in each TDD frame and the duration of the RACH slot are configurable parameters. A maximum of 32 RACH slots may be available for use in each TDD frame. The guard interval between the end of the last RACH slot and the start of the BCH PDU for the next TDD frame is also a configurable parameter. These three parameters for the RACH can change from frame to frame and are indicated by the RACH Length, RACH Slot Size, and RACH Guard Interval fields of the BCH message.

[0433] When a user terminal desires to access the system, it first processes the BCH to obtain pertinent system parameters. The user terminal then sends a RACH PDU on the RACH. This RACH PDU includes a RACH message that contains information needed by the access point to process the access request from the user terminal. For example, the RACH message includes the user terminal's assigned MAC ID that allows the access point to identify the user terminal. A registration MAC ID (i.e., a specific MAC ID value) may be reserved for unregistered user terminals. In this case, the user terminal's long ID may be included in the Payload field of the RACH message along with the registration MAC ID.

[0434] As described above, the RACH PDU may be transmitted at one of four data rates, which are listed in Table 15. The selected rate is embedded in the preamble of the RACH PDU (as shown in FIG. 5C). The RACH PDU also has a variable length of 1, 2, 4, or 8 OFDM symbols (as also listed in Table 15), which is indicated in the Message Duration field of the RACH message.

[0435] To transmit the RACH PDU, the user terminal first determines the number of RACH slots that may be used for transmission (i.e., the number of "usable" RACH slots). This determination is made based on (1) the number of RACH slots available in the current TDD frame, (2) the duration of each RACH slot, (3) the guard interval, and (4) the length of the RACH PDU to be transmitted. The RACH PDU cannot extend beyond the end of the RACH segment of the TDD frame. Thus, if the RACH PDU is longer than one RACH slot plus the guard interval, then this PDU may not be transmitted in one or more later available RACH slots. The number of RACH slots that may be used to transmit the RACH PDU may be fewer than the number of available RACH slots, based on the factors enumerated above. The RACH segment includes a guard interval, which is provided to prevent the uplink transmission from the user terminals from interfering with the next BCH segment, which is a possibility for user terminals that do not compensate for their round trip delay.

[0436] The user terminal then randomly selects one of the usable RACH slots to transmit the RACH PDU. The user terminal then transmits the RACH PDU starting in the selected RACH slot. If the user terminal knows the round trip delay to the access point, then it can account for this delay by adjusting its timing accordingly.

[0437] When the access point receives a RACH PDU, it checks the received RACH message using the CRC included in the message. The access point discards the RACH message if the CRC fails. If the CRC passes, the access point sets the RACH Acknowledgment bit on the BCH in the subsequent TDD frame and transmits an RACH acknowledgement on the FCCH within 2 TDD frames. There may be a delay between the: setting of the Acknowledgment bit on the BCH and the sending of the acknowledgment on the FCCH, which may be used to account for scheduling delay and so on. For example, if the access point receives the message on the RACH, it can set the Acknowledgment bit on the BCH and have a delay response on the FCCH. The Acknowledgment bit prevents user terminals from retrying and allows unsuccessful user terminals to retry quickly, except during busy RACH periods.

[0438] If the user terminal is performing a registration, then it uses the registration MAC ID (e.g., 0x0001). The access

point responds by sending a MAC ID Assignment Message on the FCH. All other RACH transmission types include the user terminal's MAC ID assigned by the system. The access point explicitly acknowledges all correctly received RACH messages by sending acknowledgments on the FCCH using the MAC ID assigned to the user terminal.

[0439] After the user terminal sends the RACH PDU, it monitors the BCH and FCCH to determine whether or not its RACH PDU has been received and processed by the access point. The user terminal monitors the BCH to determine whether or not the RACH Acknowledgment Bit in the BCH message is set. If this bit is set, which indicates that an acknowledgment for this and/or some other user terminals is being sent on the FCCH, then the user terminal further processes the FCCH to obtain IE Type 3 information elements containing acknowledgements. Otherwise, if the RACH Acknowledgment Bit is not set, then the user terminal continues to monitor the BCH or resumes its access procedure on the RACH.

[0440] The FCCH IE Type 3 is used to carry quick acknowledgements for successful access attempts. Each acknowledgement information element contains the MAC ID associated with the user terminal for which the acknowledgment is sent. A quick acknowledgement is used to inform the user terminal that its access request has been received but is not associated with an assignment of FCH/RCH resources. Conversely, an assignment-based acknowledgement is associated with an FCH/RCH assignment. If the user terminal receives a quick acknowledgement on the FCCH, it transitions to the *Dormant* state. If the user terminal receives an assignment-based acknowledgement, it obtains scheduling information sent along with the acknowledgment and begins using the FCH/RCH as assigned in the current TDD frame.

[0441] The user terminal resumes the access procedure on the RACH if it does not receive an acknowledgement on the FCCH within a specified number of TDD frames after transmitting the RACH PDU. In this case, the user terminal can assume that the access point did not receive the RACH PDU correctly. A counter is maintained by the user terminal to count the number of access attempts. This counter may be initialized to zero for the first access attempt and is incremented by one for each subsequent access attempt. The user terminal would terminate the access procedure if the counter value reaches the maximum number of attempts.

[0442] For each subsequent access attempt, the user terminal first determines various parameters for this access attempt including (1) the amount of time to wait before transmitting the RACH PDU, (2) the RACH slot to use for the RACH PDU transmission, and (3) the rate for the RACH PDU. To determine the amount of time to wait, the user terminal first determines the maximum amount of time to wait for the next access attempt, which is referred to as the contention window (CW). In an embodiment, the contention window (which is given in units of TDD frames) exponentially increases for each access attempt (i.e., $CW = 2^{access\_attempt}$). The contention window may also be determined based on some other function (e.g., a linear function) of the number of access attempts. The amount of time to wait for the next access attempt is then randomly selected between zero and CW. The user terminal would wait this amount of time before transmitting the RACH PDU for the next access attempt.

[0443] For the next access attempt, the user terminal reduces the rate for the RACH PDU, if the lowest rate was not used for the last access attempt. The initial rate used for the first access attempt may be selected based on the received SNR of the pilot sent on the BCH. The failure to receive an acknowledgment may be caused by the access point's failure to correctly receive the RACH PDU. Thus, the rate for the RACH PDU in the next access attempt is reduced to improve the likelihood of correct reception by the access point.

[0444] After waiting the randomly selected wait time, the user terminal again randomly selects an RACH slot for transmission of the RACH PDU. The selection of the RACH slot for this access attempt may be performed in similar manner as that described above for the first access attempt, except that the RACH parameters (i.e., number of RACH slots, slot duration, and guard interval) for the current TDD frame, as conveyed in the BCH message, are used along with the current RACH PDU length. The RACH PDU is then transmitted in the randomly selected RACH slot.

[0445] The access procedure described above continues until either (1) the user terminal receives an acknowledgment from the access point or (2) the maximum number of permitted access attempts has been reached. For each access attempt, the amount of time to wait before transmitting the RACH PDU, the RACH slot to use for the RACH PDU transmission, and the rate for the RACH PDU may be selected as described above. If the acknowledgment is received, then the user terminal operates as indicated by the acknowledgment (i.e., it waits in the *Dormant* state if a quick acknowledgment is received or starts using the FCH/RCH if an assignment-based acknowledgment is received). If the maximum number of permitted access attempts has been reached, then the user terminal transitions back to the *Init* state.

XI. Rate, Power, and Timing Control

[0446] The access point schedules downlink and uplink transmissions on the FCH and RCH and further controls the rates for all active user terminals. Moreover, the access point adjusts the transmit power of certain active user terminals on the uplink. Various control loops may be maintained to adjust the rate, transmit power, and timing for each active user terminal.

1. Fixed and Variable Rate Services

[0447] The access point can support both fixed and variable rate services on the FCH and RCH. Fixed-rate services may be used for voice, video, and so on. Variable rate services may be used for packet data (e.g., Web browsing).

[0448] For fixed rate services on the FCH/RCH, a fixed rate is used for the entire connection. Best effort delivery is used for the FCH and RCH (i.e., no retransmission). The access point schedules a constant number of FCH/RCH PDUs per specified time interval to satisfy the QoS requirements of the service. Depending on the delay requirements, the access point may not need to schedule an FCH/RCH PDU for every TDD frame. Power control is exercised on the RCH but not the FCH for fixed rate services.

[0449] For variable rate services on the FCH/RCH, the rate used for the FCH/RCH is allowed to change with channel conditions. For some isochronous services (e.g., video, audio), the QoS requirements may impose a minimum rate constraint. For these services, the scheduler at the access point adjusts the FCH/RCH allocation so that a constant rate is provided. For asynchronous data services (e.g., web browsing, file transfer, and so on), a best effort delivery is provided with the option of retransmissions. For these services, the rate is the maximum that can be reliably sustained by the channel conditions. The scheduling of the FCH/RCH PDUs for the user terminals is typically a function of their QoS requirements. Whenever there's no data to send on the downlink/uplink, an idle PDU is sent on the FCH/RCH to maintain the link. Closed loop power control is not exercised on the FCH or RCH for variable rate services.

2. Rate Control

[0450] Rate control may be used for variable rate services operating on the FCH and RCH to adapt the rate of the FCH/RCH to changing channel conditions. The rates to use for the FCH and RCH may be independently controlled. Moreover, in the spatial multiplexing mode, the rate for each wideband eigenmode of each dedicated transport channel may be independently controlled. The rate control is performed by the access point based on feedback provided by each active user terminal. The scheduler within the access point schedules data transmission and determines rate assignments for the active user terminals.

[0451] The maximum rate that can be supported on either link is a function of (1) the channel response matrix for all of the data subbands, (2) the noise level observed by the receiver, (3) the quality of the channel estimate, and possibly other factors. For a TDD system, the channel may be considered to be reciprocal for the downlink and uplink (after calibration has been performed to account for any differences at the access point and user terminal). However, this reciprocal channel does not imply that the noise floors are the same at the access point and user terminal. Thus, for a given user terminal, the rates on the FCH and RCH may be independently controlled.

[0452] Closed-loop rate control may be used for data transmission on one or more spatial channels. Closed-loop rate control may be achieved with one or multiple loops. An inner loop estimates the channel conditions and selects a suitable rate for each spatial channel used for data transmission. The channel estimation and rate selection may be performed as described above. An outer loop may be used to estimate the quality of the data transmission received on each spatial channel and to adjust the operation of the inner loop. The data transmission quality may be quantified by packet error rate (PER), decoder metrics, and so on, or a combination thereof. For example, the outer loop may adjust the SNR offset for each spatial channel to achieve the target PER for that spatial channel. The outer loop may also direct the inner loop to select a lower rate for a spatial channel if excessive packet errors are detected for the spatial channel.

Downlink Rate Control

[0453] Each active user terminal can estimate the downlink channel based on the MIMO pilot transmitted on the BCH in each TDD frame. The access point may also transmit a steered reference in an FCH PDU sent to a specific user terminal. Using the MIMO pilot on the BCH and/or the steered reference on the FCH, the user terminal can estimate the received SNR and determine the maximum rate that can be supported on the FCH. If the user terminal is operating in the spatial multiplexing mode, then the maximum rate may be determined for each wideband eigenmode. Each user terminal can send back to the access point the maximum rate supported by each wideband eigenmode (for the spatial multiplexing mode), the maximum rate supported by the principal wideband eigenmode (for the beam-steering mode), or the maximum rate supported by the MIMO channel (for the diversity mode) in the FCH Rate Indicator field of the RCH PDU. These rates may be mapped to received SNRs, which may then be used to perform the water-filling described above. Alternatively, the user terminal may send back sufficient information (e.g., the received SNRs) to allow the access point to determine the maximum rate supported by the downlink.

[0454] The determination of whether to use the diversity, beam-steering, or spatial multiplexing mode may be made based on the feedback from the user terminal. The number of wideband eigenmodes selected for use may increase as isolation between the steering vectors improves.

[0455] **FIG. 14A** illustrates a process for controlling the rate of a downlink transmission for a user terminal. A BCH

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PDU is transmitted in the first segment of each TDD frame and includes the beacon and MIMO pilots that can be used by the user terminals to estimate and track the channel. A steered reference may also be sent in the preamble of an FCH PDU sent to the user terminal. The user terminal estimates the channel based on the MIMO and/or steered reference and determines the maximum rate(s) that can be supported by the downlink. One rate is provided for each wideband eigenmode if the user terminal is operating in the spatial multiplexing mode. The user terminal then sends the rate indicator for the FCH in the FCH Rate Indicator field of the RCH PDU it sends to the access point.

[0456] The scheduler uses the maximum rates that the downlink can support for each active user terminal to schedule downlink data transmission in subsequent TDD frames. The rates and other channel assignment information for the user terminal are reflected in an information element sent on the FCCH. The rate assigned to one user terminal can impact the scheduling for other user terminals. The minimum delay between the rate determination by the user terminal and its use is approximately a single TDD frame.

[0457] Using the Gram-Schmidt ordered procedure, the access point can accurately determine the maximum rates supported on the FCH directly from the RCH preamble. This can then greatly simplify rate control.

Uplink Rate Control

[0458] Each user terminal transmits a steered reference on the RACH during system access and on the RCH upon being assigned FCH/RCH resources. The access point can estimate the received SNR for each of the wideband eigenmodes based on the steered reference on the RCH and determine the maximum rate supported by each wideband eigenmode. Initially, the access point may not have a good estimate of the channel to permit reliable operation at or near the maximum rate supported by each wideband eigenmode. To improve reliability, the initial rate used on the FCH/RCH may be much lower than the maximum supported rate. The access point can integrate the steered reference over a number of TDD frames to obtain improved estimate of the channel. As the estimate of the channel improves, the rate may be increased.

[0459] **FIG. 14B** illustrates a process for controlling the rate of an uplink transmission for a user terminal. When scheduled for uplink transmission, the user terminal transmits an RCH PDU that includes the reference, which is used by the access point to determine the maximum rate on the uplink. The scheduler then uses the maximum rates that the uplink can support for each active user terminal to schedule uplink data transmission in subsequent TDD frames. The rates and other channel assignment information for the user terminal are reflected in an information element sent on the FCCH. The minimum delay between the rate determination by the access point and its use is approximately a single TDD frame.

3. Power Control

[0460] Power control may be used for uplink transmissions on the RCH (instead of rate control) for fixed-rate services. For fixed-rate services, the rate is negotiated at call setup and remains fixed for the duration of the connection. Some fixed-rate services may be associated with limited mobility requirement. In an embodiment, power control is implemented for the uplink to guard against interference among the user terminals but is not used for the downlink.

[0461] A power control mechanism is used to control the uplink transmit power of each active user terminal such that the received SNR at the access point is maintained at a level that achieves the desired service quality. This level is often referred to as the target received SNR, the operating point, or the setpoint. For a mobile user terminal, the propagation loss will likely change as the user terminal moves about. The power control mechanism tracks changes in the channel so that the received SNR is maintained near the setpoint.

[0462] The power control mechanism may be implemented with two power control loops - an inner loop and an outer loop. The inner loop adjusts the transmit power of the user terminal such that the received SNR at the access point is maintained near the setpoint. The outer loop adjusts the setpoint to achieve a particular level of performance, which may be quantified by a particular frame error rate (FER) (e.g., 1% FER), packet error rate (PER), block error rate (BLER), message error rate (MER), or some other measure.

[0463] **FIG. 15** illustrates the operation of the inner power control for a user terminal. After the user terminal is assigned the FCH/RCH, the access point estimates the received SNR on the RCH and compares it to the setpoint. The initial power to be used by the user terminal may be determined at call setup and is typically near its maximum transmit power level. For each frame interval, if the received SNR exceeds the setpoint by a particular positive margin δ, then the access point can direct the user terminal to reduce its transmit power by a particular amount (e.g., 1 dB) in an FCCH information element sent to this user terminal. Conversely, if the received SNR is lower than the threshold minus the margin δ, then the access point can direct the user terminal to increase its transmit power by the particular amount. If the received SNR is within the acceptable limits of the setpoint, then the access point will not request a change in transmit power by the user terminal. The uplink transmit power is given as the initial transmit power level plus the sum of all power adjustments received from the access point.

[0464] The initial setpoint used at the access point is set to achieve a particular level of performance. This setpoint is adjusted by the outer loop based on the FER or PER for the RCH. For example, if no frame/packet errors occur over a specified time period, then the setpoint may be reduced by a first amount (e.g., 0.1 dB). If the average FER is exceeded by the occurrence of one or more frame/packet errors, then the setpoint may be increased by a second amount (e.g., 1 dB). The setpoint, hysteresis margin, and outer loop operation are specific to the power control design used for the system.

4. Timing Control

[0465] Timing control may be advantageously used in a TDD-based frame structure where the downlink and uplink share the same frequency band in a time division duplexed manner. The user terminals may be located throughout in the system and may thus be associated with different propagation delays to the access point. In order to maximize efficiency on the uplink, the timing of the uplink transmission on the RCH and RACH from each user terminal can be adjusted to account for its propagation delay. This would then ensure that the uplink transmissions from different user terminals arrive within a particular time window at the access point and do not interfere with one another on the uplink, or with the downlink transmission.

[0466] **FIG. 16** illustrates a process for adjusting the uplink timing of a user terminal. Initially, the user terminal sends an RACH PDU on the uplink to gain access to the system. The access point derives an initial estimate of the round trip delay (RTD) associated with the user terminal. The round trip delay may be estimated based on (1) a sliding correlator used at the access point to determine the start of transmission, and (2) the slot ID included in the RACH PDU sent by the user terminal. The access point then computes an initial timing advance for the user terminal based on the initial RTD estimate. The initial timing advance is sent to the user terminal prior to its transmission on the RCH. The initial timing advance may be sent in a message on the FCH, a field of an FCCH information element, or by some other means.

[0467] The user terminal receives the initial timing advance from the access point and thereafter uses this timing advance on all subsequent uplink transmissions on both the RCH and RACH. If the user terminal is assigned FCH/RCH resources, then its timing advance can be adjusted by commands sent by the access point in the RCH Timing Adjustment field of an FCCH information element. The user terminal would thereafter adjust its uplink transmissions on the RCH based on the current timing advance, which is equal to the initial timing advance plus all timing adjustments sent by the access point to the user terminal.

[0468] Various parts of the MIMO WLAN system and various techniques described herein may be implemented by various means. For example, the processing at the access point and user terminal may be implemented in hardware, software, or a combination thereof. For a hardware implementation, the processing may be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein, or a combination thereof.

[0469] For a software implementation, the processing may be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in a memory unit (e.g., memory 732 or 782 in FIG. 7) and executed by a processor (e.g., controller 730 or 780). The memory unit may be implemented within the processor or external to the processor, in which case it can be communicatively coupled to the processor via various means as is known in the art.

[0470] Headings are included herein for reference and to aid in locating certain sections. These headings are not intended to limit the scope of the concepts described therein under, and these concepts may have applicability in other sections throughout the entire specification.

[0471] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

Claims

1. A method of processing data for transmission in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

   coding a data frame in accordance with a coding scheme to obtain a coded data frame;
   partitioning the coded data frame into a plurality of coded data subframes, one coded data subframe for each

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of a plurality of spatial channels;
interleaving each coded data subframe in accordance with an interleaving scheme to obtain a corresponding interleaved data subframe, wherein a plurality of interleaved data subframes are obtained for the plurality of spatial channels; and
modulating each interleaved data subframe to obtain a corresponding stream of modulation symbols, wherein a plurality of modulation symbol streams are obtained for the plurality of spatial channels.

2. The method of claim 1, wherein the coded data frame is partitioned by completely filling one coded data subframe at a time.

3. The method of claim 1, wherein the coded data frame is partitioned by cycling through the plurality of coded data subframes for a plurality of iterations and partially filling each coded data subframe with a particular number of code bits from the coded data frame in each iteration.

4. The method of claim 1, wherein each of the plurality of spatial channels is associated with a respective rate, wherein the rate for each spatial channel indicates a particular modulation scheme and a particular code rate to use for the spatial channel, and wherein the particular modulation scheme is selected from among a plurality of modulation schemes supported by the system and the particular code rate is selected from among a plurality of code rates supported by the system.

5. The method of claim 4, wherein the plurality of code rates are obtained based on a single base code and a plurality of puncturing patterns.

6. The method of claim 1, further comprising:

puncturing each coded data subframe to obtain a code rate selected for the spatial channel for the coded data subframe.

7. The method of claim 1, wherein the MIMO system utilizes orthogonal frequency division multiplexing (OFDM).

8. The method of claim 7, wherein the coded data frame is partitioned by cycling through the plurality of coded data subframes for a plurality of iterations and partially filling each coded data subframe with code bits, from the coded data frame, for a group of M subbands in each iteration, where M is greater than one and less than a total number of subbands used for data transmission.

9. The method of claim 8, wherein the interleaving is performed for the code bits for each group of M subbands.

10. The method of claim 7, further comprising:

processing the plurality of modulation symbol streams to obtain a plurality of streams of OFDM symbols, wherein the OFDM symbols have a cyclic prefix length selected from among at least two cyclic prefix lengths supported by the system.

11. The method of claim 7, further comprising:

processing the plurality of modulation symbol streams to obtain a plurality of streams of OFDM symbols, wherein the OFDM symbols are of a size selected from among at least two OFDM symbol sizes supported by the system.

12. An apparatus in a wireless multiple-input multiple-output (MIMO) communication system, comprising:

means for coding a data frame in accordance with a coding scheme to obtain a coded data frame;
means for partitioning the coded data frame into a plurality of coded data subframes, one coded data subframe for each of a plurality of spatial channels;
means for interleaving each coded data subframe in accordance with an interleaving scheme to obtain a corresponding interleaved data subframe, wherein a plurality of interleaved data subframes are obtained for the plurality of spatial channels; and
means for modulating each interleaved data subframe to obtain a corresponding stream of modulation symbols, wherein a plurality of modulation symbol streams are obtained for the plurality of spatial channels.

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13. The apparatus of claim 12, wherein each of the plurality of spatial channels is associated with a respective rate, wherein the rate for each spatial channel indicates a particular modulation scheme and a particular code rate to use for the spatial channel, and wherein the particular modulation scheme is selected from among a plurality of modulation schemes supported by the system and the particular code rate is selected from among a plurality of code rates supported by the system.

14. The apparatus of claim 12, wherein the MIMO system utilizes orthogonal frequency division multiplexing (OFDM).

15. The apparatus of claim 14, wherein the coded data frame is partitioned by cycling through the plurality of coded data subframes for a plurality of iterations and partially filling each coded data subframe with code bits, from the coded data frame, for a group of M subbands in each iteration, where M is greater than one and less than a total number of subbands used for data transmission.

16. The apparatus of claim 14, further comprising:

means for processing the plurality of modulation symbol streams to obtain a plurality of streams of OFDM symbols, wherein the OFDM symbols have a cyclic prefix length selected from among at least two cyclic prefix lengths supported by the system.

17. The apparatus of claim 14, further comprising:

means for processing the plurality of modulation symbol streams to obtain a plurality of streams of OFDM symbols, wherein the OFDM symbols are of a size selected from among at least two OFDM symbol sizes supported by the system.

18. The apparatus of claims 16 or 17, wherein the means for processing the plurality of modulation symbol streams is a plurality of OFDM modulators.

19. The apparatus of any of claims 12 to 18 wherein:

the means for coding is an encoder;
the means for partitioning is a demultiplexer;
the means for interleaving is an interleaver; and
the means for modulating is a symbol mapping unit.

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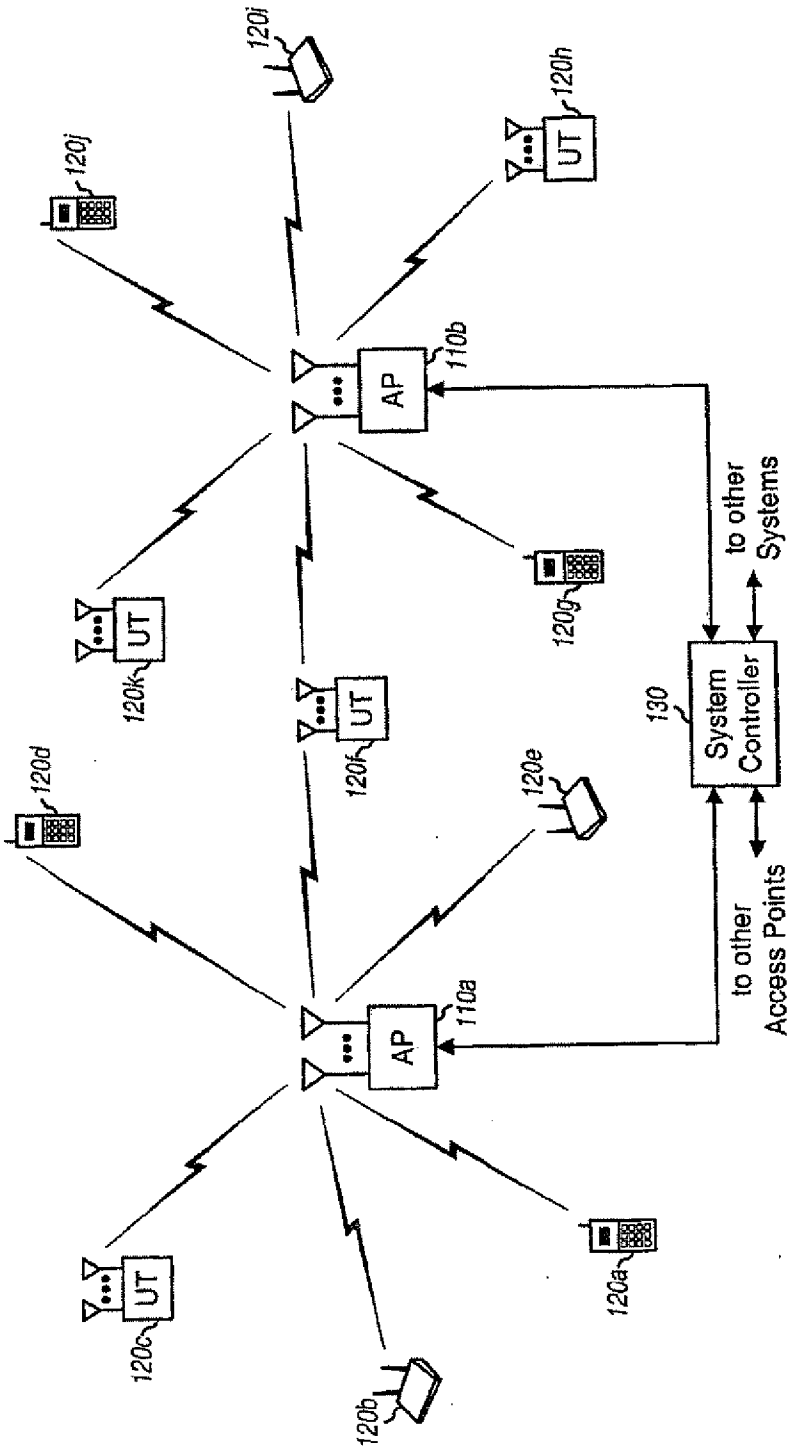

100
120i
120h
120j
UT
AP
110b
120g
to other Systems
120k
UT
120f
UT
120d
120e
130
System Controller
to other Access Points
AP
110a
120a
120c
UT
120b

FIG. 1

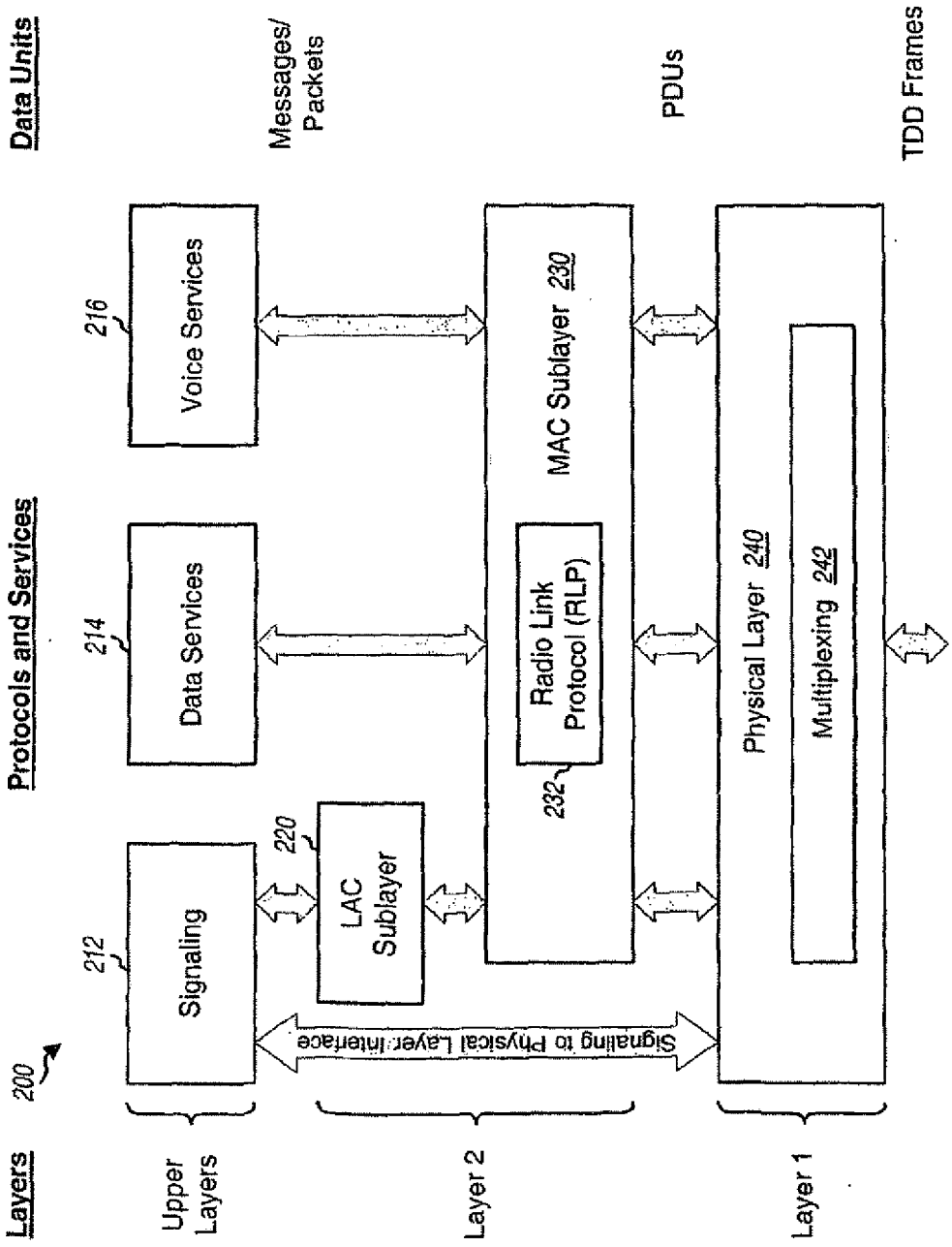

Layers
200
Protocols and Services
Data Units
Upper Layers
Layer 2
Layer 1
212
Signaling
220
LAC Sublayer
214
Data Services
216
Voice Services
232
Radio Link Protocol (RLP)
MAC Sublayer 230
Physical Layer 240
Multiplexing 242
Signaling to Physical Layer Interface
Messages/ Packets
PDUs
TDD Frames

FIG. 2

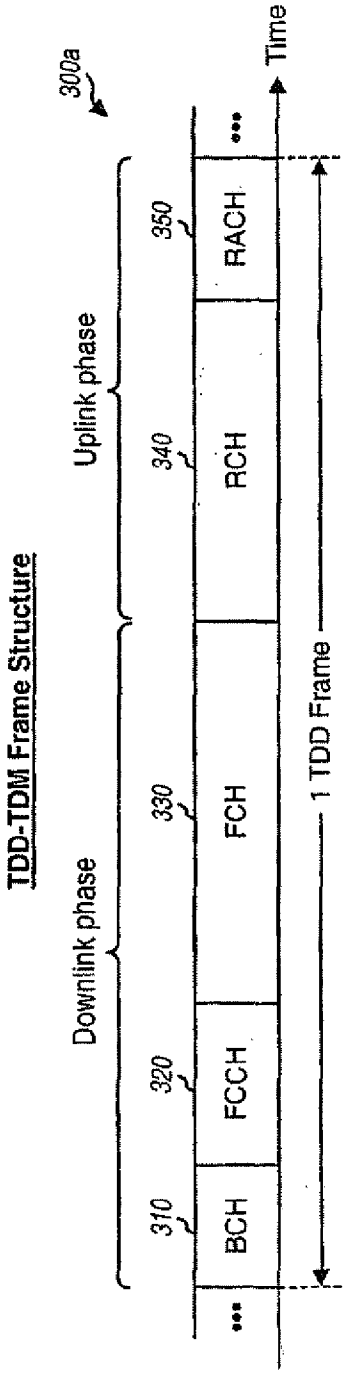

TDD-TDM Frame Structure
300a
Downlink phase
Uplink phase
310
320
330
340
350
BCH
FCCH
FCH
RCH
RACH
Time
1 TDD Frame

FIG. 3A

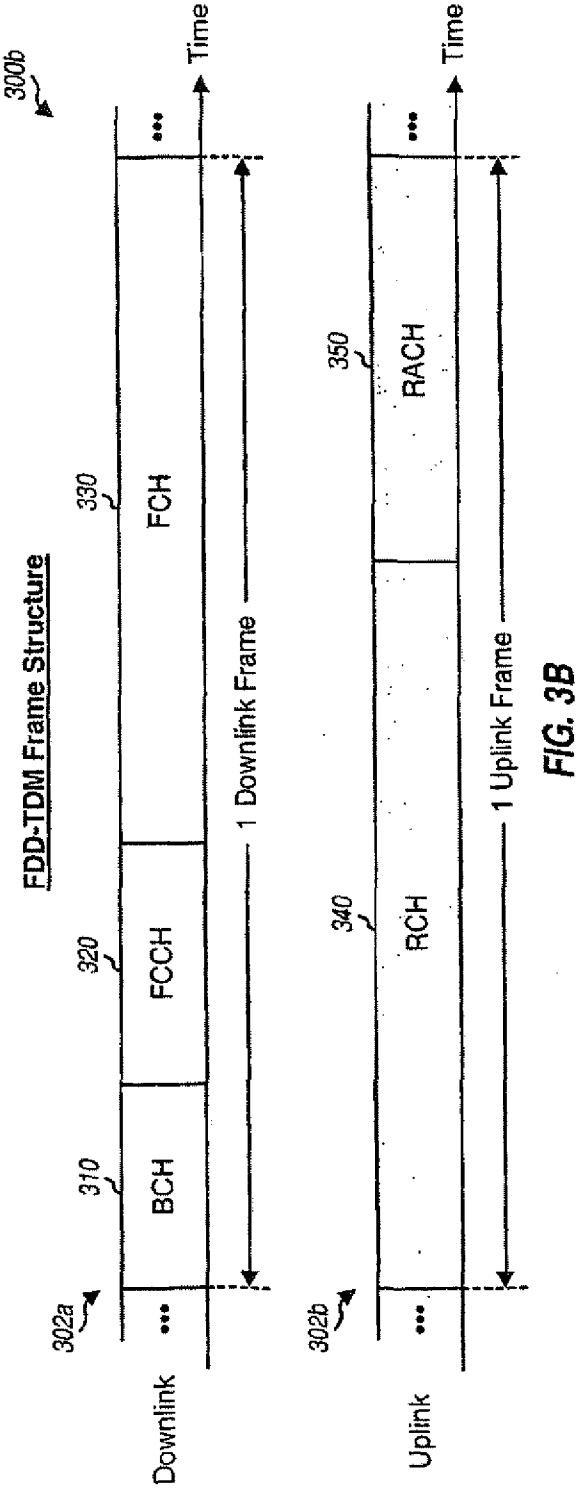

FDD-TDM Frame Structure
300b
310
320
330
340
350
BCH
FCCH
FCH
RCH
RACH
Time
1 Downlink Frame
1 Uplink Frame
302a
302b
Downlink
Uplink

FIG. 3B

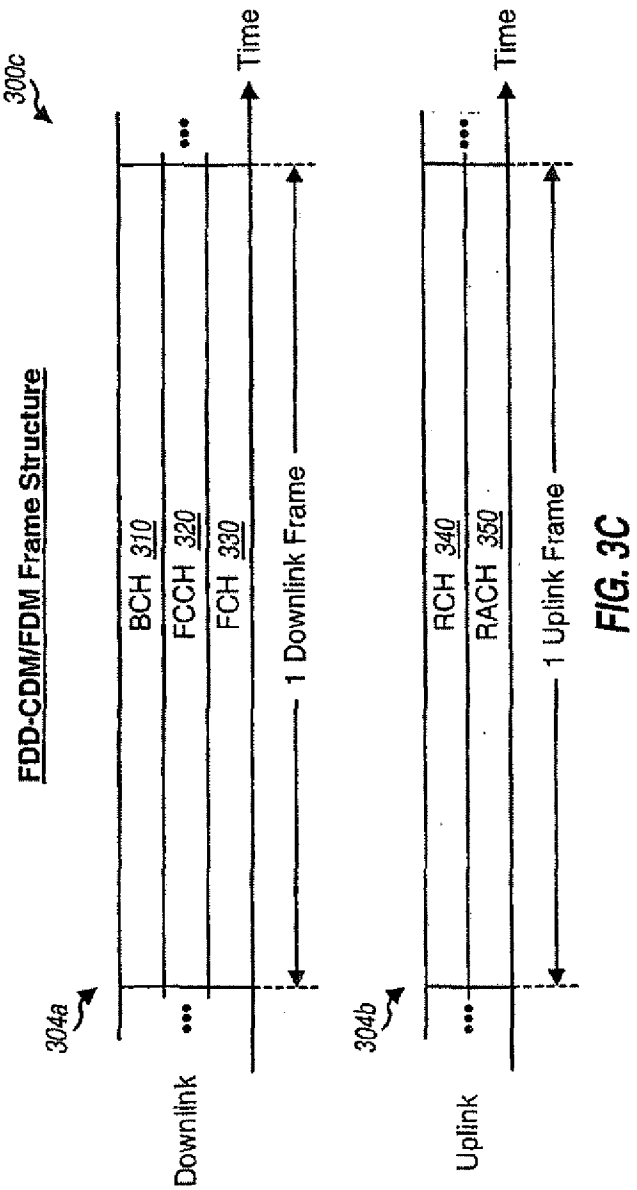

300c
FDD-CDM/FDM Frame Structure
Time
BCH 310
FCCH 320
FCH 330
1 Downlink Frame
304a
Downlink
Time
RCH 340
RACH 350
1 Uplink Frame
304b
Uplink

FIG. 3C

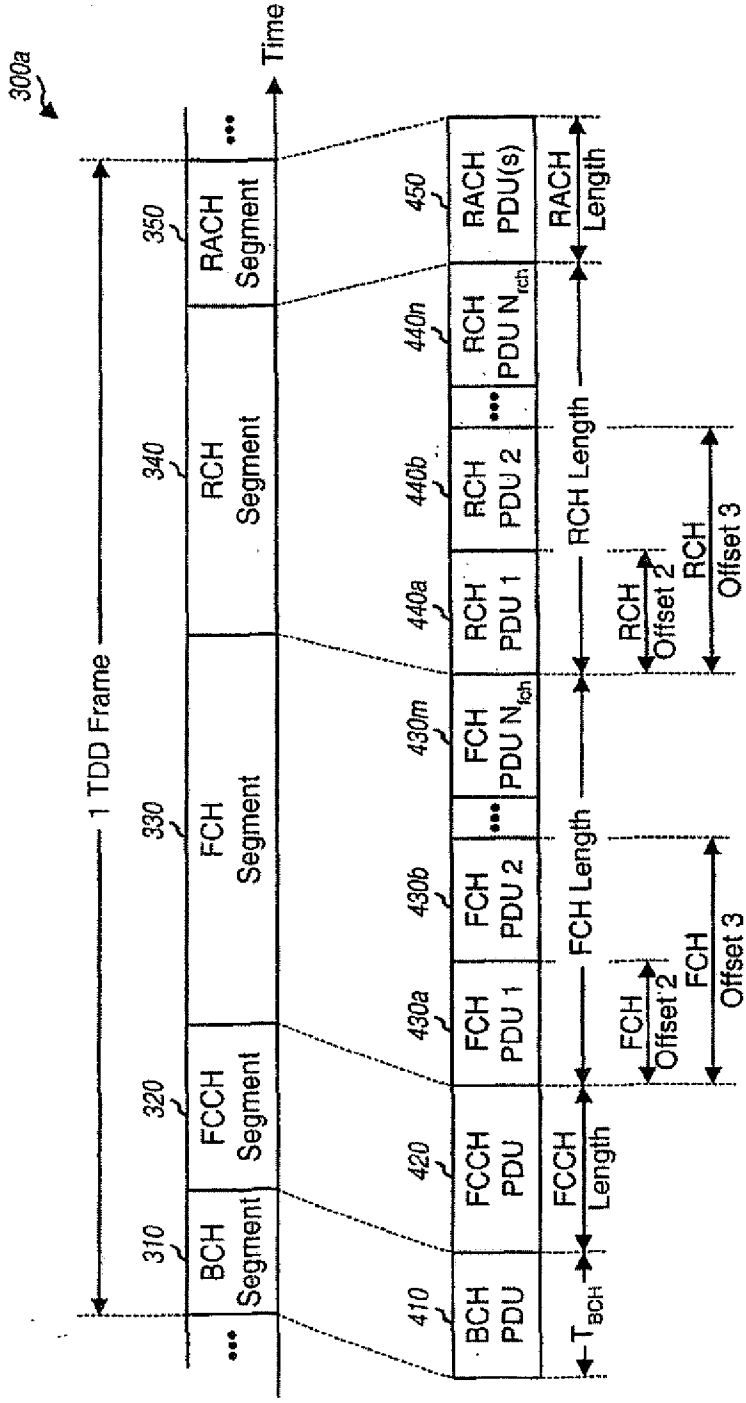

300a
Time
1 TDD Frame
BCH Segment
FCCH Segment
FCH Segment
RCH Segment
RACH Segment
310
320
330
340
350
BCH PDU
FCCH PDU
FCH PDU 1
FCH PDU 2
FCH PDU N_{fch}
RCH PDU 1
RCH PDU 2
RCH PDU N_{rch}
RACH PDU(s)
410
420
430a
430b
430m
440a
440b
440n
450
T_{BCH}
FCCH Length
FCH Length
RCH Length
RACH Length
FCH Offset 2
FCH Offset 3
RCH Offset 2
RCH Offset 3

FIG. 4

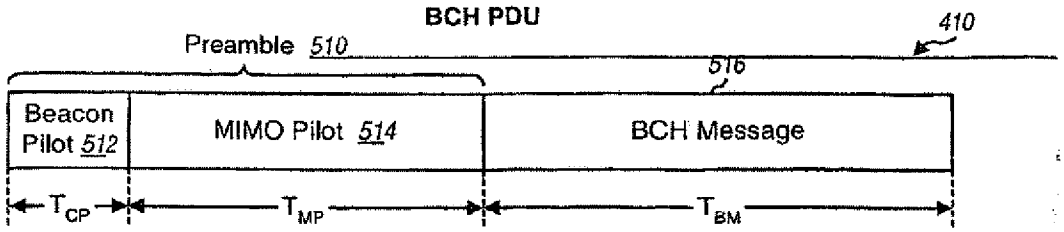


FIG. 5A

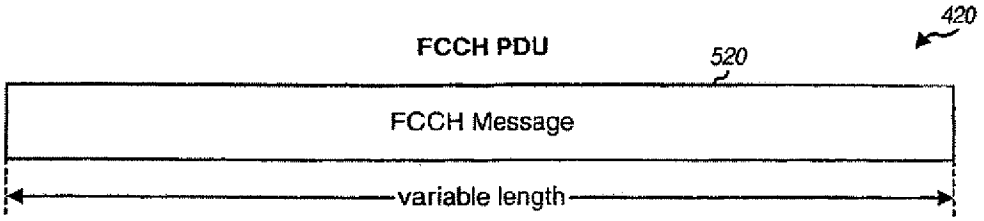


FIG. 5B

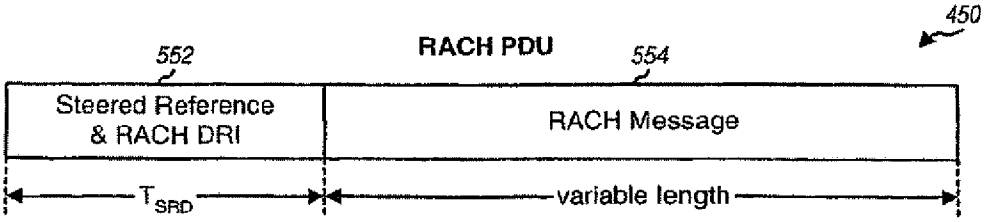


FIG. 5C

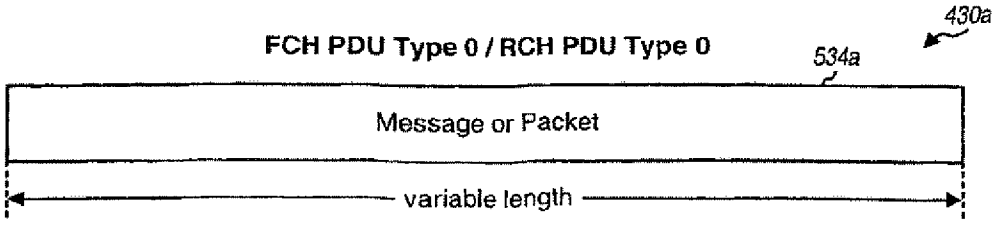


FIG. 5D

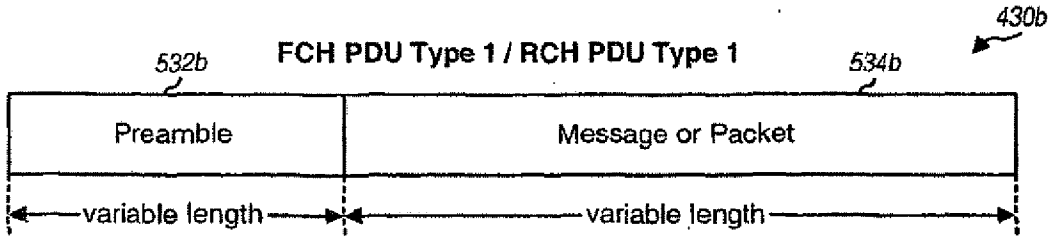


FIG. 5E

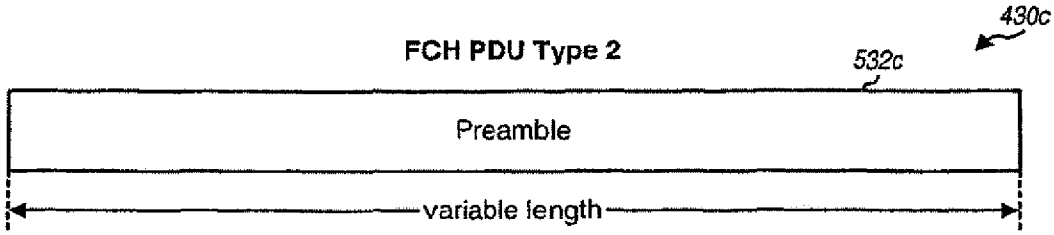


FIG. 5F

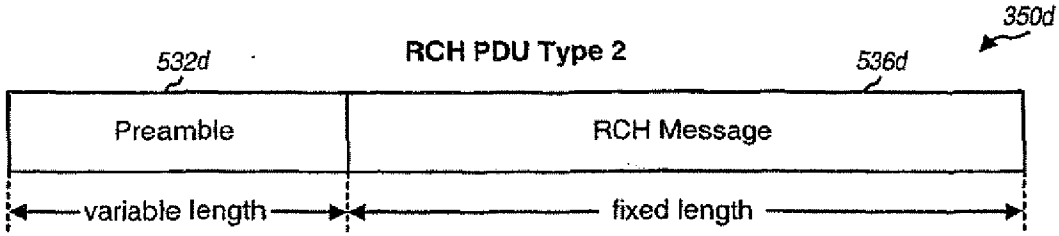


FIG. 5G

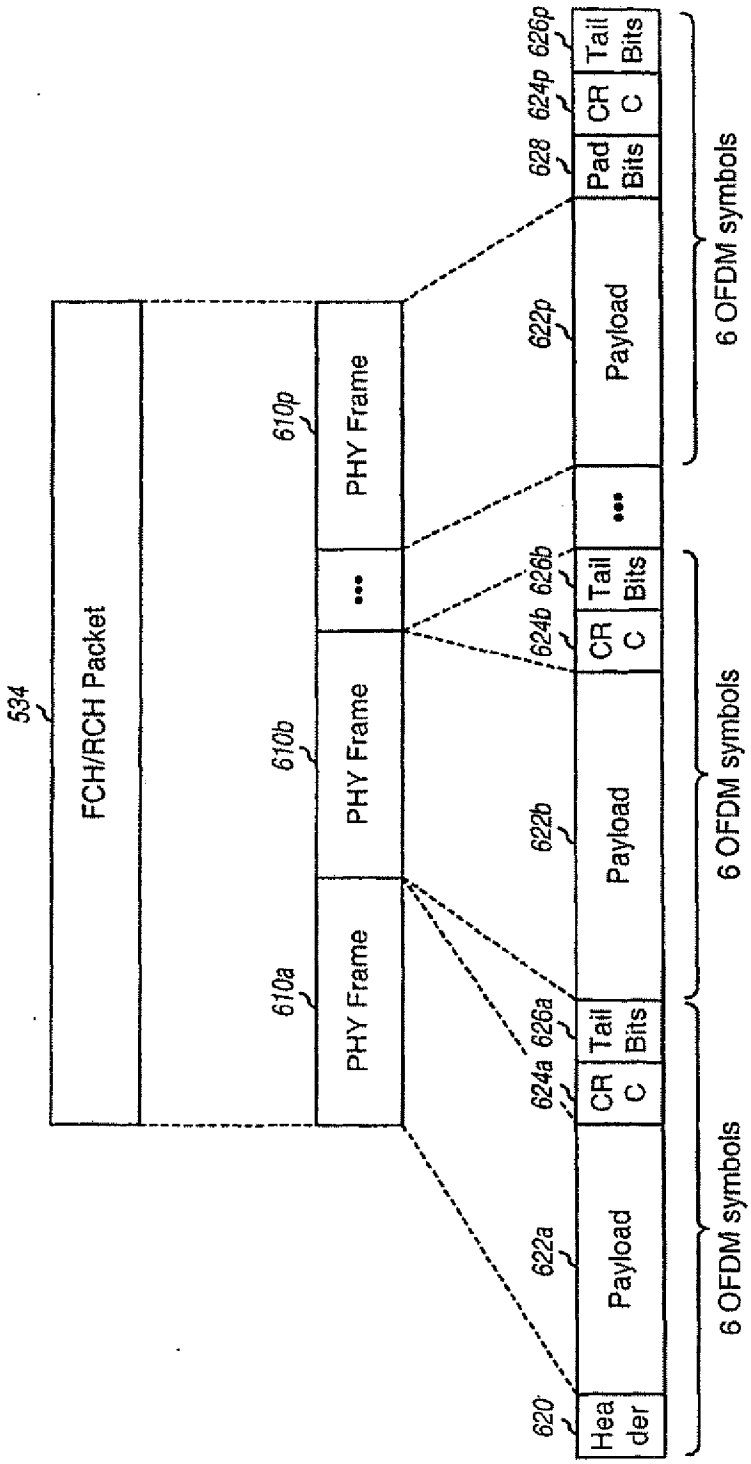

534
FCH/RCH Packet
610a
PHY Frame
610b
PHY Frame
610p
PHY Frame
620
Hea der
622a
Payload
624a
CR C
626a
Tail Bits
622b
Payload
624b
CR C
626b
Tail Bits
622p
Payload
628
Pad Bits
624p
CR C
626p
Tail Bits
6 OFDM symbols
6 OFDM symbols
6 OFDM symbols

FIG. 6

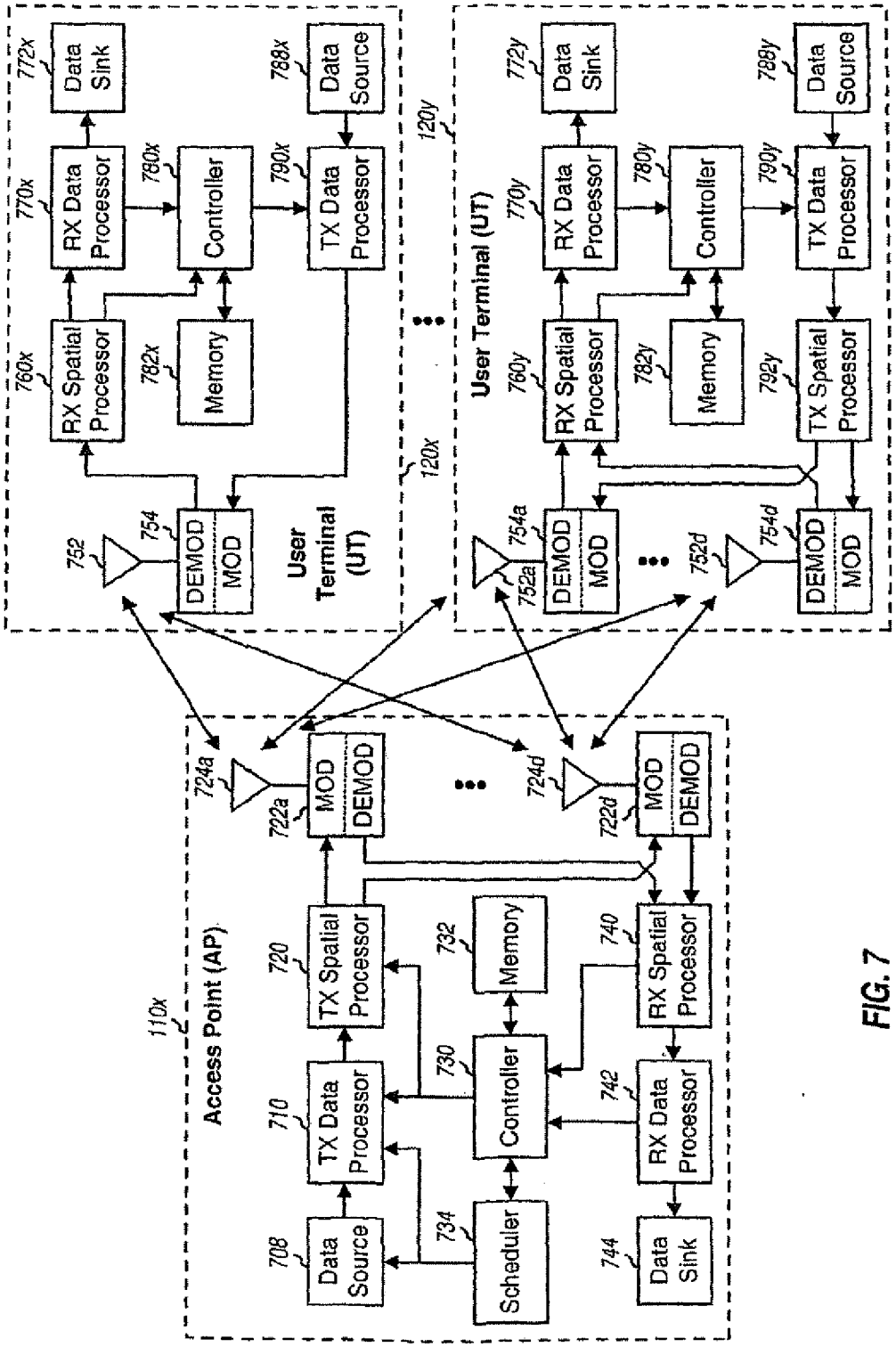

Access Point (AP)
110x
User Terminal (UT)
120x
120y
User Terminal (UT)
Data Source
TX Data Processor
Controller
Memory
Scheduler
RX Data Processor
Data Sink
TX Spatial Processor
RX Spatial Processor
MOD
DEMOD
708
710
720
722a
722d
724a
724d
730
732
734
740
742
744
752
752a
752d
754
754a
754d
760x
760y
770x
770y
772x
772y
780x
780y
782x
782y
788x
788y
790x
790y
792y

FIG. 7

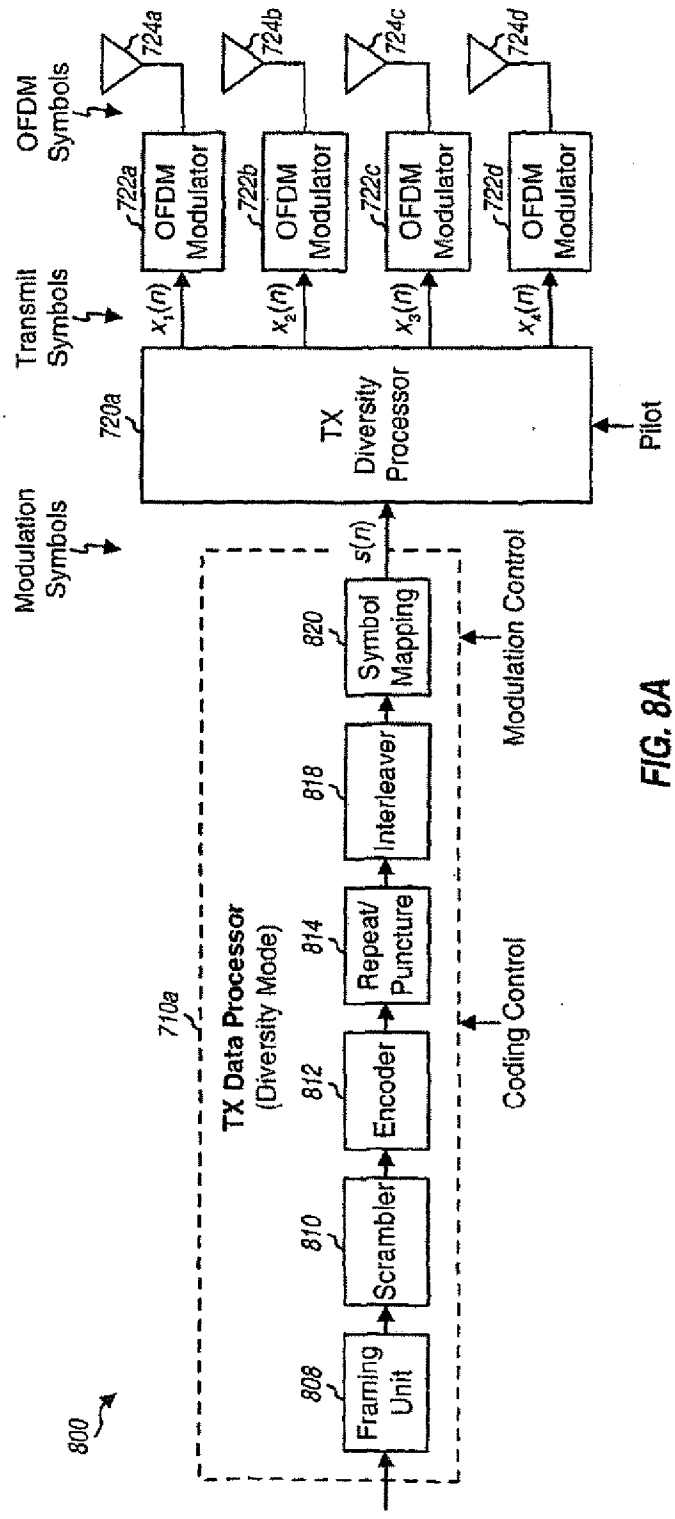


FIG. 8A

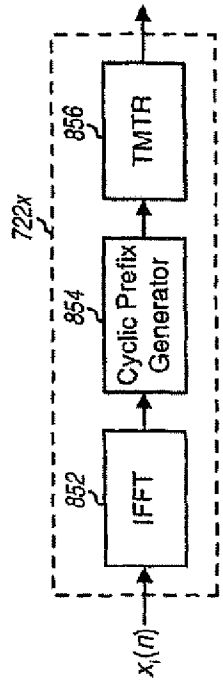


FIG. 8C

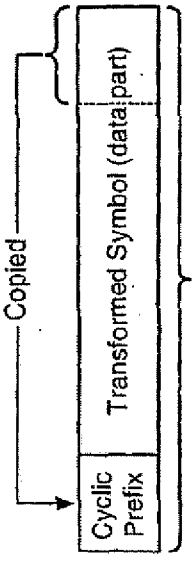


FIG. 8D

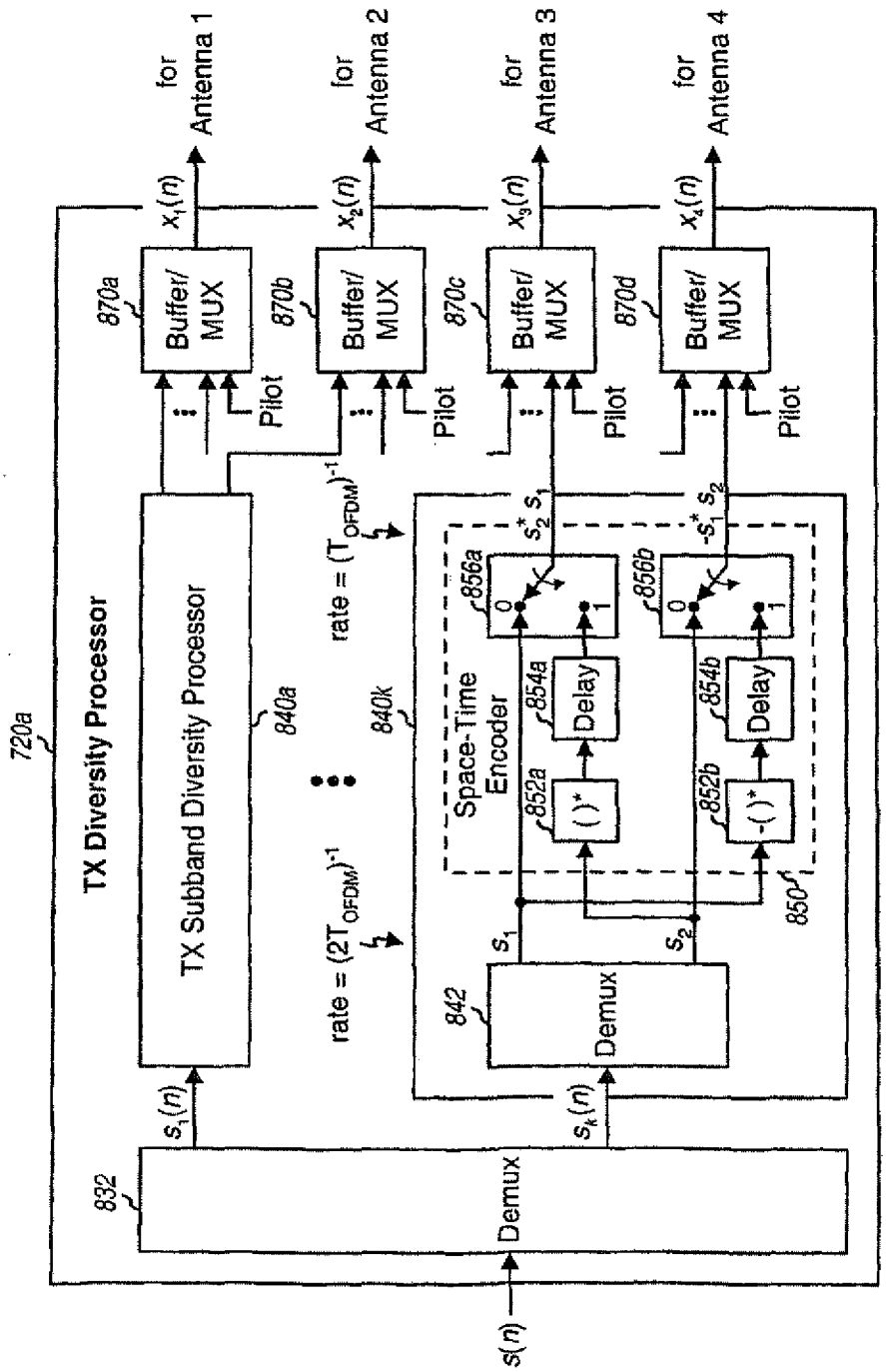

TX Diversity Processor
720a
TX Subband Diversity Processor
840a
840k
Space-Time Encoder
850
Demux
832
Demux
842
Buffer/ MUX
870a
870b
870c
870d
Pilot
for Antenna 1
for Antenna 2
for Antenna 3
for Antenna 4
Delay
854a
854b
856a
856b
852a
852b
rate = $(T_{OFDM})^{-1}$
rate = $(2T_{OFDM})^{-1}$
$s(n)$
$s_1(n)$
$s_k(n)$
$x_1(n)$
$x_2(n)$
$x_3(n)$
$x_4(n)$
s_1
s_2
s_2^* s_1
$-s_1^*$ s_2

FIG. 8B

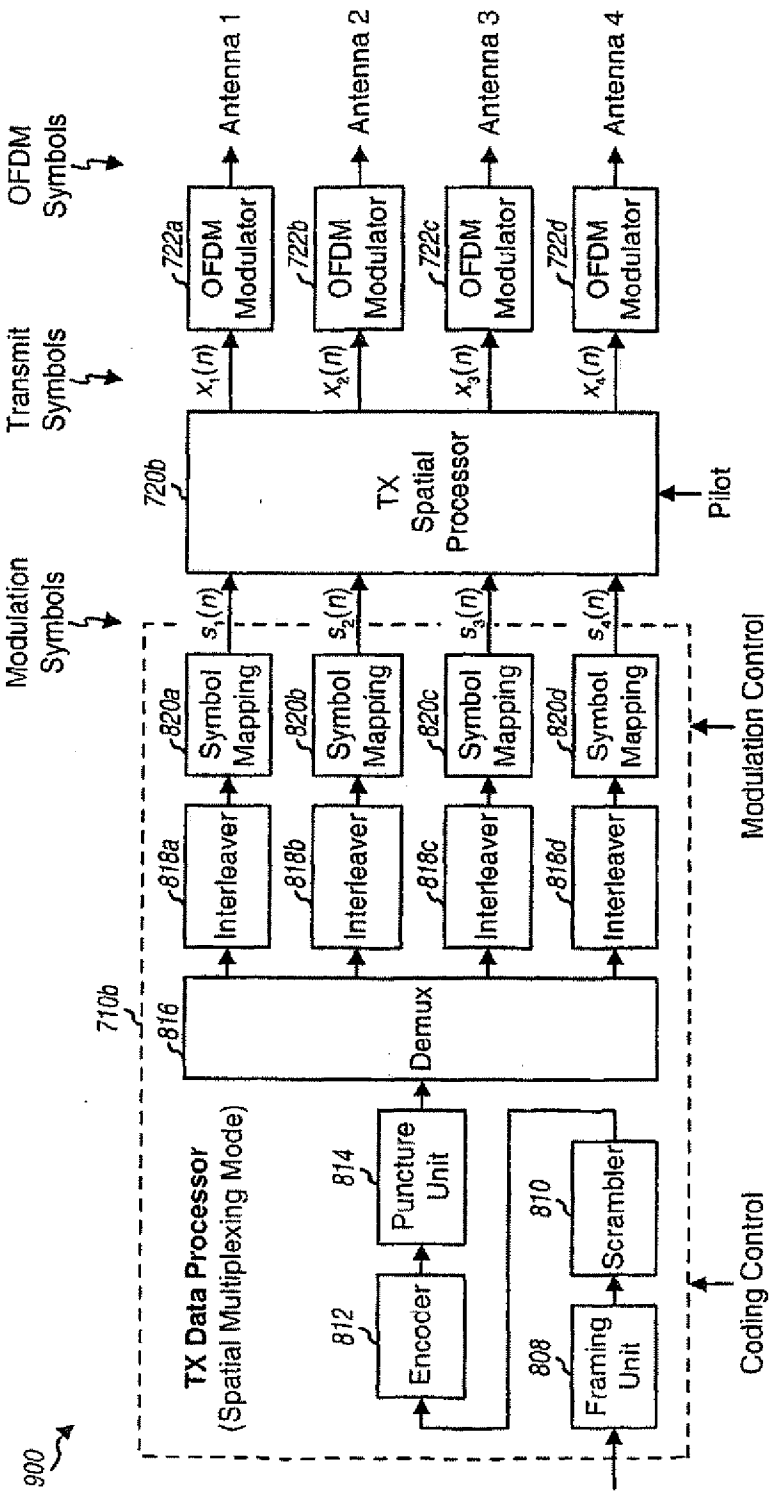

900
TX Data Processor
(Spatial Multiplexing Mode)
710b
808
Framing Unit
812
Encoder
814
Puncture Unit
810
Scrambler
816
Demux
818a
Interleaver
818b
Interleaver
818c
Interleaver
818d
Interleaver
820a
Symbol Mapping
820b
Symbol Mapping
820c
Symbol Mapping
820d
Symbol Mapping
Modulation Symbols
$s_1(n)$
$s_2(n)$
$s_3(n)$
$s_4(n)$
720b
TX Spatial Processor
Pilot
Transmit Symbols
$x_1(n)$
$x_2(n)$
$x_3(n)$
$x_4(n)$
722a
OFDM Modulator
722b
OFDM Modulator
722c
OFDM Modulator
722d
OFDM Modulator
OFDM Symbols
Antenna 1
Antenna 2
Antenna 3
Antenna 4
Coding Control
Modulation Control

FIG. 9A

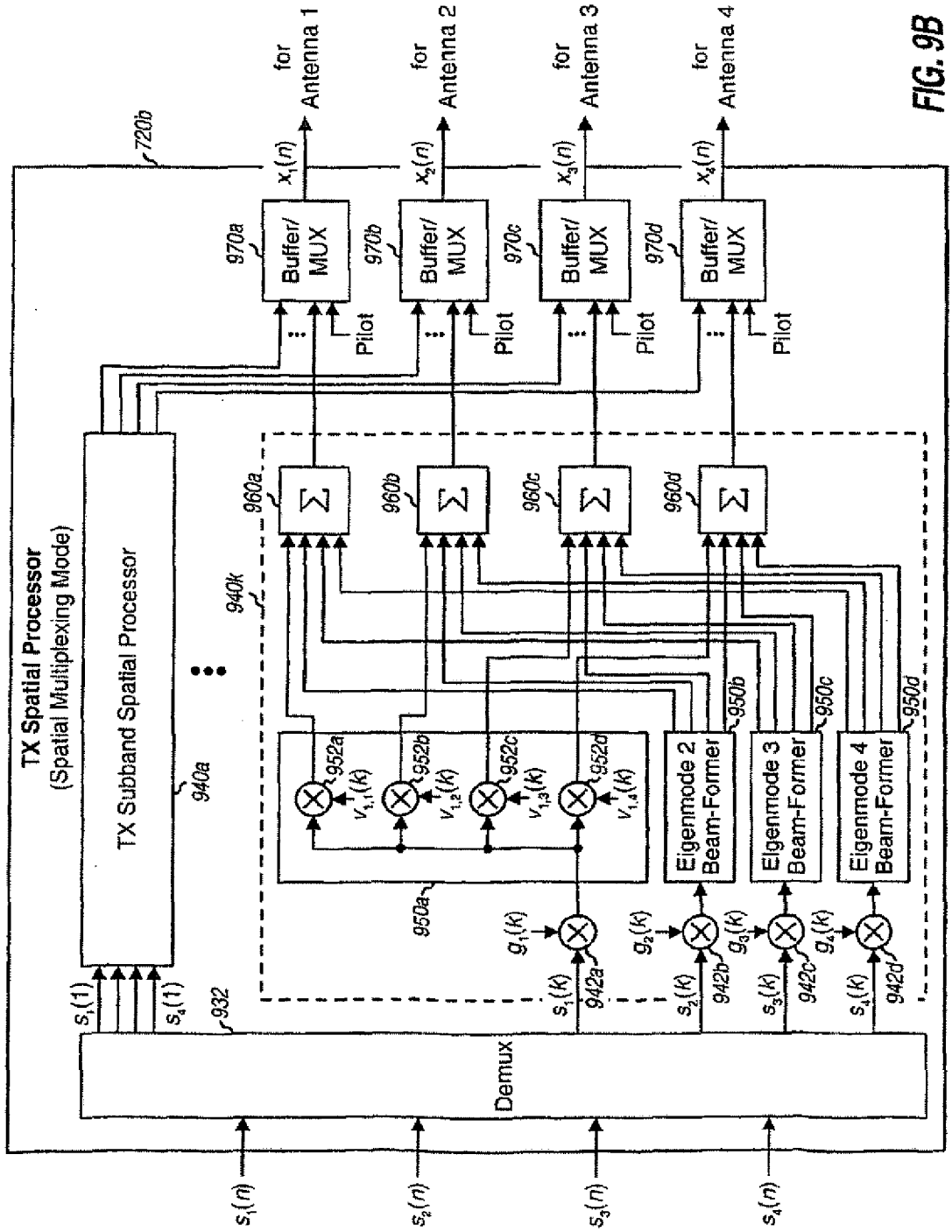

TX Spatial Processor
(Spatial Multiplexing Mode)
TX Subband Spatial Processor
Demux
Buffer/ MUX
Pilot
Eigenmode 2 Beam-Former
Eigenmode 3 Beam-Former
Eigenmode 4 Beam-Former
for Antenna 1
for Antenna 2
for Antenna 3
for Antenna 4

FIG. 9B

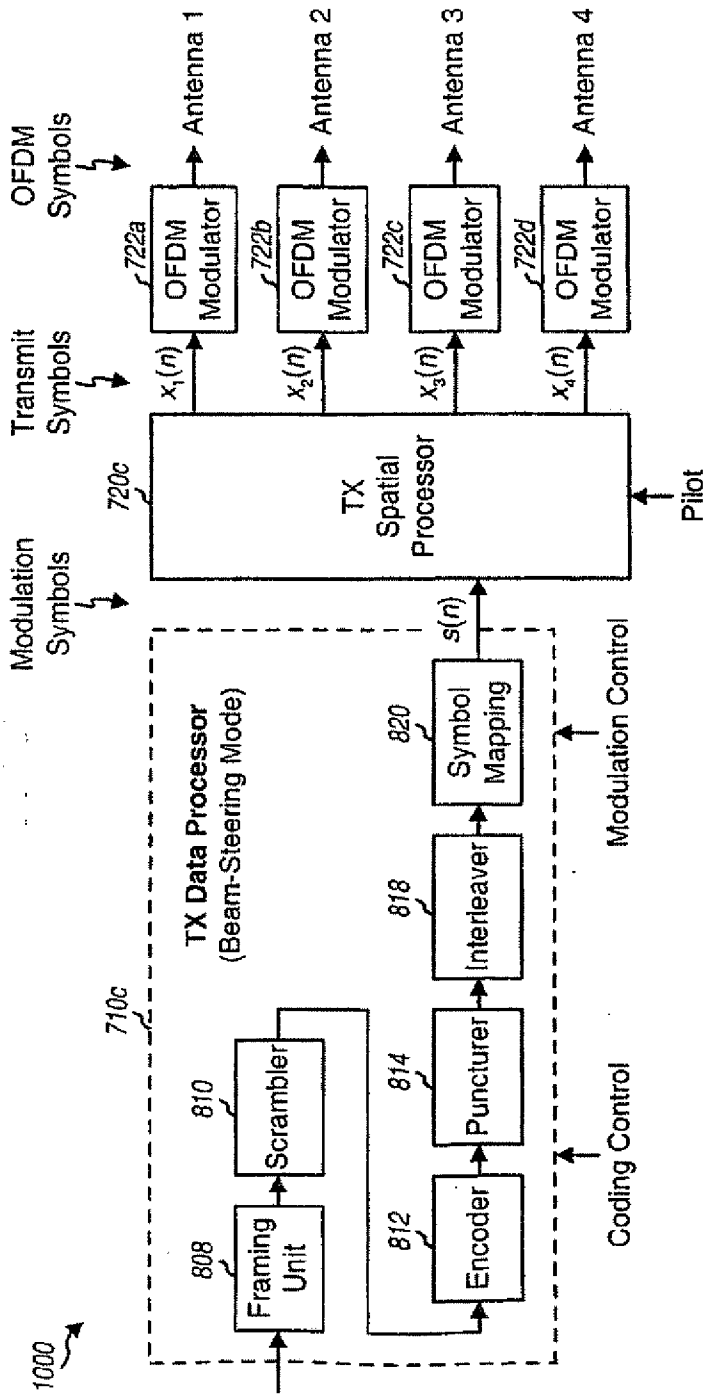

1000
710c
TX Data Processor
(Beam-Steering Mode)
808
Framing Unit
810
Scrambler
812
Encoder
814
Puncturer
818
Interleaver
820
Symbol Mapping
Coding Control
Modulation Control
Modulation Symbols
s(n)
720c
TX Spatial Processor
Pilot
Transmit Symbols
$x_1(n)$
$x_2(n)$
$x_3(n)$
$x_4(n)$
722a
722b
722c
722d
OFDM Modulator
OFDM Symbols
Antenna 1
Antenna 2
Antenna 3
Antenna 4

FIG. 10A

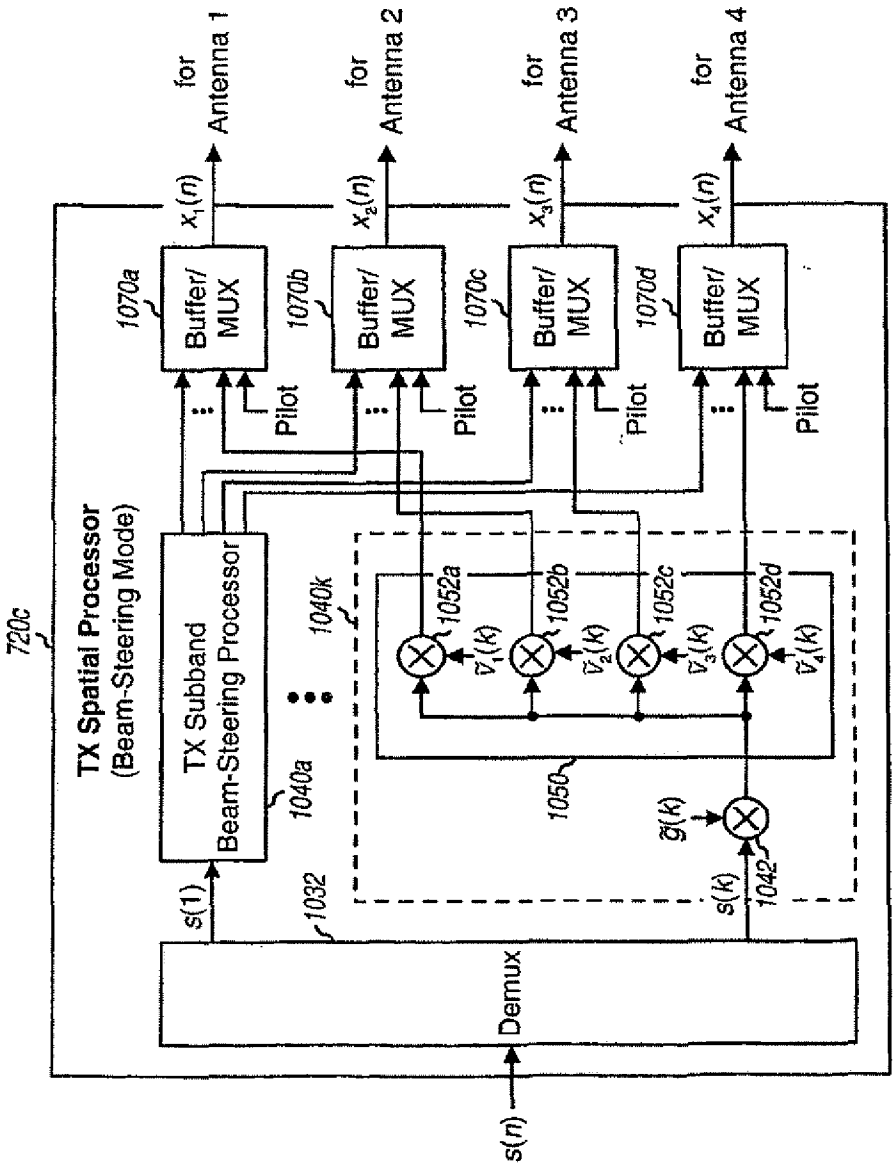

720c
TX Spatial Processor
(Beam-Steering Mode)
TX Subband
Beam-Steering Processor
1040a
1040k
1032
s(1)
Demux
s(n)
1050
1052a
1052b
1052c
1052d
g(k)
s(k)
1042
Buffer/
MUX
1070a
1070b
1070c
1070d
Pilot
for
Antenna 1
for
Antenna 2
for
Antenna 3
for
Antenna 4

FIG. 10B

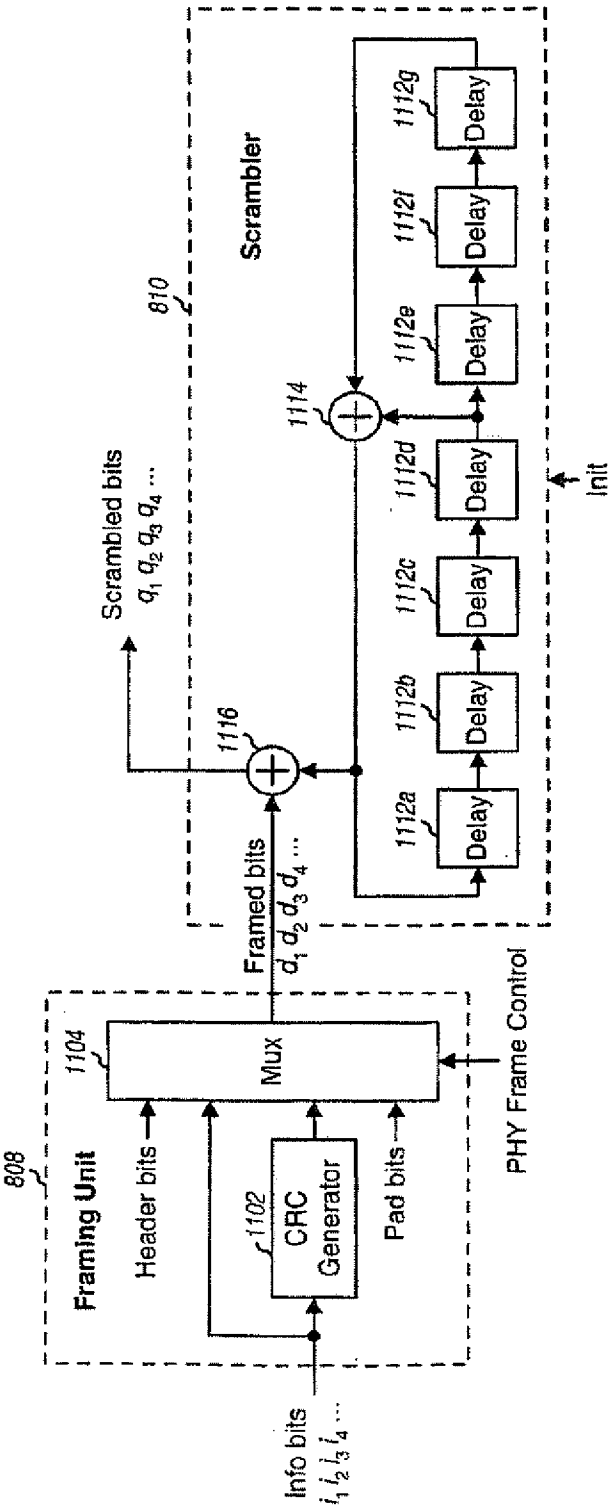

Framing Unit
808
Info bits
$i_1 i_2 i_3 i_4 \ldots$
Header bits
CRC Generator
1102
Pad bits
Mux
1104
PHY Frame Control
Framed bits
$d_1 d_2 d_3 d_4 \ldots$
Scrambler
810
Scrambled bits
$q_1 q_2 q_3 q_4 \ldots$
1116
1114
Delay
1112a
1112b
1112c
1112d
1112e
1112f
1112g
Init

FIG. 11A

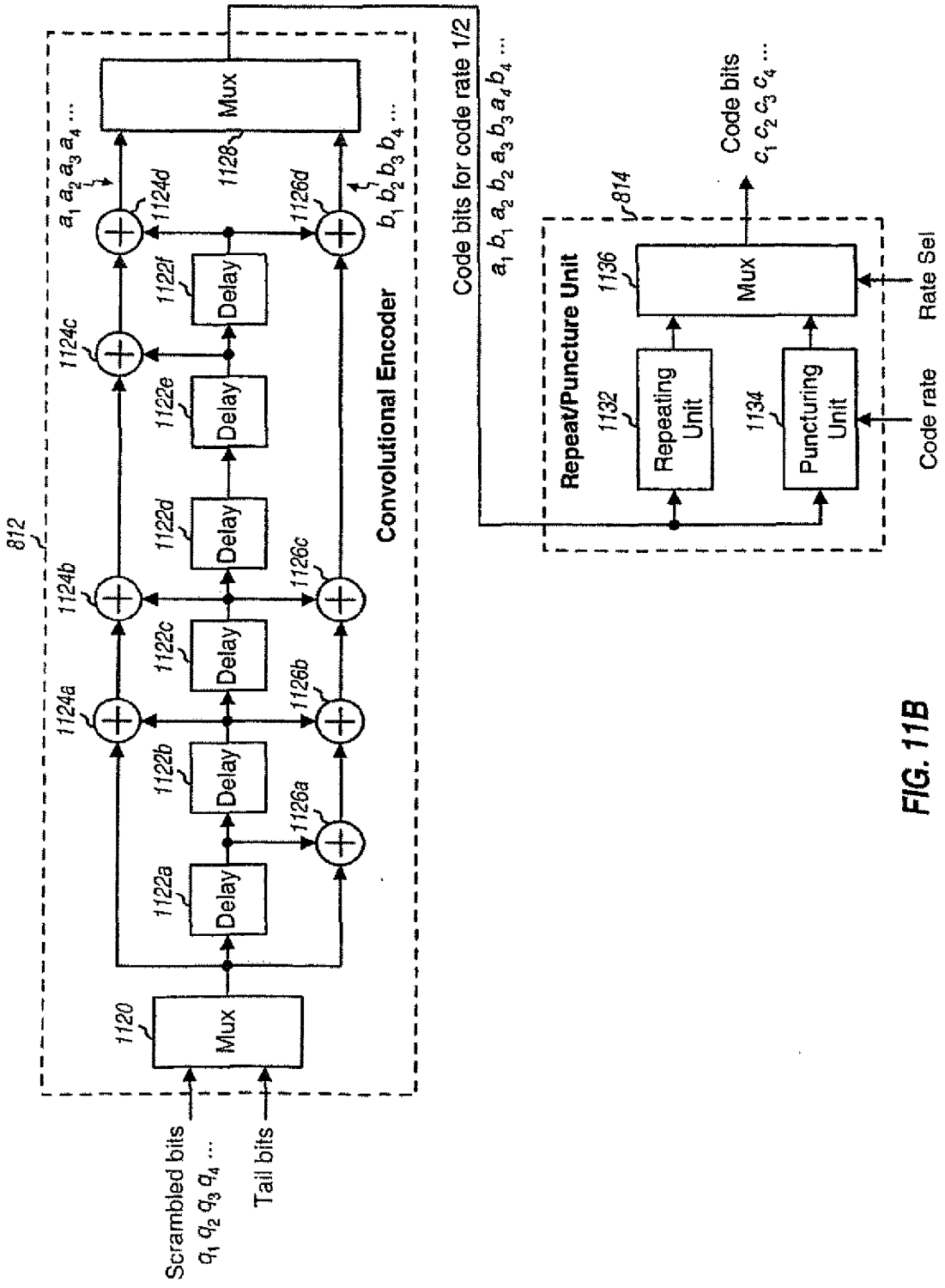

812
Convolutional Encoder
Mux
1120
Delay
1122a
1122b
1122c
1122d
1122e
1122f
1124a
1124b
1124c
1124d
1126a
1126b
1126c
1128
Scrambled bits
$q_1 q_2 q_3 q_4 \ldots$
Tail bits
$a_1 a_2 a_3 a_4 \ldots$
$b_1 b_2 b_3 b_4 \ldots$
Code bits for code rate 1/2
$a_1 b_1 a_2 b_2 a_3 b_3 a_4 b_4 \ldots$
814
Repeat/Puncture Unit
1132
Repeating Unit
1134
Puncturing Unit
1136
Mux
Code rate
Rate Sel
Code bits
$c_1 c_2 c_3 c_4 \ldots$

FIG. 11B

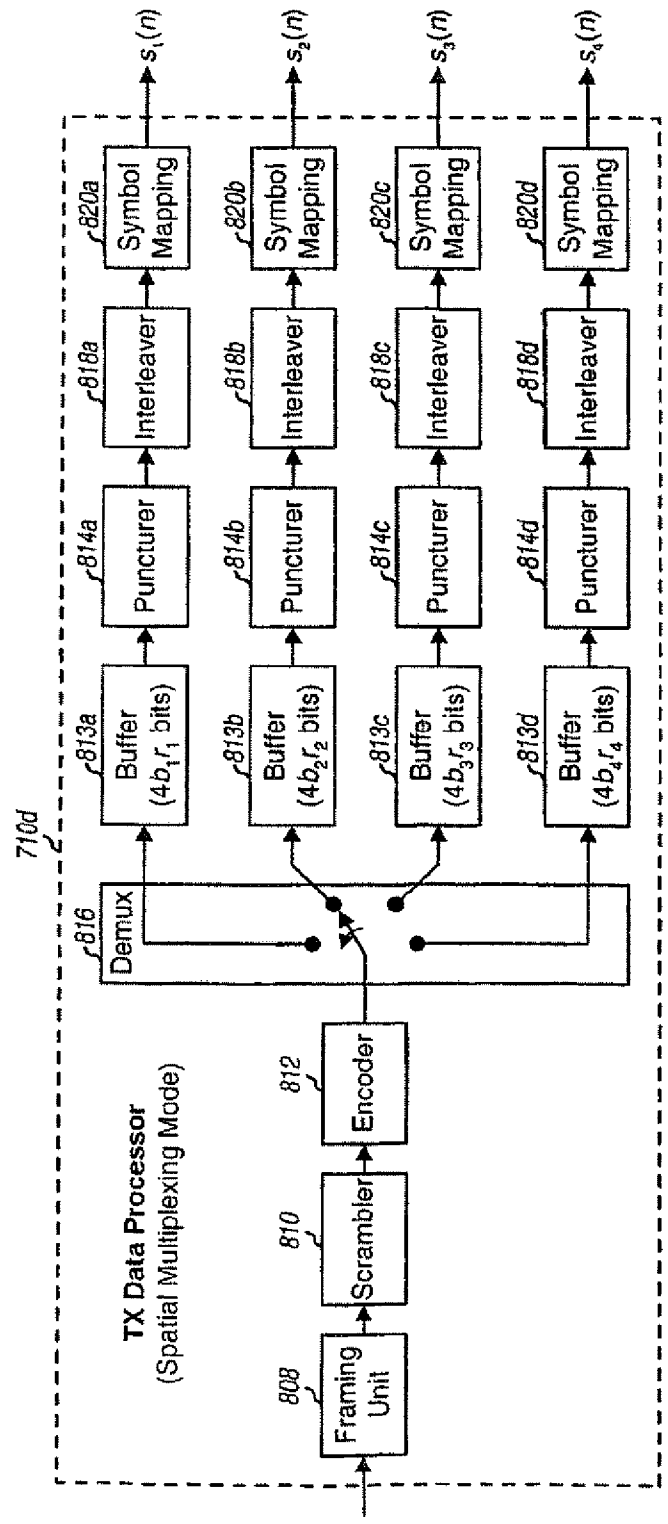

710d
TX Data Processor
(Spatial Multiplexing Mode)
808
Framing Unit
810
Scrambler
812
Encoder
816
Demux
813a
Buffer
(4b1r1 bits)
813b
Buffer
(4b2r2 bits)
813c
Buffer
(4b3r3 bits)
813d
Buffer
(4b4r4 bits)
814a
Puncturer
814b
Puncturer
814c
Puncturer
814d
Puncturer
818a
Interleaver
818b
Interleaver
818c
Interleaver
818d
Interleaver
820a
Symbol Mapping
820b
Symbol Mapping
820c
Symbol Mapping
820d
Symbol Mapping
s1(n)
s2(n)
s3(n)
s4(n)

FIG. 11C

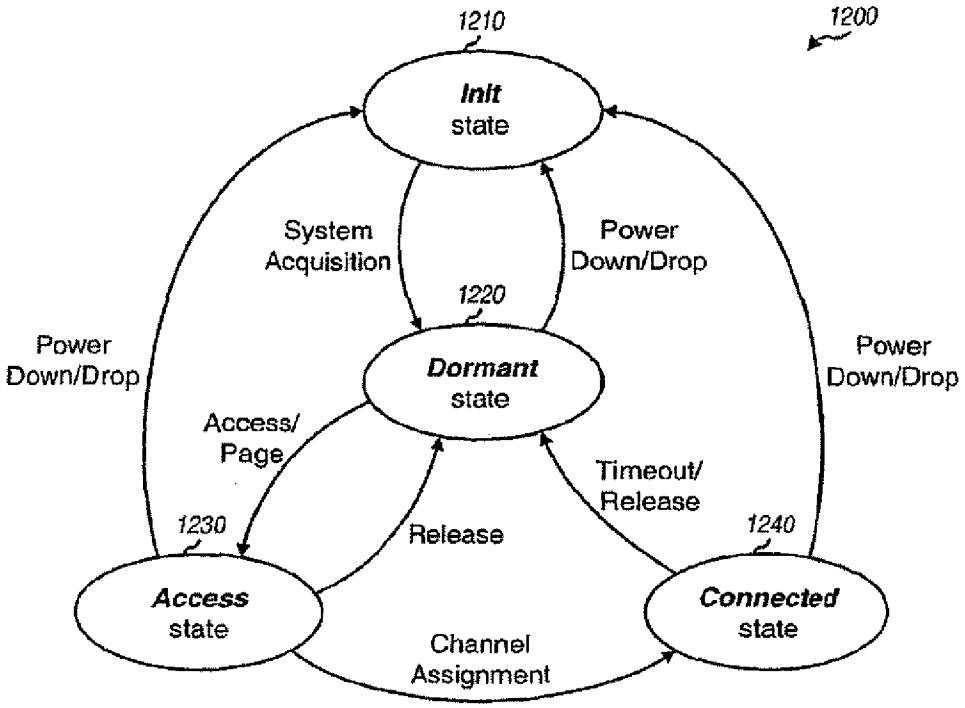


FIG. 12A

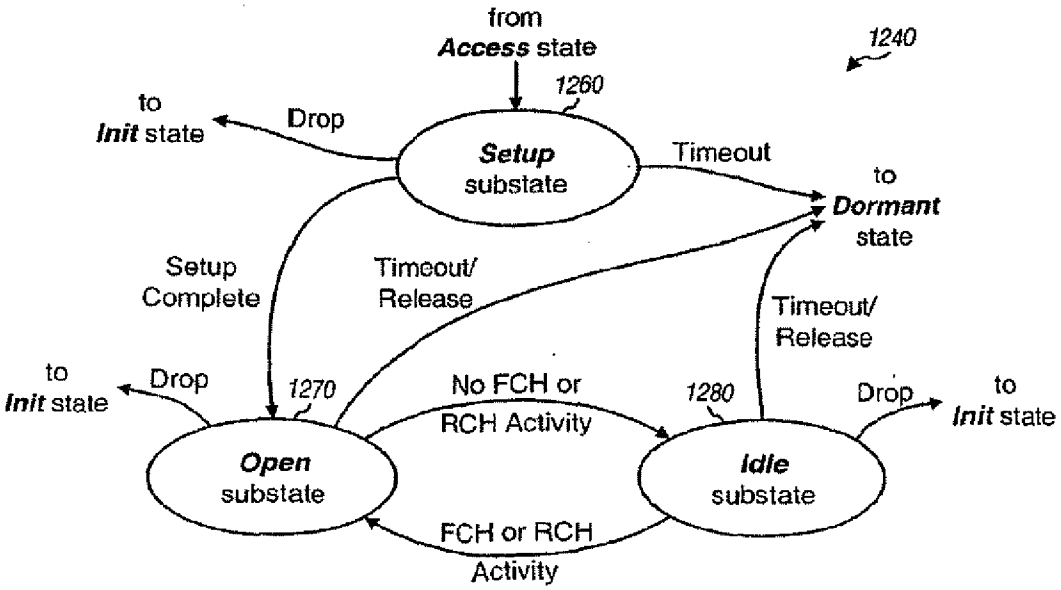


FIG. 12B

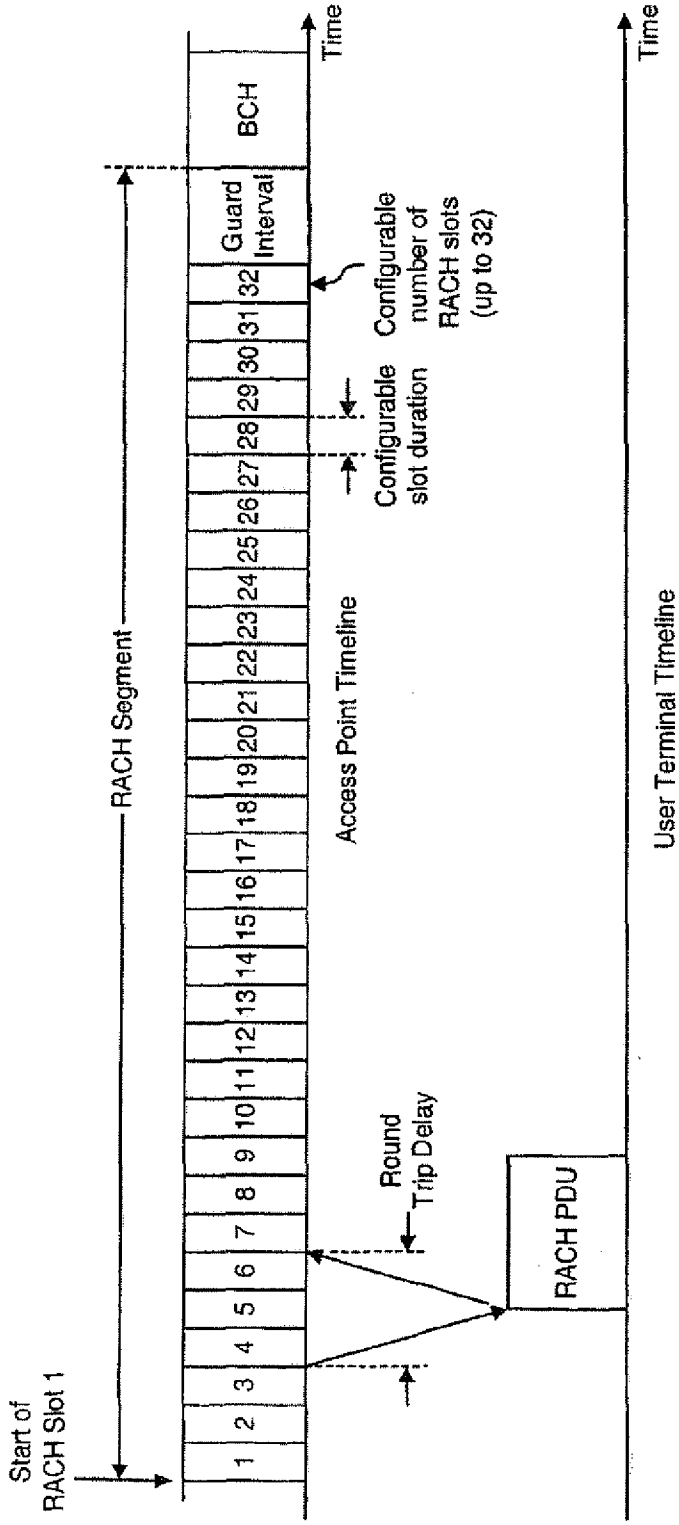

Start of
RACH Slot 1
RACH Segment
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
BCH
Guard
Interval
Time
Configurable
number of
RACH slots
(up to 32)
Configurable
slot duration
Access Point Timeline
Round
Trip Delay
RACH PDU
Time
User Terminal Timeline

FIG. 13

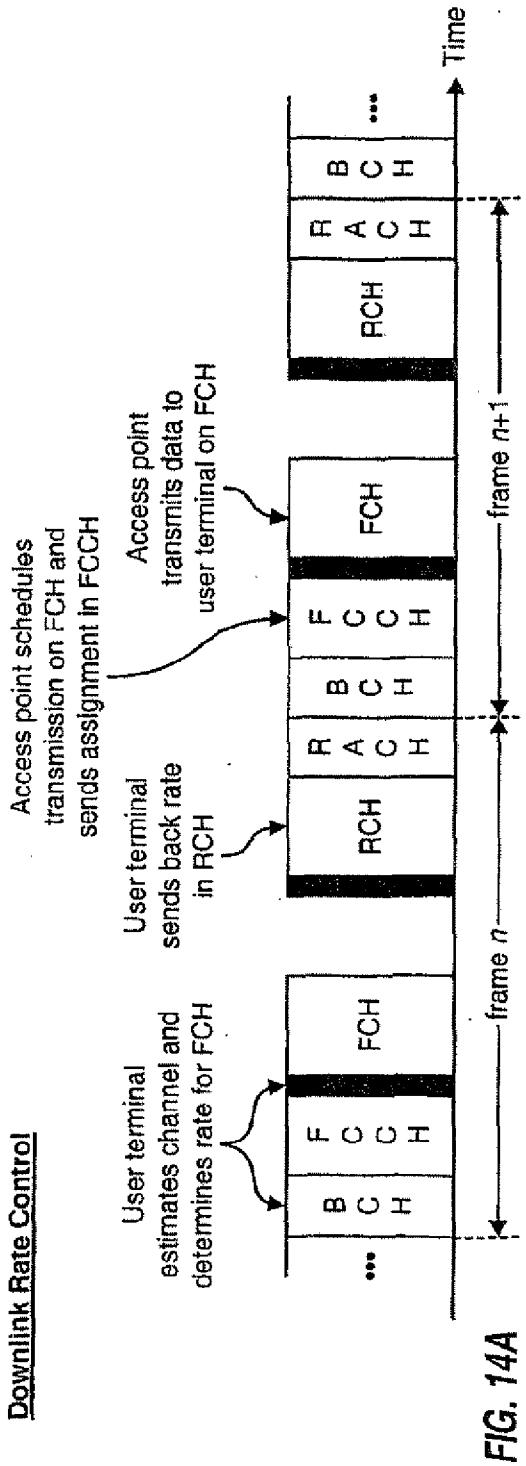


FIG. 14A

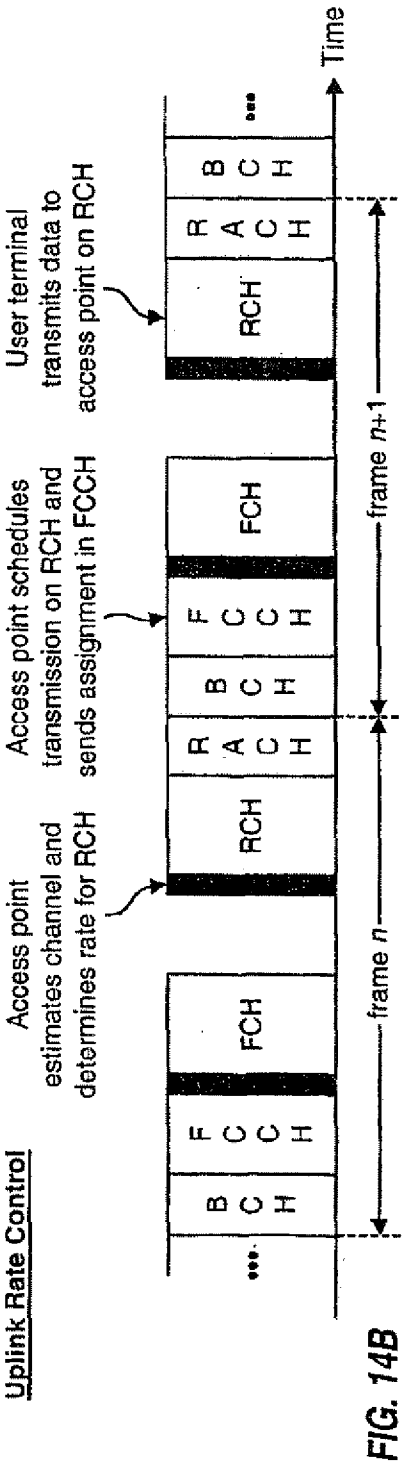


FIG. 14B

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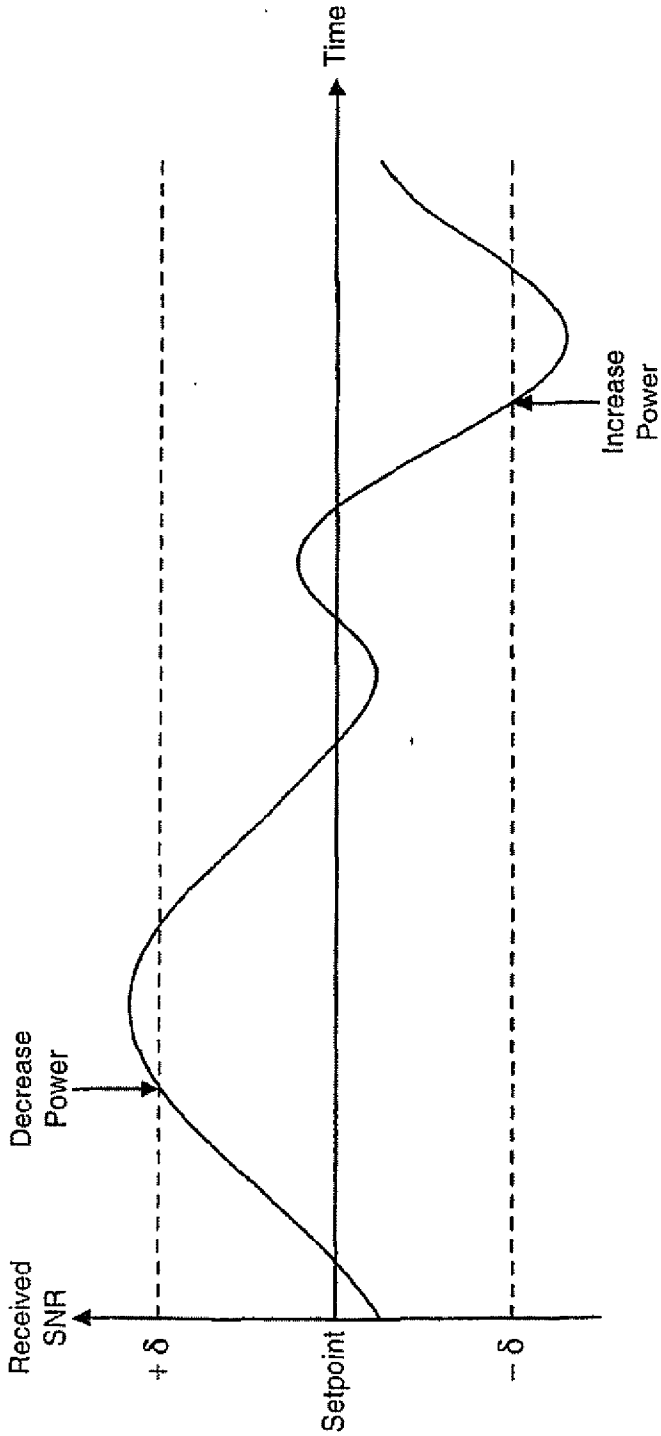

Time
Increase Power
Decrease Power
Received SNR
+ δ
Setpoint
– δ

FIG. 15

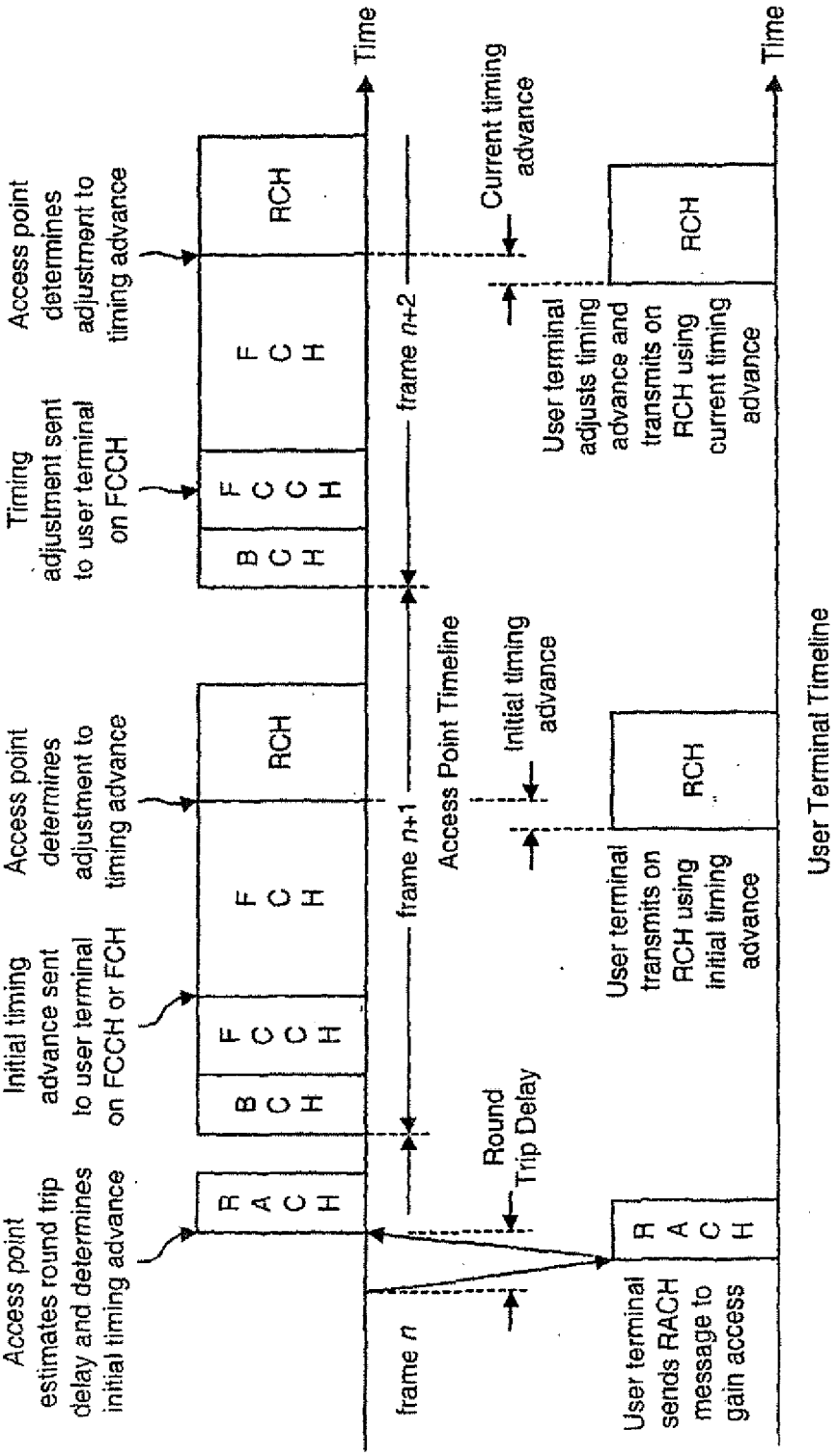

Time
Access point estimates round trip delay and determines initial timing advance
RACH
Initial timing advance sent to user terminal on FCCH or FCH
BCCH
FCCH
Access point determines adjustment to timing advance
RCH
Timing adjustment sent to user terminal on FCCH
BCCH
FCCH
Access point determines adjustment to timing advance
RCH
frame n
Round Trip Delay
frame n+1
frame n+2
Access Point Timeline
Initial timing advance
Current timing advance
User terminal sends RACH message to gain access
RACH
User terminal transmits on RCH using initial timing advance
RCH
User terminal adjusts timing advance and transmits on RCH using current timing advance
RCH
User Terminal Timeline
Time

FIG. 16

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 01 9630

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 02/078211 A (QUALCOMM INCORPORATED) 3 October 2002 (2002-10-03) * abstract * * paragraphs [1019] - [1025], [1032] * * paragraphs [1056], [1057] *	1-19	H04L12/28
A	US 5 509 003 A (SNIJDERS ET AL) 16 April 1996 (1996-04-16) * column 2, line 5 - line 22 * * column 4, line 4 - line 65; claims 1,2 *	1-19	
A	TUJKOVIC D ED - INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS: "High bandwidth efficiency space-time turbo coded modulation" ICC 2001. 2001 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS. CONFERENCE RECORD. HELSINKY, FINLAND, JUNE 11 - 14, 2001, IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS, NEW YORK, NY : IEEE, US, vol. VOL. 1 OF 10, 11 June 2001 (2001-06-11), pages 1104-1109, XP010553500 ISBN: 0-7803-7097-1 * par. II *	1-19	

TECHNICAL FIELDS SEARCHED (IPC)
H04B
H04L
H04Q
H01Q
H04J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 November 2005	Falò, L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 01 9630

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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16-11-2005

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 02078211 A	03-10-2002	CN 1552132 A	01-12-2004
		EP 1371147 A2	17-12-2003
		JP 2005502223 T	20-01-2005
		US 2004165558 A1	26-08-2004
		US 2002191703 A1	19-12-2002
		US 2005002326 A1	06-01-2005
		US 2003003880 A1	02-01-2003
US 5509003 A	16-04-1996	DE 69423546 D1	27-04-2000
		DE 69423546 T2	21-09-2000
		JP 3514823 B2	31-03-2004
		JP 7170284 A	04-07-1995

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 681 780 A1

(12) EUROPEAN PATENT APPLICATION

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(51) Int Cl.:
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(22) Date of filing: **27.04.2005**

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Designated Extension States:
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(30) Priority: **14.01.2005 JP 2005007508**

(71) Applicant: **FUJITSU LIMITED**
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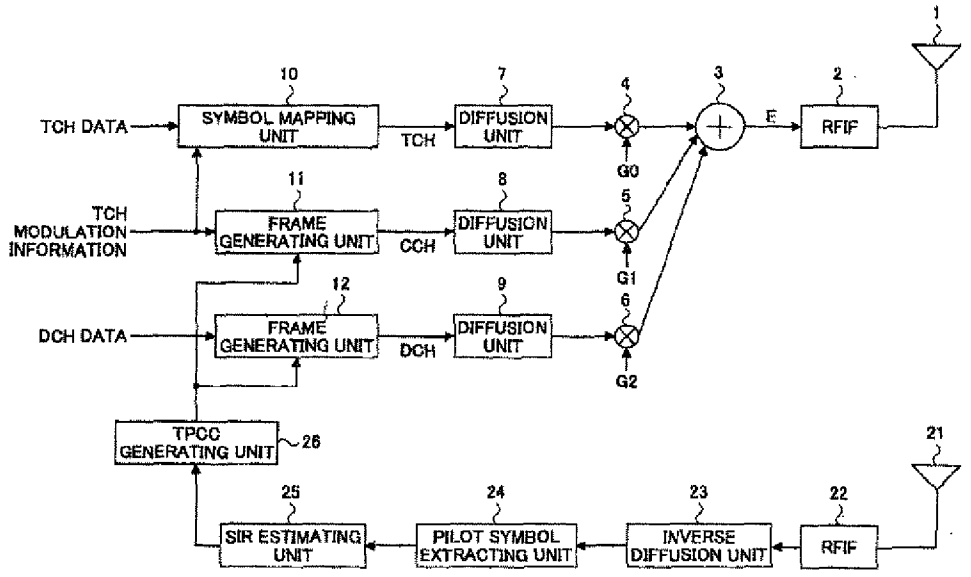
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(54) Mobile wireless communication system and wireless communication apparatus

(57) A mobile wireless communication system including a wireless communication apparatus and a counterpart wireless communication apparatus is provided, the system establishing wireless communication between the wireless communication apparatus and the counterpart wireless communication apparatus by multiplexing (3, 44) plural channels including at least a traffic channel (TCH) for transmitting a packet, a control channel (CCH) for transmitting control information for receiving the packet, and a channel (DCH) for transmitting information including transmission power control information. The wireless communication apparatus includes a transmission unit (1) that transmits the transmission control information to the counterpart wireless communication apparatus via the channel for transmitting information including transmission power control information at intervals of a prescribed period that is longer than a length of the packet, and transmits the transmission power control information via the control channel when the packet is being transmitted via the traffic channel.

FIG.3



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a mobile wireless communication system and a wireless communication apparatus that establishes wireless communication by controlling transmission power according to transmission power control information.

2. Description of the Related Art

[0002] A mobile wireless communication system that establishes wireless communication between wireless communication apparatuses such as a mobile station and a base station may have a configuration as is shown in FIG.1. The mobile wireless communication system of FIG.1 includes plural base stations 50a and 50b as wireless communication apparatuses that are located in different areas, and a mobile station 50c that conducts wireless communication while moving within the service areas of the base stations 50a and 50b. The base stations 50a and 50b and the mobile station 50c include antennas 51a, 51b, and 51c, transmission/reception units53a, 53b, and 53c that include amplifiers, modulators, and demodulators, for example, and signal processing units 54a, 54b, and 54c, respectively. Also, the base stations 50a and 50b include interface units 52a and 52b, respectively, that form interfaces with a network (not shown).

[0003] The wireless communication scheme used in the wireless communication between the mobile station 50c and the base stations 50a and 50b may correspond to the W-CDMA (Wide-Code Division Multiple Access) scheme, the OFDM (Orthogonal Frequency Division Multiplexing) scheme, or other various schemes. Also, it is noted that transmission power control (TPC) information is transmitted from the base stations 50a and 50b to the mobile station 50c at predetermined intervals via downlink channels (dedicated channels) so that a signal transmitted from the mobile station 50c to the base stations 50a and 50b may be received with a suitable power that is sufficient for proper signal reception but is below a level that may cause interference with other channels. Based on the transmission power control information, the mobile station 50c conducts transmission power control to increase/decrease the transmission power of the transmission/reception unit 53c. The transmission power control information is generated according to the reception level (quality) of a signal such as a pilot signal that is transmitted from the mobile station 50c. For example, when the reception level (quality) is high, control information directing a decrease of the transmission power may be generated, and when the reception level (quality) is low, control information directing an increase of the transmission power may be generated.

[0004] In a mobile wireless communication system that realizes packet communication, an ACK signal is transmitted when a packet is properly received, and a NACK signal is transmitted when a packet cannot be properly received, the signals being transmitted via a dedicated channel. In such a system, even when packet transmission is rarely conducted, and transmission of reception response signals such as ACK and NACK signals is not necessary, a signal such as a pilot signal is continually transmitted via another dedicated channel for suitably adjusting the transmission power of the dedicated channel used for transmitting the reception response signals such as ACK and NACK signals. Thus, the mobile station unnecessarily consumes power for transmitting such signals.

[0005] In the W-CDMA scheme, HSDPA (High Speed Downlink Packet Access) for realizing a maximum downlink transmission speed of 14 Mbps is defined. According to this scheme, adaptive coding modulation is used for packet transmission. For example, QPSK (Quadrature Phase Shift Keying) modulation and 16-QAM (Quadrature Amplitude Modulation) may be adaptively interchanged to realize a transmission rate in accordance with the state of the wireless propagation path.

[0006] It is noted that HSDPA uses the H-ARQ (Hybrid Automatic Repeat Request) scheme. For example, in the mobile wireless communication system of FIG.1, when the mobile station 50c receives packet data from the base station 50a and detects an error, the mobile station 50c sends a request to the base station 50a to retransmit the packet data. In turn, the base station 50a conducts retransmission of the packet data, and the mobile station 50c conducts an error correction decoding process using both the initially received data and the retransmitted data.

[0007] Also, it is noted that wireless channels such as HS-SCCH (High Speed-Shared Control Channel), HS-PDSCH (High Speed-Physical Downlink Shared Channel), and HS-DPCCH (High Speed-Dedicated Physical Control Channel) are used in HSDPA.

[0008] The wireless channels HS-SCCH and HS-PDSCH in a mobile wireless communication system correspond to downlink shared channels from the base station to the mobile station. The HS-SCCH corresponds to a control channel for transmitting parameter information pertaining to data transmitted by the HS-PDSCH. The parameter information may include modulation type information indicating the modulation method used in transmitting data via the HS-PDSCH, the diffusion code number, and pattern information for a rate matching process that is conducted on transmission data, for example.

[0009] The HS-DPCCH in the mobile wireless communication system corresponds to an uplink dedicated control channel from the mobile station to the base station, and is used upon transmitting from the mobile station to the base station an ACK signal or a NACK signal indicating whether data received via the HS-PDSCH are properly received. For example, in a case where CRC error is detected in the received data, a NACK signal is transmitted to the base station, and the base station con-

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ducts retransmission of the data in response to the NACK signal. Also, the HS-DPCCH is used to measure the reception quality (e.g. , SIR: Signal to Interference Ratio) of a signal received from the base station, and periodically transmit the measurement result to the base station as a CQI (Channel Quality Indicator). The base station determines the state of the downlink wireless environment based on the CQI, and when it is determined that the wireless environment is in a good state, the base station switches to a modulation method that enables data transmission at a higher speed. On the other hand, when it is determined that the wireless environment is not in a good state, the base station switches to a modulation method that realizes data transmission at a lower speed.

[0010] FIG.2 is a diagram showing the channels used in HSDPA. In this drawing, the wireless channels CPICH, P-CCPCH, HS-SCCH, HS-PDSCH, HS-DPCCH are shown. It is noted that the CPICH (Common Pilot Channel) and the P-CCPCH (Primary Common Control Physical Channel) correspond to downlink shared channels. The CPICH corresponds to a channel used for channel estimation and cell search at the mobile station, and as a timing reference of other downlink physical channels within the same cell; that is, the CPICH corresponds to a channel for transmitting the so-called pilot signal. The P-CCPCH corresponds to a channel for transmitting report information. The channels HS-SCCH, HS-PDSCH, and HS-DPCCH correspond to control channels as described above, and the HS-DPCCH is used to transmit the CQI and ACK/NACK signals.

[0011] In the illustrated example of FIG.2, 15 slots make up one frame (10 ms), and since the CPICH is used as a timing reference, the beginning (head) of the frames of the channels P-CCPCH and HS-SCCH correspond to the beginning (head) of the frame of CPICH; however, the beginning (head) of the frame of the HS-PDSCH is delayed by two slots. Such a delay is made so that the mobile station may receive and identify information pertaining to demodulation of the HS-PDSCH beforehand. That is, information pertaining to the modulation method and diffusion code is provided beforehand via the HS-SCCH so that demodulation and decoding of the HS-PDSCH may be suitably realized. Also, it is noted that in the channels HS-SCCH and HS-PSDCH, three slots make up one sub frame.

[0012] According to 3GPP TS 25.212 v.5.7.0 (3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (FDD)), the HS-SCCH represents the following information items:

(a) Xccs (Channelization Code Set Information); 7 bits; information on the diffusion code used for the HS-PDSCH;
(b) Xms (Modulation Scheme Information); 1 bit; modulation method used for the HS-PDSCH;
(c) Xtbs (Transport-Block Size Information) ; 6 bits; transmission data block size for error correction coding;
(d) Xhap (Hybrid-ARQ Process Information); 3 bits; process number for conducting retransmission control;
(e) Xrv (Redundancy and Constellation Version); 3 bits; parameter for rate matching;
(f) Xnd (New Data Indicator); 1 bit; information indicating whether data corresponds to new data; and
(g) Xue (UE Identity); 16 bits; user identification information.

[0013] As can be appreciated from the above descriptions, the HS-SCCH is made up of 37 bits, and by receiving the HS-SCCH, parameter information pertaining to the modulation method, the diffusion code, and error correction, for example, may be identified. In turn, demodulation and decoding of the HS-DSCH may be conducted according to the parameter information.

[0014] The information (a) Xccs represents information on the diffusion code used in transmitting data via the HS-PDSCH. For example, Xccs may represent a combination of the multi-code number and code offset. The information (b) Xms indicates the modulation method being used, and for example, Xms may correspond to '1' or '0' depending on whether the current modulation method corresponds to QPSK modulation or 16-QAM. The information (c) Xtbs corresponds to data for calculating the data size for transmitting a sub frame of the HS-PDSCH. The information (d) Xhap represents a process number for H-ARQ, and corresponds to a consecutive number with respect to that of a previously transmitted data block. It is noted that in the case of a retransmission process, the same process number assigned to the previously transmitted data block is used.

[0015] The information (e) Xrv represents redundancy parameter or constellation parameter information in the retransmission of the HS-PDSCH. It is noted that in some cases, the parameter information may be updated upon transmission or retransmission, and in other cases, the parameter information may be left as it is. The information (f) Xnd corresponds to data indicating whether the transmitted block corresponds to a new data block or a retransmitted data block. For example, in the case of a new block, '1' and '0' may be interchanged, and in the case of a retransmitted block, the arrangement of '1' and '0' may be left unchanged. The information (g) Xue corresponds to identification information of the mobile station (user)

[0016] By receiving the HS-SCCH, parameter information pertaining to the modulation method, the diffusion code, and error correction used at the HS-PDSCH may be identified, and demodulation and decoding of the HS-PDSCH may be conducted (e.g., see "Multi-Antenna Transceiver Techniques for 3G and Beyond" by Ari Hottinen, Olav Tirkkonen, and Risto Wichman; 3GPP TS 25.211, Physical Channels and Mapping of Transport Channels onto Physical Channels (FDD), v. 5.5.0; 3GPP

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TS 25.213, Spreading and Modulation (FDD), v. 5.5.0; and 3GPP TS 25.214, Physical Layer Procedures (FDD), v. 5.7.0).

[0017] Also, to enhance the W-CDMA system, use of the F-DPCH (Fractional Dedicated Physical Channel) is proposed (e.g. see 3GPP RI-031073) . According to this technique, the same diffusion code is assigned to the pilot signals and transmission power control (TPC) information of a dedicated channel for plural users, and transmission is conducted through time division multiplexing within the same slot.

[0018] Generally, a mobile station (user) that receives data via a shared channel (traffic channel) such as the HS-PDSCH transmits traffic data via the HS-PDSCH, and thereby, data to be transmitted via the dedicated channel (e.g. , DPCH as opposed to an HS channel) are virtually non-existent at such a mobile station. Nonetheless, TPC bits and pilot signals have to be transmitted in order to conduct transmission power control, and thereby, the dedicated channel (DPCH) and the HS-PDSCH have to be connected at the same time. In this case, a code is occupied even when data transmission does not have to be conducted, and when plural mobile stations (users) in similar situations exist, a deficiency in code resources may be created. In response to such a problem, the technique implementing the F-DPCH involves using the same code to conduct a diffusion process and time division multiplexing with respect to TPC bits and pilot signals of plural users that have no transmission data to be transmitted through a dedicated channel.

[0019] Also, as another measure for countering a deficit of code resources, Japanese Laid-Open Patent Publication No. 11-145901 discloses a wireless communication apparatus that conducts transmission power control through providing a dedicated power control channel, embedding TPC bits of plural users into the transmission power control channel through time division multiplexing, and embedding identical TPC bits into traffic channels for conducting packet transmission, wherein when a packet to be transmitted is generated, the TPC bits of the power control channel is converted into invalid information so that the TPC bits of the traffic channel is prioritized.

[0020] In the W-CDMA scheme, transmission power control (TPC) of a dedicated channel (DPCH) is conducted via an uplink channel. The transmission power control (TPC) involves controlling the transmission power of the mobile station by feeding back transmission control information referred to as TPC bits in slot units from the base station to the mobile station. On the other hand, in a packet communication scheme using shared channels such as the HS-PDSCH, pilot signals and TPC bits are periodically transmitted via uplink and downlink DPCH channels so that transmission power for transmitting a reception response signal is adjusted to a suitable level at a mobile station even when data are not addressed to the mobile station. In such a case, code resources have to be used for transmission power control of the respective dedicated channels, and thereby, a deficiency in code resources is created. Also, since the mobile station has to transmit pilot signals on a constant basis, a large amount of power is consumed as a result.

[0021] Also, a technique is proposed in the prior art that uses the F-DPCH in the W-CDMA scheme to integrate plural A-DPCH channels through time division multiplexing for realizing efficient use of code resources. However, since transmission power control (TPC) bits are transmitted in slot units, multiplexing may not be conducted for a large number of users. That is, according to this technique, a large number of mobile stations conducting packet transmission cannot be accommodated within the same area. Also, according to this technique, it is assumed that a signal is transmitted on a constant basis via the uplink channel. That is, the mobile station is arranged to transmit a signal such as a pilot signal for realizing transmission power control regardless of whether packet transmission is conducted. This arrangement is disadvantageous from the point of view of power conservation. It is noted that the mobile station uses a relatively small battery as a power source to conduct transmission/reception processes, and thereby, it is desired that power consumption be reduced in order to realize packet transmission for a long period of time.

[0022] Also, in the prior art technique involving the use of a power control channel and a traffic channel for transmitting TPC bits, when the TPC bits are transmitted via the traffic channel, the TPC bits at the power control channel have to be invalidated in order to prevent generation of a conflict. Such processes may be quite complicated thereby leading to high power consumption. Also, since the power control channel is arranged to be transmitted when a transmission control packet does not exist and is therefore not transmitted on a periodic basis, power control may not be stabilized.

SUMMARY OF THE INVENTION

[0023] The present invention has been conceived in response to one or more of the problems of the related art, and its object is to enable transmission power control with low power consumption and high accuracy.

[0024] According to an aspect of the present invention, a mobile wireless communication system is provided that includes:

a wireless communication apparatus and a counterpart wireless communication apparatus; wherein wireless communication is established between the wireless communication apparatus and the counterpart wireless communication apparatus by multiplexing a plurality of channels including at least a traffic channel for transmitting a packet, a control channel for transmitting control information for receiving the packet, and a channel for transmitting information including transmission power control information; and

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the wireless communication apparatus includes a transmission unit that transmits the transmission control information to the counterpart wireless communication apparatus via the channel for transmitting information including transmission power control information at intervals of a prescribed period that is longer than a length of the packet, and transmits the transmission power control information via the control channel when the packet is being transmitted via the traffic channel.

[0025] In a preferred embodiment of the present invention, the counterpart wireless communication apparatus includes a transmission unit that transmits a pilot signal right before receiving the transmission power control information transmitted from the wireless communication apparatus via the channel for transmitting information including transmission power control information and right after receiving the transmission power control information transmitted from the wireless communication apparatus via the control channel.

[0026] In another preferred embodiment of the present invention, the transmission power control information transmitted from the wireless communication apparatus to the counterpart wireless communication apparatus includes first transmission power control information that is transmitted via the channel for transmitting information including transmission power control information and second transmission power control information that is transmitted via the control channel, and the transmission unit of the counterpart wireless communication apparatus transmits the pilot signal at periodic intervals shorter than a transmission period at which the first transmission power control information is transmitted.

[0027] In another preferred embodiment of the present invention, the transmission power control information transmitted from the wireless communication apparatus to the counterpart wireless communication apparatus includes first transmission power control information that is transmitted via the channel for transmitting information including transmission power control information and second transmission power control information that is transmitted via the control channel, and a transmission power control level represented by the second transmission power control information is arranged to be greater than or equal to a transmission power control level represented by the first transmission power control information.

[0028] According to another aspect of the present invention, a wireless communication apparatus is provided that is configured to transmit data within a mobile wireless communication system that realizes data transmission via a shared channel, the apparatus including:

a transmission unit that is configured to transmit to a mobile station first transmission power control information at intervals of a prescribed period, and transmit control information for receiving the data including second transmission power control information when transmitting the data to the mobile station.

[0029] In a preferred embodiment of the present invention, a transmission power control level represented by the second transmission power control information that is included in the control information is arranged to be greater than or equal to a transmission power control level represented by the first transmission power control information that is transmitted at intervals of the prescribed period.

[0030] According to another aspect of the present invention, a wireless communication apparatus is provided that is configured to receive data within a mobile wireless communication system that realizes data transmission via a shared channel, the apparatus including:

a transmission unit that is configured to transmit a pilot signal in conjunction with receiving control information for receiving the data.

[0031] In a preferred embodiment of the present invention, the transmission unit is further configured to transmit the pilot signal at intervals of a prescribed period, and the transmission of the pilot signal in conjunction with the reception of the control information is conducted at periodic intervals shorter than the prescribed period.

[0032] According to an aspect of the present invention, transmission power control information is transmitted at prescribed periodic intervals via a channel for transmitting information including the transmission power control information, and when packet transmission is conducted, transmission power control information is also transmitted via a control channel. When packet transmission is not conducted, the transmission power control information is transmitted via the channel for transmitting information including transmission power control information at prescribed periodic intervals that are set to be relatively long, thereby enabling conservation of power. According to an embodiment of the present invention, a pilot signal is transmitted at prescribed periodic intervals rather than being continuously transmitted, and the packet signal is also transmitted upon indicating the presence of a packet for transmission to thereby enable further power conservation. According to an embodiment of the present invention, the transmission power control information includes first transmission power control information that is transmitted via the channel for transmitting information including transmission power control information and second transmission power control information that is transmitted via the control channel, and a transmission power control level represented by the second transmission power control information is arranged to be greater than that represented by the first transmission power control information to improve responsiveness of the transmission power control operation.

[0033] According to another aspect of the present invention, by transmitting the transmission power control

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information at prescribed periodic intervals, the transmission power control information may be included in the control information for receiving data while maintaining stability in the transmission power control operation, and the transmission power control information may be transmitted in conjunction with data transmission.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034]

FIG.1 is a diagram showing a configuration of a mobile wireless communication system;
FIG.2 is a diagram showing channels used in HSDPA;
FIG.3 is a diagram showing a configuration of a wireless communication apparatus according to an embodiment of the present invention;
FIG.4 is a diagram showing a configuration of a counterpart wireless communication apparatus according to an embodiment of the present invention;
FIG.5 is a diagram illustrating a transmission power control operation according to a first embodiment of the present invention; and
FIG.6 is a diagram illustrating a transmission power control operation according to a second embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] In the following, preferred embodiments of the present invention are described with reference to the accompanying drawings.

[0036] A mobile wireless communication system according to an embodiment of the present invention includes a wireless communication apparatus such as a base station and a counterpart wireless communication apparatus such as a mobile station, and is arranged to establish wireless communication between the wireless communication apparatus and the counterpart wireless communication apparatus by multiplexing a plurality of channels including at least a traffic channel for transmitting a packet, a control channel for transmitting control information for receiving the packet, and a channel for transmitting information including transmission power control information. In such a system, the wireless communication apparatus corresponding to a base station, for example, is arranged to include a transmission unit that transmits the transmission control information to the counterpart wireless communication apparatus corresponding to the mobile station, for example, via the channel for transmitting information including transmission power control information at intervals of a prescribed period that is longer than the length of the packet, and transmits the transmission power control information via the control channel when the packet is being transmitted via the traffic channel.

[0037] A wireless communication apparatus according to an embodiment of the present invention corresponds to a wireless communication apparatus such as a base station of a mobile wireless communication system, and includes a transmission unit that is configured to transmit to a mobile station via a dedicated channel first transmission power control information at intervals of a prescribed period that is longer than a length of a packet transmitted by a traffic channel, and transmit second transmission power control information via a control channel when transmitting the packet via the traffic channel.

[0038] It is noted that the transmission power control information in the following descriptions is assumed to be. valid information (to be used at the reception side)o

[0039] FIG.3 is a diagram showing an exemplary configuration of a wireless communication apparatus according to an embodiment of the present invention. The wireless communication apparatus of FIG.3 may correspond to a wireless communication apparatus such as a base station of a mobile wireless communication system implementing the CDMA scheme that includes at least a wireless communication apparatus and a counterpart wireless communication apparatus. According to the present example, the wireless communication apparatus includes antennas 1 and 21, a high frequency processing unit (RFIF) 2, a multiplexing unit 3, multiplying units 4, 5, and 6, diffusion units 7, 8, and 9, a symbol mapping unit 10, frame generating units 11 and 12, a high frequency processing unit (RFIF) 22, an inverse diffusion unit 23, a pilot symbol extracting unit 24, a SIR (Signal to Interference Ratio) estimating unit 25, and a TPCC (transmission power control information) generating unit 26. It is noted that known configurations may be implemented to realize the interface with the network (in a case where the apparatus corresponds to a base station) and generation processing units for generating TCH data, TCH modulation information, and DCH data, and thereby, such components are omitted from the present drawing.

[0040] According to the present embodiment, the high frequency processing unit 2 that is connected to the antenna 1 includes an encoder, a modulator, and an amplifier, for example. The high frequency processing unit 22 that is connected to the antenna 21 includes a low noise amplifier, a demodulator, and a decoder, for example. Also, TCH (traffic channel such as HS-PDSCH) data are input to the symbol mapping unit 10, TCH modulation information (e.g., information to be transmitted via the HS-SCCH) is input to the symbol mapping unit 10 and the frame generating unit 11, and DCH (dedicated channel such as DPCH) data are input to the frame generating unit 12. At the symbol mapping unit 10, the TCH data are mapped according to the TCH modulation information, and input to the diffusion unit 7 as traffic channel TCH. At the diffusion unit 7, a diffusion process is conducted on the TCH using a diffusion code assigned to the TCH, and the diffused signal is input to the multiplying unit 4.

[0041] The frame generating unit 11 generates a frame including the TCH modulation information and transmis-

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sion power control information from the TPCC generating unit 26, and inputs the generated frame to the diffusion unit 8 as a control channel CCH. At the diffusion unit 8, a diffusion process is conducted using a diffusion code assigned to the control channel CCH, and the diffused signal is input to the multiplying unit 5. The frame generating unit 12 generates a frame including the DCH data and the transmission power control information from the TPCC generating unit 26, and inputs the generated frame to the diffusion unit 9 as a dedicated channel DCH. At the diffusion unit 9, a diffusion process is conducted using a diffusion code assigned to the dedicated channel, and the diffused signal is input to the multiplying unit 6. As can be appreciated from the above descriptions, in the present embodiment, the TCH data, the TCH modulation information, and the DCH data are diffused by differing diffusion codes. Also, the multiplying units 4, 5, and 6 multiply their inputs by gains G0, G1, and G2, respectively, to set the transmission power ratios of the respective channels, and at the multiplexing unit 3, multiplexing is realized by conducting adding processes on chips. The multiplexed signal is then input to the high frequency processing unit 2 at which modulation and amplification processes are conducted, and the resulting signal is transmitted via the antenna 1. It is noted that in this example, the diffusion codes used in the diffusion units 7, 8, and 9 are arranged to differ from each other.

[0042] The high frequency processing unit 22 conducts processes such as amplification, demodulation, and decoding on a signal received by the antenna 21. The inverse diffusion unit 23 receives the signal processed by the high frequency processing unit 22 and conducts an inverse diffusion process on the signal. Then, the pilot symbol extracting unit 24 receives the inverse-diffused signal and extracts a pilot symbol (e.g., upon receiving an uplink DPSCH). The SIR estimating unit 25 estimates a SIR (Signal to Interference Ratio) from plural pilot symbols, and inputs the estimated SIR value to the TPCC generating unit 26. The TPCC generating unit 26 compares the input SIR value with a threshold value, and sets the TPCC according to the comparison result. For example, when the SIR value is greater than the threshold value, the TPCC may be set to TPCC = -1 , and when the SIR value is less than the threshold value, the TPCC may be set to TPCC = +1. The TPCC is then input to the frame generating units 11 and 12 as transmission power control information. As is described below, the TPCC may also be arranged to conduct transmission power control in plural stages.

[0043] According to the present embodiment, the TCH modulation information and the transmission power control information TPCC are transmitted from the frame generating unit 11 by a control channel CCH (e.g., HS-SCCH), and the DCH data and the transmission power control information TPCC are transmitted from the frame generating unit 12 by a dedicated channel DCH (e.g., DPCH). That is, the transmission power control information is transmitted by both the control channel CCH and the dedicated channel DCH. In a case where the transmission power control information TPCC is transmitted by the dedicated channel DCH at relatively long periodic intervals and packet transmission is conducted based on a signal from the control channel CCH indicating whether a packet is present, the transmission power control information TPCC is transmitted by the control channel CCH in accordance with the packet transmission timing. It is noted that the transmission of the transmission power control information as is described above may be controlled by a control unit (not shown) . The transmission of the transmission power control information TPCC according to the packet transmission timing is conducted at shorter periodic intervals compared to that for the transmission of the transmission power control information TPCC by the dedicated channel DCH. Thereby, the responsiveness of the transmission power control operation may be improved. It is noted that in one embodiment, the power control level represented by the transmission power control information transmitted by the control channel CCH may be arranged to be greater than the power control level represented by the transmission power control information transmitted by the dedicated channel DCH.

[0044] FIG. 4 is a diagram showing an exemplary configuration of a counterpart wireless communication apparatus according to an embodiment of the present invention. The counterpart wireless communication apparatus of FIG.4 may correspond to a mobile station of the mobile wireless communication system using the CDMA scheme that includes a wireless communication apparatus and a counterpart wireless communication apparatus. The counterpart wireless communication apparatus of FIG.4 includes antennas 31 and 42, a high frequency processing unit (RFIF) 32, a CCH inverse diffusion unit 33, a TCH inverse diffusion unit 34, a DCH inverse diffusion unit 35, a bit determination unit 36, a TPCC extracting unit 37, a transmission power control unit 38, a high frequency processing unit (RFIF) 42, a multiplying unit 43, a multiplexing unit 44, and diffusion units 45, 46, and 47. It is noted that known configurations may be implemented to realize processing units for processing downlink traffic data and uplink traffic data, and thereby, such components are omitted from the present drawing.

[0045] The antenna 31 receives a signal transmitted from the antenna 1 of FIG.3, for example, and inputs the received signal to the high frequency processing unit 32. The high frequency processing unit 32 includes a low noise amplifier, a demodulator and a decoder, for example. The antenna 41 is configured to transmit a signal from the high frequency processing unit 42 to the antenna 21 of FIG. 3, for example. The high frequency processing unit 42 includes an encoder, a modulator, and a transmission power amplifier, for example. The high frequency processing unit 32 demodulates and decodes a received signal and inputs the processed signal to the CCH inverse diffusion unit 33, the TCH inverse diffusion unit 34, and the DCH inverse diffusion unit 35. In turn, the CCH in-

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verse diffusion unit 33, the TCH inverse diffusion unit 34, and the DCH inverse diffusion unit 35 conduct inverse diffusion processes on the input signal using the respective diffusion codes used in the corresponding diffusion processes conducted at the transmission side.

[0046] The CCH inverse diffusion unit 33 conducts an inverse diffusion process on the CCH information that is transmitted from the transmission side, and inputs the inverse-diffused information to the bit determination unit 36. The TCH inverse diffusion unit 34 conducts an inverse diffusion process on the TCH modulation information that is transmitted from the transmission side, and inputs the inverse-diffused information to the bit determination unit 36. In turn, the bit determination unit outputs downlink traffic data. Also, inverse diffusion outputs including transmission power control information that are obtained by inverse diffusion processes conducted by the TCH inverse diffusion unit 34 and the DCH inverse diffusion unit 35, respectively, are input to the TPCC extracting unit 37 at which the transmission power control information is extracted. The extracted transmission power information is then input to the transmission power control unit 38.

[0047] Also, according to the present embodiment, uplink traffic data, a pilot symbol, and a ACK/NACK signal based on the reception processing result of processing downlink traffic data output are input to the diffusion units 45, 46, and 47, respectively, to be diffused by differing diffusion codes. Then the diffused signals are multiplexed at the multiplexing unit 44, and multiplied at the multiplying unit 43 by a control value from the transmission power control unit 38 to realize transmission power control. Then, processes such as coding, modulation and amplification are conducted by the high frequency processing unit 42, after which the processed signal is transmitted via the antenna 41. According to an embodiment, the transmission power control unit 38 is configured to increment the transmission power Ptx by +1 dB when the transmission power control information TPCC extracted by the TPCC extracting unit 37 is greater than 0 (TPCC > 0), and the transmission power control unit 38 is configured to decrement the transmission power Ptx by -1 dB when the transmission power control information is TPCC is less than 0 (TPCC <0). In this way, the transmission power control unit 38 is arranged to input a value to the multiplying unit 43 according to the updated transmission power Ptx. It is noted that the transmission power control information TPCC may be arranged to use plural bits so that transmission power control may be conducted in plural stages (i.e., so that transmission power may be increased or decreased in plural stages).

[0048] FIG. 5 is a diagram illustrating a transmission power control operation according to a first embodiment of the present invention. In this drawing, a dedicated channel DCH, a control channel CCH, a traffic channel TCH, an uplink ACK/NACK signal transmission, and an uplink pilot signal transmission are shown. In the present embodiment, the uplink pilot signal is successively transmitted irrespective of the uplink ACK/NACK transmission. It is noted that in the present drawing, the transmission power levels are represented by the relative heights of the indicated signals. Given that transmission power control information TPCC transmitted by the dedicated channel DCH is referred to as first transmission.power control information, and the transmission power control information TPCC transmitted by the control channel CCH is referred to as second transmission power-control information, the first transmission power control information includes a slot that is made up of TPCC addressed to a present mobile station (self-addressed TPCC) and TPCC addressed to another mobile station, and a slot that does not include a self-addressed TPCC. In other words, first transmission power control information TPCC that is addressed to the present mobile station is transmitted at relatively long periodic intervals which transmission period may be set in advance at the transmission side. The self-addressed TPCC that is transmitted by the control channel CCH; namely, the second transmission power control information, is transmitted in accordance with the packet transmission period, which is arranged to be shorter than the transmission period of the first transmission power control information.

[0049] As can be appreciated from the above descriptions, when packet transmission is not conducted, the first transmission power control information is transmitted at relatively long periodic intervals, and accordingly, transmission power control is conducted at relatively long periodic intervals. When packet transmission is conducted, the second transmission power control information is transmitted according to the packet transmission period, and thereby, transmission power control may be conducted at a faster pace. Thus, when packet transmission is not conducted, unnecessary transmission power control processes are omitted so that the power consumption rate may be reduced. On the other hand, when packet transmission is conducted, the first transmission power control information and the second transmission power control information are transmitted so that high-pace transmission power control may be conducted with regard to state changes such as fading occurring in the wireless propagation path.

[0050] FIG.6 is a diagram illustrating a transmission power control process according to a second embodiment of the present invention. According to the present embodiment, F-DPCH (Fractional Dedicated Physical Channel) is used. The F-DPCH is made up of slots including at least a TPC bit and a pilot signal. In this drawing, a HS-SCCH (Shared Control Physical Channel) (downlink packet control channel), a HS-PDSCH (High Speed Downlink Shared Channel) (downlink traffic channel), an uplink ACK/NACK transmission (the transmission channel corresponding to a HS-DPCCH), and an uplink pilot transmission (the transmission channel corresponding to a DPCH are shown.

[0051] The TPC bit (transmission power control information) is transmitted via the F-DPCH and HS-SCCH.

[0052] The F-DPCH corresponds to a channel that is capable of transmitting a slot including plural TPC bits addressed to differing mobile stations. In the illustrated example, TPC bits addressed to two mobile stations are temporally multiplexed. It is noted that in this example, the transmission period of the TPC bits addressed to one mobile station (i.e., indicated as self-addressed TPC bits) is set to two slots. That is, the self-addressed TPC bit is not included in every other slot. Also, the transmission period of the TPCC addressed to another mobile station is also set to two slots in this example; however, it is noted that differing transmission periods may be set for the respective mobile stations.

[0053] The frames of the HS-SCCH are also configured to transmit TPC bits to mobile stations that are subject to control data transmission. It is noted that in the present drawing, HS-SCCH transmission to one mobile station is illustrated.

[0054] The mobile station receiving the HS-SCCH receives the HS-PDSCH and packet data, and transmits the reception result as a response signal (e.g., ACK/NACK signal) via the HS-DPCCH. According to the present example, the HS-PDSCH is received three times, and the ACK/NACK signal is transmitted after the elapse of a predetermined time from the channel reception timing, taking into account factors such as reception processing delay.

[0055] The pilot signal is transmitted in conjunction with the transmission period of the first transmission power control information (self-addressed TPCC), and is transmitted before the transmission timing of the first transmission power control information. It is noted that such a transmission power control may be realized by a control unit (not shown) according to the timing of inputting the pilot symbol to the diffusion unit 46 of the wireless communication apparatus shown in FIG.4, for example.

[0056] That is, a self-addressed TPCC is periodically transmitted, and in order to generate such transmission power control information, a known signal (pilot signal) is transmitted from the mobile station before the self-addressed TPCC is transmitted (i.e., prior to the TPCC transmission by a predetermined time period so as to be in time for the TPC bit generation).

[0057] The pilot signal is also transmitted in conjunction with the transmission of control information and ACK/NACK signals that are transmitted via the HS-SCCH.

[0058] That is, when a mobile station recognizes that data is being transmitted to itself via the HS-SCCH, or when it receives data addressed to itself via the HS-PDSCH, it transmits a known signal (pilot signal) upon transmitting an ACK signal or a NACK signal.

[0059] It is noted that the reception of the HS-PDSCH and the transmission of the ACK/NACK signal are conducted in conjunction with the reception of the HS-SCCH, and thereby, in either case, the known signal is transmitted in conjunction with the reception of the HS-SCCH.

[0060] According to the present embodiment, the wireless communication apparatus as is shown in FIG.3 that may correspond to a base station receives a pilot signal, conducts SIR estimation on the pilot signal at the SIR estimating unit 25, generates transmission power control information TPCC at the TPCC generating unit 26, and transmits the transmission power control information TPCC via the F-DPCH as first transmission power control information TPCC at relatively long periodic intervals (transmission period of the present mobile station). Also, in a case where packet transmission is conducted, the transmission power control information is transmitted via the HS-SCCH as second transmission power control information TPCC at a shorter periodic cycle. In this embodiment, transmission power control may be realized without having to transmit the pilot signal on a continual basis, and thereby, the power consumption rate for transmitting the pilot signal may be reduced. Also, in a case where data are transmitted via the HS-PDSCH, transmission power control may be conducted through transmission of an ACK/NACK signal before the transmission period of the first transmission power control information TPCC based on the transmission power control information TPCC that is previously transmitted via the HS-SCCH. Thereby, transmission power may be suitably controlled to quickly respond to the transmission quality such as the SIR of the wireless propagation path.

[0061] In a preferred embodiment, a predetermined number of pilot signals of a predetermined length are transmitted at a transmission period that is shorter than the transmission period of the first transmission power control information TPCC. When packet data are transmitted, it is likely that more data to be transmitted remain, and thereby, according to the present embodiment, preparation may be made for the transmission of the next data transmission in accordance with the transmission schedule.

[0062] Also, it is noted that the pilot transmission other than that in conjunction with the HS-SCCH transmission may be arranged to be conducted at a transmission period that is shorter than the transmission period of the first transmission power control information TPCC via the F-DPCH. When pilot signals are received and processed to realize SIR estimation, the estimation accuracy may be improved by increasing the number of pilot signals although increasing the pilot signal transmission leads to an increase in the power consumption for transmitting the pilot signal. Accordingly, in one embodiment, the transmission period for the first transmission power control information may be arranged to be relatively long to reduce power consumption, and the transmission period for transmitting the pilot signal may be adjusted to a shorter period in order to avoid degradation of the estimation accuracy.

[0063] In another embodiment, the first transmission power control information TPCC1 transmitted via the F-DPCH, and the second transmission power control information TPCC2 transmitted via the HS-SCCH may be arranged to represent different transmission power control levels. In such a case, the second transmission power

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control information TPCC2 is arranged to be greater than the first transmission power control information TPCC1 (TPCC1 < TPCC2). According to the present embodiment, in transmitting the ACK/NACK signal, for example, the second transmission power control information TPCC2 that is previously received via the HS-SCCH may be used to swiftly control the transmission power to a desired level.

[0064] It is noted that in the illustrated example of FIG. 6, the leftmost TPC bit in the HS-SCCH is generated based on the most recently received pilot signal before this TPC bit (i.e., the second pilot signal from the left in FIG.6). When a mobile station receives the third (from the left) pilot signal, the mobile station may generate the second (from the left) TPC bit in the HS-SCCH based on the third pilot signal, and thereby, accurate transmission power control may be conducted upon transmitting the first ACK signal.

[0065] Also, in the illustrated example of FIG.6, there is an interval between the second TPC bit and the third TPC bit in the HS-SCCH; however, since a predetermined number of the pilot signals at predetermined lengths are arranged to be transmitted in conjunction with the HS-SCCH transmission in the present embodiment, the TPC bit may be generated based on a pilot signal being transmitted at a shorter period compared to the transmission period of the first transmission power control information (e.g., the third TPC bit in the HS-SCCH is generated based on the sixth pilot signal). It is noted that in a preferred embodiment, the base station may recognize the transmission timing of the first transmission power control information TPCC1 addressed to plural mobile stations, and define and store a time period T that is shorter than the transmission period of the first transmission power control information TPCC1 for the respective mobile stations so that a HS-SCCH and/or a HS-PDSCH addressed to a mobile station may be transmitted to this mobile station before the time period T elapses from the transmission timing of the first transmission power control information TPCC1.

[0066] It is noted that the channel HS-PDSCH corresponds to a shared channel, and thereby, data addressed to plural mobile stations may be transmitted via this channel. According to the present embodiment, the HS-PDSCH is arranged to prioritize data transmission to a mobile station at which the elapsed time from a transmission timing of the first transmission power control information TPCC1 is not so long. According to such an arrangement, transmission power control may be effectively realized without including transmission power control information in the HS-SCCH. In one embodiment, the transmission power control information may be omitted for a first HS-SCCH (e. g. , a HS-SCCH of which transmission timing interval with respect to a previous HS-SCCH is longer than the transmission period of the first transmission power control information TPCC1), and the transmission power control information may be included in a next HS-SCCH of which the transmission timing interval with respect to a previous HS-SCCH is shorter than the transmission period of the first transmission power control information TPCC1.

[0067] In this embodiment, the transmission period of the pilot signal for a mobile station is arranged to be shorter in response to receiving a first HS-SCH, and accordingly, transmission power control may be conducted at shorter intervals. Also, it is noted that in FIG.6, some of the pilot signals are transmitted in conjunction with the transmission timing of the ACK/NACK signals. By transmitting the ACK signal, the NACK signal, and the pilot signal in sync with the transmission of an uplink signal, transmission efficiency may be realized. Arranging the transmission timing of the pilot signal transmitted in conjunction with the HS-SCCH to be in accordance with the transmission timing of the pilot signal may be one way of improving the transmission efficiency.

[0068] It is noted that application of the present invention is not limited to the W-CDMA scheme or the OFDM scheme; rather, the present invention may be equally applied to wireless communication apparatuses and mobile wireless communication systems using other various wireless communication schemes.

[0069] Further, the present invention is not limited to the specific embodiments described above, and variations and modifications may be made without departing from the scope of the present invention.

Claims

1. A mobile wireless communication system that includes a wireless communication apparatus and a counterpart wireless communication apparatus, and is configured to establish wireless communication between the wireless communication apparatus and the counterpart wireless communication apparatus by multiplexing a plurality of channels including at least a traffic channel for transmitting a packet, a control channel for transmitting control information for receiving the packet, and a channel for transmitting information including transmission power control information, the system being **characterized in that**:

   the wireless communication apparatus includes a transmission unit that transmits the transmission control information to the counterpart wireless communication apparatus via the channel for transmitting information including transmission power control information at intervals of a prescribed period that is longer than a length of the packet, and transmits the transmission power control information via the control channel when the packet is being transmitted via the traffic channel.

2. The mobile wireless communication system as

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claimed in claim 1 wherein:

the counterpart wireless communication apparatus includes a transmission unit that transmits a pilot signal right before receiving the transmission power control information transmitted from the wireless communication apparatus via the channel for transmitting information including transmission power control information and right after receiving the transmission power control information transmitted from the wireless communication apparatus via the control channel.

3. The mobile wireless communication system as claimed in claim 2, wherein:

the transmission power control information transmitted from the wireless communication apparatus to the counterpart wireless communication apparatus includes first transmission power control information that is transmitted via the channel for transmitting information including transmission power control information and second transmission power control information that is transmitted via the control channel; and
the transmission unit of the counterpart wireless communication apparatus transmits the pilot signal at periodic intervals shorter than a transmission period at which the first transmission power control information is transmitted.

4. The mobile wireless communication system as claimed in claim 1, wherein
the transmission power control information transmitted from the wireless communication apparatus to the counterpart wireless communication apparatus includes first transmission power control information that is transmitted via the channel for transmitting information including transmission power control information and second transmission power control information that is transmitted via the control channel; and
a transmission power control level represented by the second transmission power control information is arranged to be greater than or equal to a transmission power control level represented by the first transmission power control information.

5. A wireless communication apparatus that is configured to transmit data within a mobile wireless communication system that realizes data transmission via a shared channel, the apparatus being **characterized by** comprising:

a transmission unit that is configured to transmit to a mobile station first transmission power control information at intervals of a prescribed period, and transmit control information for receiving the data including second transmission power control information when transmitting the data to the mobile station.

6. The wireless communication apparatus as claimed in claim 5, wherein a transmission power control level represented by the second transmission power control information that is included in the control information is arranged to be greater than or equal to a transmission power control level represented by the first transmission power control information that is transmitted at intervals of the prescribed period.

7. A wireless communication apparatus that is configured to receive data within a mobile wireless communication system that realizes data transmission via a shared channel, the apparatus being **characterized by** comprising:

a transmission unit that is configured to transmit a pilot signal in conjunction with receiving control information for receiving the data.

8. The wireless communication apparatus as claimed in claim 7 wherein:

the transmission unit is further configured to transmit the pilot signal at intervals of a prescribed period; and
the transmission of the pilot signal in conjunction with the reception of the control information is conducted at periodic intervals shorter than the prescribed period.

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FIG.1

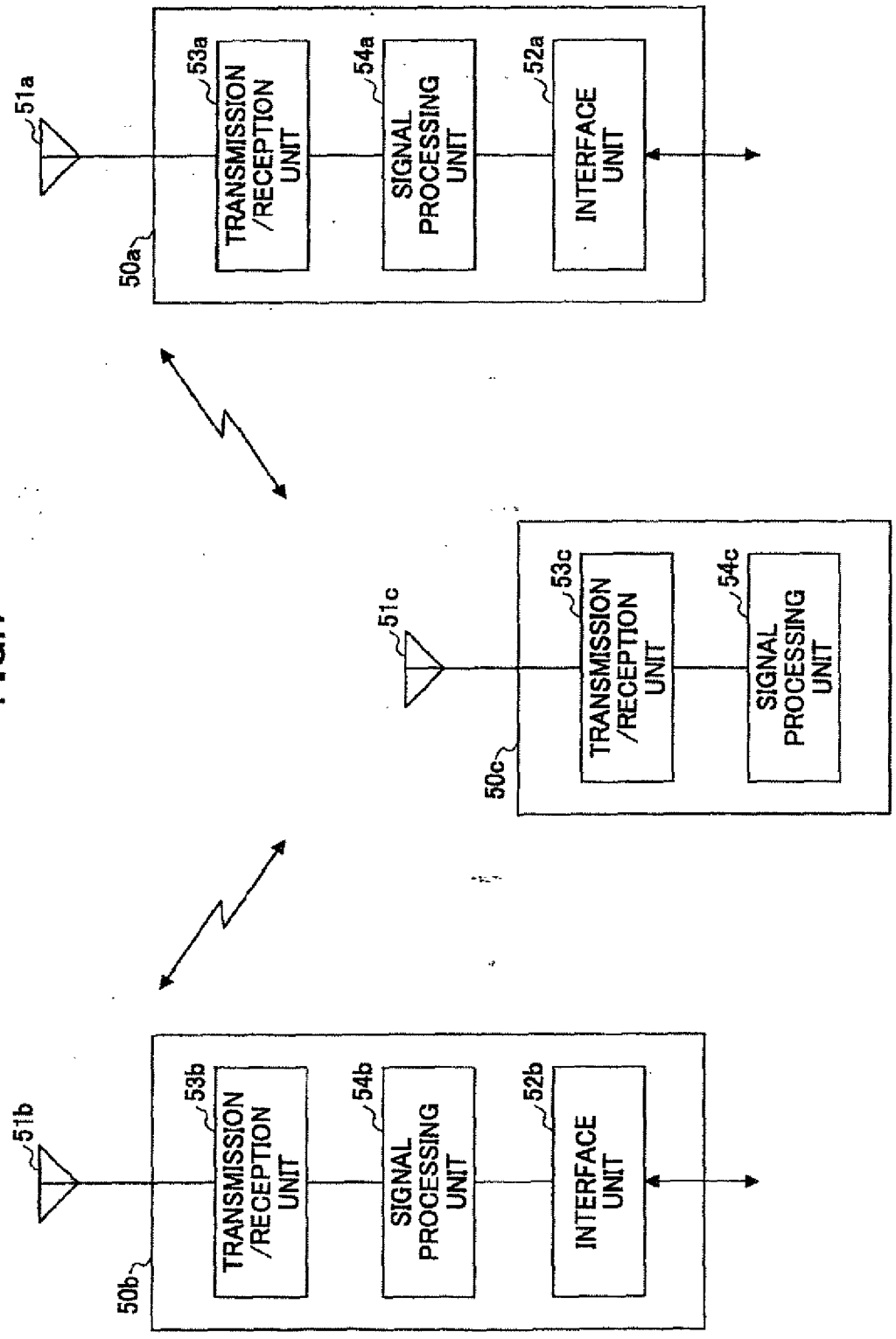
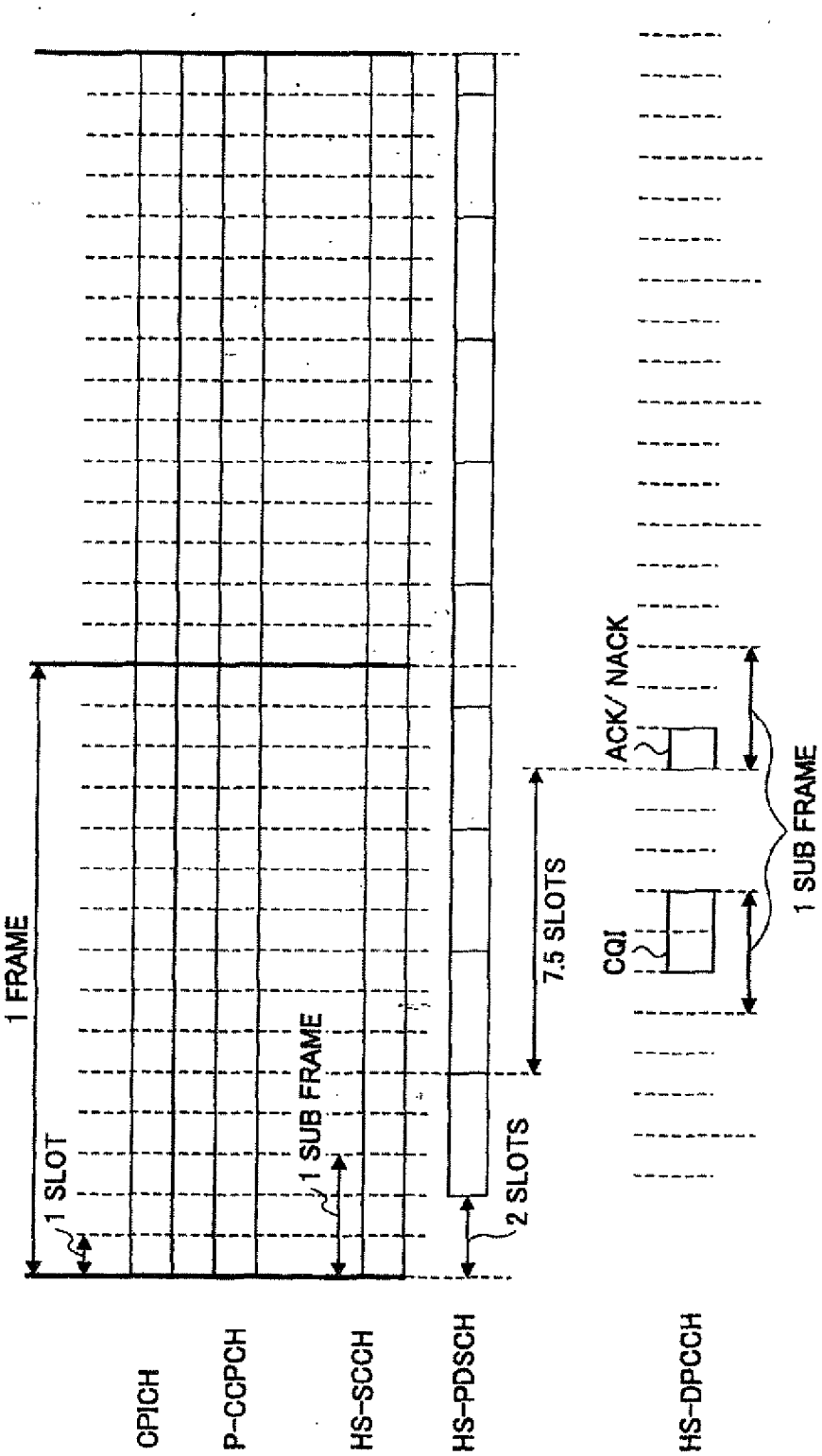

51a
53a
TRANSMISSION /RECEPTION UNIT
54a
SIGNAL PROCESSING UNIT
52a
INTERFACE UNIT
50a
51c
53c
TRANSMISSION /RECEPTION UNIT
54c
SIGNAL PROCESSING UNIT
50c
51b
53b
TRANSMISSION /RECEPTION UNIT
54b
SIGNAL PROCESSING UNIT
52b
INTERFACE UNIT
50b

FIG.2



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FIG.3

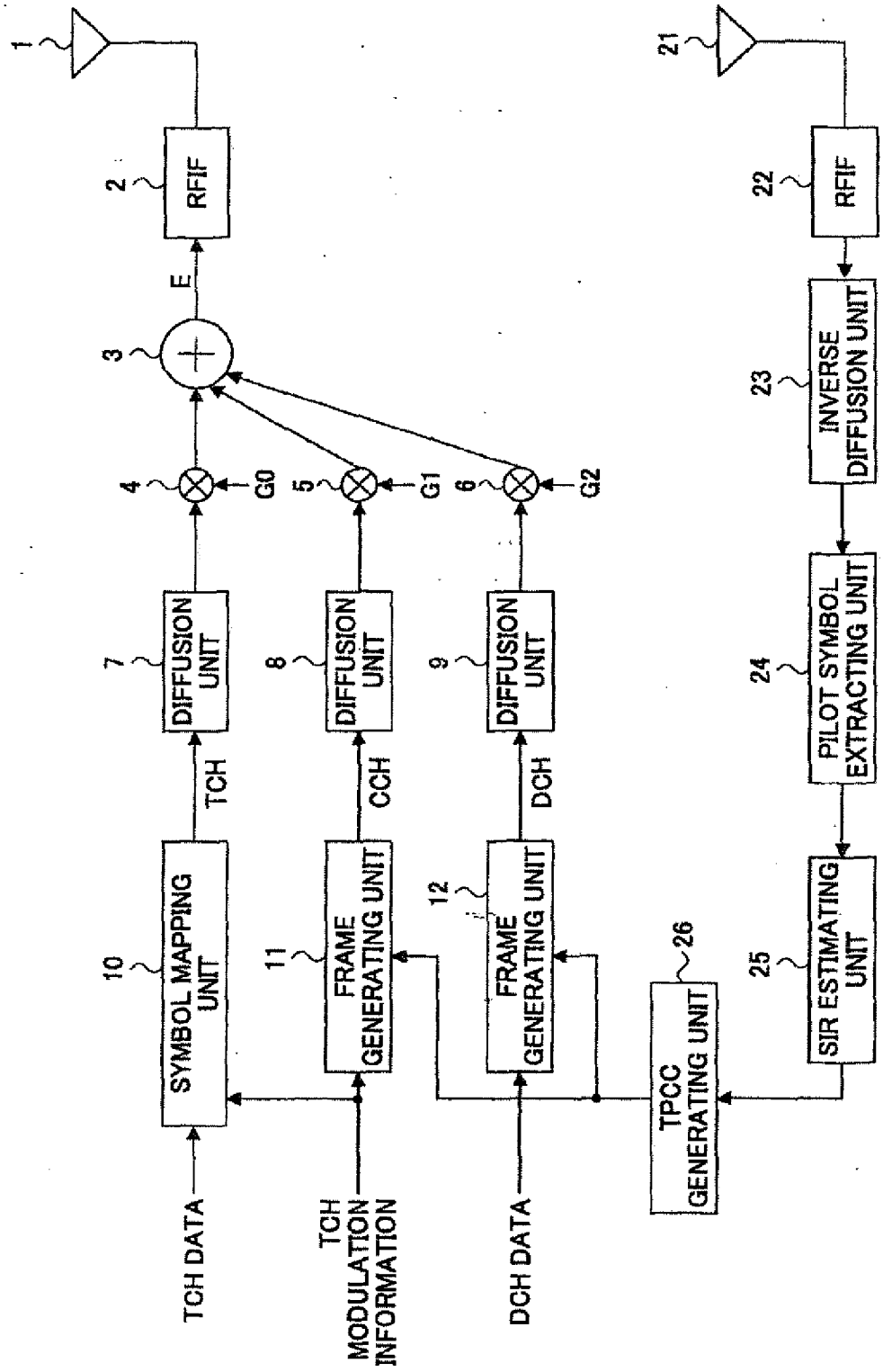

1
2
RFIF
E
3
4
G0
5
G1
6
G2
7
DIFFUSION UNIT
8
DIFFUSION UNIT
9
DIFFUSION UNIT
TCH
CCH
DCH
10
SYMBOL MAPPING UNIT
11
FRAME GENERATING UNIT
12
FRAME GENERATING UNIT
TCH DATA
TCH MODULATION INFORMATION
DCH DATA
26
TPCC GENERATING UNIT
21
22
RFIF
23
INVERSE DIFFUSION UNIT
24
PILOT SYMBOL EXTRACTING UNIT
25
SIR ESTIMATING UNIT

FIG.4

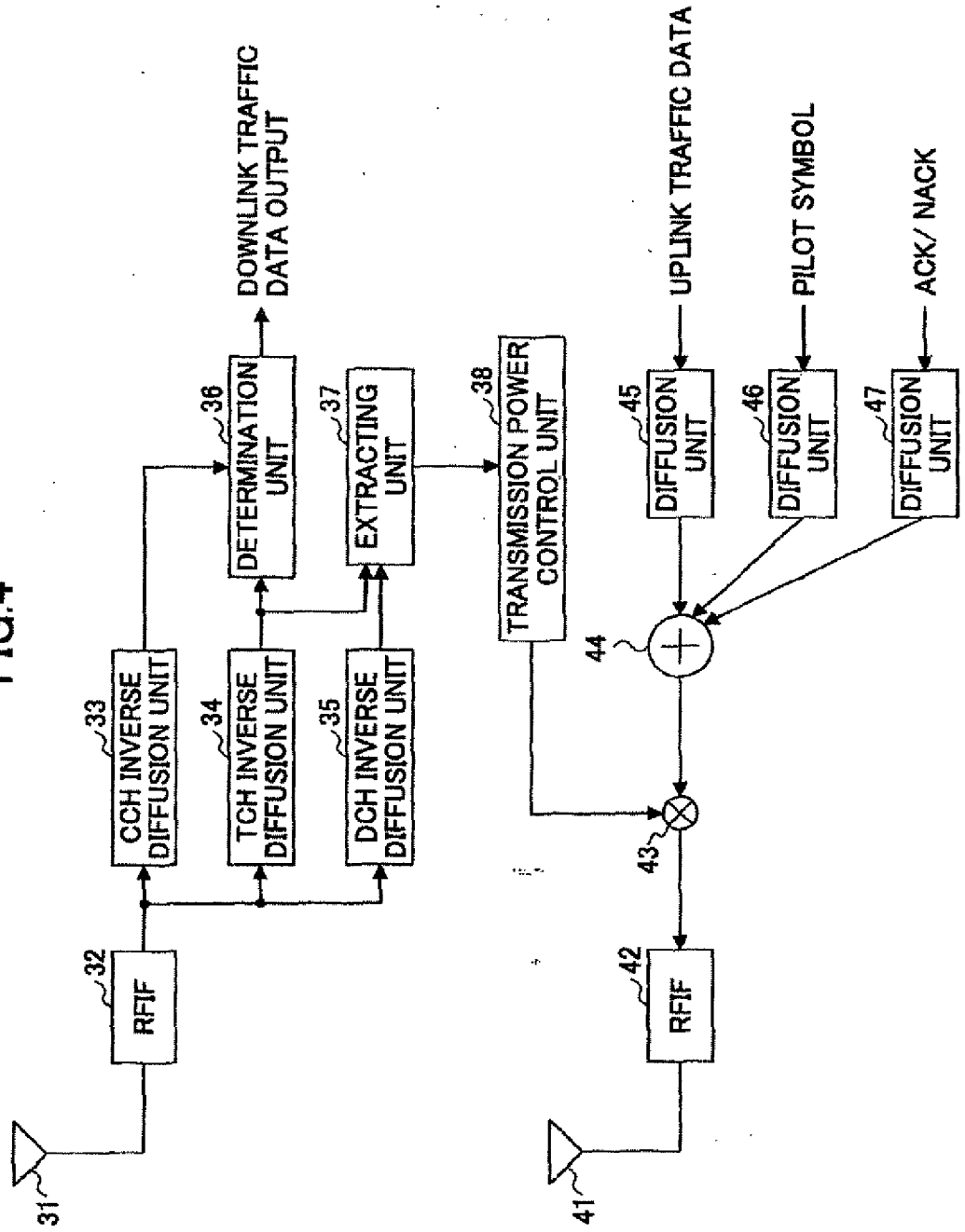

31
41
32
RFIF
42
RFIF
33
CCH INVERSE DIFFUSION UNIT
34
TCH INVERSE DIFFUSION UNIT
35
DCH INVERSE DIFFUSION UNIT
36
DETERMINATION UNIT
37
EXTRACTING UNIT
38
TRANSMISSION POWER CONTROL UNIT
43
44
45
DIFFUSION UNIT
46
DIFFUSION UNIT
47
DIFFUSION UNIT
DOWNLINK TRAFFIC DATA OUTPUT
UPLINK TRAFFIC DATA
PILOT SYMBOL
ACK/ NACK

FIG.5

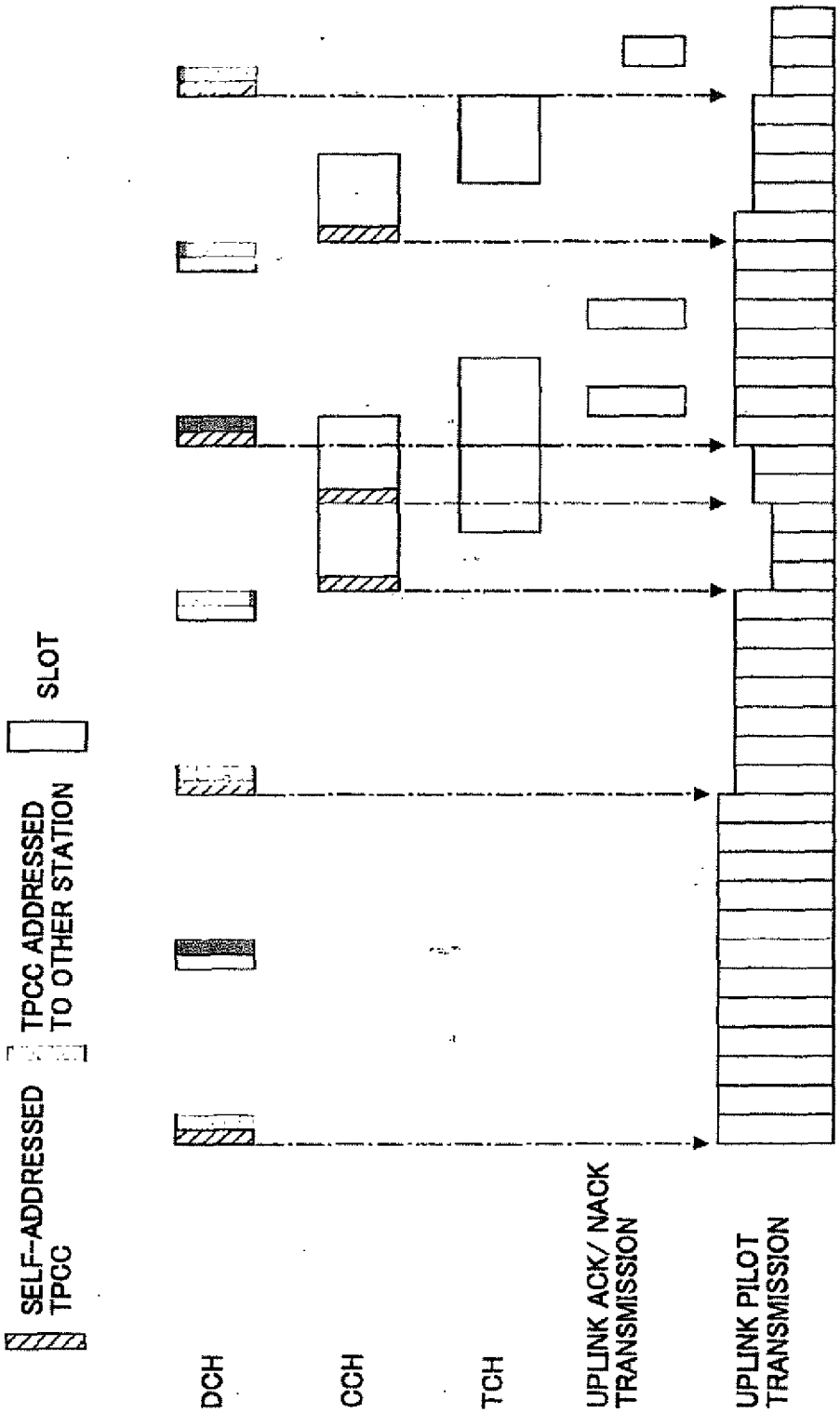
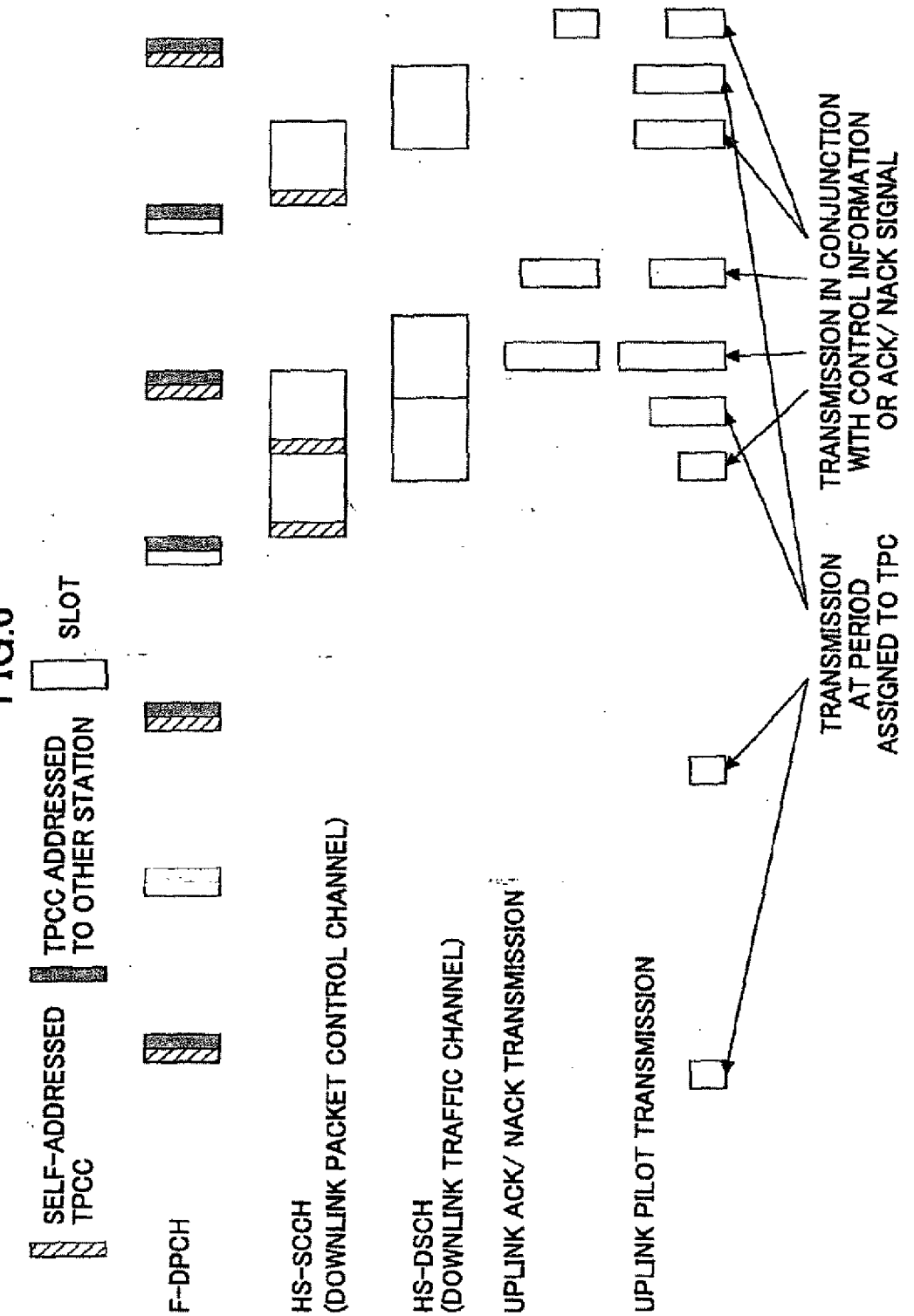

SELF-ADDRESSED TPCC
TPCC ADDRESSED TO OTHER STATION
SLOT
DCH
CCH
TCH
UPLINK ACK/ NACK TRANSMISSION
UPLINK PILOT TRANSMISSION

FIG.6


SELF-ADDRESSED TPCC
TPCC ADDRESSED TO OTHER STATION
SLOT
F-DPCH
HS-SCCH (DOWNLINK PACKET CONTROL CHANNEL)
HS-DSCH (DOWNLINK TRAFFIC CHANNEL)
UPLINK ACK/ NACK TRANSMISSION
UPLINK PILOT TRANSMISSION
TRANSMISSION AT PERIOD ASSIGNED TO TPC
TRANSMISSION IN CONJUNCTION WITH CONTROL INFORMATION OR ACK/ NACK SIGNAL

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 25 2610

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 6 611 508 B1 (ABE MASAMI) 26 August 2003 (2003-08-26) * abstract * * column 2, line 54 - column 6, line 5 * * claim 1 * * figures 1-4 *	5,6 1-4,7,8	H04B7/005
X	EP 1 351 411 A (LUCENT TECHNOLOGIES INC) 8 October 2003 (2003-10-08) * abstract * * paragraphs [0007], [0012] * * claim 1 * * figure 2 *	7,8	
A	EP 1 206 047 A (SAMSUNG ELECTRONICS CO., LTD) 15 May 2002 (2002-05-15) * abstract * * paragraphs [0134] - [0137] * * figure 16 *	1-8	
			TECHNICAL FIELDS SEARCHED (IPC) H04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 March 2006	Helms, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 25 2610

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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13-03-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6611508 B1	26-08-2003	JP 3307573 B2	24-07-2002
		JP 11145901 A	28-05-1999
EP 1351411 A	08-10-2003	DE 60300227 D1	27-01-2005
		DE 60300227 T2	15-12-2005
		JP 2003318821 A	07-11-2003
		US 2004203980 A1	14-10-2004
EP 1206047 A	15-05-2002	AU 768951 B2	08-01-2004
		AU 1437102 A	21-05-2002
		CA 2396672 A1	16-05-2002
		CN 1404667 A	19-03-2003
		JP 3696204 B2	14-09-2005
		JP 2004514320 T	13-05-2004
		WO 0239623 A1	16-05-2002
		US 2002115464 A1	22-08-2002

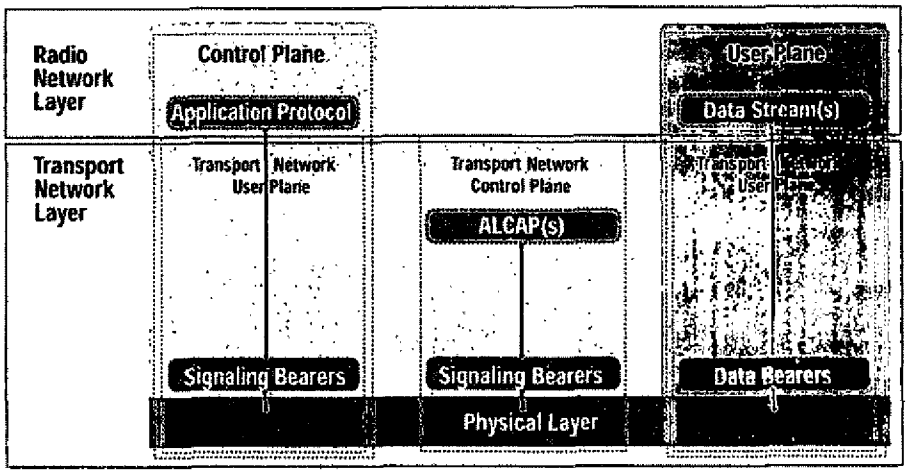
EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

Appln No. 11/646,692
Docket No. 562492007400

3 UMTS Interfaces

Many new protocols have been developed for the four new interfaces specified in UMTS: Uu, Iub, Iur, and Iu. This primer is organized by the protocols and shows their usage in the interfaces. That means protocols will be described individually. Only the references to the interfaces are indicated. Interface specific explanations of the protocols are however not included. Before we review the individual interface protocols, we introduce the UMTS general protocol model.



▶ *Figure 9. General Protocol Model (adopted from 3G TS 25.401 V3.1.0, p. 25)*

3.1 General Protocol Model [3G TS 25.401]

UTRAN interface consists of a set of horizontal and vertical layers (see figure 9). The UTRAN requirements are addressed in the horizontal **Radio Network Layer** across different types of control and user planes. Control planes are used to control a link or a connection; user planes are used to transparently transmit user data from the higher layers. Standard transmission issues, which are independent of UTRAN requirements, are applied in the horizontal **Transport Network Layer**.

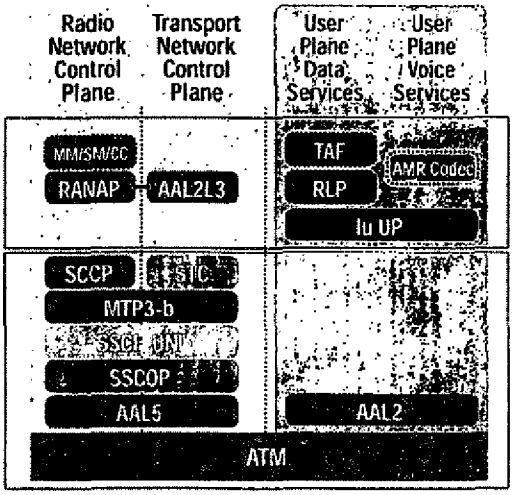
Five major protocol blocks are shown in figure 9:

- **Signaling Bearers** are used to transmit higher layers' signaling and control information. They are set up by O&M activities.
- **Data Bearers** are the frame protocols used to transport user data (data streams). The Transport Network Control Plane (ALCAP) sets them up.
- **Application Protocols** are used to provide UMTS specific signaling and control within UTRAN, such as to set up bearers in the Radio Network Layer.
- **Data Streams** contain the user data that are transparently transmitted between the network elements. User data comprises the subscriber's personal data and mobility management information that are exchanged between the peer entities MSC and UE.
- **ALCAP** (Access Link Control Application Part) protocol layers are provided in the Transport Network Control Plane. They react to the Radio Network Layer's demands to set up, maintain, and release data bearers. The primary objective of introducing the Transport Network Control Plane was to totally separate the selection of the Data Bearer technology from the Control Plane (where the UTRAN specific Application Protocols are located). The Transport Network Control Plane is present in the Iu-CS, Iur, and Iub interfaces. In the remaining interfaces where there is no ALCAP signaling, pre-configured Data Bearers are activated.

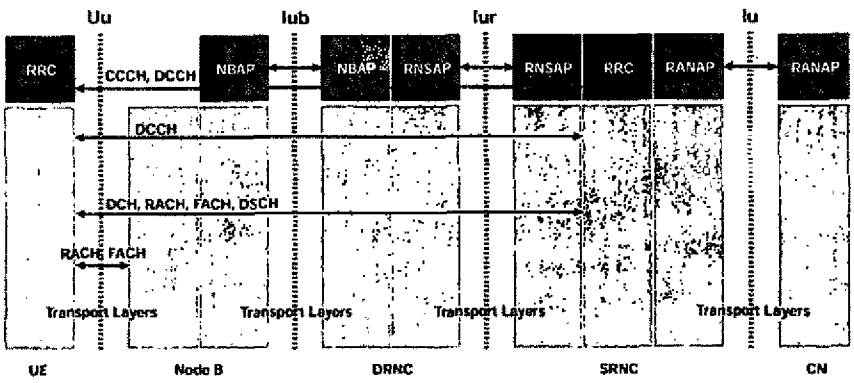
3.2 Application Protocols

Application Protocols are layer 3 protocols that are defined to perform UTRAN specific signaling and control. A complete UTRAN and UE control plane protocol architecture is illustrated in figure 11. UTRAN specific control protocols exist in each of the four interfaces.

Iu: Radio Access Network Application Part (RANAP) [3G TS 25.413]



▶ *Figure 10. Iu-CS Protocol Stack*



▶ ***Figure 11.*** *Control Plane Protocols: adopted from 3G TS 25.931 V3.3.0, p. 8 (note: only the RRC, NBAP, RNSAP and RANAP shall be portrayed in a final version).*

This protocol layer provides UTRAN specific signaling and control over the Iu-interface. The following is a subset of the RANAP functions:

- Overall Radio Access Bearer (RAB) Management, which includes the RABs' setup, maintenance, and release
- Management of Iu connections
- Transport of Non-Access Stratum (NAS) information between the UE and the CN. For example, NAS contains the mobility management signaling and broadcast information.
- Exchanging UE location information between the RNC and CN
- Paging requests from the CN to the UE
- Overload and general error situation handling

Iur: Radio Network Sublayer Application Part (RNSAP) [3G TS 25.423]

UTRAN specific signaling and control over this interface contains:

- management of radio links, physical links and common transport channel resources
- paging
- affecting an SRNC relocation
- measurements of dedicated resources
- measurement handling and control
- synchronization (TDD)
- reporting of error situations

Iub: Node B Application Part (NBAP) **[3G TS 25.433]**

UTRAN specific signaling and control in the Iub-interface includes:

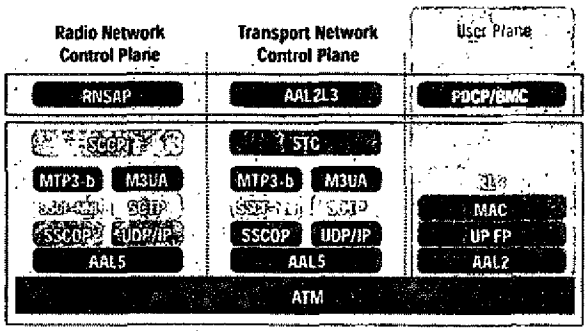
- management of common channels, common resources, and radio links
- configuration management, such as cell configuration management

Uu: Radio Resource Control (RRC) **[3G TS 25.331]**

This layer handles the control plane signaling over the Uu interface between the UE and the UTRAN (see also figure 15). Some of the functions offered by the RRC are:[1]

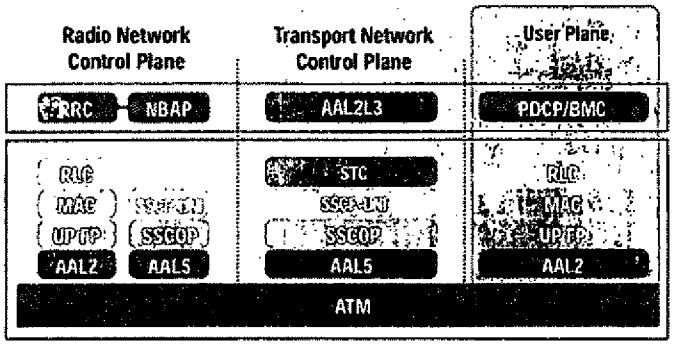
- Broadcasting information
- Management of connections between the UE and the UTRAN, which include their establishment, maintenance, and release.
- Management of the Radio Bearers, which include their establishment, maintenance, release, and the corresponding connection mobility.

[1] The RRCs also perform local inter-layer control services, which are not discussed in this document



▶ ***Figure 12.*** *Iur Protocol Stack*

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▶ *Figure 13. Iub Protocol Stack*

- Ciphering control
- Outer loop power control
- Message integrity protection
- Timing advance in the TDD mode
- UE measurement report evaluation
- Paging and notifying

Two modes of operation are defined for the UE – the idle mode and the dedicated mode. In the idle mode the peer entity of the UE's RRC is at the Node B, while in the dedicated mode it is at the SRNC. The dedicated mode is shown in figure 11.

Higher-layer protocols to perform signaling and control tasks are found on top of the RRC. The MM and CC are defined in the existing GSM specifications. Even though MM and CC occur between the UE and the CN and are therefore not part of UTRAN specific signaling (see figure UU), they demand basic support from the transfer service which is offered by Duplication Avoidance (see 3G TS 23.110). This layer is responsible for in-sequence transfer and priority handling of messages. It belongs to UTRAN, even though its peer entities are located in the UE and CN.

3.3 Transport Network Layer specific layer 3 signaling and control protocols.

Two types of layer 3 signaling protocols are found in the Transport Network Layer:

- Iu, Iur: **Signaling Connection Control Part (SCCP)** [ITU-T Q.711 - Q.716] provides connectionless and connection-oriented services. On a connection-oriented link it separates each mobile unit and is responsible for the establishment of a connection-oriented link for each and every one of them.
- Iu-CS, Iur, Iub: **Access Link Control Application Part (ALCAP)** [ITU-T Q.2630.1, Q.2150.1, and Q.2150.2]. Layer 3 signaling is needed to set up the bearers to transmit data via the User Plane. This function is the responsibility of the ALCAP, which is applied to dynamically establish, maintain, release, and control AAL2 connections. ALCAP also has the ability to link the connection control to another higher layer control protocol. This, and additional capabilities were specified in ITU-T Q.2630.1. Because of the protocol layer specified in Q.2630.1, a converter is needed to correspond with underlying sub-layers of the protocol stack. These converters are called (generically) Signaling Transport Converter (STC). Two converters are defined and applied in UTRAN:
  - Iu-CS, Iur: **AAL2 STC on Broadband MTP (MTP3b)** [Q.2150.1]
  - Iub: **AAL2 STC on SSCOP** [Q.2150.2]

3.4 Transport Network Layer specific "transmission" technologies.

Now that we have a circuit switched and packet switched domain in the CN and a growing market for packet switched network solutions, a new radio access network must be open to both types of traffic in the long run. That network must also transmit the layer 3 signaling and control information. ATM was selected as the layer 2 technology, but higher layer protocols used in the Transport Network Layer demonstrate the UMTS openness to a pure IP solution.

Iu, Iur, Iub: Asynchronous Transfer Mode **(ATM)** [ITU-T I.3610] Broadband communication will play an important role with UMTS. Not only voice, but also multimedia applications such as video conferencing, exploring the Internet and document sharing are anticipated. We need a data link technology that can handle both circuit-switched and packet-switched traffic as well as isochronous and asynchronous traffic. In UMTS (Release '99), ATM was selected to perform this task.

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An ATM network is composed of ATM nodes and links. The user data is organized and transmitted in each link with a stream of ATM cells. ATM Adaptation Layers (AAL) are defined to enable different types of services with corresponding traffic behavior. Two of these are applied in UTRAN:

- Iu-CS, Iur, Iub: **ATM Adaptation Layer 2 (AAL2)** [ITU-T I.363.2] With AAL2, isochronous connections with variable bit rate and minimal delay in a connection-oriented mode are supported. This layer was designed to provide real time service with variable data rates, such as voice and video.
- Iu-PS, Iur, Iub: **ATM Adaptation Layer 5 (AAL5)** [ITU-T I.363.5] With AAL5, isochronous connection with CBR, VBR, UBR, and ABR in a connection-oriented mode are supported. This layer is used for IP and signaling. In UTRAN, AAL5 is used to carry the packet switched user traffic in the Iu-PS-interface and the signaling and control data throughout.

In order to carry signaling and control data, the AAL5 has to be "enhanced." Here, UTRAN offers both a "classical" ATM solution and an IP-based approach:

- Signaling AAL and MTP3b

  To make Signaling AAL (SAAL) available in place of the AAL5 sub-layer SSCS, the SSCOP, which provides a reliable data transfer service, and the SSCF, which acts as coordination unit, are defined:

- Iu, Iur, Iub: **Service Specific Connection Orientated Protocol (SSCOP)** [ITU-T Q.2110]

  The SSCOP is located on top of the AAL layer. It is a common connection-oriented protocol which provides a reliable data transfer between peer entities. Its capabilities include the transfer of higher layer data with sequence integrity, flow control, connection maintenance in case of a longer data transfer break, error correction by protocol control information, error correction by retransmission, error reporting to layer management, status report, and more.

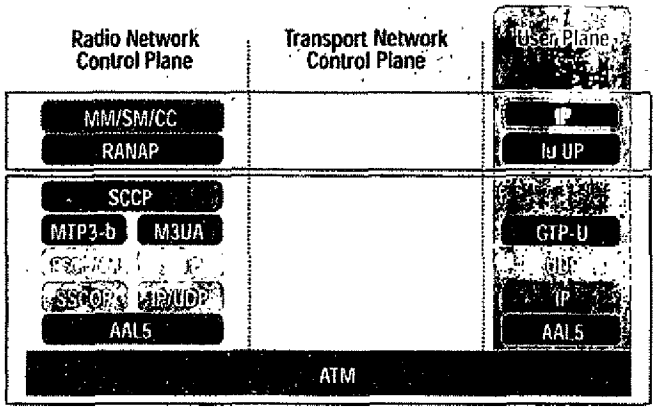
Two versions of the Service Specific Coordination Function (SSCF) are defined: one for signaling at the User-to-Network Interface (UNI), and one for signaling at the Network-Node Interface (NNI):

- Iub: **Service Specific Coordination Function for Support of Signaling at the User-Network Interface (SSCF-UNI)** [ITU-T Q.2130]

  The SSCF-UNI receives layer 3 signaling and maps it to the SSCOP, and visa versa. The SSCF-UNI performs coordination between the higher and lower layers. Within UTRAN, it is applied in Iub with the NBAP and ALCAP on top of the SSCF-UNI.

- Iu, Iur: **Service Specific Coordination Function at the Network Node Interface (SSCF-NNI)** [ITU-T Q.2140]

  The SSCF-NNI receives the SS7 signaling of a layer 3 and maps it to the SSCOP, and visa versa. The SSCF-NNI performs coordination between the higher and the lower layers. Within UTRAN, MTP3b has the higher layer 3, which requires service from the SSCOP-NNI.



▶ *Figure 14. Iu-PS Protocol Stack*

Originally the SS7 protocol layer, SCCP relies on the services offered by MTP, so the layer 3 part of the MTP must face the SCCP layer:

- Iu, Iur: **Message Transfer Part Level 3 (MTP3b)** [ITU-T Q.2210]

  Signaling links must be controlled in level 3 for: message routing, discrimination and distribution (for point-to-point link only), signaling link management, load sharing, etc. The specific functions and messages for these are defined by the MTP3b, which requires the SSCF-NNI to provide its service.

The layer 3 signaling and control data can also be handled by an enhanced IP-protocol stack using a tunneling function (see figure 12). Tunneling is also applied for packet switched user data over the Iu-PS-interface (see figure 14).

- IP over ATM:
  - Iu-PS, Iur: **Internet Protocol (IP)** [IETF RFC 791, 2460, 1483, 2225], **User Datagram Protocol (UDP)** [IETF RFC 768] The

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Internet Protocol can be encapsulated and then transmitted via an ATM connection, a process which is described in the RFC 1483 and RFC 2225. Both IPv4 and IPv6 are supported. IP is actually a layer 3 protocol. UDP is applied on top of the unreliable layer 4 protocol. The objective is to open this signaling link to future "pure IP" network solutions.

In order to tunnel SCCP or ALCAP signaling information, two protocols are applied:

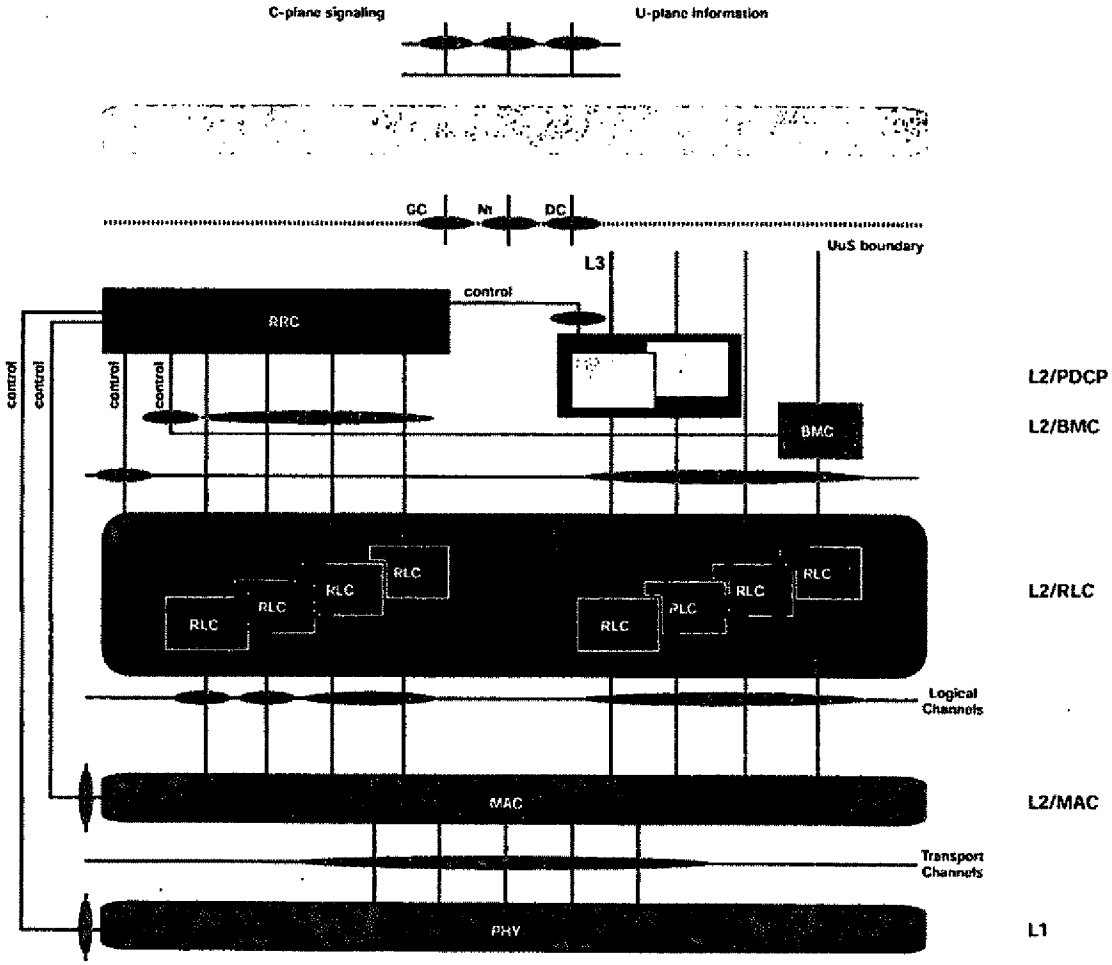
- Iu-PS, Iur: **Simple Control Transmission Protocol (SCTP)** [IETF draft-ieft-sigtran-sctp-v0.txt]

  This protocol layer allows the transmission of signaling protocols over IP networks. Its tasks are comparable with MTP3b. On Iu-CS, SS7 signaling must be tunneled between the CN and the RNC. This is planned to be done with the Iu-PS, Iur: **SS7 MTP3-User Adaptation Layer (M3UA)** [IETF draft-ietf-sigtran-m3ua-02.txt]

The tunneling of packet switched user data is done with the:

- Iu-PS: **GPRS Tunneling Protocol (GTP)** [3G TS 29.060]

  The GTP provides signaling (GTP-C) and data transfer (GTP-U) procedures. Only the latter is applied in the Iu-PS interface, since the control function is handled by the RANAP protocol. The GTP-U is used to tunnel user data between the SGSN and the RNC.



▶ *Figure 15. Uu Interface Protocol Structure (adopted from 3G TS 25.301 V3.3.0, p. 11)*

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3.5 Iu, Iur, Iub: The Physical Layers [3G TS 25.411]

The physical layer defines the access to the transmission media, the physical and electrical properties and how to activate and de-activate a connection. It offers to the higher layer physical service access points to support the transmission of a uniform bit stream. A huge set of physical layer solutions is allowed in UTRAN; including: ETSI STM-1 (155 Mbps), STM-4 (622 Mbps); SONET STS-3c (155 Mbps), STS-12c (622 Mbps); ITU STS-1 (51 Mbps), STM-0 (51 Mbps); E1 (2 Mbps), E2 (8 Mbps), E3 (34 Mbps), T1 (1.5 Mbps), T3 (45 Mbps); J1 (1.5 Mbps), J2 (6.3 Mbps).

With the above protocol layers, the interfaces Iu, Iur, and Iur are fully described. There is only the air interface left for a more detailed analysis:

3.6 The air interface Uu [3G TS 25.301]

The air interface solution is usually a major cause for dispute when specifying a new radio access network. Figure Uu shows the realization of the lower parts of the protocol stack in the UE. As can be seen, a physical layer, data link layer, and network layer (the part for the radio resource control (RRC)) have been specified.

The physical layer is responsible for the transmission of data over the air interface. The FDD and TDD W-CDMA solutions have been specified in UMTS Rel. '99.

The data link layer contains four sub-layers:

- **Medium Access Control (MAC)** [3G TS 25.321]

  The MAC layer is located on top of the physical layer. Logical channels are used for communication with the higher layers. A set of logical channels is defined to transmit each specific type of information. Therefore, a logical channel determines the kind of information it uses.

  The exchange of information with the physical layer is realized with transport channels. They describe how data is to be transmitted over the air interface and with what characteristics.

  The MAC layer is responsible for more than mapping the logical channels into the physical ones. It is also used for priority handling of UEs and the data flows of a UE, traffic monitoring, ciphering, multiplexing, and more.

- **Radio Link Control (RLC)** [3G TS 25.322] is responsible for acknowledged or unacknowledged data transfer, establishment of RLC connections, transparent data transfer, QoS settings, unrecoverable error notification, ciphering, etc. There is one RLC connection per Radio Bearer.

The two remaining layer 2 protocols are used only in the user plane:

- **Packet Data Convergence Protocol (PDCP)** [3G TS 25.323] is responsible for the transmission and reception of Radio Network Layer PDUs. Within UMTS several different network layer protocols are supported to transparently transmit protocols. At the moment IPv4 and IPv6 are supported, but UMTS must be open to other protocols without forcing the modification of UTRAN protocols. This transparent transmission is one task of PDCP; another is to increase channel efficiency (by protocol header compression, for example).
- **Broadcast/Multicast Control (BMC)** [3G TS 25.324] offers broadcast/multicast services in the user plane. For instance, it stores SMS CB messages and transmits them to the UE.

4 UMTS and UTRAN Measurement Objectives

As noted in the preceding section, four new interfaces have been introduced with UMTS/UTRAN. With the new interfaces came a huge set of protocol layers for mobile communication networks. Dealing with these new protocols presents a demanding challenge to manufacturers, operators, and measurement equipment suppliers.

4.1 Measurement Approaches

Nearly all measurement situations can be considered in three categories with related approaches. Even though there are situations where two or more approaches could be applied to the same interface, the first steps in protocol testing should always be to determine the characteristics of the system under test and the test objectives.

➔ Do you have a living network that you should not, or are not, allowed to disturb?
Use the non-intrusive *Monitoring* approach.

➔ Do you have a 'dead' node or system that needs to be externally stimulated?
Use the *Simulation/Emulation* approach.

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3GPP TR 25.912 V0.0.4 (2006-3)

Technical Report

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Feasibility Study for Evolved UTRA and UTRAN (Release 7)



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Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

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  - 1 presented to TSG for information;
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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

This present document is the technical report for the study item "Evolved UTRA and UTRAN" [1]. The objective of the study item is to develop a framework for the evolution of the 3GPP radio-access technology towards a high-data-rate, low-latency and packet-optimized radio access technology.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3GPP TD RP-040461: "Proposed Study Item on Evolved UTRA and UTRAN".

[2] 3GPP TR 25.814 V1.0.1 (2005-12) "Physical Layer Aspects for Evolved UTRA"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

<defined term>: <definition>.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

4 Introduction

At the 3GPP TSG RAN #26 meeting, the SI description on "Evolved UTRA and UTRAN" was approved [1].

The justification of the study item was, that with enhancements such as HSDPA and Enhanced Uplink, the 3GPP radio-access technology will be highly competitive for several years. However, to ensure competitiveness in an even longer time frame, i.e. for the next 10 years and beyond, a long-term evolution of the 3GPP radio-access technology needs to be considered.

Important parts of such a long-term evolution include reduced latency, higher user data rates, improved system capacity and coverage, and reduced cost for the operator. In order to achieve this, an evolution of the radio interface as well as the radio network architecture should be considered.

Considering a desire for even higher data rates and also taking into account future additional 3G spectrum allocations the long-term 3GPP evolution should include an evolution towards support for wider transmission bandwidth than 5 MHz. At the same time, support for transmission bandwidths of 5MHz and less than 5MHz should be investigated in order to allow for more flexibility in whichever frequency bands the system may be deployed

5 Deployment Scenario

Editor's notes: This chapter will capture e.g. possible deployment in scalable frequency bandwidth, multiple antenna, etc.

6 Radio Interface Protocol Architecture for evolved UTRA

Editor's notes: This chapter will capture the overall protocol architecture for evolved UTRA.

7 Physical Layer for evolved UTRA

Editor's notes: This chapter will capture physical layer specific solutions to meet requirements for evolved UTRA and UTRAN.

7.1 Downlink Transmission Scheme

For both FDD and TDD, the downlink transmission scheme is based on OFDM. Each 10 ms radio frame is divided into 20 equally sized sub-frames. In addition, for coexistence with LCR-TDD, a frame structure according to [1], section 6.2.1.1.1, is also supported when operating E-UTRA in TDD mode. Channel-dependent scheduling and link adaptation can operate on a sub-frame level.

7.2 Uplink Transmission Scheme

For both FDD and TDD, the basic uplink transmission scheme is based on low-PAPR single-carrier transmission (SC-FDMA) with cyclic prefix to achieve uplink inter-user orthogonality and to enable efficient frequency-domain equalization at the receiver side. Each 10 ms radio frame is divided into 20 equally sized sub-frames and scheduling can operate on a sub-frame level. In addition, for coexistence with LCR-TDD, a frame structure according to [2], section 6.2.1.1.1, is also supported when operating E-UTRA in TDD mode. To allow for multi-user MIMO reception at the Node B, transmission of orthogonal pilot patterns from single Tx-antenna UEs is part of the baseline uplink transmission scheme.

8 Layer 2 and RRC Evolution for evolved UTRA

Editor's notes: This chapter will capture specific solutions of layer 2 and RRC to meet requirements for evolved UTRA and UTRAN.

9 Architecture for evolved UTRAN

9.1 RAN-CN functional split

Editor's notes: This chapter will capture agreed RAN-CN functional split with SA2.

9.2 System migration scenario

Editor's notes: This chapter will capture possible UTRAN internal and RAN-CN system migration scenario.

9.3 UTRAN architecture

Editor's notes: This chapter will capture specific solutions of UTRAN internal architecture to meet requirements for evolved UTRA and UTRAN.

9.3.A Key Issue Intra LTE-Access-System Mobility Support for UE in LTE_ACTIVE

9.3.A.1 Description of Key Intra-LTE-Access Mobility Support for UEs in LTE_ACTIVE

The key issue Intra-LTE-Access Mobility Support for UEs in LTE_ACTIVE handles all necessary steps already known from state of the art relocation/handover procedures, like processes that precedes the final HO decision on the source network side (control and evaluation of UE and "PHY/MAC control" measurements taking into account certain UE specific area restrictions), preparation of resources on the target network side, commanding the UE to the new radio resources and finally releasing resources on the (old) source network side. It contains mechanisms to transfer context data between evolved nodes, and to update node relations on C- and U-plane.

9.3.A.2 Solution for key issue Intra-LTE-Access Mobility Support for UEs in LTE_ACTIVE

9.3.A.2.1 C-plane handling:

The HO procedure is performed without MME/UPE involvement, i.e. preparation messages are directly exchanged between the RRC entities. The release of the resources at the source side during the HO completion phase is triggered by the "target RRC" entity.

The HO procedure comprises the following steps:

UEs in LTE_ACTIVE are still controlled by a function controlling UE's radio link quality and neighbour-cell measurements in DL as well as the "PHY/MAC" to provide corresponding UL measurements. Additional information like load and interference states in neighbours is beneficial, the provision is FFS.

Typically, the "source RRC" entity triggers the HO process after it has made a definite decision to serve the user in another cell.

After the "target RRC" has received the final confirmation from the UE on HO completion it starts to trigger the release source-cell and related transport/context resources.

Note 1: The location of the functional entity "RRC" is not yet decided, either in the eNodeB or in the MME/UPE. The functional entity "PHY/MAC" is located in the eNodeB.

Note 2: The MME/UPE is co-located in one functional entity for simplicity reasons; however it is ffs in SA2.

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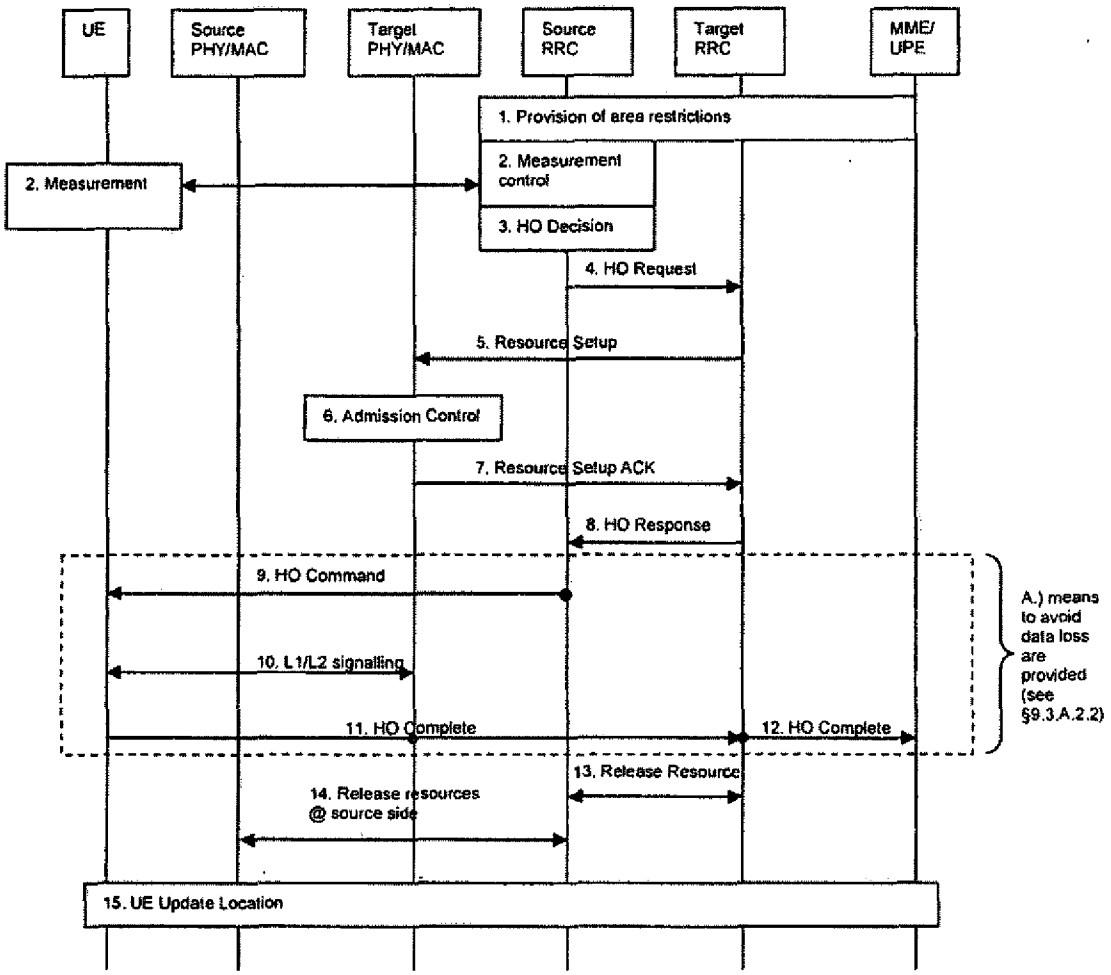


Figure 9.3.A-1: Information flow for Intra-LTE-Access Mobility Support

1) The UE context within the "Source RRC" contains information regarding roaming restrictions which where provided either at connection establishment or at the last TA update.

2) The "Source RRC" entity configures the UE measurement procedures according to the area restriction information. Measurements provided by the "Source PHY/MAC" entity may assist the function controlling the UE's connection mobility.

3) Based on measurement results from the UE and the "Source PHY/MAC", probably assisted by additional RRM specific information, the "Source RRC" decides to handover the UE to a cell controlled by the "Target RRC".

4) The "Source RRC" issues a HO Request to the "Target RRC" entity passing necessary information to prepare the HO at the target side.

5) The "Target RRC" requests the "Target PHY/MAC" to configure the required resources.

6) Admission control is performed by "Target PHY/MAC" to increase the likelihood of a successful HO.

7) If the resources can be granted the "Target RRC" is informed by the "Target PHY/MAC".

8) The HO preparation is finished at the target side, information for the UE to reconfigure the radio path towards the target side is passed to the "Source RRC".

A) from step 9) until 12) means to avoid data loss during HO are provided and are detailed in §9.3.A.2.2.

9) The UE is commanded by the "Source RRC" entity to perform the HO, target side radio resource information is contained.

10) The UE gains synchronisation at the target side.

11) Once the UE has successfully accessed the cell, it sends an indication to the "Target RRC" that the handover is completed.

12) The MME/UPE is informed that the UEs data path has to be switched to the target side and TNL resources towards the source side can be released.

13) The "Target RRC" triggers the release of resources at the source side which is performed after probably unsent buffered user data have been forwarded to the target side.

Note: It is ffs whether the release of the resources on the source side is done with MME/UPE involvement or by the "Target RRC" directly.

14) The "Source RRC" entity releases radio, context and TNL resources.

15) If the new cell is member of a new Tracking Area, the UE needs to register with the MME/UPE which in turn updates the area restriction information on the target side.

9.3.A.2.2 User plane handling

Editors Note: Text for this section should be agreed in RAN3 or RAN.

9.3.A.3 Impact on the baseline CN Architecture

Editors Note: It is FFS whether there is any particular impact

9.3.A.4 Impact on the baseline RAN Architecture

Editors Note: It is FFS whether there is any particular impact

9.3.A.5 Impact on terminals used in the existing architecture

Editors Note: It is FFS whether there is any particular terminal impact.

9.3.X Key Issue Resource Establishment and QoS Signalling

9.3.X.1 Description of Key Issue Resource Establishment and QoS Signalling

The key issue on Resource Establishment and QoS signalling encompasses the following aspects:

- Means for providing enhanced QoS for services that require QoS or policies beyond what the default IP Access service provides including the provisioning of QoS/policy information to the network entities that control radio/network resources;
- Signalling of QoS profiles and signalling for Resource Establishment or Resource Reservation, including the direction of such signalling procedures (i.e. Network initiated / UE initiated);

9.3.X.2 Solution for key issue Resource Establishment and QoS Signalling

Resource Establishment and QoS Signalling handle the provisioning of QoS/policy information to the network entities that control radio/network resources. Radio/network resources are controlled applying information about the users' subscription, the UE's and the radio/network capabilities, the availability of radio/network resources and certain operator policies.

It is assumed that resources can always be granted even though the requested QoS may not, i.e. the QoS can be downgraded by the network/radio. It is FFS to which extent a negotiation/re-negotiation of requested network resources shall be possible.

Resource Establishment and QoS Signalling for resources with different QoS than for default IP Access service assume a preeceding signalling of QoS requirements. This could be performed either by application signalling (e.g. IMS) or by other TBD means. It is FFS if this will lead to the establishment of additional IP Access services (comparable to UMTS PS bearers).

Signalling of QoS requirements takes place on the already established resources of the default IP Access service. An application function performs the negotiation with the UE on media components and their characteristics. The media information is translated (e.g. by the PCRF) into the necessary Policy/QoS information which is contained in the resource request triggering the Resource Establishment.

The Resource Establishment function contains both, the functions that are needed to setup network and radio resources and the respective signalling towards the UE to link the radio resources with the application layer and provide it with the authorised QoS.

The MME/UPE checks whether the granted resources correspond to the limits defined in the subscription profile of the user and initiates a resource assignment towards the radio part of the network.

The responsible radio function checks the availability of resources and sets up the required resources and finally informs the UE on the radio resource configuration for the service and which resources are bound to which IP or session flows.

In the information flow below MME and UPE are shown together for simplicity reasons. This does not preclude a separation of the two, which would however require the definition of an interface between both entities. Further the radio functions are depicted in the functional entities "PHY/MAC control" comprising PHY/MAC functions and "RRC" comprising RRC termination and possible access to inter-cell RRM functions (to be further detailed).

Note that allocation of radio functions to logical entities needs to be further discussed within RAN WGs

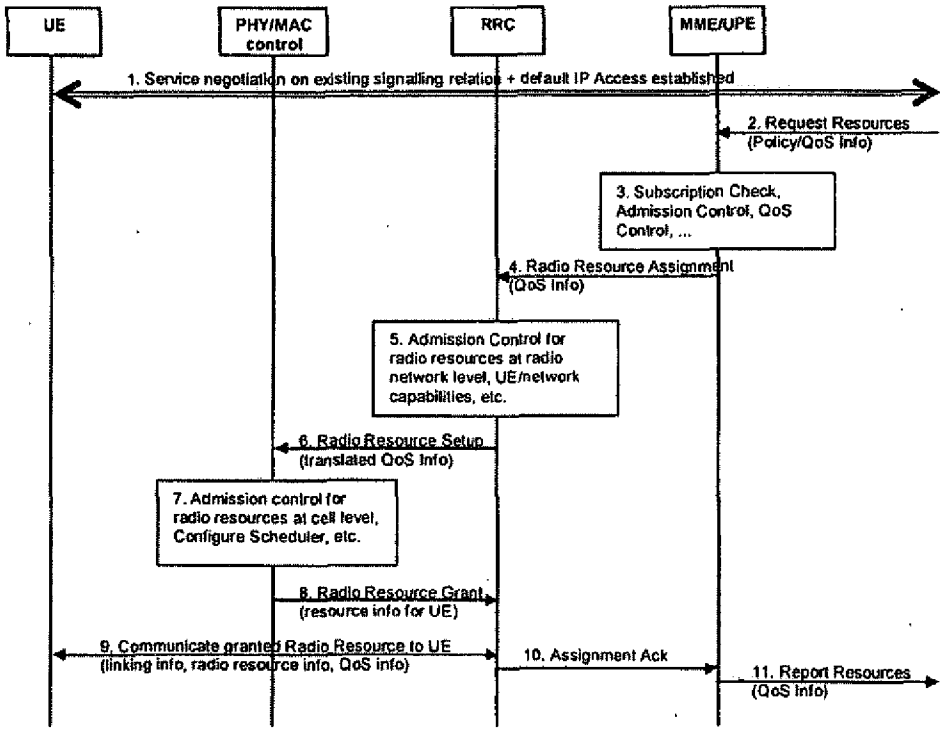


Figure 1: Information flow for Resource Establishment in the Radio Network for application level signalling

1) The UE has a signalling relation established with the network which relies on the default IP Access service.
2) The MME/UPE is triggered by a resource request which contains Policy/QoS Information corresponding to the requested service.
3) The MME/UPE checks the UE's subscription, performs admission control according to the received Policy/QoS information and applies the received policy information.

   Note: The location of the policy enforcement point is FFS, it might be located in the (inter-access-) mobility anchor).

4) MME/UPE initiates the Resource Establishment towards the responsible radio functions.
5) The "RRC" entity performs admission control for radio resources at radio network level, and translates the received QoS information for the "PHY/MAC control" entity and triggers the allocation of radio resources.
6) The "PHY/MAC control" receives the QoS information from the "RRC".
7) The "PHY/MAC control" uses this information to perform admission control for radio and processing resources at cell level and to generate the relevant HARQ entities and also to perform any mapping of logical channel to resource identifier configures the scheduler according to the received QoS information and allocates resources according to the received QoS information.
8) The "PHY/MAC control" returns the relevant configuration information (e.g. HARQ configuration, air interface identifiers, channel mapping etc) to the "RRC" entity. Details of the information provided is FFS
9) The UE is provided with information about the radio configuration necessary for the service and related information to link radio resources with IP or session flows.

   Note, that the "RRC" entity does not grant the resource for the UE in a cell, but only provides the information required for the "PHY/MAC control" to grant the physical resource in the cell.

10) The MME/UPE is informed about the successful outcome of the resource establishment.
11) The MME/UPE reports the outcome of the resource establishment together with the negotiated QoS. Renegotiation is FFS.

9.3.X.3 Impact on the baseline CN Architecture

Editors Note: It is FFS whether there is any particular impact

9.3.X.4 Impact on the baseline RAN Architecture

Editors Note: It is FFS whether there is any particular impact

9.3.X.5 Impact on terminals used in the existing architecture

Editors Note: It is FFS whether there is any particular terminal impact.

10 RF Related aspects of evolved UTRA

Editor's notes: This chapter will capture RF related specific solutions to meet requirements for evolved UTRA and UTRAN.

11 Radio Resource Management Aspects of evolved UTRA

Editor's notes: This chapter will capture solution of the RRM aspect, e.g. inter-RAT support

12 System and Terminal Complexity

Editor's notes: This chapter will capture study results on system and terminal complexity.

13 Performance Assessments

Editor's notes: This chapter will capture assumptions for the study and study results on spectrum efficiency, data rate, latency, etc.

14 Conclusions and Recommendations

14.1 Conclusions

14.2 Recommendations

15 Change History

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2005-12	*RAN#30*				*Text proposals approved in RAN#30 were added in section 7 and 9*	*0.0.0*	*0.0.2*
2005-12					*Reference [2] added*	*0.0.2*	*0.0.3*
2006-3	*RAN#31*				*Text agreed in the RAN2-RAN3-SA2 joint meeting was added in section 9*	*0.0.3*	*0.0.4*

3GPP TR 23.882 V0.3.0 (2005-07)

Technical Report

3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3GPP System Architecture Evolution: Report on Technical Options and Conclusions (Release 7)





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Foreword

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  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

To ensure competitiveness of the 3GPP systems in a time frame of the next 10 years and beyond, a long-term evolution of the 3GPP access technology needs to be considered.

In particular, to enhance the capability of the 3GPP system to cope with the rapid growth in IP data traffic, the packet-switched technology utilised within 3G mobile networks requires further enhancement. A continued evolution and optimisation of the system concept is also necessary in order to maintain a competitive edge in terms of both performance and cost. Important parts of such a long-term evolution include reduced latency, higher user data rates, improved system capacity and coverage, and reduced overall cost for the operator.

Additionally, it is expected that IP based 3GPP services will be provided through various access technologies. A mechanism to support seamless mobility between heterogeneous access networks, e.g. I-WLAN and 3GPP access systems, is a useful feature for future network evolution.

In order to achieve this, an evolution or migration of the network architecture, as well as an evolution of the radio interface, partly addressed already by individual WIDs, should be considered.

Architectural considerations will include end-to-end systems aspects, including core network aspects and the study of a variety of IP connectivity access networks (e.g. fixed broadband access).

1 Scope

The objective of this feasibility study is to develop a framework for an evolution or migration of the 3GPP system to a higher-data-rate, lower-latency, packet-optimized system that supports, multiple RATs. The focus of this work will be on the PS domain with the assumption that voice services are supported in this domain.

The main objectives are to address the following aspects:

1) Overall architecture impacts stemming from requirements coming out from TSG-RAN's Study Item on Radio Evolution (see SP-040915). The architectural developments should take into account the targets for the evolution of the radio-interface, e.g.:

    i. whether there is a need for a modified network architecture and/or different functional split between network nodes (compared to the current 3GPP architecture);

    ii. how to provide a very low latency (including C-plane) for the overall network (including core network, radio access network and radio access technology);

    iii. how to provide the efficient support of the various types of services, especially from the PS domain (e.g. Voice over IP, Presence).

2) Overall architecture impacts stemming from the work in SA1 on an All-IP Network (AIPN) (see TR 22.978), e.g.:

    i. support of a variety of different access systems (existing and future) and access selection based on combinations of operator policies, user preferences and access network conditions;

    ii. how to realize improvements in basic system performance e.g. communication delay, communication quality, connection set-up time etc....;

    iii. how to maintain the negotiated QoS across the whole system; in particular to address inter-domain and inter-network interworking, and, QoS on the network link to the Base Station site.

Note: Although used in the SA1 TR 22.978 [4], the All-IP Network (AIPN) term is not used in the network architecture in this SAE TR as mapping between the term AIPN used in SA1 and the evolved architecture is not deemed necessary to progress the SAE work. Instead, the requirements on AIPN in TR 22.978 [4] are treated as overall system requirements. Even though the AIPN includes an evolved, IP based, core network and evolved IMS domain, the scope of this SAE TR does not include the IMS domain aspects.

3) Overall architecture aspects of supporting mobility between heterogeneous access networks, including service continuity. E.g.:

    i. service continuity between I-WLAN and the 3GPP PS domain;

    ii. how to support multiple radio access technologies and terminal mobility between different radio access technologies;

    iii. how to maintain and support the same capabilities of access control (authentication, authorization), privacy and charging when moving between different radio access technologies.

Migration aspects should be taken into account for the above, i.e. how to migrate from the existing architecture.

In the course of conducting this feasibility study additional individual Work Items may be identified and prepared to address certain aspects and to take care of the respective specification work. The timelines of those Work Items may or may not concur with the timeline of this feasibility study.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[<seq>] <doctype> <#>[([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

[1] 3GPP TR 41.001: "GSM Release specifications".

[2] 3GPP TR 21 912 (V3.1.0): "Example 2, using fixed text".

[3] 3GPP TS 23.002: "Network Architecture"

[4] 3GPP TR 22.978 "All-IP network (AIPN) feasibility study"

3 Definitions, symbols and abbreviations

Delete from the above heading those words which are not applicable.

Subclause numbering depends on applicability and should be renumbered accordingly.

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

Definition format

***<defined term>**: <definition>.*

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Symbol format

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

Abbreviation format

<ACRONYM> <Explanation>

4 Architecture Baseline

4.1 Architecture starting point

This chapter describes the architecture baseline as the basis for further evolving the architecture. The full view of Release 6 network architecture is the reference logical architecture with some additions from Release 7 work.

The Release 7 work that is included in the baseline architecture is:

- PCRF and related reference points

Editors Note: It is FFS what other Release 7 work that may be added to the baseline architecture

Note: For simplification reasons Gx+ and Rx+ is made explicit in the figure but it should be clear that in Release 6 then the interfaces Gx/Rx and Go/Gq are applicable towards the CRF and PDF respectively.

More specifically the feasibility study shall focus on evolving the PS and I-WLAN architecture, functionalities and figure 4.1-1. Refer to 3GPP TS 23.002 [3] for further detailed description. The functional entities that are depicted in figure 4.1-1 are those that are potentially impacted as a result of this study, in relation to the reference points shown.

Editors Note: The interfaces and network entities related to CAMEL and LCS are currently not shown in figure 4.1-1.

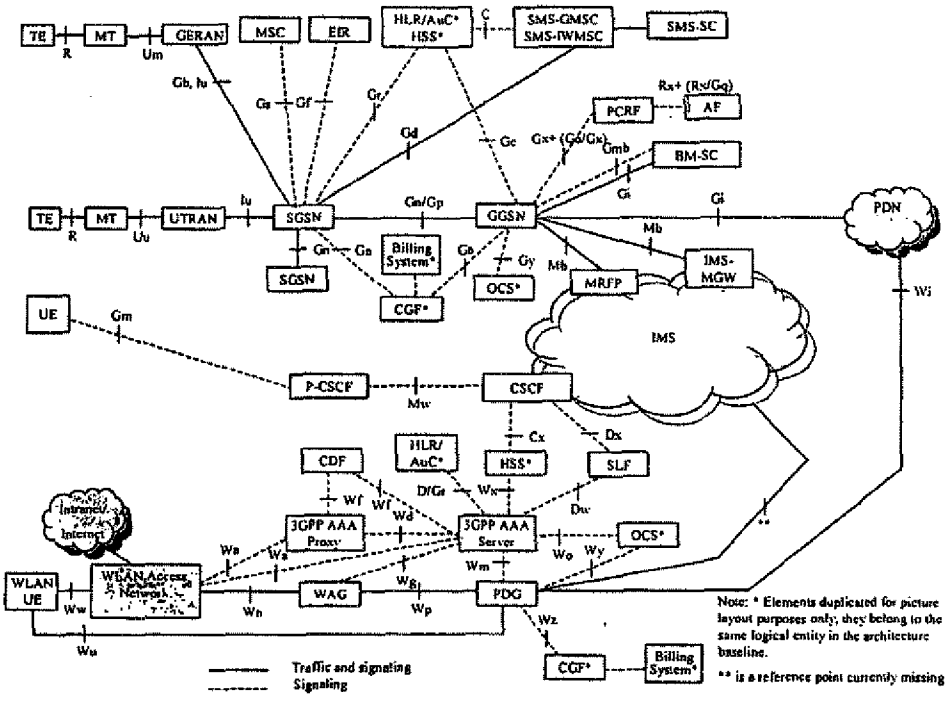


Figure 4.1-1. Logical baseline architecture for 3GPP

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5 Requirements on the Architecture

[Editors Note: This clause identifies the major requirements on the architecture that guide the architecture evolution.]

High-level principles

- 3GPP and non 3GPP access systems shall be supported.
- Shall provide scalable system architecture and solutions without compromising the system capacity, e.g. by separating the control plane and the transport plane.
- Interworking with release 6 3GPP systems (i.e. 3GPP-PS core, 3GPP-IP access and IMS) shall be supported
- The C plane response time for the IP-CAN shall be such that (excluding DRX times) the mobile can move from a fully idle state (this is an idle state where the mobile is GMM attached, has an IP address allocated and is IMS registered) to one where it is sending and receiving user plane data in a significantly reduced time. The target time is less than 200 ms;
- The Evolved 3GPP System shall support SMS and equivalent functionality to that provided by the MSC's "SMS message waiting flag". Note: this might be provided by the R'7 WID for "support of SMS and MMS over generic 3GPP IP access".
- The Evolved 3GPP System shall support basic IP configuration for terminals that do not have IP connectivity.
- The functional split will be defined to sufficient level of detail to avoid overlapping/duplicated functionality, signalling and related delays.
- The basic IP connectivity in the evolved architecture is established during the initial access phase of the UE to the network.
- For the set-up of IP connectivity with enhanced QoS, the number of signalling transactions shall be minimised.

[Editor's note: Initial list to be completed]

6 Scenarios and Solutions

[Editors Note: This clause identifies potential scenarios based on drivers such as social and new emerging technologies that have an impact on the existing reference architecture. The identified scenarios are used to explore the architecture options and as a base for identifying the key architectural issues. The scenarios may be based on the outcome from AIPN in SA1 and the TSG-RAN's Study Item on Radio Evolution (see SP-040915). The scenarios should identify how migration and/or evolution from current systems occur.]

7 Key Architectural Issues

[Editors Note: this clause identifies key issues e.g. related to mobility and QoS mechanisms, solutions for key Issues and impact on the Architecture i.e.

7.1 Key Issue 1

7.1.1 Description of Key Issue 1

7.1.2 Solution for key issue 1

7.1.3 Impact on the baseline CN Architecture

7.1.4 Impact on the baseline RAN Architecture

7.1.5 Impact on terminals used in the existing architecture]

7.1 Key Issue Policy control and Charging

7.1.1 Description of Key Issue Policy control and Charging

The PCC functionality comprises important functionality related to the configuration of certain filters and packet processing rules. Typical use of such rules and filters include flow based charging, gating,QoS control, etc. Such rules may implement multiple services of various types, including ones from 3rd party suppliers and hence are an important part since it is related to a subscription and how services are authorized and charged for e.g. zero rating, price bundling, premium price etc depending on the particular configuration of an operator. In a Rel-7 context PCC considers a number of input parameters such as QoS parameters and for GPRS case TFTs and if a PDP context was activated by a secondary PDP context activation procedure, etc. before finally implementing a rule. It is key for an operator to be able to use a configuration of rules (policy and charging), which apply to Rel-7 architecture and terminals also in long term, i.e., smooth migration is important. The PCRFs interaction with future CN should be based on the existing PCC Rel-7 interfaces. It should be noted that some Rel-7 models (e.g. the QoS model) may be further evolved in the SAE work.

With the introduction of new 3GPP radio access technologies operators need to be in control of the use of each 3GPP radio access technology. The policy should take subscriber identity and other circumstances into account. The use of a different radio access technology may also lead to changes in other policies, e.g., different rating, etc.

7.1.2 Solution for key issue Policy control and Charging

- It shall be possible to inform the PCRF what radio access technology a subscriber is utilizing since depending on operator configuration it may influence what policy control and charging rule is being activated by a PCRF
- The PCC interfaces already defined in Rel-7 shall be used as a basis in an SAE context and may be evolved to meet SAE requirements

Editors Note: In a B1 context, cf. Annex B, the enforcement point of the mobility anchor that resides in the core network shall be controlled by a PCRF. In a B2 context, it is FFS if the Inter AS-MM shall contain an enforcement point that is controlled by a PCRF. Alternatively in a B2 context, it is FFS how the interaction between the PCRF(s) and IP Gateways is performed in Inter Access System Handover.

- The PCC functionality shall in an effective way be able to handle different QoS models cf. e.g. I-WLAN vis-à-vis WCDMA

7.1.3 Impact on the baseline CN Architecture

The PCC functionality shall be evolved from the existing Rel-7 PCC interfaces.

It shall be possible to inform the baseline CN architecture what radio access technology (including an evolved RAN) is being used by a subscriber.

7.1.4 Impact on the baseline RAN Architecture

In case the baseline RAN architecture support multiple RAN access technologies it may be needed to inform the PCRF what radio access technology a subscriber is utilizing including an evolved RAN access technology.

7.1.5 Impact on terminals used in the existing architecture

[Editors Note: It is FFS whether there is any particular terminal impact from the evolution of Policy control and Charging architecture. However at the moment no particular terminal impact has been identified.]

8 Consolidated architecture

9 Conclusions

[Editors Note: both interim and final conclusions can be documented]

Annex A: Open Issues

- How to achieve mobility within the Evolved Access System?
- Is the evolved access system envisioned to work on new and/or existing frequency band?
- Is connecting the Evolved RAN to the legacy PS core needed?
- How to add support for non-3GPP access systems?
- WLAN 3GPP IP access system might need some new functionality for Inter-system Mobility with the Evolved Access System
- Clarify which interfaces are the roaming interfaces, and how roaming works in general
- Inter-access-system mobility
- Possible difference between PCC functionality, mainly stemming from the difference in how Inter-AS mobility is provided
- How do UEs discover Access Systems and corresponding radio cells ? Autonomous per Access System and the UEs scans/monitors any supported Access System to discover Systems and cells. Or, do Access Systems advertise other Access Systems to support UEs in discovering alternative Access Systems ? How is such advertising performed (e.g. system broadcast, requested by UE, ...) ? How do these procedures impact battery lifetime ?
- In case Access Systems advertise other Access Systems: will any Access System provide seamless coverage (avoiding loss of network/network search), or is a hierarchy of Access Systems needed to provide seamless coverage for continuous advertisement ?
- Is user access control/authentication per access system or more centralized for multiple access systems ?
- How are Access Systems, PLMNs and operators discovered and selected ? Can a UE access/attach multiple PLMN/operator in parallel ? If yes, how many ? Or, has a UE to select the same PLMN/operator for each Access System in case the UE accesses/attaches multiple Access systems in parallel?
- How many identities and temporary identities has a UE/subscriber? For every Access System another identity? In case of multiple identities: is user context transfer and identity translation required at a change of the Access System to avoid re-authentication?
- In case a UE accesses/attaches multiple Access Systems in parallel: how does reservation of guaranteed resources work? Are multiple reservations in parallel required (same resource on every Access System) to allow for fast change between Access Systems ? Or, does a mobility/handover mechanism reserve resources during the mobility/handover process ?
- Shall inter Access System mechanisms and signaling for load sharing and mobility be generic for all Access Systems or peer-to-peer between Access Systems ?

- Will any Access Systems have an idle or paging mode ? And, shall the wake-up work over multiple Access Systems (e.g. paging in multiple Access Systems in parallel) ?
- Are User or UE access and service rights specific per Access Systems or common for all or multiple Access Systems ?
- How many network nodes are between UE and top level mobility anchor ? And is there only one set traffic plane functions for user data (policing and charging) ? Or, may the traffic plane functions change during an ongoing service because of an Access System change?
- Are there layers of multiple Access Systems in same physical location required ? And how dynamic do UEs change between different Access Systems in the same location in idle and in connected mode? What signaling traffic is acceptable during such mobility (e.g. signaling via HPLMN) and how does it influence system performance and QoS (e,g. packet loss / service interruption during change of Access System)?
- May functions be transferred to application/services level (e.g. mobility supported by IMS services) ? If yes, to which extent is this feasible for application/services ?
- Does every Access System provide its own security mechanisms (encryption, integrity) ? Is a parameter mapping between different security mechanisms possible? Or, can security associations be established in parallel to ongoing services ?
- How is data compression provided for the different access systems ? And how re-synchronizes compression when the access system changes ?

Annex B:
Summary of different high level architecture proposals.

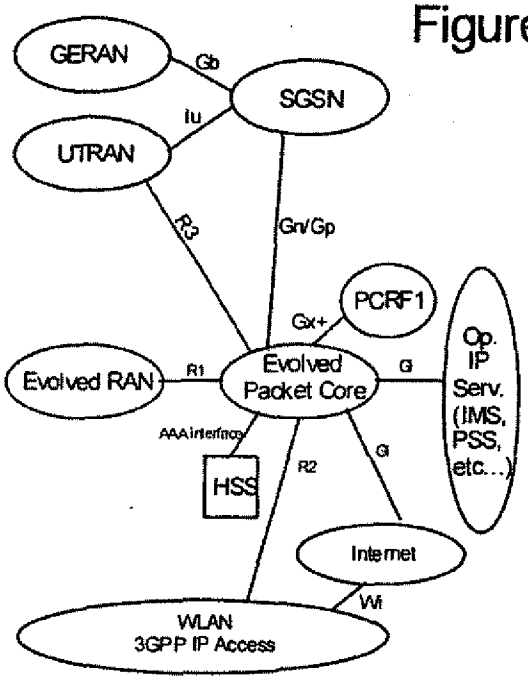
Current company inputs have been summarized into the following 2 separate high level architecture figures. These figures represent the spectrum of company inputs. The key differences between the two figures are:

a) Inter-access-system mobility is achieved differently

b) Possible difference between PCC functionality, mainly stemming from the difference in how Inter-AS mobility is provided

Key issues for further consideration and contributions have been added to the list of open issues in Annex A.

Figure-B.1

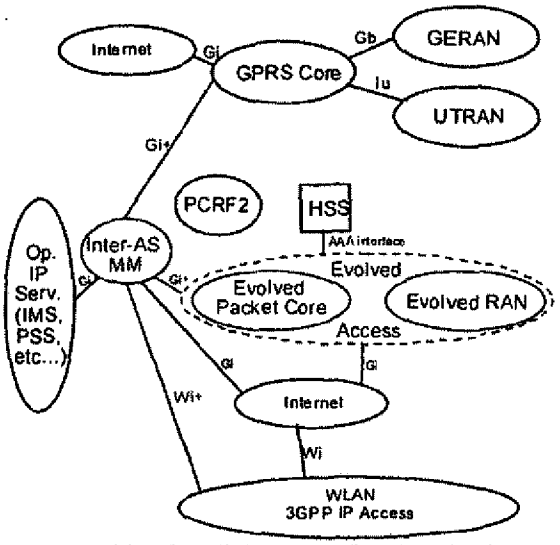


* Color coding: red indicates new functional element / interface

- R1, R2, R3 are working names for reference points
- Gx+ denotes evolved/extended Gx
- PCRF1 denotes evolved Policy and Charging Rules Function

Figure-B.2

- Inter-AS MM: Inter-Access-System Mobility Management
- PCRF2: Evolved Policy and Charging Rules Function
- Gi+ : Gi with added Inter-AS mobility support
- Wi+ : Wi with added Inter-AS mobility support



Note: It is FFS how PCRF2 connects to other elements

* Color coding: red indicates new functional element / interface

Annex C: Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev.	Subject/Comment	Old	New
2005-04	*44*	*S2-050352*	-	-	*Section 7 was updated in line with Tdoc S2-050352*	*V0.0.1*	*V0.0.2*
2005-04	*SA2 #45*				*Includes approves contributions S2-050921, S2-050723, S2-050962*	*V0.0.2*	*V0.1.0*
2005-04					*Editorial update to contents section*	*V0.1.0*	*V0.1.1*
2005-05	*SA2 #46*				*Includes approved contribution S2-051359*	*V0.1.1*	*V0.2.0*
2005-07	*SA2 #47*				*Includes approved contributions SRJ-050116, SRJ-050117 (incorporated into section 5 rather than section 7), SRJ-050121, SRJ-050124, S2-051854 (with change of TS to TR in reference [4]), and, S2-051891.*	*V0.2.0*	*V0.3.0*

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3G TS 23.101 3.0.1 (1999-04)

Technical Specification

3rd Generation Partnership Project; Technical Specification Group Services and System Aspects General UMTS Architecture (3G TS 23.101 version 3.0.1)



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Foreword

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Version 3.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 Indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the specification;

Introduction

UMTS will support a wide range of applications with different quality of service profiles. At present many of these applications are not possible to predict. Also the usage of the different applications are difficult to predict i.e. it is not possible to optimise UMTS to only one set of applications. One conclusion of this is that UMTS must be built in such a way that it is flexible and possible to evolve so it will have a long technical lifetime. Therefore a modular approach is recommended when defining the network parts of UMTS. This is in line with the recommendation from GMM. In this context a module represents a part of a UMTS network i.e. one or several physical network nodes that together implements some functionality. The modular approach should also make UMTS possible to implement efficiently in different environments.

1 Scope

This TS defines the basic physical and functional separation of UMTS. The contents of this specification is limited to those features that are common to all UMTS networks independent of their origin. It identifies and names the reference points and functional groupings appearing at this level.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

2.1 Informative references

[1] ETSI Global Multimedia Mobility (GMM) report

[2] UMTS 22.01: "Universal Mobile Telecommunications System (UMTS): Service aspects; Service principles".

3 Definitions, symbols and abbreviations

3.1 Definitions

Terms introduced in this document:

Domain: The highest-level group of physical entities. Reference points are defined between domains.

Stratum: Grouping of protocols related to one aspect of the services provided by one or several domains.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Cu	Reference point between USIM and ME
Iu	Reference point between Access and Serving Network domains
Uu	Reference point between User Equipment and Infrastructure domains, UMTS radio interface
[Yu]	Reference point between Serving and Transit Network domains
[Zu]	Reference point between Serving and Home Network domains

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

USIM	User Services Identity Module

ME	Mobile Equipment
MT	Mobile Termination
MExE	Mobile Station Application Execution Environment
TE	Terminal Equipment

4 General

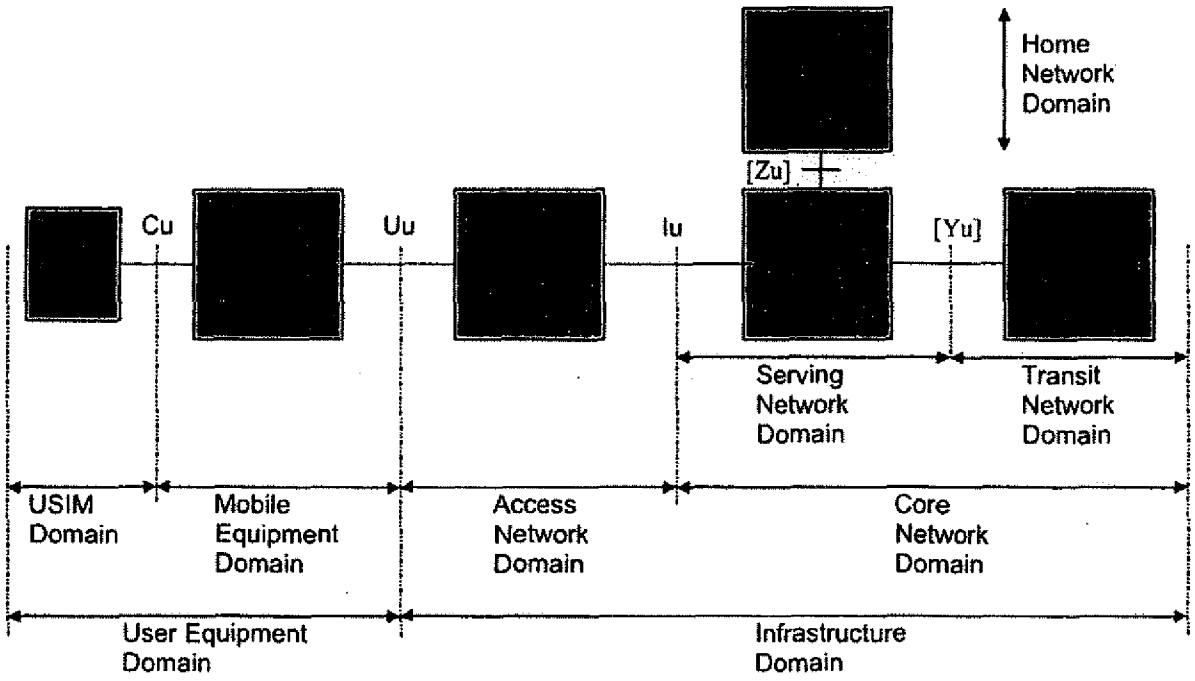
The general UMTS architecture is modelled, at a high level, from both physical and functional viewpoints. The physical aspects are modelled using the domain concept and the functional aspects are modelled using the strata concept.

The two views are introduced separately and then the mapping between the views is discussed.

This specification shows at a basic level physical and functional separations to allow a UMTS network to fit within the context of the IMT-2000 family of networks. It does not attempt to develop aspects of a UMTS network that are highly specific to that implementation.

5 Domains in UMTS

The following figure shows the basic domains in UMTS as described in this section.



NOTE : The domains identified in the figure will generally result from an evolution of existing network infrastructures. The core network domain may result from evolutions of existing network infrastructures, e.g., a GSM infrastructure, a N-ISDN infrastructure, a B-ISDN infrastructure or a PDN infrastructure. The evolution of these infrastructures may be performed via the use of IWUs, hidden within the domains shown in the figure.

Figure 1: UMTS domains and reference points

Cu	= Reference point between USIM and ME
Iu	= Reference point between Access and Serving Network domains
Uu	= Reference point between User Equipment and Infrastructure domains, UMTS radio interface
[Yu]	= Reference point between Serving and Transit Network domains
[Zu]	= Reference point between Serving and Home Network domains

5.1 Domain split

A basic architectural split is between the user equipment (terminals) and the infrastructure. This results in two domains: the **User Equipment Domain** and the **Infrastructure domain.**

User equipment is the equipment used by the user to access UMTS services. User equipment has a radio interface to the infrastructure. The infrastructure consists of the physical nodes which perform the various functions required to terminate the radio interface and to support the telecommunication services requirements of the users. The infrastructure is a shared resource that provides services to all authorised end users within its coverage area.

The reference point between the user equipment domain and the infrastructure domain is termed the "Uu" reference point (UMTS radio interface).

NOTE: The description assumes an access interface based on UTRA. However, the physical and functional separation described in this document is general and is applicable also if other access technologies are used.

5.2 User equipment Domain

This domain encompasses a variety of equipment types with different levels of functionality. These equipment types are referred to as user equipment (terminals), and they may also be compatible with one or more existing access (fixed or radio) interfaces e.g. dual mode UMTS-GSM user equipment. The user equipment may include a removable smart card that may be used in different user equipment types. The user equipment is further sub-divided in to the **Mobile Equipment Domain** (ME) and the **User Services Identity Module Domain** (USIM).

The reference point between the ME and the USIM is termed the "Cu" reference point.

5.2.1 Mobile equipment Domain

The Mobile Equipment performs radio transmission and contains applications. The mobile equipment may be further sub-divided into several entities, e.g. the one which performs the radio transmission and related functions, **Mobile Termination,** MT, and the one which contains the end-to-end application or (e.g. laptop connected to a mobile phone), **Terminal Equipment.** TE. This separation is used in the description of the functional communication in figure 3 but no reference point is defined in this specification.

5.2.2 USIM Domain

The USIM contains data and procedures which unambiguously and securely identify itself. These functions are typically embedded in a stand alone smart card. This device is associated to a given user, and as such allows to identify this user regardless of the ME he uses.

5.3 Infrastructure Domain

The Infrastructure domain is further split into the **Access Network Domain,** which is characterised by being in direct contact with the User Equipment and the **Core Network Domain.** This split is intended to simplify/assist the process of de-coupling access related functionality from non-access related functionality and is in line with the modular principle adopted for the UMTS.

The Access Network Domain comprises roughly the functions specific to the access technique, while the functions in the Core network domain may potentially be used with information flows using any access technique. This split allows for different approaches for the Core Network Domain, each approach specifying distinct types of Core Networks connectable to the Access Network Domain, as well as different access techniques, each type of Access Network connectable to the Core Network Domain.

The reference point between the access network domain and the core network domain is termed the "Iu" reference point.

NOTE: The split into the User Equipment Domain, the Access Network Domain and the Core Network Domain is consistent with the GMM report.

5.3.1 Access Network Domain

The Access Network Domain consists of the physical entities which manage the resources of the access network and provides the user with a mechanism to access the core network domain.

Additional reference points within the access domain may be identified in other specifications.

5.3.2 Core Network Domain

The Core Network Domain consists of the physical entities which provide support for the network features and telecommunication services. The support provided includes functionality such as the management of user location information, control of network features and services, the transfer (switching and transmission) mechanisms for signalling and for user generated information.

[Note: Much more could/should be written about the reference points between the core network and other networks].

The core network domain is sub-divided into the **Serving Network Domain**, the **Home Network Domain** and the **Transit Network Domain**.

The reference point between the serving network domain and the home network domain is termed the [Zu] reference point.

The reference point between the serving network domain and the transit network domain is termed the [Yu] reference point.

Additional sub-divisions and reference points within the core network domain may be identified in other specifications.

5.3.2.1 Serving Network Domain

The serving network domain is the part of the core network domain to which the access network domain that provides the user's access is connected. It represents the core network functions that are local to the user's access point and thus their location changes when the user moves. The serving network domain is responsible for routing calls and transport user data/information from source to destination. It has the ability to interact with the home domain to cater for user specific data/services and with the transit domain for non user specific data/services purposes.

5.3.2.2 Home Network Domain

The home network domain represents the core network functions that are conducted at a permanent location regardless of the location of the user's access point.

The USIM is related by subscription to the home network domain. The home network domain therefore contains at least permanently user specific data and is responsible for management of subscription information. It may also handle home specific services, potentially not offered by the serving network domain.

NOTE: Most of the functionality associated with the service provider role according to the UMTS role model (ref UMTS 22.01), is normally contained within the home network domain.

5.3.2.3 Transit Network Domain

The transit network domain is the core network part located on the communication path between the serving network domain and the remote party. If, for a given call, the remote party is located inside the same network as the originating UE, then no particular instance of the transit domain is activated.

6 Functional Communication between UMTS domains

The following strata have been identified within UMTS:

- Application stratum;
- Home stratum;
- Serving stratum and
- Transport stratum

The following figures show the interactions between the UMTS domains. Two figures are used to reflect the path diversion between the flows exchanged between serving and home domains on one side and between serving and transit on the other side.

Figure 2 below shows the interactions between the USIM, MT/ME, Access Network, Serving Network and Home Network domains. Figure 3 shows the interactions between TE, MT, Access Network, Serving Network, Transit Network domains and the Remote Party . The Home Stratum only involves domains from figure 2, the Application Stratum only involves domains from figure 3. The Serving and Transport Strata involve domains from figures 2 and 3, so part of them are duplicated in the two figures

The direct flows between non-contiguous domains (i.e. between domains non directly interconnected) are transparently transported across all the domains and interfaces located on the communication path between these end domains. E.g. the USIM-Home Network flows are transparently transported through USIM-MT, MT-Access Network, Access Network-Serving Network and Serving Network-Home Network interfaces, and relayed without interpretation by MT, Access Network and Serving Network domains.

The dotted lines indicates that the protocol used is not specific to UMTS, in some cases different protocols are possible. However, to provide easy roaming capabilities, it is desirable to agree upon the protocols used. The definition of these protocols is outside the scope of the UMTS specifications.

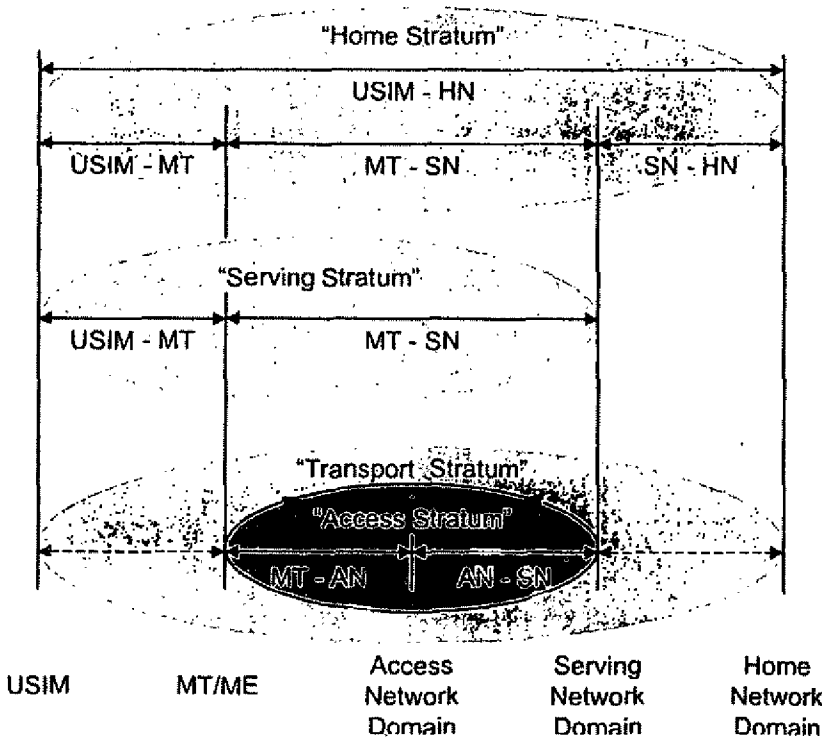


Figure 2: Functional flows between the USIM, MT/ME, Access Network, Serving Network and Home Network domains.

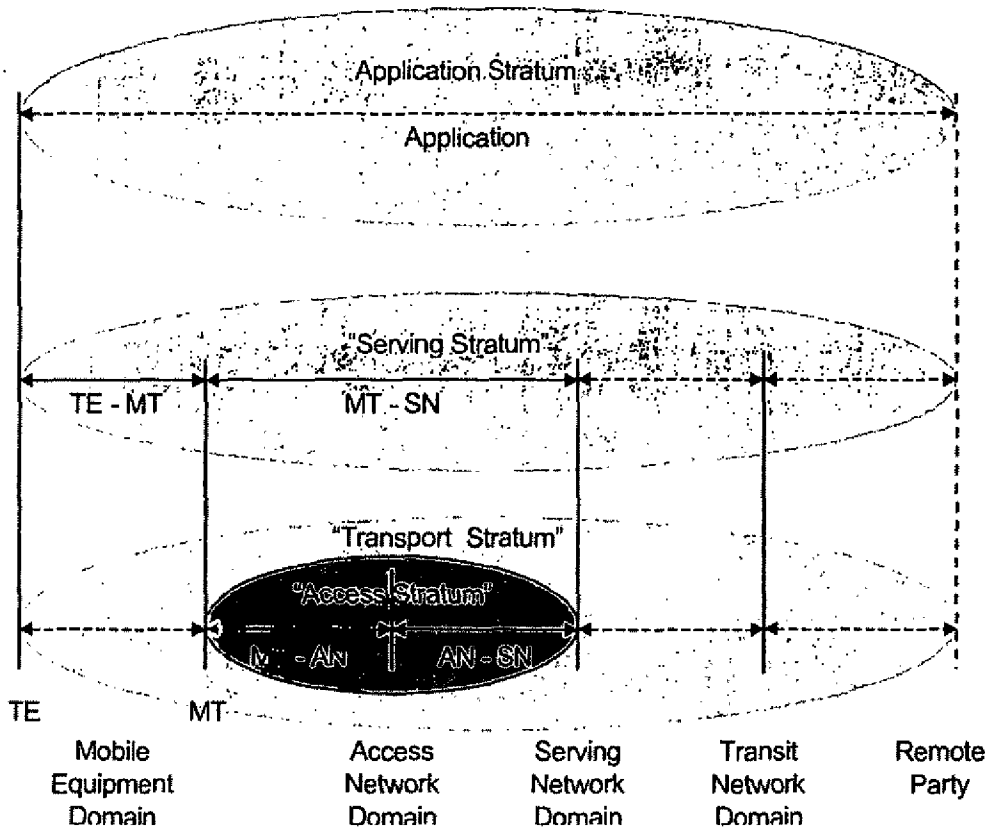


Figure 3: Functional flow between TE, MT, Access Network, Serving Network, Transit Network domains and the Remote Party

The "Remote Party" represents the remote end entity (user or machine) and is included in the figure to show the end-to-end character of the communication, the specification of the remote party is outside the scope of the UMTS specifications.

6.1 Transport stratum

This stratum supports the transport of user data and network control signalling from other strata through UMTS. The transport stratum includes consideration of the physical transmission format used for transmission and also:

- mechanisms for error correction and recovery;
- mechanisms to encrypt data over the radio interface and in the infrastructure part if required;
- mechanisms for adaptation of data to use the supported physical format (if required); and
- mechanisms to "transcode" data to make efficient use of, e.g., the radio interface (if required).

It may also include resource allocation and routing local to the different interfaces.

The **Access Stratum**, which is specific to UMTS, is the part of the transport stratum located between the edge node of the serving core network domain and the MT ('MT-Access Network' and 'Access Network-Serving Network' arrows in figure 2 and 3).

6.2 Access Stratum

This is the functional groupings consisting of the parts in the infrastructure and in the user equipment and the protocols between these parts being specific to the access technique (i.e. the way the specific physical media between the User Equipment and the Infrastructure is used to carry information). The access stratum provides services related to the transmission of data over the radio interface and the management of the radio interface to the other parts of UMTS.

The access stratum includes the following protocols:

- Mobile Termination - Access Network
  This protocol supports transfer of detailed radio-related information to co-ordinate the use of radio resources between the MT and the access network.

- Access Network - Serving Network
  This protocol supports the access from the serving network to the resources provided by the access network. It is independent of the specific radio structure of the access network.

6.3 Serving Stratum

This stratum consists of protocols and functions to route and transmit data/information, user or network generated, from source to destination. The source and destination may be within the same or different networks. Functions related to telecommunication services and are located in this stratum.

The serving stratum includes the following protocols:

- USIM - Mobile Termination
  This protocol supports access to subscriber-specific information for support of functions in the user equipment domain.

- Mobile Termination - Serving Network
  This protocol supports access from the MT to the services provided by the serving network domain.

- Terminal Equipment- Mobile Termination
  This protocol support exchange of control information between the TE and the MT.

6.4 Home Stratum

This stratum contains the protocols and functions related to the handling and storage of subscription data and possibly home network specific services. It also includes functions to allow domains other than the home network domain to act on behalf of the home network. Functions related to subscription data management, customer care, including billing and charging, mobility management and authentication are located in this stratum.

The home stratum includes the following protocols:

- USIM - Home Network
  This protocol supports co-ordination of subscriber-specific information between the USIM and the home network.

- USIM - MT
  This protocol provides the MT with access to user specific data and resources necessary to perform actions on behalf of the home network.

- MT - Serving Network
  This protocol supports user specific data exchanges between the MT and the Serving Network.

- Serving Network - Home Network
  This protocol provides the serving network with access to home network data and resources necessary to perform its actions on behalf of the home network, e.g., to support the users communications, services and features (including VHE).

6.5 Application Stratum

This stratum represents the application process itself, provided to the end-user. It includes end-to-end protocols and functions which make use of services provided by the home, serving and transport strata and infrastructure to support services and/or value added services.

The functions and protocols within the application stratum may adhere to GSM/UMTS standards such as MExE or may

be outside the scope of the UMTS standards. However, the definition of the services provided by the other strata, and the interfaces to them, is within the scope of the standards

End-to-end functions are applications which are consumed by users at the edge of/outside the overall network. The applications may be accessed by authenticated users who are authorised to access such applications. The users may access the applications by using any of the variety of available user equipment.

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Technical Specification

3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description (Release 6)



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Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

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1 Scope

The present document describes the stage 2 description (architectural solution and functionalities) for the MBMS Bearer Service, which includes, together with MBMS User Services defined in [7], all the elements necessary to realise the stage 1 requirements in 3GPP TS 22.146 [2] and 3GPP TS 22.246 [6].

The present document also includes considerations on the manner in which User Services should make use of the MBMS Bearer Service described herein. It should be noted that the specification of MBMS User Services in [7] takes precedence over User Service aspects described in this document.

The present document includes information applicable to network operators, service providers and manufacturers.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.146: "Multimedia Broadcast/Multicast Service; Stage 1".

[3] 3GPP TS 23.107: "Quality of Service (QoS) concept and architecture".

[4] 3GPP TS 29.061: "Interworking between the Public Land Mobile Network (PLMN) supporting packet based services and Packet Data Networks (PDN)".

[5] 3GPP TS 33.246: "Security of Multimedia Broadcast/Multicast Service"

[6] 3GPP TS 22.246: "Multimedia Broadcast/Multicase Service (MBMS) user services"

[7] 3GPP TS 26.346: "MBMS:Protocols and Codecs"

[8] void

[9] void

[10] 3GPP TS 25.346: "Introduction of the Multimedia Broadcast Multicast Service (MBMS) in the Radio Access Network"

[11] 3GPP TS 43.246: "Technical Specification Group GSM/EDGE Radio Access Network; Multimedia Broadcast Multicast Service (MBMS) in the GERAN"

[12] 3GPP TS 23.125: "Flow Based Charging"

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions defined in 3GPP TR 21.905 [1] and 3GPP TS 22.146 [2] and the following apply:

MBMS Service Announcement: Mechanism to allow users to be informed about the MBMS user services available.

MBMS Bearer Service: the service provided by the PS Domain to MBMS User Services to deliver IP multicast datagrams to multiple receivers using minimum network and radio resources.

MBMS User Service: the MBMS service provided to the end user by means of the MBMS Bearer Service and possibly other capabilities.

MBMS Service Area: The area within which data of a specific MBMS session are sent. Each individual MBMS session of an MBMS Bearer Service may be sent to a different MBMS Service Area. This MBMS Service Area is the same or a subset of the MBMS Service Area as defined in 3GPP TS 22.146 [2]. An MBMS Service Area smaller than the MBMS Service Area as defined in 3GPP TS 22.146 [2] is typically used for localized services.

3.2 Abbreviations

For the purposes of the present document, the abbreviations in 3GPP TR 21.905 [1] and 3GPP TS 22.146 [2] apply.

4 MBMS Architecture

4.1 Overview

MBMS is a point-to-multipoint service in which data is transmitted from a single source entity to multiple recipients. Transmitting the same data to multiple recipients allows network resources to be shared.

The MBMS bearer service offers two modes:

- Broadcast Mode
- Multicast Mode

MBMS architecture enables the efficient usage of radio-network and core-network resources, with an emphasis on radio interface efficiency.

MBMS is realised by the addition of a number of new capabilities to existing functional entities of the 3GPP architecture and by addition of a number of new functional entities.

The existing PS Domain functional entities (GGSN, SGSN, UTRAN, GERAN and UE) are enhanced to provide the MBMS Bearer Service. In the bearer plane, this service provides delivery of IP Multicast datagrams from the Gi reference point to UEs with a specified Quality of Service. In the control plane, this service provides mechanisms for:

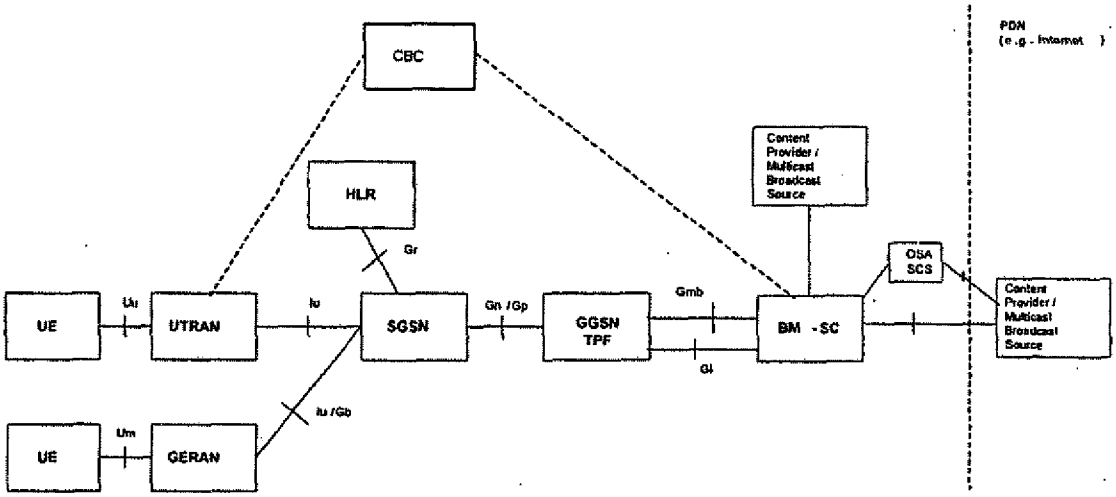
- managing the MBMS bearer service activation status of UEs (in the case of multicast mode)
- outsourcing authorisation decisions to the MBMS User Service (i.e. to the BM-SC) (in the case of multicast mode)
- providing control of session initiation/termination by the MBMS User Service and managing bearer resources for the distribution of MBMS data (in the case or multicast and broadcast modes)

A particular instance of the MBMS Bearer Service is identified by an IP Multicast Address and an APN Network Identifier.

The boundary of the MBMS Bearer Service is the Gmb and Gi reference points as shown in Figure 1 below. The former provides access to the control plane functions and the latter the bearer plane.

A functional entity, the Broadcast Multicast Service Centre (BM-SC) provides a set of functions for MBMS User Services. BM-SC functions for different MBMS User Services may be supported from the same or different physical network elements.

4.2 Reference Architecture Model



Note: dotted lines means functions / reference points that are FFS. Gp applies only when SGSN and GGSN are in different PLMN.

Figure 1: Reference architecture to support MBMS

4.3 MBMS Specific Reference points

4.3.1 Gmb

Signalling between GGSN and BM-SC is exchanged at Gmb reference point. .This represents the network side boundary of the MBMS Bearer Service from a control plane perspective. This includes user specific Gmb signalling and MBMS bearer service specific signalling.

MBMS bearer service specific Gmb signalling:

- The GGSN establishes the MBMS bearer context and registers at BM-SC.
- The GGSN or the BM-SC releases the MBMS bearer context and de-register the GGSN from the BM-SC.
- The BM-SC indicates session start and stop to the GGSN including session attributes like QoS or MBMS service area.

User specific Gmb signalling:

- The BM-SC authorises the user specific MBMS multicast service activation (join) at the GGSN.
- The GGSN reports to the BM-SC the successful user specific MBMS multicast activation (join) to allow the BM-SC to synchronise the BM-SC UE MBMS context and charging with the MBMS UE contexts in SGSN and GGSN.
- The GGSN reports to the BM-SC when a user specific MBMS multicast service is released or deactivated (e.g. when the radio contact is lost) to synchronise BM-SC UE MBMS contexts and charging with the MBMS UE contexts in SGSN and GGSN.

The BM-SC initiates the deactivation of a user specific MBMS bearer service when the MBMS user service is terminated.

BM-SC functions for different MBMS bearer services may be provided by different physical network elements. Further, MBMS bearer service specific and user specific signalling for the same MBMS bearer service may also be provided by different physical network elements. To allow this distribution of BM-SC functions, the Gmb protocol must support the use of proxies to correctly route the different signalling interactions in a manner which is transparent to the GGSN.

4.4 MBMS Service Provision

4.4.1 MULTICAST MODE

Reception of an MBMS MULTICAST service is enabled by certain procedures that are illustrated in the Figure below.

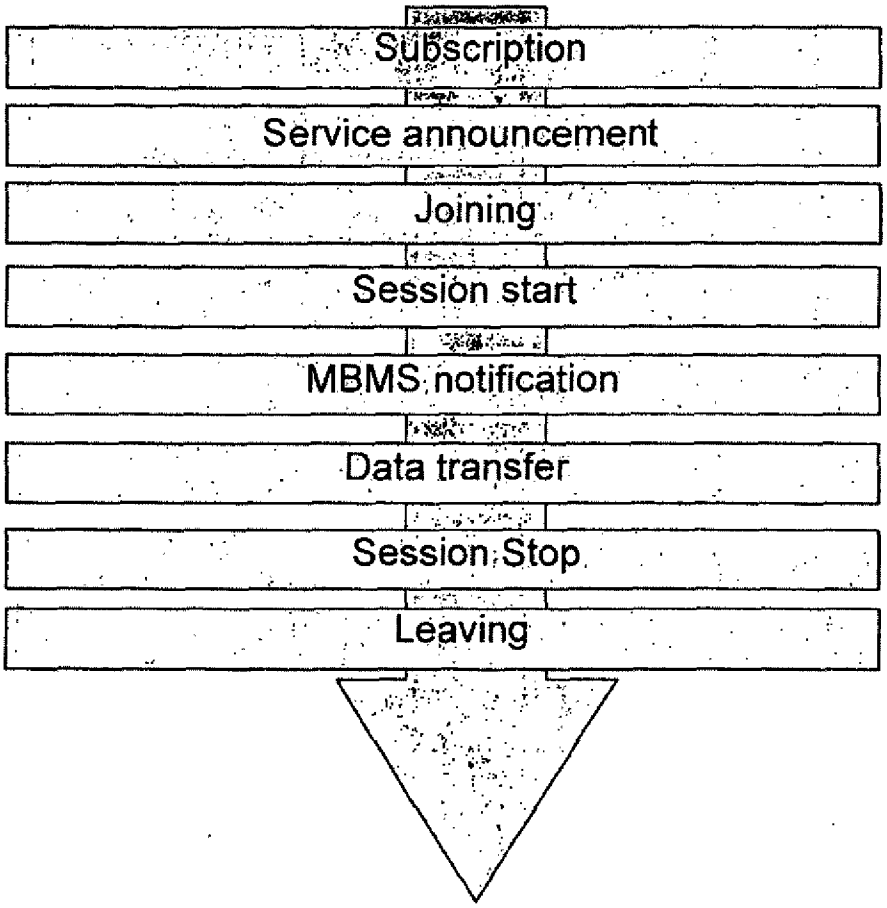


Figure 2: Phases of MBMS Multicast service provision

The phases subscription, joining and leaving are performed individually per user. The other phases are performed for a service, i.e. for all users interested in the related service. The sequence of phases may repeat, e.g. depending on the need to transfer data. Also subscription, joining, leaving, service announcement as well as MBMS notification may run in parallel to other phases.

This is illustrated with the following example of timeline:

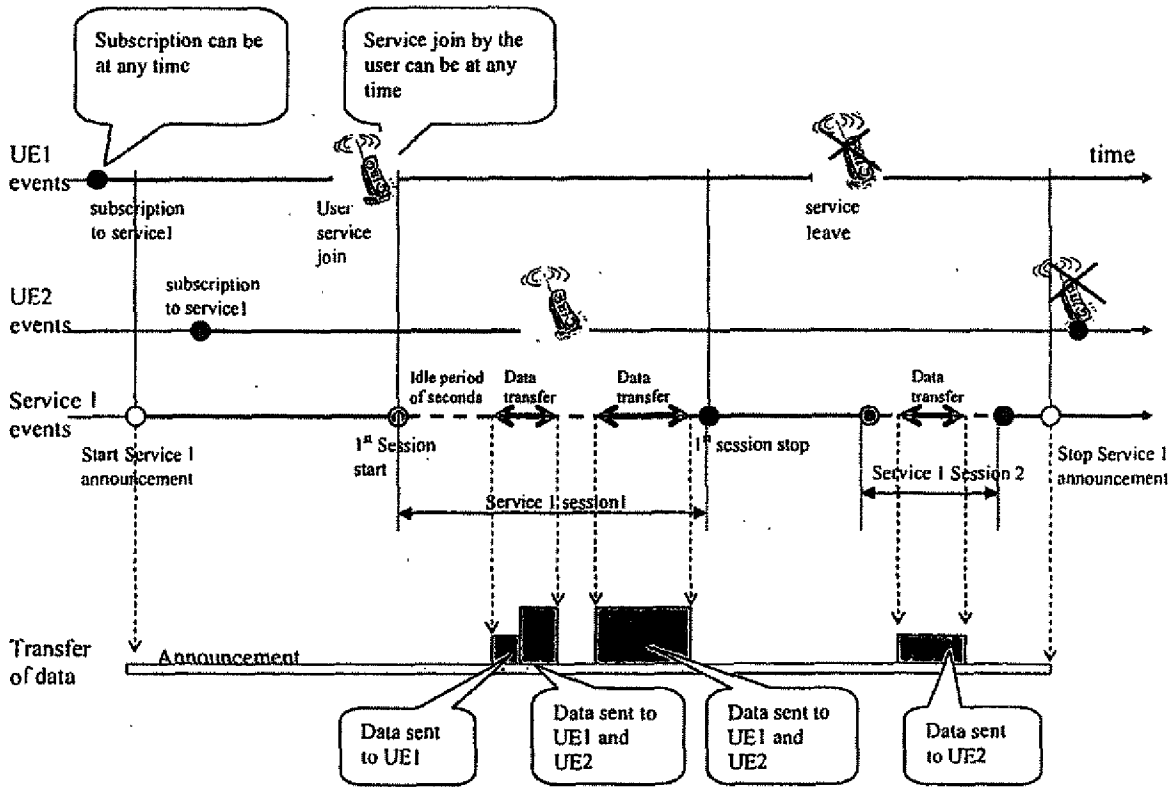


Figure 3: Timeline example

4.4.1.1 Subscription

Establishes the relationship between the user and the service provider, which allows the user to receive the related MBMS multicast service.

Service Subscription is the agreement of a user to receive service(s) offered by the operator. Subscription information is recorded in the BM-SC. Subscription information and other BM-SC functionality may be on separate entities, which is enabled by proxy capability of the Gmb interface.

Note: procedures for the subscription phase are out of scope of this specification.

4.4.1.2 Service announcement

MBMS user service announcement/discovery mechanisms shall allow users to request or be informed about the range of MBMS user services available. This includes operator specific MBMS user services as well as services from content providers outside of the PLMN. Service announcement is used to distribute to users information about the service, parameters required for service activation (e.g. IP multicast address) and possibly other service related parameters (e.g. service start time).

Operators/service providers may consider several service discovery mechanisms. This could include standard mechanisms such as SMS, or depending on the capability of the terminal, applications that encourage user interrogation. The method chosen to inform users about MBMS user services may have to account for the user' s location, (e.g. current cell, in the HPLMN or VPLMN). Users who have not already subscribed to a MBMS user service should also be able to discover MBMS user services.

The following could be considered useful for MBMS user service announcement mechanisms (not exhaustive): -

- CBS

- MBMS Broadcast mode to advertise MBMS Multicast and Broadcast user Services
- MBMS Multicast mode to advertise MBMS Multicast user Services
- PUSH mechanism (WAP, SMS-PP, MMS)
- URL (HTTP, FTP)

The details of the MBMS service announcement mechanisms are not specified, but MBMS shall allow the utilisation of solutions using IETF protocols.

Service announcement is further defined within MBMS User Service specifications 3GPP TS 26.346 [7].

4.4.1.3 Joining

Joining (i.e. MBMS multicast activation by the user) is the process by which a subscriber joins (becomes a member of) a multicast group, i.e. the user indicates to the network that he/she is willing to receive Multicast mode data of a specific MBMS bearer service.

4.4.1.4 Session Start

Session Start is the point at which the BM-SC is ready to send data. This can be identified with the start of a "Multicast session" as defined in the Stage 1. Session Start occurs independently of activation of the service by the user – i.e. a given user may activate the service before or after Session Start. Session Start is the trigger for bearer resource establishment for MBMS data transfer.

4.4.1.5 MBMS notification

Informs the UEs about forthcoming (and potentially about ongoing) MBMS multicast data transfer.

4.4.1.6 Data transfer

It is the phase when MBMS data are transferred to the UEs.

4.4.1.7 Session Stop

It is the point at which the BM-SC determines that there will be no more data to send for some period of time – this period being long enough to justify removal of bearer resources associated with the session. At Session Stop, the bearer resources are released.

4.4.1.8 Leaving

Leaving (i.e. MBMS multicast deactivation by the user) is the process by which a subscriber leaves (stops being a member of) a multicast group, i.e. the user no longer wants to receive Multicast mode data of a specific MBMS bearer service.

4.4.2 Multicast Mode timeline

4.4.2.1 Period between Service Announcement and Session Start

The service announcement may contain a schedule of Session Start times and may be sent some time before the service is due to start. So, this time period could be hours, days or even weeks.

4.4.2.2 Period between Service Announcement and Service Subscription

Service Subscription can be done anytime before or after Service announcement.

4.4.2.3 Period between Service Announcement and Joining

The Joining time is chosen by the user possibly in response to a Service Announcement. Users will typically join at the time of their choosing so that the period between announcement and joining may be very long or very short.

4.4.2.4 Period between Joining and Session Start

Some MBMS bearer services may be 'always on'. In this case, Joining can take place starting immediately after Service Announcement and possibly many hours before, or after, Session Start.

In other cases, if a Session Start time is known, Joining may take place immediately before Session Start or after Session Start. For these services, the announcement may contain some indication of a time period within which users should choose a time to Join the MBMS bearer service.

4.4.2.5 Period between Session Start and First Data Arrival

Session Start indicates that the transmission is about to start. The time delay between a Session Start indication and actual data should be long enough for the network actions required at Session Start to take place e.g. provision of service information to the UTRAN, establishment of the bearer plane.

Session Start may be triggered by an explicit notification from the BM-SC. In the case of bearer plane resources which are set-up after the start of session data transmission, the network is not required to buffer the session data and loss of data can be assumed.

4.4.2.6 Period between Session Start and Session Stop

When the BM-SC knows that there is no more data to be sent for a "long idle period", it should indicate Session Stop to the network, causing the release of bearer resources. However, if this idle period with no data is short, this may not be appropriate as it brings more signalling and processing.

There is no absolute value on the duration of this "long idle period". The order of magnitude (i.e. is it closer to 30 seconds or 30 minutes) is to be defined taking into account UTRAN constraints.

4.4.3 BROADCAST MODE

An example for the phases of MBMS broadcast service provision is described in the figure below:

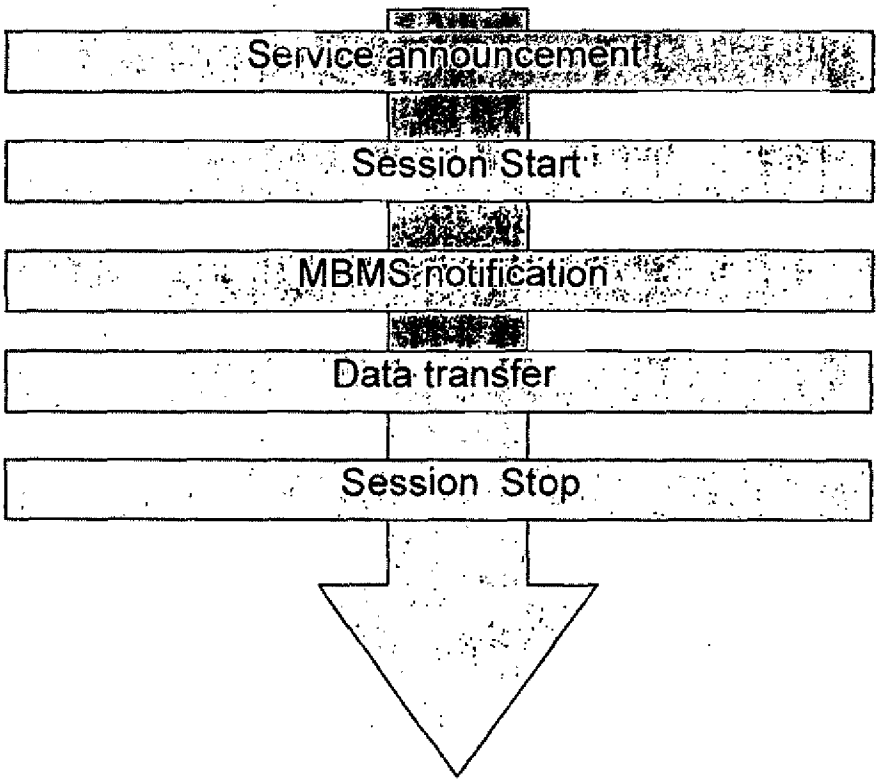


Figure 4: Phases of MBMS broadcast service provision

The sequence of phases may repeat, e.g. depending on the need to transfer data. It is also possible that the service announcement and MBMS notification phase may run in parallel with other phases, in order to inform UEs which have not yet received the related service.

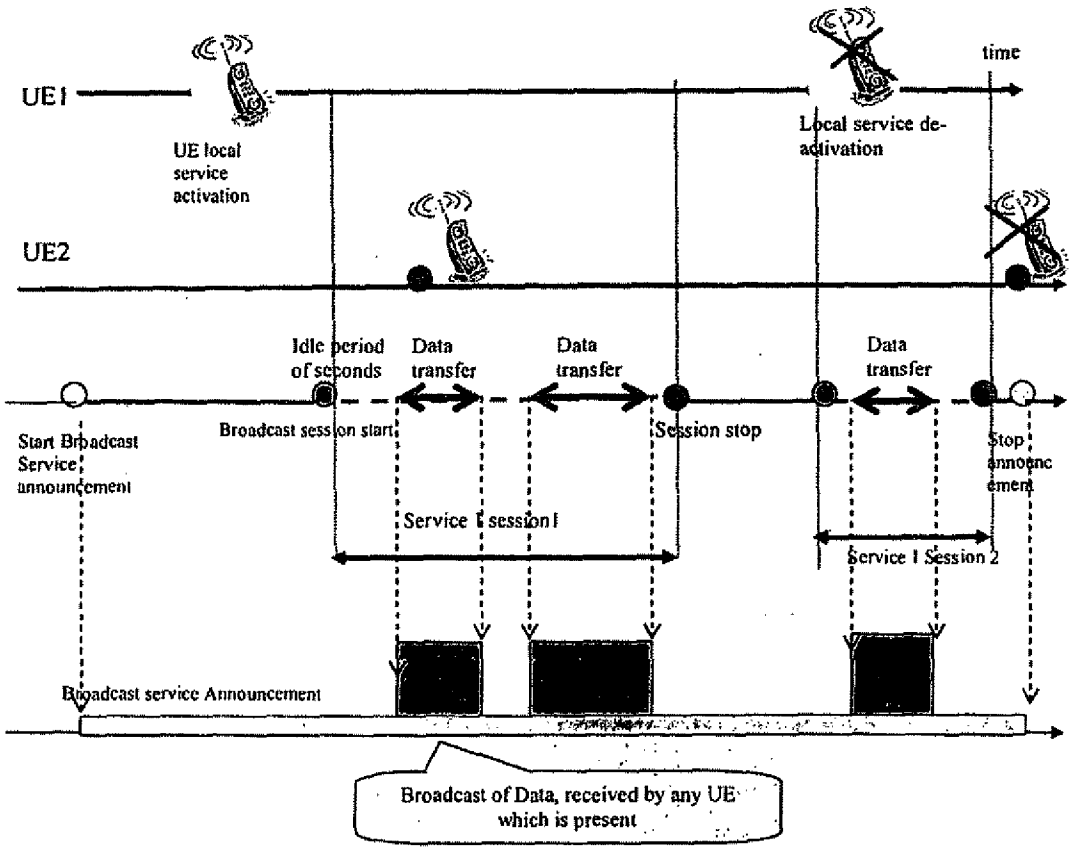


Figure 5: Broadcast service timeline

4.4.3.1 Service announcement

Informs UEs about forthcoming MBMS user services. Also see section on Multicast mode (4.4.1.2)

4.4.3.2 Session Start

Session Start is the point at which the BM-SC is ready to send data. This can be identified with the start of a "Broadcast session" as defined in the Stage 1. Session Start occurs independently of Service Activation by the user – i.e. a given user may activate the service before or after the start of the session. Session Start is the trigger for bearer resource establishment for MBMS data transfer.

4.4.3.3 MBMS notification

Informs the UEs about forthcoming (and potentially about ongoing) MBMS broadcast data transfer.

4.4.3.4 Data transfer

It is the phase when MBMS data are transferred to the UEs.

4.4.3.5 Session Stop

It is the point at which the MBMS user service determines that there will be no more data to send for some period of time – this period being long enough to justify removal of bearer resources associated with the service. At Session Stop, the bearer resources are released.

4.4.4 Broadcast Mode timeline

4.4.4.1 Period between Service Announcement and Session Start

Same as for Multicast mode.

4.4.4.2 Period between Session Start and First Data Arrival

Same as for Multicast mode.

4.4.4.3 Period between Session Start and Session Stop

Same as for Multicast mode.

5 Functional Entities To Support MBMS

To provide MBMS bearer services existing functional entities, GGSN, SGSN, RNC/BSC, perform several MBMS related functions and procedures, some of which are specific to MBMS. An MBMS specific functional entity – Broadcast Multicast Service Centre (BM-SC) supports various MBMS user service specific service provisioning and delivery.

5.1 Broadcast-Multicast Service Centre (BM-SC)

The BM-SC provides functions for MBMS user service provisioning and delivery. It may serve as an entry point for content provider MBMS transmissions, used to authorise and initiate MBMS Bearer Services within the PLMN and can be used to schedule and deliver MBMS transmissions.

The BM-SC is a functional entity, which must exist for each MBMS User Service.

This section describes BM-SC functions, which are defined for the standardised MBMS User Services. Which of these functions are provided as general purpose capabilities to be used by multiple MBMS User Services and which are specific to a particular MBMS User Service is defined in conjunction with the definition of the standardised MBMS User Services.

5.1.1 Content Provider Charging

The BM-SC shall be able to generate charging records for content provider transmitted data.

5.1.2 MBMS Transport

The BM-SC shall be able to provide the GGSN with transport associated parameters such as quality-of-service and MBMS service area.

The BM-SC shall be able to initiate and terminate MBMS bearer resources prior to and following transmission of MBMS data.

5.1.3 MBMS Transmissions

The BM-SC should be able to accept content from external sources and transmit it using error resilient schemes (e.g. specialized MBMS codecs).

Further, the BM-SC might be used to schedule MBMS session transmissions, retrieve content from external sources and provide this content using MBMS bearer services.

The BM-SC should be able to schedule MBMS session retransmissions, and label each MBMS session with an MBMS Session Identifier to allow the UE to distinguish the MBMS session retransmissions.

Each transmission and subsequent retransmission(s) of a specific MBMS session are identifiable by a common MBMS Session Identifier (2-3 Octets) passed at the application layer in the content, and also passed in a shortened form (i.e. the least significant octet) in the MBMS Session Start Request message to the RNCs/BSCs. The full MBMS Session Identifier should be used by the UE to identify an MBMS session when completing point-to-point repair, while the shortened MBMS Session Identifier is included by the RANs in the notification messages for MBMS.

5.1.4 Service Advertisement and Description

The BM-SC shall be able to provide service announcements for multicast and broadcast MBMS user services.

The BM-SC shall be able to provide the UE with media descriptions specifying the media to be delivered as part of an MBMS user service (e.g. type of video and audio encodings).

The BM-SC shall be able to provide the UE with MBMS session descriptions specifying the MBMS sessions to be delivered as part of an MBMS user service (e.g. multicast service identification, addressing, time of transmission, etc.)

The BM-SC shall be able to deliver media and session descriptions by means of service announcements using IETF specified protocols over MBMS multicast and broadcast bearer services.

5.1.5 Separate MBMS Bearer Services for 2G and 3G for the same MBMS User Service

The same MBMS user service may transfer its data on separate MBMS bearer services for 2G or 3G coverage, typically with different QoS. For this purpose two IP multicast addresses and the associated two TMGIs should be allocated for the same MBMS user service. One pair of IP multicast address and TMGI is for 2G coverage and another pair of IP multicast address and TMGI is for 3G coverage. The detailed impacts on the network nodes are listed below:

a) The service announcement instructs the UE to join two multicast MBMS bearer services (one is for 2G coverage and the other is for 3G coverage), i.e. two IP multicast addresses allocated in BM-SC will be sent to UE within one service announcement message.

b) A UE that might move between 3G coverage areas and 2G coverage areas activates both MBMS bearer services.

c) The UE monitors the paging/notification channels for both TMGIs and receives MBMS data when transferred by the MBMS bearer services.

d) When the BM-SC needs to deliver the content, the BM-SC produces two sets of MBMS data from the same content and sends independent Session Start messages for both of the MBMS bearer services. The "different" 2G and 3G content streams for the same MBMS user service are sent on the different IP multicast address associated with 2G and 3G TMGIs. A 2G/3G indicator in the Session Start message (which the GGSN passes transparently to the SGSN) indicates whether the content should be delivered in 2G-only or 3G-only (or both) coverage areas.

e) The SGSN uses the 2G/3G indicator to decide whether a MBMS Session Start Request message should be sent to the BSCs and/or the RNCs.

Although this procedure mentions 2G and 3G extensively, only the BM-SC (which renders the content differently) and the SGSN have to implement functionality to deliver this. The GGSN, RNC and BSC shall all be transparent to this functionality.

5.2 User Equipment

The UE shall support functions for the activation/deactivation of the MBMS bearer service.

Once a particular MBMS bearer service is activated, no further explicit user request is required to receive MBMS data although the user may be notified that data transfer is about to start.

The UE shall support security functions as appropriate for MBMS.

The UE should, depending on terminal capabilities, be able to receive MBMS user service announcements, paging information (non MBMS specific) or support simultaneous services (For example the user can originate or receive a call

or send and receive messages whilst receiving MBMS video content). Reception of this paging or announcements may however, create losses in the MBMS data reception. The MBMS user service should be able to cope with such losses.

Some UE depending upon terminal capability may be able to store MBMS data. This may involve DRM but this is out of scope of this specification.

The MBMS Session Identifier contained in the notification to the UE shall enable the UE to decide whether it needs to ignore the forthcoming transmission of MBMS session (e.g. because the UE has already received this MBMS session).

5.3 UTRAN/GERAN

UTRAN/GERAN are responsible for efficiently delivering MBMS data to the designated MBMS service area.

Efficient delivery of MBMS data in multicast mode may require mechanisms in the UTRAN/GERAN, e.g. the number of users within a cell prior to and during MBMS transmission could be used to choose an appropriate radio bearer.

MBMS transmissions may be initiated and terminated intermittently. The UTRAN/GERAN shall support the initiation and termination of MBMS transmissions by the core-network. Further, the UTRAN/GERAN shall be able to receive MBMS data from the core-network over Iu bearers shared by many UEs.

The UTRAN/GERAN shall support intra-RNC/BSC, inter-RNC/BSC mobility of MBMS receivers. Mobility is expected to cause limited data loss. Therefore, MBMS user services should be able to cope with potential data loss caused by UE mobility.

The UTRAN/GERAN shall be able to transmit MBMS user service announcements, paging information (non MBMS specific) and support other services in parallel with MBMS (for example depending on terminal capabilities the user could originate or receive a call or send and receive messages whilst receiving MBMS video content).

5.4 SGSN

The SGSN role within MBMS architecture is to perform user individual MBMS bearer service control functions and to provide MBMS transmissions to UTRAN/GERAN.

The SGSN shall provide support for intra-SGSN and inter-SGSN mobility procedures. Specifically this requires the SGSN to store a user-specific MBMS UE context for each activated multicast MBMS bearer service and to pass these contexts to the new SGSN during inter-SGSN mobility procedures.

The SGSN shall be able to generate charging data per multicast MBMS bearer service for each user. Further, the SGSN may provide functions to support the charging of prepaid users.

The SGSN shall be able to establish Iu and Gn bearers shared by many users on demand when data has to be transferred to the users. This shall be done upon notification from the GGSN. Likewise, when data is no longer available the SGSN shall be able to tear down these bearers upon notification from the GGSN.

5.5 GGSN

The GGSN role within the MBMS architecture is to serve as an entry point for IP multicast traffic as MBMS data. Upon notification from the BM-SC the GGSN shall be able to request the establishment of a bearer plane for a broadcast or multicast MBMS transmission. Further, upon BM-SC notification the GGSN shall be able to tear down the established bearer plane. Bearer plane establishment for multicast services is carried out towards those SGSNs that have requested to receive transmissions for the specific multicast MBMS bearer service.

The GGSN shall be able to receive IP multicast traffic (whether from BM-SC or other data sources) and to route this data to the proper GTP tunnels set-up as part of the MBMS bearer service.

Other functions to note here that GGSN may provide in support of MBMS bearer service but not exclusive to MBMS are:

- Message Screening (not needed if the MBMS sources are internal in the PLMN);
- Charging Data Collection;

5.6 MBMS Data Sources and Content Provider

The reference point from the content provider to the BM-SC is not standardised.

5.7 Optional Functional Element

NOTE: The following are FFS.

5.7.1 Void

5.7.2 CBC

The Cell Broadcast Centre (CBC) may be used to announce MBMS user services to the users.

5.7.3 OSA-SCS

The BM-SC might use OSA-SCS to interact with third parties.

6 MBMS attributes and Parameters

6.1 MBMS UE Context

The MBMS UE Context contains UE-specific information related to a particular MBMS bearer service that the UE has joined. An MBMS UE Context is created in the UE, SGSN,GGSN and BM-SC when the UE joins an MBMS bearer service. In the SGSN, an MBMS UE Context is also created as a result of an inter-SGSN routing area update after the transfer of the MBMS UE Context from the old SGSN.

In Iu mode, all MBMS UE Contexts of a UE are provided via MBMS UE Linking mechanism to the BSC/SRNC at least when the first PS RAB is established for the UE, or when the UE performs MBMS Multicast Service Activation. MBMS UE Contexts are provided to the Iu mode BSC/SRNC regardless whether MBMS Sessions are ongoing or not (i.e. before, between and after Sessions). In addition, all MBMS UE Contexts of a UE are provided via MBMS UE Linking mechanism when a UE, which has an MBMS context active, moves to PMM-Connected state via the MBMS Service Request procedure for the purpose of MBMS.

In the UE and SGSN, the MBMS UE Context is stored as part of the MM Context for the UE. The MBMS UE Context is stored in the GGSN. There is one MBMS UE Context per MBMS bearer service that the UE has joined.

In the Iu mode BSC/RNC, the MBMS UE Contexts are stored as part of the UE Context of the BSC/RNC.

The content of the MBMS UE Context is described in Table 1.

Table 1: MBMS UE Context

Parameter	Description	UE	SGSN	GGSN	RNC	BSC	BM-SC
IP multicast address	IP multicast address identifying an MBMS bearer that the UE has joined.	X	X	X	X	Iu - X Gb - none	X
APN	Access Point Name on which this IP multicast address is defined.	X	X	X	X	Iu - X Gb – none	X
TMGI	Temporary Mobile Group Identity allocated to the MBMS bearer.	X					
Linked NSAPI	NSAPI of the PDP context used by the UE to carry IGMP/MLD signalling.	X	X				
IMSI	IMSI identifying the user.	(1)	(1)	X	(2)	Iu – (2) Gb – (3)	X
TI	Transaction Identifier	X	X				
MBMS_NSAPI	Network layer Service Access Point Identifier which identifies an MBMS UE Context.	X	X	X			

(1) In the UE and SGSN, the IMSI is available within the MM Context which contains the MBMS UE Context

(2) The IMSI is available within the UE Context which contains the MBMS UE Context.

(3) IMSI availability does not depend on MBMS.

6.2 MBMS Bearer Context

The MBMS Bearer Context, which is referred to as MBMS Service Context in RAN, contains all information describing a particular MBMS bearer service and is created in each node involved in the delivery of the MBMS data.

An MBMS Bearer Context is created in the SGSN and GGSN when the first MBMS UE Context is created in the node or when a downstream node requests it. The MBMS Bearer Context is statically configured in the BM-SC; how this is done is out of the scope of this specification. The MBMS Bearer Context is created in the Iu mode BSC and in SRNC when a first MBMS UE Context is created in BSC/SRNC. Session Start procedure may create MBMS Bearer Context in a BSC/RNC which has no MBMS Bearer Context yet.

An MBMS Bearer Context, once created, can be in one of two states reflecting the bearer plane resource status of the corresponding MBMS bearer service.

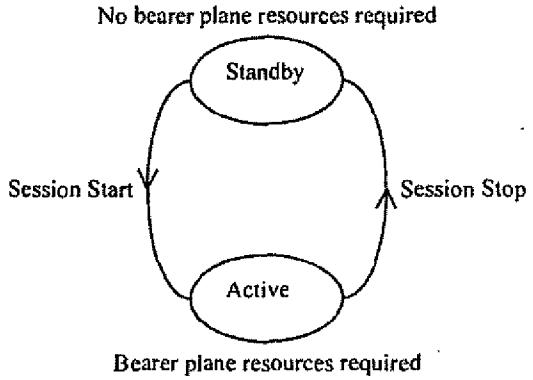


Figure 6: MBMS Bearer Context State Model

'Active' reflects the state of an MBMS Bearer Context in which bearer plane resources are required in the network for the transfer of MBMS data. This state is maintained as long as there is a corresponding MBMS session ongoing.

'Standby' reflects the state of an MBMS Bearer Context in which no bearer plane resources are required in the network for the transfer of MBMS data. This state is maintained as long as there is no corresponding MBMS session ongoing.

The content of the MBMS Bearer Context is described in Table 2.

Table 2: MBMS Bearer Context

Parameter	Description	RAN	SGSN	GGSN	BM-SC
IP multicast address	IP multicast address identifying the MBMS bearer described by this MBMS Bearer Context.	X	X	X	X
APN	Access Point Name on which this IP multicast address is defined.	X	X	X	X
TMGI	Temporary Mobile Group Identity allocated to the MBMS bearer service.	X	X	X	X
State	State of bearer plane resources ('standby' or 'active')	X	X	X	X
Required MBMS Bearer Capabilities	Minimum bearer capabilities the UE needs to support		X	X	X
QoS	Quality of Service required for the MBMS bearer service.	X	X	X	X
MBMS Service Area	Area over which the MBMS bearer service has to be distributed.	X	X	X	X
List of downstream nodes	List of downstream nodes that have requested the MBMS bearer service and to which notifications and MBMS data have to be forwarded.		X	X	X
Number of UEs	Number of UEs hosted by the node that have joined the multicast MBMS bearer service.		X	X	
List of number of PMM-IDLE UEs per RA	List of number of PMM-IDLE UEs for each RA, which contains at least one UE that has joined the MBMS service.		X[1]		
List of RAs	List of RAs, each of which contains at least one UE that has joined the MBMS service.	X[1]			

Note 1: It is an optional parameter. The SGSN may include a list of RAs which lists each RA that contains at least one PMM-IDLE UE that has activated the MBMS bearer service. This list may be empty.

6.3 Quality-of-Service

It shall be possible for the network to control quality-of-service parameters for sessions of multicast and broadcast MBMS bearer services. All QoS attributes related to the UMTS bearer service described in 3GPP TS 23.107 [3] are applicable to MBMS bearer services. Compared to point-to-point bearer services the following limitations exist:

- For **traffic class**, only the background and streaming classes shall be supported.
- For **SDU error ratio**, only higher values are supported, i.e. the values describing higher numbers of lost or corrupted SDUs (actual values are for the background and streaming classes are 10^{-2} and 10^{-1}).
- For **maximum bit-rate**, see the values described in 3GPP TS 22.246.

MBMS bearer services of background class are best suited for the transport of MBMS user services such as messaging or downloading. Buffering, shaping schemes and packet dropping may be applied to the traffic flow to adapt to the available resources and changing network conditions. The total transfer time is not critical for background class bearer services since the content must normally have been received in totality and stored in the UE before the user can access it.

MBMS bearer services of streaming class are best suited for the transport of MBMS user services such as streaming. As for point-to-point bearer services, the network should minimise the packet transfer delay of streaming class bearer services as far as possible. Packet dropping should be the preferred traffic conditioning action applied to the traffic flow to adapt to the available resources.

The principle difference between background and streaming classes for MBMS is the support of a guaranteed bit-rate in the streaming case.

MBMS user services that would normally use MBMS bearer services of background class may however need to use a streaming class MBMS bearer service. This will reduce packet loss due to congestion, since a minimum bit-rate is guaranteed. Otherwise the MBMS user service will have to provide sufficient redundancy within the data to be able to cope with the high packet loss.

The Allocation and Retention Priority of the MBMS bearer service allows for prioritisation between MBMS bearer services and between MBMS bearer services and non MBMS bearer services.

As the MBMS bearer service transfers data to many UEs in parallel and because of the lack of feedback channel on radio level low SDU error ratios are difficult to achieve. When the resulting packet error ratio is not suitable for the MBMS user service or when prevention of data loss is required, an MBMS user service may perform retransmission of MBMS data over point-to-point PDP bearer services.

6.3.1 MBMS QoS distribution tree

MBMS data will be distributed to multiple users through a MBMS distribution tree that can go through many BSCs/RNCs, many SGSNs and one or more GGSNs. Furthermore some bearer resources may be shared between many users accessing the same MBMS bearer service in order to save resources. As a result, each branch of a MBMS distribution tree shall be established with the same QoS.

MBMS distribution tree shall have the same QoS for all its branches.

When a branch of the MBMS distribution tree has been created, it is not possible for another branch (e.g. due to arrival of a new UE or change of location of a UE with removal of a branch and addition of a new one) to impact the QoS of already established branches.

There is no QoS value negotiation between UMTS network elements. This implies that some branches may not be established if QoS requirement cannot be accepted by the concerned network node.

Also in RAN there is no QoS (re-)negotiation feature for the MBMS bearer service.

6.4 Temporary Mobile Group Identity

Temporary Mobile Group Identity (TMGI) is used for MBMS notification purpose. The BM-SC allocates a globally unique TMGI per MBMS bearer service. The TMGI contains two parts: Globally unique MCC/MNC (PLMN ID) and a local MBMS bearer service identity that is unique within the PLMN. For Multicast MBMS bearer services the TMGI will be transmitted to UE via service activation procedure. For Broadcast Service the TMGI can be obtained via service announcement see " Service Announcement".

The TMGI is a radio resource efficient MBMS bearer service identification, which is equivalent to the MBMS bearer service identification consisting of IP multicast address and APN.

7 Architectural Aspects of MBMS User Services

MBMS bearers may be used in numerous ways to provide different types of applications. MBMS user services employ MBMS bearers and possibly point-to-point bearers in order to provide application data in an efficient manner. This section is used to discuss different aspects of MBMS user services that directly relate to the usage of MBMS and point-to-point bearers. This section is not intended to deal with the architecture and interfaces of MBMS user services.

7.1 Alternative User Service Support

For many MBMS services, it will be necessary to provide alternative means for the UE to access the service without using MBMS bearer capabilities. This is required, for example, after completion of the MBMS session for a file download to permit errors in the file to be corrected; to permit the network to charge for a successful download; to pass a decrypt key to the UE; etc. It may also be useful in cases where all or part of an MBMS transmission has been missed due to the UE being out of coverage, switched off etc.

Care is needed to ensure that such alternative access mechanisms do not create traffic that overloads the network (radio, RNC, BSC, SGSN, GGSN and BM-SC). In the case that such alternative access requires direct interaction between the UE and a network server, one way for this load to be distributed is for the BM-SC to distribute to each UE, at activation time, one or more server addresses (from a group of addresses), along with parameter(s) that are used to generate a random time dispersion of the requests.

8 MBMS Procedures

8.1 MBMS Notification

8.1.1 Iu mode notification (UTRAN and GERAN)

When an MBMS Session starts, UEs interested in the MBMS bearer service (PMM-CONNECTED UEs and PMM-IDLE UEs) shall be notified.

MBMS Session attributes such as Session Identifier and MBMS Service Area(s) are made available in all interested RNCs during the Session Start procedure.

For radio efficiency reasons, the UTRAN may select on per cell basis whether to establish point-to-point or point-to-multipoint links for the distribution of MBMS data to the UEs.

In order to perform this selection, the UTRAN requests a proportion of UEs to move to PMM-CONNECTED mode by means of MBMS notification sent in the MBMS service Area.

The exact number of UEs moved to PMM-CONNECTED mode is a decision of RAN node. It is not necessary for all UEs to move to PMM-CONNECTED mode in order for the RAN to decide to use point-to-multipoint, other UEs may remain in PMM-IDLE state. This is a UTRAN choice (based on RRM criteria…)..

Following the decision to set up point-to-point or point-to-multipoint links, the number of UEs that need to be maintained in PMM-CONNECTED mode or moved to PMM-IDLE mode for MBMS data reception is also a decision of a RAN node.

8.1.2 A/Gb mode notification (GERAN)

When an MBMS Session starts, UEs interested in the MBMS bearer service (READY UEs and STANDBY) shall be notified. The MBMS notification triggers detection or counting of UEs per cell for selection of the most appropriate MBMS radio bearer.

MBMS Session attributes such as Session Identifier, MBMS Service Area, QoS are made available in all interested BSCs that are connected to a registered SGSN by the Session Start procedure.

8.2 MBMS Multicast Service Activation

The MBMS multicast service activation procedure registers the user in the network to enable the reception of data from a specific multicast MBMS bearer service. The activation is a signalling procedure between the UE and the network. The procedure establishes MBMS UE contexts in UE, SGSN and GGSN and Iu mode BSC/RNC for each activated multicast MBMS bearer service comparable to regular PDP contexts.

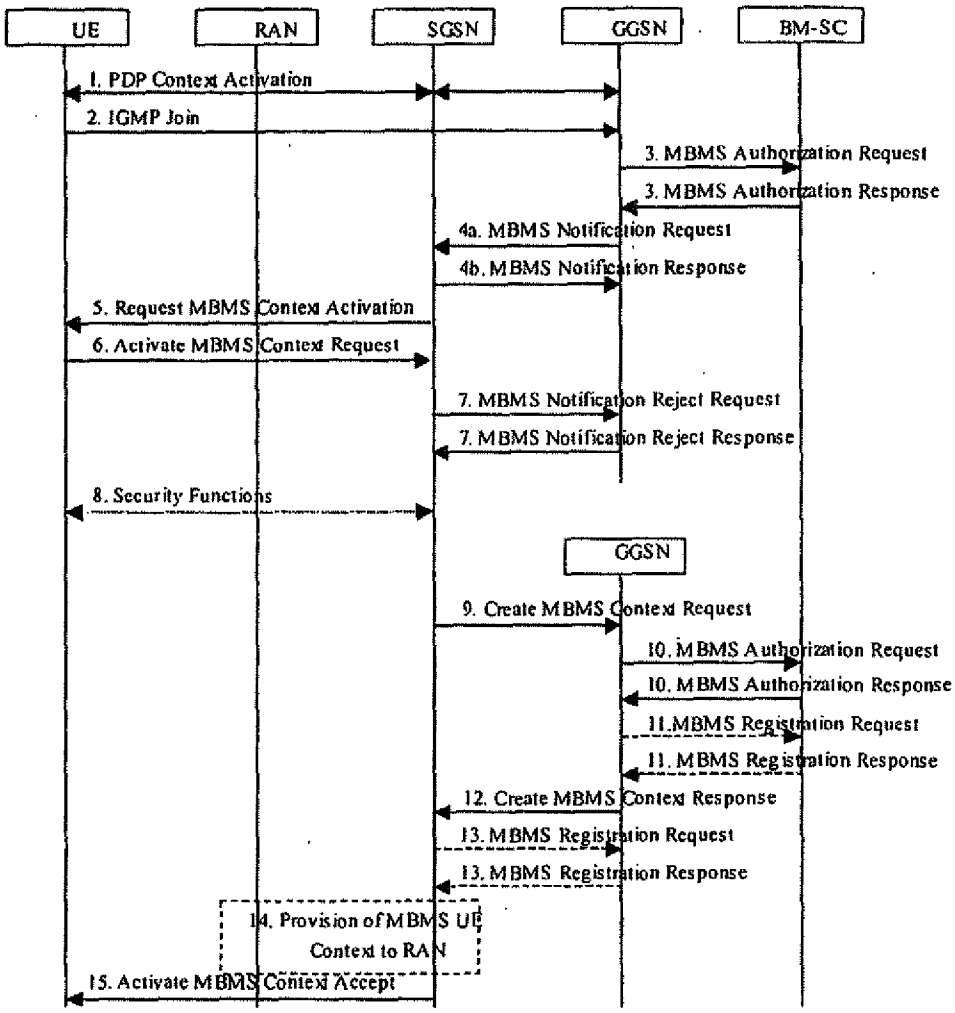


Figure 7: The activation of an MBMS multicast service

1. The UE activates a default, typically best-effort PDP context if not already established. This can be a PDP context used for basic IP services like WAP or Internet access, or it might be the signalling PDP context used for IMS access.

2. The UE sends an IGMP (IPv4) or MLD (IPv6) Join message over the default PDP context to signal its interest in receiving a particular multicast MBMS bearer service identified by an IP multicast address.

3. The GGSN sends an MBMS Authorization Request seeking authorization for the activating UE to receive data. The authorization decision, which may be based on subscription data in the BM-SC, is provided in the MBMS Authorization Response together with the APN to be used for creation of the MBMS UE context. If the MBMS Authorization Response indicates that the UE is not authorized to receive the MBMS data the process terminates with no additional message exchange.

4a. The GGSN sends an MBMS Notification Request (IP multicast address, APN, Linked NSAPI) to the SGSN. Linked NSAPI is set equal to the NSAPI of the PDP context over which the Join request was received. The IP multicast address is the one requested by the UE in the Join request. The APN may be different from the APN to which the default PDP context has been activated. In any case, the APN may resolve to a GGSN that is different from the GGSN receiving the IGMP/MLD Join request. The GGSN starts a MBMS Activation Timer as GGSN may receive no response, e.g. in case SGSN or UE does not support MBMS.

4b. The SGSN sends a MBMS Notification Response (Cause) to the GGSN that sent the MBMS Notification Request, where Cause shall indicate whether or not the MBMS context activation will proceed. Upon reception

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of the response message with Cause indicating unsuccessful operation the GGSN should not send any further MBMS Notification Request messages. The procedure is then terminated.

5. The SGSN sends a Request MBMS Context Activation (IP multicast address, APN, Linked NSAPI, TI) to the UE to request it to activate an MBMS context. Linked NSAPI allows the UE to associate the MBMS Context with the PDP context over which it sent the IGMP/MLD Join message in step 2. TI was chosen by the SGSN and contains a value not used by any other activated PDP context and MBMS UE context for this UE.

6. The UE creates an MBMS UE context and sends an Activate MBMS Context Request (IP multicast address, APN, MBMS_NSAPI, MBMS bearer capabilities) to the SGSN. The IP multicast address identifies the MBMS multicast service, which the UE wants to join/activate. An APN may indicate a specific GGSN. The MBMS bearer capabilities indicate the maximum QoS the UE can handle. The MBMS_NSAPI was chosen by the UE and contains a value not used by any other activated PDP context and MBMS UE context for this UE. If the SGSN has the MBMS Bearer Context information for this MBMS bearer service, the SGSN should verify the UE's MBMS bearer capabilities. If the SGSN determines that the UE's MBMS bearer capabilities are less than the Required MBMS Bearer Capabilities, it shall reject the request for activation of an MBMS context with an appropriate cause.

7. If the MBMS UE Context was not established, the SGSN sends a MBMS Notification Reject Request (Cause) to the GGSN that sent the MBMS Notification Request, where Cause shall indicate the reason why the MBMS UE Context could not be established. The GGSN then sends a MBMS Notification Reject Response back to the SGSN. This should prevent further sending of MBMS Notification Request messages. The procedure is then terminated.

8. Security Functions may be performed, e.g. to authenticate the UE.

9. The SGSN creates an MBMS UE context and sends a Create MBMS Context Requests (IP multicast address, APN, MBMS_NSAPI, IMSI, MSISDN, Serving network identity) to the GGSN.

10. The GGSN sends an MBMS Authorization Request (IMSI, MSISDN, Serving network identity) seeking authorization for the activating UE. The authorization decision is provided in the MBMS Authorization Response. The BM-SC creates an MBMS UE Context.

11. If the GGSN does not have the MBMS Bearer Context information for this MBMS bearer service, the GGSN sends a MBMS Registration Request to the BM-SC. See subclause "MBMS Registration Procedure".

    If no TMGI has been allocated for this MBMS bearer service, the BM-SC will allocate a new TMGI. This TMGI will be passed to GGSN and SGSN via the MBMS Registration Response message and further to UE via Activate MBMS Context Accept message.

    The BM-SC responds with a MBMS Registration Response containing the MBMS Bearer Context information for this MBMS bearer service and adds the identifier of the GGSN to the "list of downstream nodes" parameter in its MBMS Bearer Context. See subclause "MBMS Registration Procedure".

12. The GGSN creates an MBMS UE context and sends a Create MBMS Context Response to the SGSN.

13. If the SGSN does not have the MBMS Bearer Context information for this MBMS bearer service, the SGSN sends a MBMS Registration Request to the GGSN. See subclause "MBMS Registration Procedure".

    The GGSN responds with a MBMS Registration Response containing the MBMS Bearer Context information for this MBMS bearer service and adds the identifier of the SGSN to the "list of downstream nodes" parameter in its MBMS Bearer Context. See subclause "MBMS Registration Procedure".

14. The SGSN provides Iu mode RAN with the MBMS UE Context(s) if at least one PS RAB is established for the UE.

15. The SGSN sends an Activate MBMS Context Accept (TMGI, MBMS bearer capabilities) to the UE. The MBMS bearer capabilities indicate the maximum QoS that is used by this MBMS bearer service and the UE may take it into account when further MBMS bearer services are activated. If it was not possible to verify the UE's MBMS bearer capabilities in Step 6, the UE's MBMS bearer capabilities will be verified now. If the SGSN determines that the UE's MBMS bearer capabilities are lower than the Required MBMS Bearer Capabilities the SGSN rejects the request for activation of an MBMS context indicating an appropriate cause and starts the deactivation of the already established MBMS UE contexts.

8.3 MBMS Session Start Procedure

The BM-SC initiates the MBMS Session Start procedure when it is ready to send data. This is a request to activate all necessary bearer resources in the network for the transfer of MBMS data and to notify interested UEs of the imminent start of the transmission.

Through this procedure, MBMS session attributes such as QoS, MBMS service Area, estimated session duration if available are provided to the GGSN(s) and SGSN(s) that have previously registered for the corresponding MBMS bearer service and to all BSCs/RNCs that are connected to a registered SGSN. In addition the procedure allocates the bearer plane to all registered GGSNs and all registered SGSNs and to BSCs/RNCs that respond to the session start accordingly.

The overall Session Start procedure is presented in the following figure:

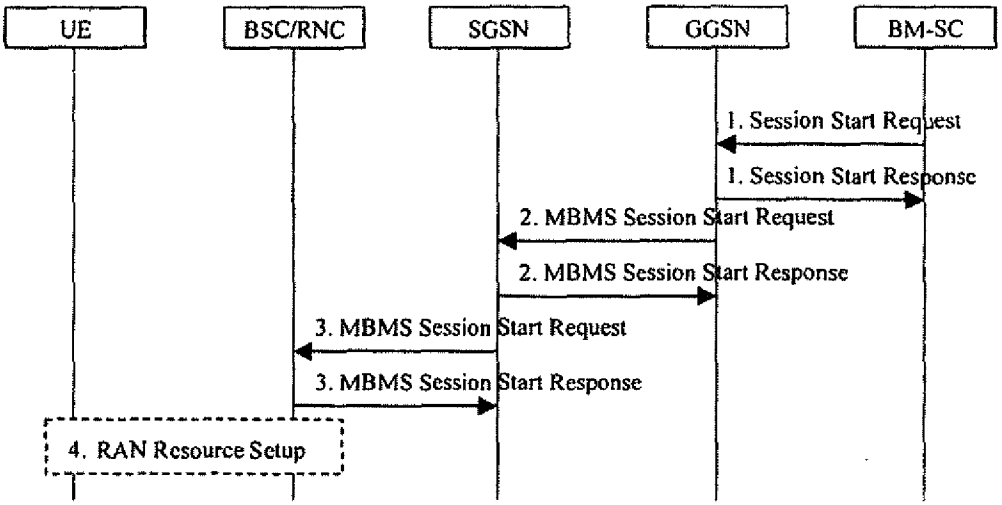


Figure 8 Session Start procedure

1. The BM-SC sends a Session Start Request message to indicate the impending start of the transmission and to provide the session attributes (TMGI, QoS, MBMS service Area, Session identifier, estimated session duration...) and the 2G/3G indicator to the GGSNs listed in the "list of downstream nodes" parameter of the corresponding MBMS Bearer Context. The BM-SC sets the state attribute of its MBMS Bearer Context to 'Active'. The GGSN stores the session attributes in the MBMS Bearer Context, sets the state attribute of its MBMS Bearer Context to 'Active' and sends a Session Start Response message to the BM-SC.

2. The GGSN sends an MBMS Session Start Request message containing the session attributes (TMGI, QoS, MBMS service Area, Session identifier, estimated session duration...) and the 2G/3G indicator to the SGSNs listed in the "list of downstream nodes" parameter of the corresponding MBMS Bearer Context. The SGSN stores the session attributes and the 2G/3G indicator in the MBMS Bearer Context, sets the state attribute of its MBMS Bearer Context to 'Active' and responds with an MBMS Session Start Response message providing the TEID for bearer plane that the GGSN shall use for forwarding the MBMS data.

3. The SGSN sends an MBMS Session Start Request message including the session attributes (TMGI, QoS, MBMS service Area, Session identifier, estimated session duration...) to each BSC and/or each RNC that is connected to this SGSN. The 2G/3G indicator shall be used by the SGSN to determine whether the MBMS Session Start Request message is sent only to BSCs, or only to RNCs, or to both RNCs and BSCs. The SGSN may include a list of RAs which lists each RA that contains at least one PMM-IDLE UE that has activated the MBMS bearer service. This list may be empty. The BSC/RNC responds with an MBMS Session Start Response to the SGSN. The BSC in Iu mode/RNC stores the session attributes in the MBMS Service Context, sets the state attribute of its MBMS Service Context to 'Active' and responds with an MBMS Session Start Response message and the RNC includes the TEID in the MBMS Session Start Response message for the Iu bearer plane that the SGSN shall use for forwarding the MBMS data. A BSC in Gb mode which does not serve the MBMS Service Area may decide not to store the session attributes and not to set the state of its MBMS Service Context to 'Active'. A BSC/RNC receiving multiple MBMS Session Start Request messages establishes only one bearer plane with one SGSN.

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4. The BSC/RNC establishes the necessary radio resources for the transfer of MBMS data to the interested UEs.

Note: The upstream node normally provides the MBMS Session Start Request message once per MBMS session to a downstream node. Due to "Intra Domain Connection of RAN Nodes to Multiple Core Network Nodes" however, a BSC/RNC may receive the MBMS Session Start Request message from several SGSNs.

8.4 MBMS Registration Procedure

The MBMS Registration is the procedure by which a downstream node informs an upstream node that it would like to receive session attributes and data for a particular MBMS bearer service in order to distribute it further downstream. This procedure builds up a distribution tree for the delivery of MBMS session attributes and data from the BM-SC to the UEs interested in the service. This procedure results in the set-up of a corresponding MBMS Bearer Context in the nodes along the distribution tree, but it does not result in the establishment of bearer plane which will be established by the Session Start procedure.

The MBMS Registration procedure is initiated:

- When the first MBMS UE Context for a particular MBMS bearer service is created in the SGSN or GGSN (see subclause "MBMS UE Context") and the corresponding MBMS Bearer Context is not already established in the node;
- When an MBMS Registration Request for a particular MBMS bearer service is received from a downstream node but the corresponding MBMS Bearer Context is not established in the node; or
- When a DRNC detects that it hosts UEs interested in the MBMS bearer service.

NOTE: The terms 'downstream' and 'upstream' refer to the topological position of one node with respect to another and relative to the direction of the MBMS data flow, i.e. from BM-SC to UE.

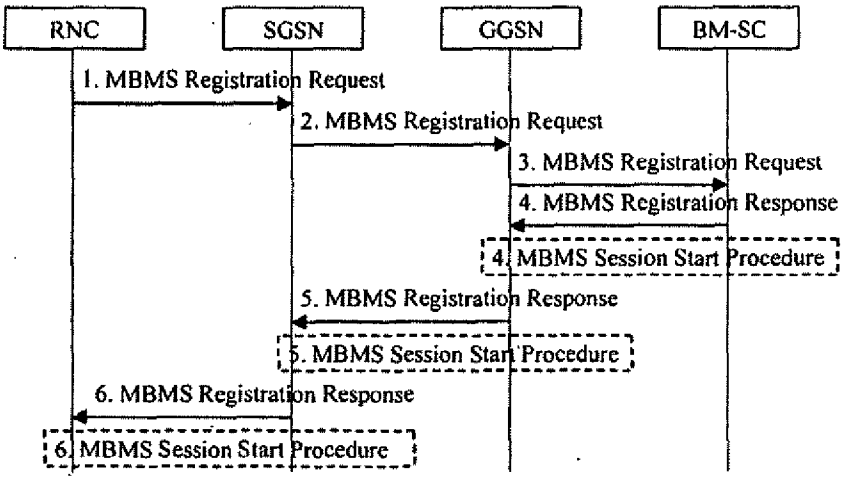


Figure 9: MBMS Registration procedure

1. When the DRNC detects that it hosts UEs interested in the MBMS bearer service, the DRNC sends a MBMS Registration Request message to its parent SGSN if not already done. How the RNC determines its parent SGSN is a matter of implementation.

2. If the SGSN has no MBMS Bearer Context for an MBMS bearer service and the SGSN receives an MBMS Registration Request from an RNC for this MBMS bearer service, or if the first MBMS UE Context is created in the SGSN for an MBMS bearer service for which the SGSN has no corresponding MBMS Bearer Context, the SGSN creates an MBMS Bearer Context (in "Standby" state) and sends an MBMS Registration request (IP multicast address, APN) message to the GGSN. How the SGSN selects a GGSN is a matter of implementation; it may for instance be based on prior signalling related to a particular UE or via APN resolution.

3. If the GGSN has no MBMS Bearer Context for an MBMS bearer service and the GGSN receives an MBMS Registration from an SGSN for this MBMS bearer service, or when the first MBMS UE Context is created in the

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GGSN for an MBMS bearer service for which the GGSN has no MBMS Bearer Context, the GGSN creates an MBMS Bearer Context (in "Standby" state) and sends a Registration Request (IP multicast address, APN) message to the BM-SC. The exact nature of the signalling between GGSN and BM-SC via Gmb interface is specified in 3GPP TS 29.061 [4].

4. Upon reception of an MBMS Registration Request from a GGSN, the BM-SC adds the identifier of the GGSN to the "list of downstream nodes" parameter in its MBMS Bearer Context and responds with a MBMS Registration Response (TMGI, Required Bearer Capabilities) message. The exact nature of the signalling between GGSN and BM-SC is however FFS in general. If the MBMS Bearer Context is in the 'Active' state, the BM-SC initiates the Session Start procedure with the GGSN, as described in clause "MBMS Session Start Procedure".

5. If the GGSN receives a Registration Request from the SGSN in step 2, the GGSN:

   - adds the identifier of the SGSN to the "list of downstream nodes" parameter in its MBMS Bearer Context,
   - responds with an MBMS Registration Response (TMGI, Required Bearer Capabilities) message, and
   - if the MBMS Bearer Context is in the 'Active' state, initiates the Session Start procedure with the SGSN, as described in clause "MBMS Session Start Procedure".

6. If the SGSN received MBMS Registration Request from the DRNC in step 1, the SGSN:

   - adds the identifier of the RNC to the "list of downstream nodes" parameter in its MBMS Bearer Context,
   - responds with an MBMS Registration Response message, and
   - if the MBMS Bearer Context is in the 'Active' state, initiates the Session Start procedure with the DRNC, as described clause "MBMS Session Start Procedure".

8.5 MBMS Session Stop Procedure

The BM-SC initiates the MBMS Session Stop procedure when it considers the MBMS session to be terminated. The session is typically terminated when there is no more MBMS data expected to be transmitted for a sufficiently long period of time to justify a release of bearer plane resources in the network. The procedure is propagated to all SGSNs and GGSNs that are registered for the corresponding MBMS bearer service and to BSCs/RNCs that have an established Iu bearer plane with an SGSN.

The overall MBMS Session Stop procedure is presented in the following figure:

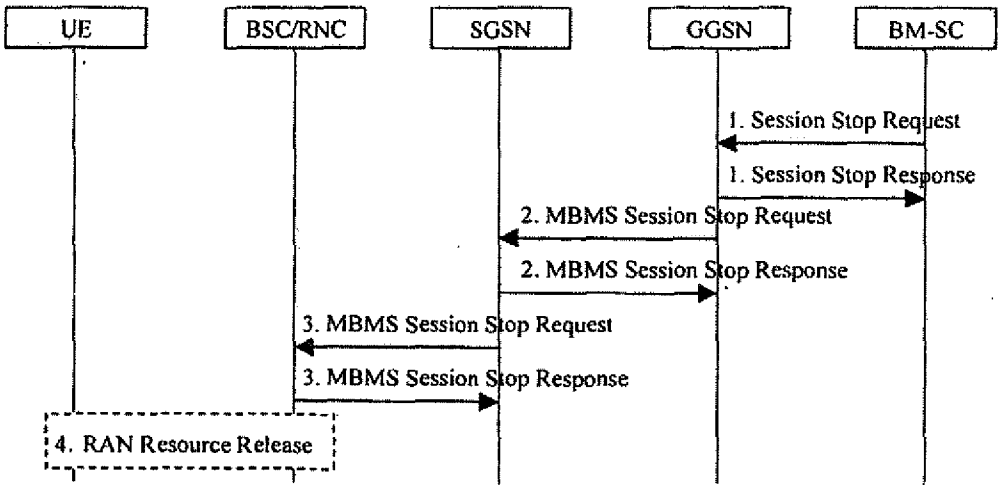


Figure 10: MBMS Session Stop procedure

1. The BM-SC sends a Session Stop Request message to all GGSNs listed in the "list of downstream nodes" parameter of the affected MBMS Bearer Context to indicate that the MBMS session is terminated and the bearer plane resources can be released. The BM-SC sets the state attribute of its MBMS Bearer Context to 'Standby'.

2. The GGSN sends an MBMS Session Stop Request message to all SGSNs listed in the "list of downstream nodes" parameter of the affected MBMS Bearer Context, releases the corresponding bearer plane resources towards these SGSNs and sets the state attribute of its MBMS Bearer Context to 'Standby'.

3. The SGSN releases the TEID and bearer plane resources on which it was receiving MBMS data from the GGSN for the affected MBMS bearer service and sends an MBMS Session Stop Request message to all BSCs/RNCs that have a bearer plane established with the SGSN.

4. The RNC releases the affected radio and Iu resources; the BSC releases the affected radio resources.

8.6 MBMS De-Registration Procedure

The MBMS De-Registration is the procedure by which a downstream node informs an upstream node that it does not need a to receive signalling, session attributes and data for a particular MBMS bearer service anymore and therefore would like to be removed from the corresponding distribution tree.

The MBMS De-registration procedure is initiated:

- By the SGSN or GGSN when the last MBMS UE Context for a particular MBMS bearer service is deleted from the node and the "list of downstream nodes" parameter in the corresponding MBMS Bearer Context is empty;
- By the SGSN or GGSN when the last node registered in the "list of downstream nodes" de-registers from an MBMS bearer service for which there is no corresponding MBMS UE Context; or
- By the DRNC that registered at an SGSN when it deletes the associated MBMS Service Context.

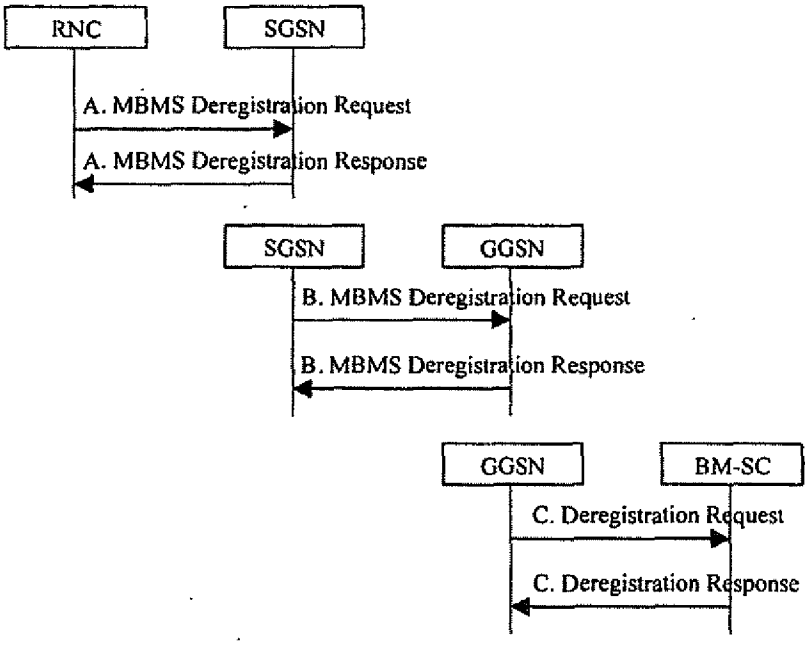


Figure 11: MBMS De-Registration Procedure

A. When the DRNC that is registered at an SGSN no longer hosts any UE interested in that MBMS bearer service, the DRNC requests the de-registration from the MBMS bearer service to its parent SGSN. As an implementation option, the RNC may decide not to de-register from the MBMS bearer service immediately when these conditions are met, e.g. in order to avoid unnecessary signalling in the case where the RNC would again need the same MBMS bearer service shortly after.

   The SGSN removes the identifier of the RNC from the "list of downstream nodes" parameter of the affected MBMS Bearer Context and confirms the operation by sending an MBMS De-Registration Response message to the RNC. If an Iu bearer plane had been established between the RNC and the SGSN for this MBMS bearer service, the Iu bearer plane is released.

B. When the "list of downstream nodes" of a particular MBMS Bearer Context in the SGSN becomes empty and the SGSN has no MBMS UE Contexts linked to that MBMS Bearer Context, the SGSN sends an MBMS De-Registration Request (IP multicast address, APN) message to its upstream GGSN.

The GGSN removes the identifier of the SGSN from the "list of downstream nodes" parameter of the affected MBMS Bearer Context and confirms the operation by sending an MBMS De-Registration Response message to the SGSN. If a bearer plane had been established between the SGSN and the GGSN for this MBMS bearer service, the bearer plane is released.

C. When the "list of downstream nodes" of a particular MBMS Bearer Context in the GGSN becomes empty and the GGSN has no MBMS UE Contexts linked to that MBMS Bearer Context, the GGSN sends a De-Registration Request (IP multicast address, APN) message to the BM-SC. If a bearer plane had been established over Gi for this MBMS bearer service, the bearer plane is released.

The BM-SC removes the identifier of the GGSN from the "list of downstream nodes" parameter of the affected MBMS Bearer Context and confirms the operation by sending a De-Registration Response message to the GGSN.

8.6.1 BM-SC initiated MBMS De-Registration Procedure

This MBMS De-Registration Procedure is initiated by BM-SC when the specific MBMS bearer service is terminated. This procedure tears down the distribution tree for the delivery of session attributes and MBMS data. This procedure results in releasing of all MBMS Bearer Contexts and associated MBMS UE Contexts in the nodes along the distribution tree.

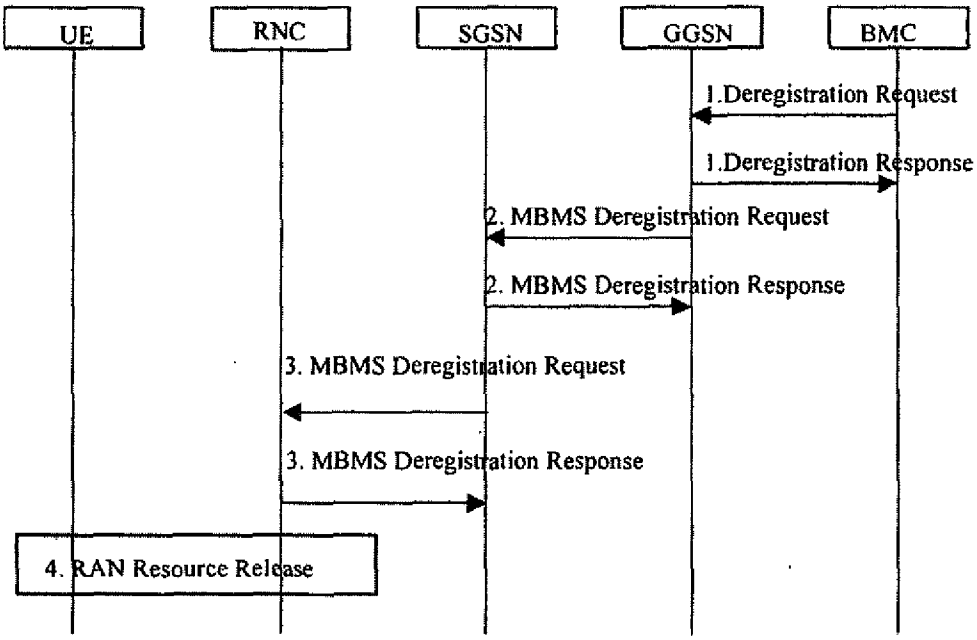


Figure 12: BM-SC initiated MBMS De-Registration Procedure

1. The BM-SC sends a De-Registration Request message to all GGSNs contained in the "list of downstream nodes" parameter of the corresponding MBMS Bearer Context to indicate the session is terminated and any related MBMS bearer resources shall be released.

   The GGSN returns a De-Registration Response message to the BM-SC. The BM-SC releases all MBMS UE Contexts and the corresponding MBMS Bearer context.

2. The GGSN sends an MBMS De-Registration Request message to all SGSNs contained in the "list of downstream nodes" parameter. of the corresponding MBMS Bearer Context. The SGSN returns an MBMS De-registration Response message to the GGSN. The GGSN releases all MBMS UE Contexts and the affected MBMS Bearer Context. If a bearer plane had been established over Gi for this MBMS bearer service, the bearer plane is released.

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3. The SGSN sends an MBMS De-Registration Request message to all RNCs connected with this SGSN. The RNC returns an MBMS De-Registration Response message to the SGSN, and releases all bearer resources if the state attribute of the MBMS Service Context is 'Active'. The SGSN releases all MBMS UE Contexts and the affected MBMS Bearer Context. If a bearer plane had been established between the SGSN and the GGSN for this MBMS bearer service, the bearer plane is released.

4. The RNC releases the affected radio resources, all MBMS UE Contexts and the MBMS Service Context. The detailed procedures are specified in 3GPP TS 25.346 [10] and 3GPP TS 43.246 [11]. RAN may notify the UEs that the MBMS Bearer service has being terminated, so that the UE can locally deactivate its MBMS UE context, detailed procedures are specified in 3GPP TS 25.346 [10] and 3GPP TS 43.246 [11].

8.7 MBMS Multicast Service Deactivation

The multicast service deactivation is a signalling procedure between the UE and the network. The procedure removes the MBMS UE Context from the UE, SGSN and GGSN for a particular MBMS multicast service. The multicast service deactivation can be initiated by:

- The UE;
- The GGSN;
- The BM-SC; or
- The SGSN

All these cases are contained in the procedure illustrated in figure 13. The UE initiated Multicast Service Deactivation starts with step 1), the BM-SC initiated Multicast Service Deactivation starts with step 3), the GGSN initiated Multicast Service Deactivation starts with step 4), and the SGSN initiated Multicast Service Deactivation starts with step 5) or 8).

At GPRS detach, all MBMS UE contexts of the UE are implicitly deactivated in the UE, SGSN and GGSN, i.e. the SGSN performs the deactivation procedure starting with step 8).

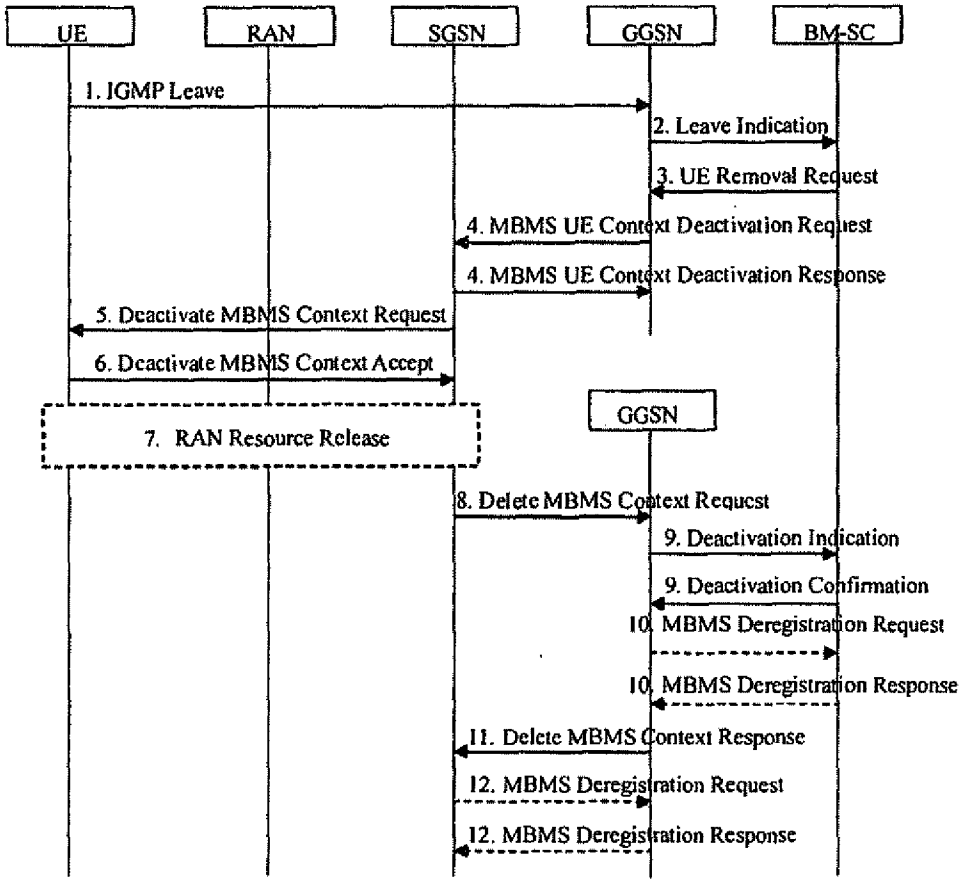


Figure 13: MBMS Multicast Service Deactivation

1. The UE sends an IGMP (IPv4) or MLD (IPv6) Leave message over the default PDP context to leave a particular multicast service identified by an IP multicast address.

2. The GGSN sends a Leave Indication (IP multicast address, IMSI) to the BM-SC, indicating that the UE is requesting to leave the multicast service identified by the IP multicast address. The exact nature of the signalling between GGSN and BM-SC is specified in 3GPP TS 29.061[4].

3. Upon reception of the Leave Indication, the BM-SC verifies that the IP multicast address corresponds to a valid MBMS bearer service and sends a UE Removal Request (IP multicast address, APN, IMSI) to the GGSN that originated the Leave Indication. The APN shall be the same that was provided during service activation (see "MBMS Multicast Service Activation"). The exact nature of the signalling between GGSN and BM-SC is specified in 3GPP TS 29.061 [4]. The BM-SC may also initiate the deactivation of an MBMS UE Context for service-specific reasons (e.g. the service is terminated but the UE has not yet left the multicast group) by directly sending a UE Removal Request message to the GGSN.

4. Upon reception of the UE Removal Request or for other reasons (e.g. Error cases), the GGSN sends an MBMS UE Context Deactivation Request (IP multicast address, APN, IMSI) to the SGSN. The IP multicast address, APN and IMSI together identify the MBMS UE Context to be deleted by the SGSN. The APN is the one received in step 3. The SGSN acknowledges reception of the MBMS UE Context Deactivation Request by sending an MBMS UE Context Deactivation Response to the GGSN.

5. Upon reception of the MBMS UE Context Deactivation Request or for other reasons (e.g. due to a change in the roaming restrictions for the user) the SGSN sends a Deactivate MBMS Context Request (TI) to the UE. The TI identifies the MBMS UE Context to be deleted by the UE.

6. The UE deletes the MBMS UE Context and sends a Deactivate MBMS Context Accept (TI) to the SGSN.

7. If dedicated radio resources are currently assigned to the UE for the reception of the MBMS data, the RAN releases these radio resources. If shared radio resources are currently assigned for the distribution of the MBMS

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data, the RAN may decide to move the remaining UEs to dedicated resources. The detailed procedures and conditions are FFS depending on ongoing work in RAN groups.

8. Upon reception of the Deactivate MBMS Context Accept or for other reasons (e.g. due to missing periodic updates) the SGSN sends a Delete MBMS Context Request (MBMS_NSAPI) to the GGSN that holds the MBMS UE Context. This GGSN may be different from the GGSN that receives IGMP Leave request in step 1.

9. The GGSN deletes the MBMS UE Context and sends a Deactivation Indication to the BM-SC to confirm the successful deactivation of the MBMS UE Context. The BM-SC, after receiving the Deactivation Indication, deletes the MBMS UE Context and sends a confirmation to the GGSN. The exact nature of the signalling between GGSN and BM-SC is however FFS in general.

10. If the GGSN does not have any more users interested in this MBMS bearer service and the "list of downstream nodes" in the corresponding MBSM Bearer Context is empty, the GGSN sends a MBMS De-Registration Request to the BM-SC. The BM-SC responds with a MBMS De-Registration Response and removes the identifier of the GGSN from the "list of downstream nodes" parameter in its MBMS Bearer Context. See subclause "MBMS De-Registration Procedure".

11. The GGSN confirms the deactivation of the MBMS UE Context to the SGSN by sending a Delete MBMS Context Response to the SGSN, which then deletes the MBMS UE Context.

12. If the SGSN does not have any more users interested in this MBMS bearer service and the "list of downstream nodes" in the corresponding MBMS Bearer Context is empty, the SGSN sends an MBMS De-Registration Request to the GGSN. The GGSN responds with an MBMS De-Registration Response and removes the identifier of the SGSN from the "list of downstream nodes" parameter in its MBMS Bearer Context. See subclause "MBMS De-Registration Procedure".

8.8 MBMS Session Update procedure

If the SGSN has provided a list of RAs in the Session Start message (even if the list was empty) and RAs are added or removed from the list, the SGSN uses the MBMS Session Update procedure to inform the RNCs that the list has changed. The SGSN sends the Session Update message only to the RNCs that are affected by the list change. The procedure is used only during the session and when SGSN has already sent a Session Start to the RNC.

The SGSN may send the Session Update to a RNC when:

- The first UE which have activated the service enters in a RA
- The last UE which have activated the service leaves from a RA

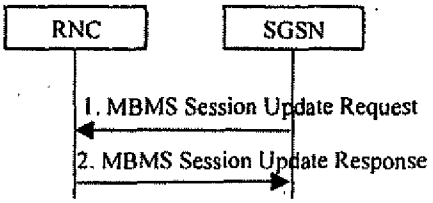


Figure 13a. Session Update procedure

1) The SGSN sends MBMS Session Update Request message to a RNC.

2) The RNC acknowledges the Session Update Request with the MBMS Session Update Response message.

8.9 Void

8.10 Inter SGSN Routeing Area Update

This procedure is performed when a UE with active MBMS bearer service performs a Routeing Area Update and the serving SGSN changes. It bases on the Inter SGSN Routeing Area Update procedure specified in TS 23.060. The procedure is performed regardless whether MBMS sessions are ongoing or not. The handling of any PDP contexts

established by the UE is not changed compared to the procedure without MBMS. The procedure described below does not show all details of the Routeing Area update procedure. Only for the MBMS specific additions the steps are described.

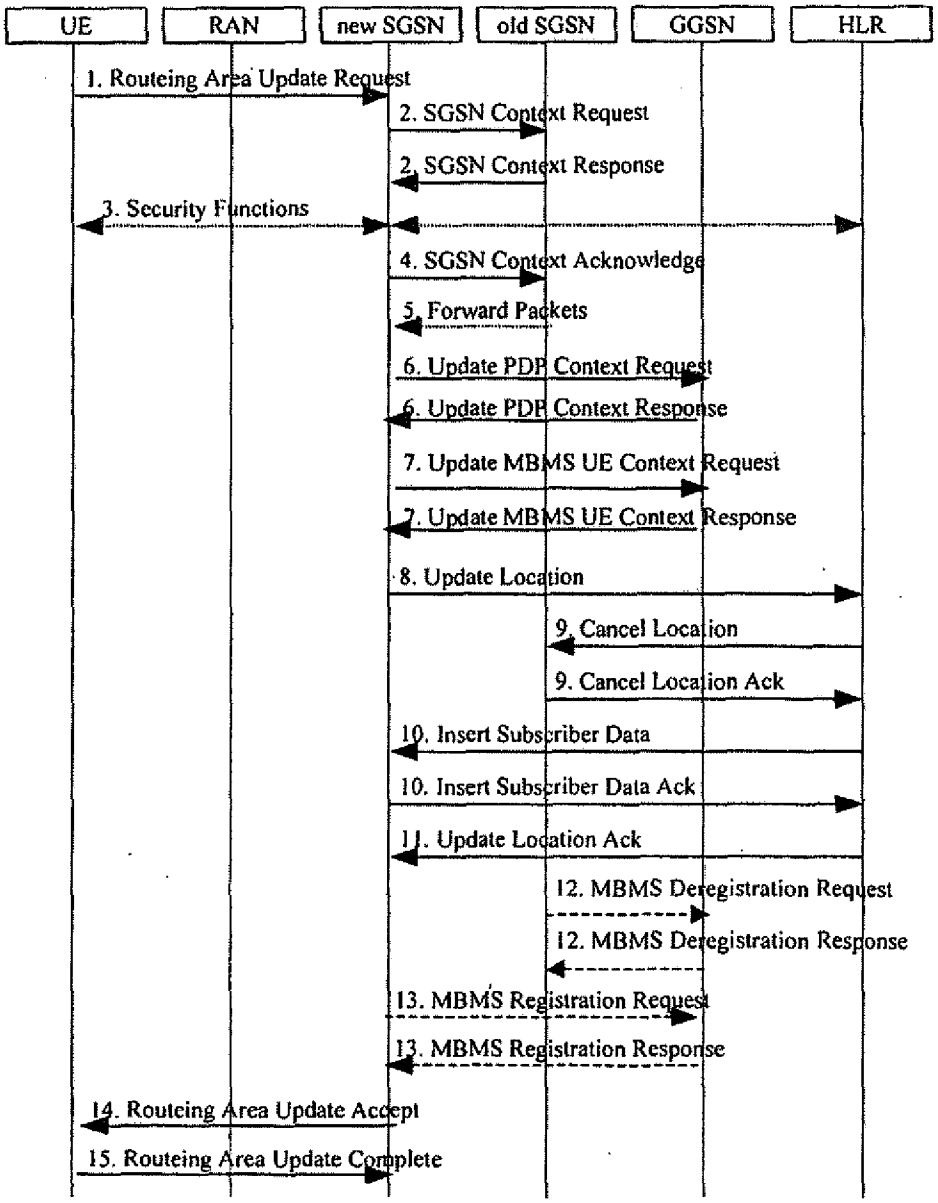


Figure 14: Inter SGSN Routeing Area Update

2) The context transfer in step 2 includes the transfer of the MBMS UE Context(s).

7) The new SGSN sends Update MBMS UE Context Request (Serving network identity) to the GGSNs concerned. The GGSNs update their MBMS UE Context fields and return Update MBMS UE Context Response. Also, GGSN sends updated Serving network identity to the BM-SC if necessary.

12) If the old SGSN does not have any more MBMS UE Contexts for the MBMS bearer service(s) and the "list of downstream nodes" in the corresponding MBMS Bearer Context is empty, the SGSN sends an MBMS Deregistration Request to the GGSN. The GGSN responds with an MBMS Deregistration Response and removes the identifier of the SGSN from the "list of downstream nodes" parameter in its MBMS Bearer Context. See subclause "MBMS Deregistration Procedure".

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13) The new SGSN verifies for each MBMS UE Context received whether it has a corresponding MBMS Bearer Context. For each MBMS Bearer Context the SGSN does not already have the SGSN creates an MBMS Bearer Context (in "Standby" state) and sends an MBMS Registration Request to a GGSN. This registration is described in subclause "MBMS Registration Procedure".

8.11 Inter SGSN Serving RNS Relocation Procedure

This procedure is performed when the SGSN changes due to SRNS relocation. It bases on the SRNS Relocation procedure specified in 3GPP TS 23.060. The procedure is performed regardless whether MBMS sessions are ongoing or not. The handling of any PDP contexts established by the UE is not changed compared to the procedure without MBMS. The procedure described below does not show all details of the SRNS relocation procedure. Only for the MBMS specific additions the steps are described.

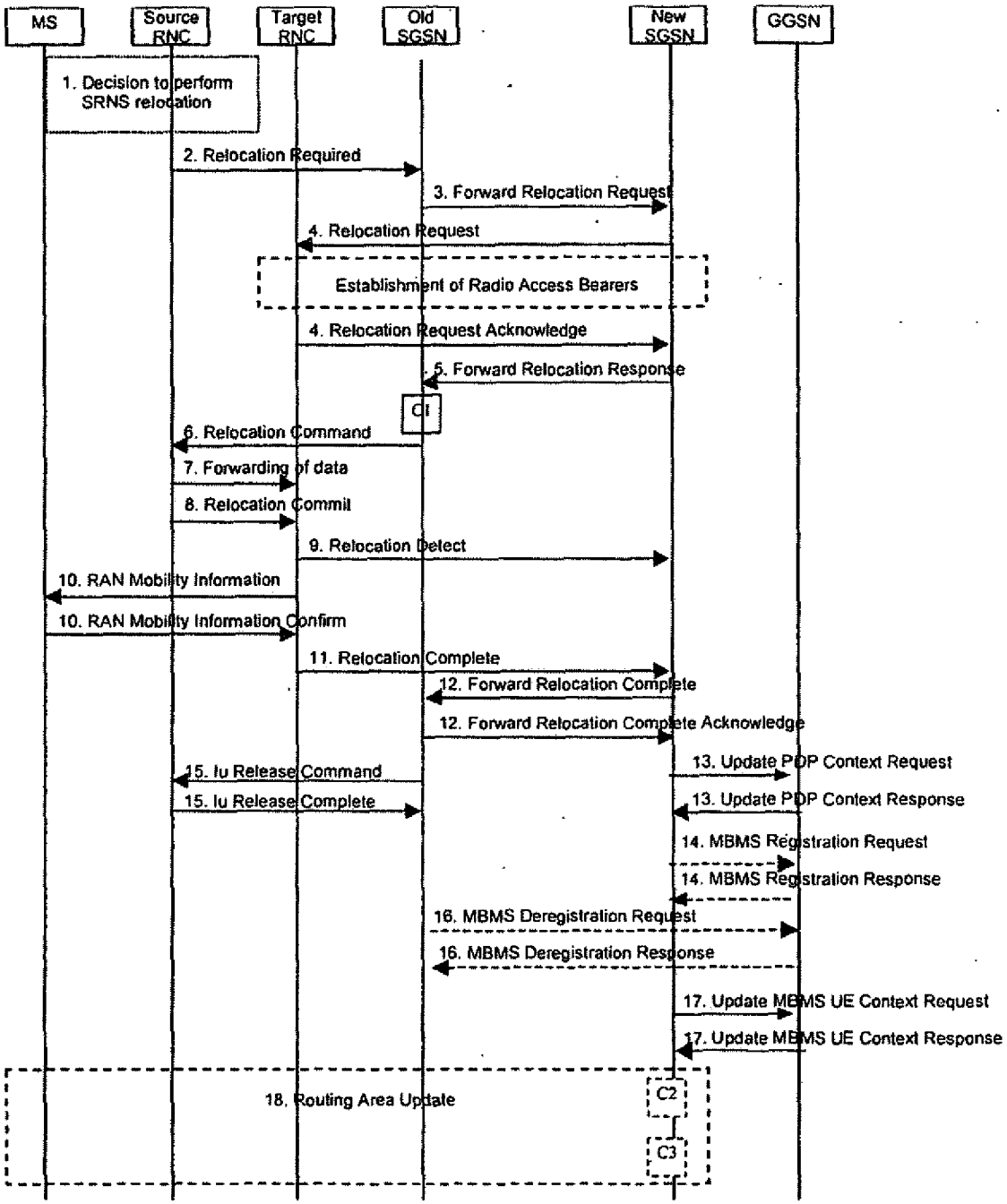


Figure 15: SRNS Relocation Procedure

3) The context transfer in step 3 includes the transfer of the MBMS UE Context(s).

14) The new SGSN verifies for each MBMS UE Context received whether it has a corresponding MBMS Bearer Context. For each MBMS Bearer Context not yet existing in the SGSN the SGSN creates an MBMS Bearer Context (in "Standby" state) and sends an MBMS Registration Request to a GGSN. This registration is described in subclause "MBMS Registration Procedure".

16) If the old SGSN does not have any more MBMS UE Contexts for this MBMS bearer service and the "list of downstream nodes" in the corresponding MBMS Bearer Context is empty, the SGSN sends an MBMS De-registration Request to the GGSN. The GGSN responds with an MBMS De-registration Response and removes the identifier of the SGSN from the "list of downstream nodes" parameter in its MBMS Bearer Context. See subclause "MBMS De-registration Procedure".

17) The new SGSN sends Update MBMS UE Context Request to the GGSNs concerned. The GGSNs update their MBMS UE Context fields and return Update MBMS UE Context Response.

8.12 MBMS Broadcast Service Activation

MBMS Broadcast service activation is the procedure by which a UE locally activates a broadcast MBMS bearer service:

- The MBMS broadcast service activation procedure does not register the user in the network. There is no MBMS bearer service specific signaling exchanged between the UE and the Network.
- The broadcast service activation procedure does not establish MBMS UE contexts in UE, SGSN and GGSN.

8.13 MBMS Broadcast service de-activation

The MBMS Broadcast service de-activation by the UE is local to the UE, i.e. without interaction with the Network.

8.14 MBMS Broadcast Session Start Procedure

The BM-SC initiates the MBMS Session Start procedure when it is ready to send data. This is a request to activate all necessary bearer resources in the network for the transfer of MBMS data. It is also used to notify interested UEs of the start of the transmission.

Through this procedure, MBMS session attributes such as TMGI, QoS, MBMS service Area , estimated session duration if available are provided to all the GGSN(s), SGSN(s) and BSCs/RNCs. In addition the procedure allocates the bearer plane to all GGSNs and all SGSNs and to BSCs/RNCs that respond to the MBMS session start accordingly.

The overall MBMS Broadcast Session Start procedure is presented in the following figure:

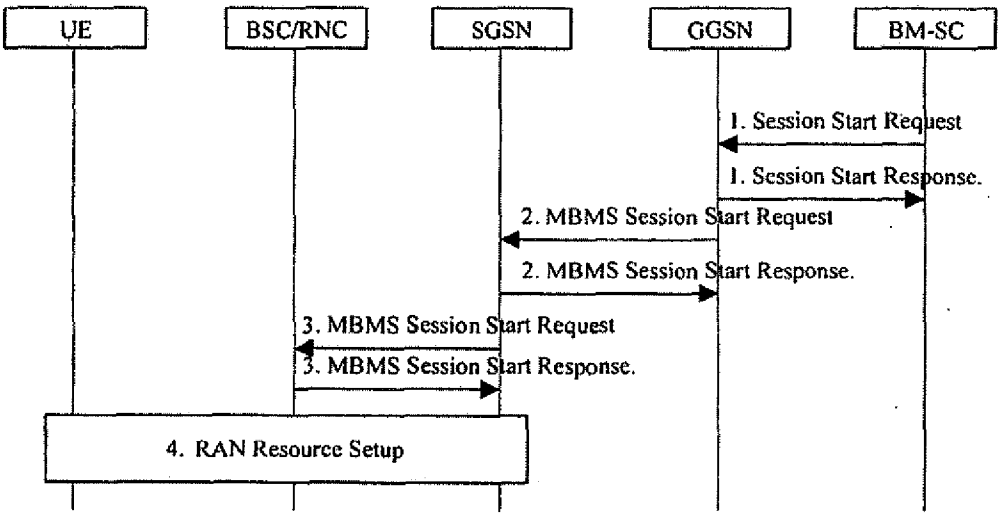


Figure 16 Session Start procedure for Broadcast MBMS Bearer Service

1) The BM-SC sends a Session Start Request message the impending start of the transmission and to provide the MBMS session attributes (TMGI, QoS, MBMS service Area, estimated session duration ...) to a GGSN of the PLMN. The BM-SC sets the state attribute of its MBMS Bearer Context to 'Active'. The GGSN creates a

MBMS Bearer Context, stores the session attributes, sets the state attribute of this MBMS Bearer Context to 'Active' and sends a Session Start Response message to the BM-SC.

2) The GGSN sends an MBMS Session Start Request message to all its SGSNs. The SGSN creates a MBMS Bearer Context, stores the session attributes, sets the state attribute of this MBMS Bearer Context to 'Active' and responds with an MBMS Session Start Response message providing the TEID for bearer plane that the GGSN shall use for forwarding the MBMS data.

3) The SGSN sends an MBMS Session Start Request message including the session attributes to each BSC/RNC that is connected to this SGSN. The BSC/RNC responds with an MBMS Session Start Response message to the SGSN. If the BSC/RNC serves the MBMS service Area, it creates a MBMS Bearer Context, stores the session attributes in this MBMS Service Context, sets the state attribute of its MBMS Service Context to 'Active' and responds with an MBMS Session Start Response message, and the Iu mode BSC/RNC includes the TEID in the MBMS Session Start Response message for the Iu bearer plane that the SGSN shall use for forwarding the MBMS data. A BSC/RNC receiving multiple MBMS Session Start Request messages from different SGSNs establishes only one bearer plane with one SGSN.

4) The BSC/RNC establishes the necessary radio resources for the transfer of MBMS data to the interested UEs.

Note: The upstream node normally provides the MBMS Session Start Request message once per MBMS session to a downstream node. Due to "Intra Domain Connection of RAN Nodes to Multiple Core Network Nodes" however, a BSC/RNC may receive the MBMS Session Start Request message from several SGSNs.

8.15 MBMS UE Linking mechanism

UE Linking is the process by which UE MBMS context(s) is (are) provided to RAN.

MBMS UE linking procedure is performed when the UE is PMM-CONNECTED at least in the following cases.

- When a UE which has joined MBMS is moved to the PMM CONNECTED state and sets up a PS RAB. This may happen at any point in time i.e. before, during and between Sessions.
- When a UE joins the service and is in the PMM CONNECTED state due to an existing PS RAB. This may happen at any point in time i.e. before, during and between Sessions.
- When a UE is moved to the PMM CONNECTED state only for MBMS purpose via Service Request procedure. This may happen at any point in time during a MBMS session.

The UE linking is performed to link a specific UE to an MBMS service. It provides the list of MBMS Service Ids activated by the UE to the SRNC. If no MBMS service context related to the MBMS service Id exists then SRNC creates an MBMS service context after this procedure.

8.16 MBMS Service Request Procedure

For MBMS, when UTRAN wants to count the number of users that are interested in a specific MBMS service present in a cell, it will request a percentage of the interested UEs to transit to PMM-CONNECTED state. The MBMS Service Request procedure is used by a UE in PMM-IDLE state to move to PMM-CONNECTED state.

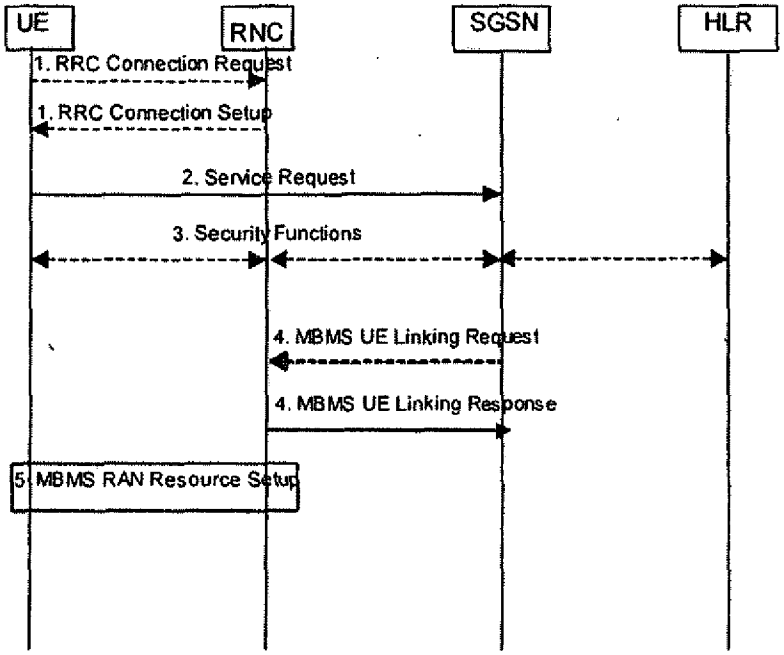


Figure 17: MBMS Service Request procedure

2) The UE sends a Service Request message to the SGSN if required to do so by the RAN after a MBMS Session Starts.

3) The SGSN may perform the security functions.

4) The SGSN provides RAN with the MBMS UE context(s) via MBMS UE Linking procedure

5) The RNC establishes the necessary radio resources for the transfer of MBMS data to the interested UEs.

8.17 Notification in case of parallel services

8.17.1 Notification of incoming CS domain call during an ongoing MBMS session

For the RRC connected mobiles in UTRAN, the RNS will have received the IMSI from the core network and hence is able to perform paging coordination. The UEs in RRC idle state in UTRAN need to perform paging coordination while receiving the MBMS session's user data.

In GERAN, this is achieved by the UE monitoring its paging channels while receiving the MBMS session's user data. If the mobile responses to the CS paging in GERAN, then the ongoing MBMS service is likely to be interrupted in the UE.

8.17.2 Notification of additional MBMS session during an ongoing MBMS session

For the RRC connected mobiles in UTRAN, the SGSN has sent the list of MBMS bearer services that the user has activated to the UTRAN. The RNS needs to notify an RRC connected UE.

For the UEs in RRC idle state, the UTRAN performs MBMS notification for the UE.

In GERAN, this is achieved by the UE monitoring its paging channel(s) where notification is sent while receiving the MBMS session's user data.

If the mobile accepts the new MBMS session in GERAN, then the ongoing MBMS service is likely to be interrupted in the UE.

8.17.3 Notification of Mobile Terminating PS data during an ongoing MBMS session

For the RRC connected mobiles in UTRAN, the SGSN request the establishment of a RAB which will be used to deliver the MT user data.

For the UEs in RRC idle state, the UTRAN performs paging notification for the UE.

In GERAN, this is achieved by the UE monitoring its paging channels while receiving the MBMS session's user data.

If the mobile responses to the PS paging in GERAN, then the ongoing MBMS service is likely to be interrupted in the UE.

8.17.4 Notification of MBMS session during an ongoing CS or PS domain "connection"

When the UE establishes the UTRAN RRC connection for a CS service, the UE shall send a flag indicating that it has activated at least one MBMS bearer service.. The RNC requests the SGSN to send the list of MBMS bearer services that the user has activated to enable the RNC to notify the UE when MBMS session starts.

When a UE moves to PMM-connected state, the SGSN sends the list of MBMS bearer services that the user has activated to the RNC. The RNC notifies the UE when an MBMS session of the user's activated MBMS bearer services starts.

These procedures are not supported by GERAN in this version of the specification.

9 Security

Security of MBMS is found in 3GPP TS 33.246 [5].

10 Charging requirement

10.1 General

MBMS architecture shall support on-line and off-line charging.

It shall be possible to collect charging information for the multicast mode. It shall also be possible to collect charging information for MBMS services in visited networks.

MBMS shall collect charging information about the transmission of MBMS broadcast or multicast data that are provided by content or service providers (e.g. 3rd parties). This shall enable billing of broadcast and multicast content or service providers.

To enable billing of broadcast and multicast content providers, data shall be collected at the BM-SC.

NOTE: SGSN, GGSN and BM-SC generate charging data for the transmitted data, always under the assumption that the UEs are within the MBMS service area. If the MBMS service area is less than the PLMN, then there is the possibility that a UE will have moved outside the MBMS service area. Charging data will still be generated for that UE causing an inaccuracy in the data. This inaccuracy increases as the size of the MBMS service area is decreased.

10.2 Bearer level charging for MBMS

To provide bearer level charging for MBMS, mechanisms and functional elements described in 3GPP TS 23.125 [12] are used. In case the BM-SC intends to provide input for bearer level charging, it acts as an Application Function (AF) from the perspective of the flow-based bearer charging architecture (see TS 23.125).

NOTE-i: It is expected that bearer level charging is used to zero-rate MBMS traffic.

NOTE-ii: It is expected that the flow filters for MBMS are statically configured in the TPF, hence BM-SC input is not required for bearer level charging.

10.3 Application level charging for MBMS

In order to meet the MBMS charging requirements in 22.146 and 22.246, the following elements and functinalities are provided by the MBMS architecture:

a) The MSISDN and IMSI are passed to the BM-SC. This provides the operator with the ability to associate GPRS location information (i.e. serving network idenity) with a user.

b) In order to permit differential roaming tariffs, the serving network identity is provided to the BM-SC.

c) Charging for MBMS services is based on application layer mechanisms, since it is only at the application layer that security is provided which can restrict content to authorised users or confirm delivery of content to users

The following general requirements apply to charging information generated by the BM-SC:

Charging information generated for application layer charging events should include the above information provided by the GPRS network to facilitate differential roaming tariffs.

Charging information should include an indicate of the point at which the user had access to the content (e.g. if and when decryption keys for encrypted content are sent to the UE.).

10.4 Generation of charging records in the VPLMN

In order to permit the settlement of inter-operator roaming charges , the SGSN needs to raise CDRs. The information that needs to be included on these CDRs is FFS.

Annex A (Informative): Information flows

A.1 General information flow

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Annex B (Informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2002-06					First Version		0.0.0
2002-09					Output from SA2 #27, inclusion of S2-023072		0.1.0
2002-11					Output from SA2 #28, inclusion of S2-023591, S2-023592, S2-023593, S2-023594, S2-023595, S2-023596 +S2-022967 From SA2#17	0.1.0	0.2.0
2002-12					Addition of official TS number	0.2.0	0.2.1
2003-02					Output from SA2#29 and e-mail approval: S2-030382, S2-030284, S2-030385rev4, S2-030386r1, S2-030387	0.2.1	0.3.0
2003-02					Output from SA#30, inclusion of S2-030626, S2-030647 an S2-030651	0.3.0	0.4.0
2003-04					Output from SA2#31, inclusion of S2-031236, S2-031238, S2-031237r2	0.4.0	0.5.0
					Output from SA2#32, inclusion of S2-031843, S2-031844, S2-031845, S2-031849, S2-031850, S2-032118, S2-032119	0.5.0	0.6.0
					Presentation to SA for information	0.6.0	1.0.0
					Output from SA2#33, inclusion of S2-031231, S2-032410, S2-032412, S2-032417, S2-032419, S2-032425,S2-032426	1.0.0	1.1.0
2003-08					Output from SA2#34, inclusion of S2-032889, S2-032894, S2-032896, S2-032898, S2-032904, S2-033143, S2-033144, S2-033145, S2-033147, S2-033148, S2-033149, S2-033150	1.1.0	1.2.0
2003-08					Editorial correction (S2-033148 was incorrectly added) + Other Minor editorials (change bars from V 1.2.0 still retained)	1.2.0	1.2.1
2003-09					Presentation to SA for Approval	1.2.1	2.0.0
2003-09	SA#21	SP-030390			Raised to v.6.0.0 after approval at SA#21	2.0.0	6.0.0
2003-12	SA#22	SP-030660	001	5	Inclusion of GERAN attributes and parameters in MBMS	6.0.0	6.1.0
2003-12	SA#22	SP-030660	002	4	Inclusion of GERAN functionality in MBMS Notification procedure and session ID	6.0.0	6.1.0
2003-12	SA#22	SP-030660	003	4	Inclusion of GERAN functionality in MBMS procedures	6.0.0	6.1.0
2003-12	SA#22	SP-030660	007	4	Clarification of MBMS UE Context plus GERAN functionality	6.0.0	6.1.0
2003-12	SA#22	SP-030660	008	1	Apply TMGI for Broadcast Service	6.0.0	6.1.0
2003-12	SA#22	SP-030660	015	3	MBMS point to point repair/charging/decrypt service	6.0.0	6.1.0
2003-12	SA#22	SP-030660	016	2	Optional provision of duration of the session	6.0.0	6.1.0
2003-12	SA#22	SP-030660	020	2	Corrections for TMGI, linked NSAPI and service ID	6.0.0	6.1.0
2003-12	SA#22	SP-030660	021	1	Removal of superfluous procedures	6.0.0	6.1.0
2003-12	SA#22	SP-030660	022	2	Verification of UE bearer capabilities	6.0.0	6.1.0
2003-12	SA#22	SP-030660	023	1	Various corrections and clarifications	6.0.0	6.1.0
2003-12	SA#22	SP-030660	026	2	Clarification on MBMS deactivation figure	6.0.0	6.1.0
2003-12	SA#22	SP-030660	027	2	MBMS Service Request Procedure	6.0.0	6.1.0
2003-12	SA#22	SP-030660	028		Removal of BG from MBMS Architecture Figure	6.0.0	6.1.0
2003-12	SA#22	SP-030660	030		Removal of security information in TS 23.246	6.0.0	6.1.0
2004-03	SA#23	SP-040039	012	4	Paging Coordination	6.1.0	6.2.0
2004-03	SA#23	SP-040039	030	2	Clarification of MBMS Multicast Service Activation	6.1.0	6.2.0
2004-03	SA#23	SP-040039	031	2	Create MBMS Bearer Context in GGSN	6.1.0	6.2.0
2004-03	SA#23	SP-040039	036	1	TMGI distribution mechanism for Broadcast mode	6.1.0	6.2.0
2004-03	SA#23	SP-040039	038	2	Buffering of MBMS data at the RNC	6.1.0	6.2.0
2004-03	SA#23	SP-040039	039	1	Distribution of BM-SC functionality	6.1.0	6.2.0
2004-03	SA#23	SP-040039	040		MBMS Application Adjunct Server	6.1.0	6.2.0
2004-03	SA#23	SP-040039	041	2	MBMS TS scope	6.1.0	6.2.0
2004-03	SA#23	SP-040039	042	3	SGSN filtering of RAs to support RA-based optimization	6.1.0	6.2.0
2004-03	SA#23	SP-040039	043		Complete the MBMS Service Request Procedure	6.1.0	6.2.0
2004-03	SA#23	SP-040039	044	1	Correction on De-Registration Procedure	6.1.0	6.2.0
2004-03	SA#23	SP-040039	049		TMGI Definition and Objective	6.1.0	6.2.0
2004-03	SA#23	SP-040039	050	1	NSAPI in MBMS Multicast Service Activation	6.1.0	6.2.0
2004-06	SA#24	SP-040322	051	4	Optimization of MBMS multicast service activation procedure	6.2.0	6.3.0
2004-06	SA#24	SP-040322	052	1	Correction of erroneous references	6.2.0	6.3.0
2004-06	SA#24	SP-040322	056	1	Session duration on Broadcast Session Start Procedure	6.2.0	6.3.0
2004-06	SA#24	SP-040322	057	3	Removing FFS from TS 23.246	6.2.0	6.3.0
2004-06	SA#24	SP-040322	058	3	Clarification on relationships between MBMS Session Stop	6.2.0	6.3.0

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					& MBMS De-registration & MBMS De-activation		
2004-06	SA#24	SP-040322	059	1	Remove some FFS on PMM-CONNECTED vs RRC-CONNECTED UEs	6.2.0	6.3.0
2004-06	SA#24	SP-040322	061	2	Correction on MBMS deregistration procedure	6.2.0	6.3.0
2004-06	SA#24	SP-040322	062	3	New addition to MBMS bearer context	6.2.0	6.3.0
2004-06	SA#24	SP-040322	066	3	CR for MBMS UE Context in 6.1	6.2.0	6.3.0
2004-06	SA#24	SP-040322	069	1	Removing Security requirements from 23.246	6.2.0	6.3.0
2004-06	SA#24	SP-040322	077	2	Proposed Flow Based Charging for MBMS	6.2.0	6.3.0
2004-06	SA#24	SP-040322	078	1	Notification of Incoming CS Domain Call/PS Data/Additional MBMS Call during An Ongoing MBMS Session for GERAN	6.2.0	6.3.0
2004-06	SA#24	SP-040322	083	2	Clarification of MBMS subscription	6.2.0	6.3.0
2004-09	SA#25	SP-040526	076	2	MBMS Service Area definition	6.3.0	6.4.0
2004-09	SA#25	SP-040526	084	1	Use Correct SA4 MBMS User Service Specification	6.3.0	6.4.0
2004-09	SA#25	SP-040526	085	1	Clarification of BM-SC create MBMS UE Context	6.3.0	6.4.0
2004-09	SA#25	SP-040526	089	1	Remove SDU FFS in section 6.3 Quality of Service	6.3.0	6.4.0
2004-09	SA#25	SP-040526	093	2	Application Level Charging Mechanisms	6.3.0	6.4.0
2004-09	SA#25	SP-040526	094	1	MBMS Session Notification	6.3.0	6.4.0
2004-09	SA#25	SP-040526	095		Removing FFS from TS 23.246	6.3.0	6.4.0
2004-09	SA#25	SP-040526	097		Clarification of reference model	6.3.0	6.4.0
2004-09	SA#25	SP-040526	099	2	Service Context creation in RNC	6.3.0	6.4.0
2004-09	SA#25	SP-040526	101		Correction for error handling in MBMS multicast activation	6.3.0	6.4.0
2004-09	SA#25	SP-040526	103	1	MBMS BSC UE context and bearer plane	6.3.0	6.4.0
2004-09	SA#25	SP-040526	106	2	Allocation and retention priority for MBMS bearers	6.3.0	6.4.0
2004-09	SA#25	SP-040526	107	1	Merged CR 88 Separate Rendering of 2G and 3G Content for the Same Service, CR 90 Definition of Session Identity and CR92 Additional information needed in section 8.3 Session Start Message	6.3.0	6.4.0

Tektronix

UMTS Protocols and Protocol Testing

Definition

Universal Mobile Telecommunications System (UMTS) is envisioned as the successor to Global System for Mobile Communications (GSM). UMTS signals the move into the third generation (3G) of mobile networks. UMTS also addresses the growing demand of mobile and Internet applications for new capacity in the overcrowded mobile communications sky. The new network increases transmission speed to 2 Mbps per mobile user and establishes a global roaming standard.

Overview

UMTS, also referred to as wideband code division multiple access (W–CDMA), is one of the most significant advances in the evolution of telecommunications into 3G networks. UMTS allows many more applications to be introduced to a worldwide base of users and provides a vital link between today's multiple GSM systems and the ultimate single worldwide standard for all mobile telecommunications, International Mobile Telecommunications–2000 (IMT–2000).

This tutorial explores the history of mobile communications leading to the proposal of UMTS. The tutorial then explains the architecture of UMTS and the protocols, interfaces, and technologies that go along with it. Finally, this tutorial looks at UMTS measurement and testing where tutorial participants will find real-world situations with practical suggestions for measurement approaches.

Topics

1. Evolution of Mobile Communications
2. UMTS Network Architecture
3. UMTS Interfaces
4. UMTS and UTRAN Measurement Objectives
5. Appendix

   Self-Test

   Correct Answers

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1. Evolution of Mobile Communications

Early Stages: 1G to 3G

Electromagnetic waves were first discovered as a communications medium at the end of the 19th century. The first systems offering mobile telephone service (car phone) were introduced in the late 1940s in the United States and in the early 1950s in Europe. Those early single cell systems were severely constrained by restricted mobility, low capacity, limited service, and poor speech quality. The equipment was heavy, bulky, expensive, and susceptible to interference. Because of those limitations, less than one million subscribers were registered worldwide by the early 1980s.

First Generation (1G): Analog Cellular

The introduction of cellular systems in the late 1970s and early 1980s represented a quantum leap in mobile communication (especially in capacity and mobility). Semiconductor technology and microprocessors made smaller, lighter weight, and more sophisticated mobile systems a practical reality for many more users. These 1G cellular systems still transmit only analog voice information. The most prominent 1G systems are Advanced Mobile Phone System (AMPS), Nordic Mobile Telephone (NMT), and Total Access Communication System (TACS). With the 1G introduction, the mobile market showed annual growth rates of 30 to 50 percent, rising to nearly 20 million subscribers by 1990.

Second Generation (2G): Multiple Digital Systems

The development of 2G cellular systems was driven by the need to improve transmission quality, system capacity, and coverage. Further advances in semiconductor technology and microwave devices brought digital transmission to mobile communications. Speech transmission still dominates the airways, but the demands for fax, short message, and data transmissions are growing rapidly. Supplementary services such as fraud prevention and encrypting of user data have become standard features that are comparable to those in fixed networks. 2G cellular systems include GSM, Digital AMPS (D-AMPS), code division multiple access (CDMA), and Personal Digital Communication (PDC). Today, multiple 1G and 2G standards are used in worldwide mobile communications. Different standards serve different applications with different levels of mobility, capability, and service area (paging systems, cordless telephone, wireless local loop, private mobile radio, cellular systems, and mobile satellite systems). Many standards are used only in one country or region, a most are incompatible.

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GSM is the most successful family of cellular standards (GSM900, GSM–railway [GSM–R], GSM1800, GSM1900, and GSM400), supporting some 250 million of the world's 450 million cellular subscribers with international roaming in approximately 140 countries and 400 networks.

2G to 3G: GSM Evolution

Phase 1 of the standardization of GSM900 was completed by the European Telecommunications Standards Institute (ETSI) in 1990 and included all necessary definitions for the GSM network operations. Several tele-services and bearer services have been defined (including data transmission up to 9.6 kbps), but only some very basic supplementary services were offered. As a result, GSM standards were enhanced in Phase 2 (1995) to incorporate a large variety of supplementary services that were comparable to digital fixed network integrated services digital network (ISDN) standards. In 1996, ETSI decided to further enhance GSM in annual Phase 2+ releases that incorporate 3G capabilities.

GSM Phase 2+ releases have introduced important 3G features such as intelligent network (IN) services with customized application for mobile enhanced logic (CAMEL), enhanced speech compression/decompression (CODEC), enhanced full rate (EFR), and adaptive multirate (AMR), high–data rate services and new transmission principles with high-speed circuit-switched data (HSCSD), general packet radio service (GPRS), and enhanced data rates for GSM evolution (EDGE). UMTS is a 3G GSM successor standard that is downward-compatible with GSM, using the GSM Phase 2+ enhanced core network.

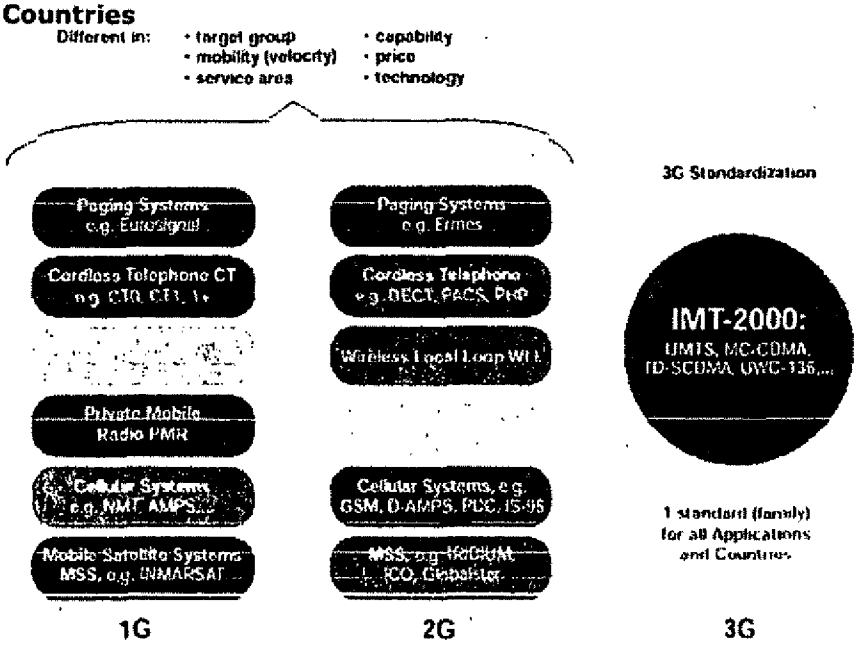
IMT–2000

The main characteristics of 3G systems, known collectively as IMT–2000, are a single family of compatible standards that have the following characteristics:

- Used worldwide
- Used for all mobile applications
- Support both packet-switched (PS) and circuit-switched (CS) data transmission
- Offer high data rates up to 2 Mbps (depending on mobility/velocity)
- Offer high spectrum efficiency

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Figure 1. Multiple Standards for Different Applications and Countries



IMT–2000 is a set of requirements defined by the International Telecommunications Union (ITU). As previously mentioned, IMT stands for International Mobile Telecommunications, and "2000" represents both the scheduled year for initial trial systems and the frequency range of 2000 MHz (WARC'92: 1885–2025 MHz and 2110–2200 MHz). All 3G standards have been developed by regional standards developing organizations (SDOs). In total, proposals for 17 different IMT–2000 standards were submitted by regional SDOs to ITU in 1998—11 proposals for terrestrial systems and 6 for mobile satellite systems (MSSs). Evaluation of the proposals was completed at the end of 1998, and negotiations to build a consensus among differing views were completed in mid 1999. All 17 proposals have been accepted by ITU as IMT–2000 standards. The specification for the Radio Transmission Technology (RTT) was released at the end of 1999.

The most important IMT–2000 proposals are the UMTS (W-CDMA) as the successor to GSM, CDMA2000 as the interim standard '95 (IS–95) successor, and time division–synchronous CDMA (TD–SCDMA) (universal wireless communication–136 [UWC–136]/EDGE) as TDMA–based enhancements to D–AMPS/GSM—all of which are leading previous standards toward the ultimate goal of IMT–2000.

UMTS allows many more applications to be introduced to a worldwide base of users and provides a vital link between today's multiple GSM systems and IMT–2000. The new network also addresses the growing demand of mobile and Internet applications for new capacity in the overcrowded mobile

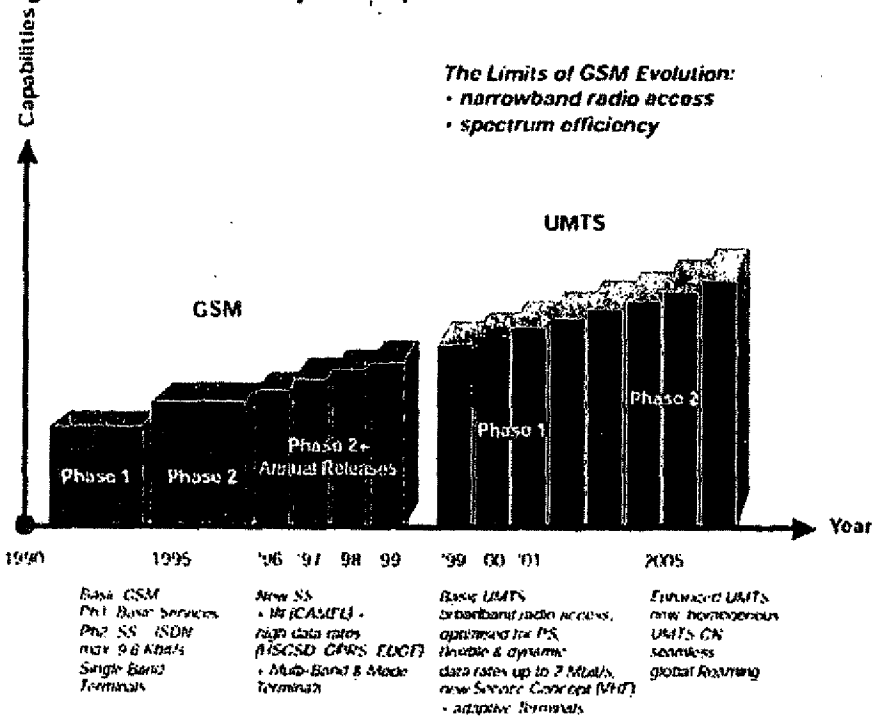
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communications sky. UMTS increases transmission speed to 2 Mbps per mobile user and establishes a global roaming standard.

UMTS is being developed by Third-Generation Partnership Project (3GPP), a joint venture of several SDOs—ETSI (Europe), Association of Radio Industries and Business/Telecommunication Technology Committee (ARIB/TTC) (Japan), American National Standards Institute (ANSI) T-1 (USA), telecommunications technology association (TTA) (South Korea), and Chinese Wireless Telecommunication Standard (CWTS) (China). To reach global acceptance, 3GPP is introducing UMTS in phases and annual releases. The first release (UMTS Rel. '99), introduced in December of 1999, defines enhancements and transitions for existing GSM networks. For the second phase (UMTS Rel. '00), similar transitions are being proposed as enhancements for IS–95 (with CDMA2000) and TDMA (with TD–CDMA and EDGE).

The most significant change in Rel. '99 is the new UMTS terrestrial radio access (UTRA), a W–CDMA radio interface for land-based communications. UTRA supports time division duplex (TDD) and frequency division duplex (FDD). The TDD mode is optimized for public micro and pico cells and unlicensed cordless applications. The FDD mode is optimized for wide-area coverage, i.e., public macro and micro cells. Both modes offer flexible and dynamic data rates up to 2 Mbps. Another newly defined UTRA mode, multicarrier (MC), is expected to establish compatibility between UMTS and CDMA2000.

Figure 2. Evolutionary Concept



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2. UMTS Network Architecture

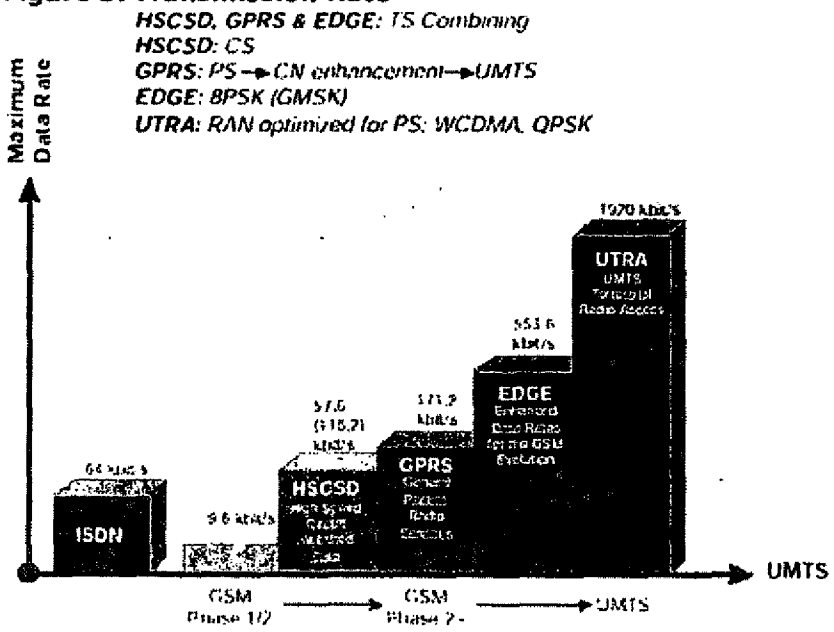
UMTS (Rel. '99) incorporates enhanced GSM Phase 2+ Core Networks with GPRS and CAMEL. This enables network operators to enjoy the improved cost-efficiency of UMTS while protecting their 2G investments and reducing the risks of implementation.

In UMTS release 1 (Rel. '99), a new radio access network UMTS terrestrial radio access network (UTRAN) is introduced. UTRAN, the UMTS radio access network (RAN), is connected via the Iu to the GSM Phase 2+ core network (CN). The Iu is the UTRAN interface between the radio network controller (RNC) and CN; the UTRAN interface between RNC and the packet-switched domain of the CN (Iu–PS) is used for PS data and the UTRAN interface between RNC and the circuit-switched domain of the CN (Iu–CS) is used for CS data.

"GSM–only" mobile stations (MSs) will be connected to the network via the GSM air (radio) interface (Um). UMTS/GSM dual-mode user equipment (UE) will be connected to the network via UMTS air (radio) interface (Uu) at very high data rates (up to almost 2 Mbps). Outside the UMTS service area, UMTS/GSM UE will be connected to the network at reduced data rates via the Um.

Maximum data rates are 115 kbps for CS data by HSCSD, 171 kbps for PS data by GPRS, and 553 kbps by EDGE. Handover between UMTS and GSM is supported, and handover between UMTS and other 3G systems (e.g., multicarrier CDMA [MC–CDMA]) will be supported to achieve true worldwide access.

Figure 3. Transmission Rate



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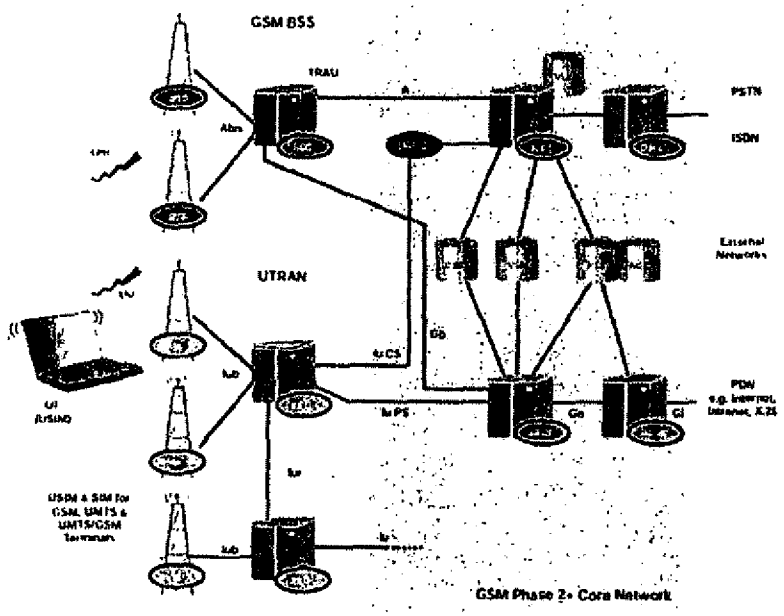
The public land mobile network (PLMN) described in UMTS Rel. '99 incorporates three major categories of network elements:

- GSM Phase 1/2 core network elements: mobile services switching center (MSC), visitor location register (VLR), home location register (HLR), authentication center (AC), and equipment identity register (EIR)
- GSM Phase 2+ enhancements: GPRS (serving GPRS support node [SGSN] and gateway GPRS support node [GGSN]) and CAMEL (CAMEL service environment [CSE])
- UMTS specific modifications and enhancements, particularly UTRAN

Network Elements from GSM Phase 1/2

The GSM Phase 1/2 PLMN consists of three subsystems: the base station subsystem (BSS), the network and switching subsystem (NSS), and the operations support system (OSS). The BSS consists of the functional units: base station controller (BSC), base transceiver station (BTS) and transcoder and rate adapter unit (TRAU). The NSS consists of the functional units: MSC, VLR, HLR, EIR, and the AC. The MSC provides functions such as switching, signaling, paging, and inter–MSC handover. The OSS consists of operation and maintenance centers (OMCs), which are used for remote and centralized operation, administration, and maintenance (OAM) tasks.

Figure 4. UMTS Phase 1 Network



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Network Elements from GSM Phase 2+

GPRS

The most important evolutionary step of GSM toward UMTS is GPRS. GPRS introduces PS into the GSM CN and allows direct access to packet data networks (PDNs). This enables high-data rate PS transmission well beyond the 64 kbps limit of ISDN through the GSM CN, a necessity for UMTS data transmission rates of up to 2 Mbps. GPRS prepares and optimizes the CN for high-data rate PS transmission, as does UMTS with UTRAN over the RAN. Thus, GPRS is a prerequisite for the UMTS introduction.

Two functional units extend the GSM NSS architecture for GPRS PS services: the GGSN and the SGSN. The GGSN has functions comparable to a gateway MSC (GMSC). The SGSN resides at the same hierarchical level as a visited MSC (VMSC)/VLR and therefore performs comparable functions such as routing and mobility management.

CAMEL

CAMEL enables worldwide access to operator-specific IN applications such as prepaid, call screening, and supervision. CAMEL is the primary GSM Phase 2+ enhancement for the introduction of the UMTS virtual home environment (VHE) concept. VHE is a platform for flexible service definition (collection of service creation tools) that enables the operator to modify or enhance existing services and/or define new services. Furthermore, VHE enables worldwide access to these operator-specific services in every GSM and UMTS PLMN and introduces location-based services (by interaction with GSM/UMTS mobility management). A CSE and a new common control signaling system 7 (SS7) (CCS7) protocol, the CAMEL application part (CAP), are required on the CN to introduce CAMEL.

Network Elements from UMTS Phase 1

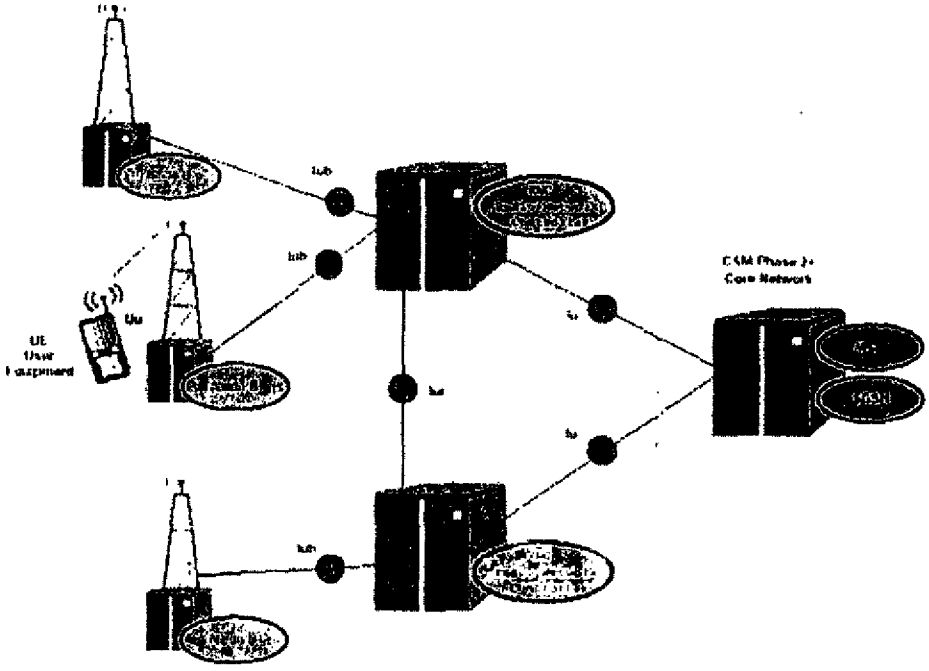
As mentioned above, UMTS differs from GSM Phase 2+ mostly in the new principles for air interface transmission (W-CDMA instead of time division multiple access [TDMA]/frequency division multiple access [FDMA]). Therefore, a new RAN called UTRAN must be introduced with UMTS. Only minor modifications, such as allocation of the transcoder (TC) function for speech compression to the CN, are needed in the CN to accommodate the change. The TC function is used together with an interworking function (IWF) for protocol conversion between the A and the Iu-CS interfaces.

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UTRAN

The UMTS standard can be seen as an extension of existing networks. Two new network elements are introduced in UTRAN, RNC, and Node B. UTRAN is subdivided into individual radio network systems (RNSs), where each RNS is controlled by an RNC. The RNC is connected to a set of Node B elements, each of which can serve one or several cells.

Figure 5. UMTS Phase 1: UTRAN



Existing network elements, such as MSC, SGSN, and HLR, can be extended to adopt the UMTS requirements, but RNC, Node B, and the handsets must be completely new designs. RNC will become the replacement for BSC, and Node B fulfills nearly the same functionality as BTS. GSM and GPRS networks will be extended, and new services will be integrated into an overall network that contains both existing interfaces such as A, Gb, and Abis, and new interfaces that include Iu, UTRAN interface between Node B and RNC (Iub), and UTRAN interface between two RNCs (Iur).

UMTS defines four new open interfaces:

- Uu: UE to Node B (UTRA, the UMTS W-CDMA air interface)
- Iu: RNC to GSM Phase 2+ CN interface (MSC/VLR or SGSN)

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- Iu-CS for circuit-switched data
- Iu-PS for packet-switched data

- Iub: RNC to Node B interface
- Iur: RNC to RNC interface, not comparable to any interface in GSM

The Iu, Iub, and Iur interfaces are based on ATM transmission principles.

The RNC enables autonomous radio resource management (RRM) by UTRAN. It performs the same functions as the GSM BSC, providing central control for the RNS elements (RNC and Node Bs).

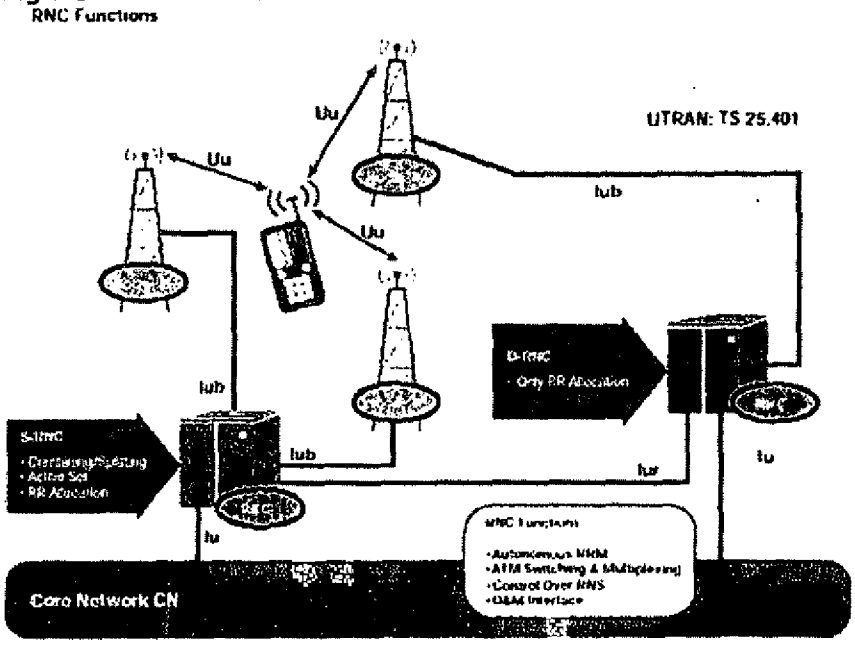
The RNC handles protocol exchanges between Iu, Iur, and Iub interfaces and is responsible for centralized operation and maintenance (O&M) of the entire RNS with access to the OSS. Because the interfaces are ATM-based, the RNC switches ATM cells between them. The user's circuit-switched and packet-switched data coming from Iu-CS and Iu-PS interfaces are multiplexed together for multimedia transmission via Iur, Iub, and Uu interfaces to and from the UE.

The RNC uses the Iur interface, which has no equivalent in GSM BSS, to autonomously handle 100 percent of the RRM, eliminating that burden from the CN. Serving control functions such as admission, RRC connection to the UE, congestion and handover/macro diversity are managed entirely by a single serving RNC (SRNC).

If another RNC is involved in the active connection through an inter-RNC soft handover, it is declared a drift RNC (DRNC). The DRNC is only responsible for the allocation of code resources. A reallocation of the SRNC functionality to the former DRNC is possible (serving radio network subsystem [SRNS] relocation). The term controlling RNC (CRNC) is used to define the RNC that controls the logical resources of its UTRAN access points.

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Figure 6. RNC Functions



Node B

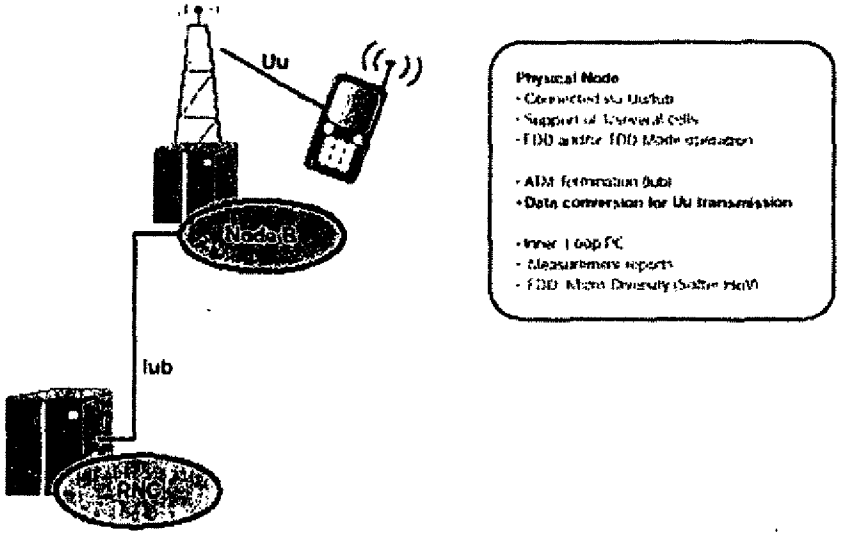
Node B is the physical unit for radio transmission/reception with cells. Depending on sectoring (omni/sector cells), one or more cells may be served by a Node B. A single Node B can support both FDD and TDD modes, and it can be co-located with a GSM BTS to reduce implementation costs. Node B connects with the UE via the W–CDMA Uu radio interface and with the RNC via the Iub asynchronous transfer mode (ATM)–based interface. Node B is the ATM termination point.

The main task of Node B is the conversion of data to and from the Uu radio interface, including forward error correction (FEC), rate adaptation, W–CDMA spreading/despreading, and quadrature phase shift keying (QPSK) modulation on the air interface. It measures quality and strength of the connection and determines the frame error rate (FER), transmitting these data to the RNC as a measurement report for handover and macro diversity combining. The Node B is also responsible for the FDD softer handover. This micro diversity combining is carried out independently, eliminating the need for additional transmission capacity in the Iub.

The Node B also participates in power control, as it enables the UE to adjust its power using downlink (DL) transmission power control (TPC) commands via the inner-loop power control on the basis of uplink (UL) TPC information. The predefined values for inner-loop power control are derived from the RNC via outer-loop power control.

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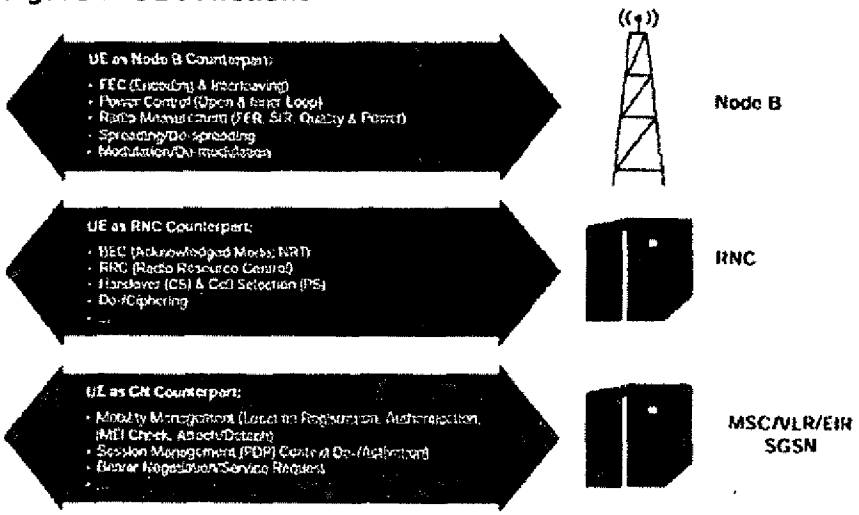
Figure 7. Node B Overview



UMTS UE

The UMTS UE is based on the same principles as the GSM MS—the separation between mobile equipment (ME) and the UMTS subscriber identity module (SIM) card (USIM). *Figure 8* shows the user equipment functions. The UE is the counterpart to the various network elements in many functions and procedures.

Figure 8. UE Functions



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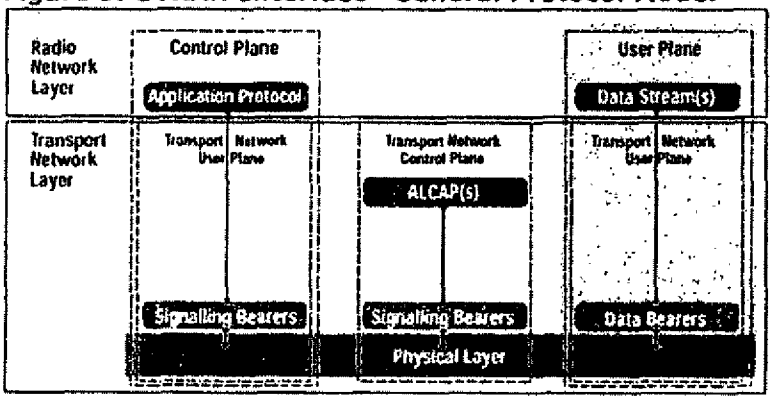
3. UMTS Interfaces

Many new protocols have been developed for the four new interfaces specified in UMTS: Uu, Iub, Iur, and Iu. This tutorial is organized by the protocols and shows their usage in the interfaces. That means protocols will be described individually. Only the references to the interfaces are indicated. Interface specific explanations of the protocols are, however, not included. Before we review the individual interface protocols, we introduce the UMTS general protocol model.

General Protocol Model [3G TS 25.401]

UTRAN interface consists of a set of horizontal and vertical layers (see *Figure 9*). The UTRAN requirements are addressed in the horizontal radio network layer across different types of control and user planes. Control planes are used to control a link or a connection; user planes are used to transparently transmit user data from the higher layers. Standard transmission issues, which are independent of UTRAN requirements, are applied in the horizontal transport network layer.

Figure 9. UTRAN Interface—General Protocol Model



Five major protocol blocks are shown in *Figure 9*:

- Signaling bearers are used to transmit higher layers' signaling and control information. They are set up by O&M activities.
- Data bearers are the frame protocols used to transport user data (data streams). The transport network–control plane (TN–CP) sets them up.
- Application protocols are used to provide UMTS–specific signaling and control within UTRAN, such as to set up bearers in the radio network layer.

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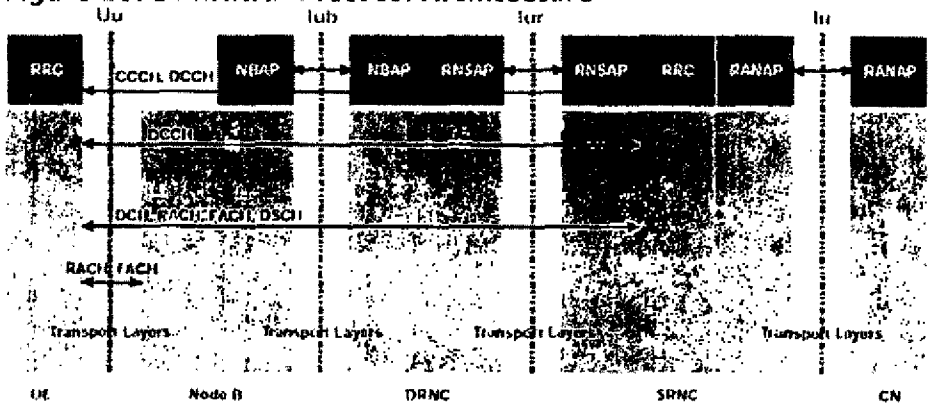
- Data streams contain the user data that is transparently transmitted between the network elements. User data is comprised of the subscriber's personal data and mobility management information that are exchanged between the peer entities MSC and UE.

- Access link control application part (ALCAP) protocol layers are provided in the TN–CP. They react to the radio network layer's demands to set up, maintain, and release data bearers. The primary objective of introducing the TN–CP was to totally separate the selection of the data bearer technology from the control plane (where the UTRAN–specific application protocols are located). The TN–CP is present in the Iu–CS, Iur, and Iub interfaces. In the remaining interfaces where there is no ALCAP signaling, preconfigured data bearers are activated.

Application Protocols

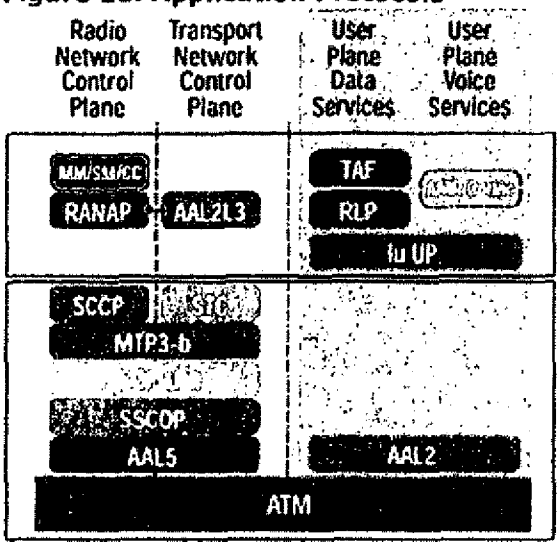
Application protocols are Layer-3 protocols that are defined to perform UTRAN–specific signaling and control. A complete UTRAN and UE control plane protocol architecture is illustrated in *Figure 10*. UTRAN–specific control protocols exist in each of the four interfaces.

Figure 10. Iu RANAP Protocol Architecture



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Figure 11. Application Protocols



Iu: Radio Access Network Application Part (RANAP) [3G TS 25.413]

This protocol layer provides UTRAN–specific signaling and control over the Iu (see *Figure 11*). The following is a subset of the RANAP functions:

- Overall radio access bearer (RAB) management, which includes the RAB's setup, maintenance, and release
- Management of Iu connections
- Transport of nonaccess stratum (NAS) information between the UE and the CN; for example, NAS contains the mobility management signaling and broadcast information.
- Exchanging UE location information between the RNC and CN
- Paging requests from the CN to the UE
- Overload and general error situation handling

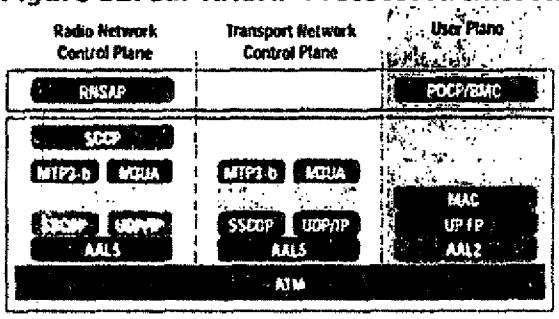
Iur: Radio Network Sublayer Application Part (RNSAP) [3G TS 25.423]

UTRAN–specific signaling and control over this interface contains the following:

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- Management of radio links, physical links, and common transport channel resources
- Paging
- SRNC relocation
- Measurements of dedicated resources

Figure 12. Iur RNSAP Protocol Architecture



Iub: Node B Application Part (NBAP) [3G TS 25.433]

UTRAN specific signaling and control in the Iub includes the following (see *Figure 13*):

- Management of common channels, common resources, and radio links
- Configuration management, such as cell configuration management
- Measurement handling and control
- Synchronization (TDD)
- Reporting of error situations

Uu: Radio Resource Control (RRC) [3G TS 25.331]

This layer handles the control plane signaling over the Uu between the UE and the UTRAN (see also *Figure 13*). Some of the functions offered by the RRC include the following:

- Broadcasting information
- Management of connections between the UE and the UTRAN, which include their establishment, maintenance, and release

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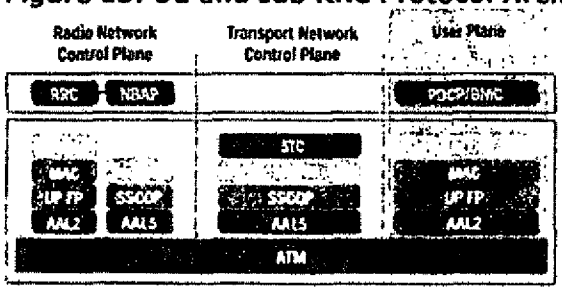
- Management of the radio bearers, which include their establishment, maintenance, release, and the corresponding connection mobility
- Ciphering control
- Outer loop power control
- Message integrity protection
- Timing advance in the TDD mode
- UE measurement report evaluation
- Paging and notifying

(Note: The RRCs also perform local inter-layer control services, which are not discussed in this document.)

Two modes of operation are defined for the UE—the idle mode and the dedicated mode. In the idle mode the peer entity of the UE's RRC is at the Node B, while in the dedicated mode it is at the SRNC. The dedicated mode is shown in *Figure 10.*

Higher-layer protocols to perform signaling and control tasks are found on top of the RRC. The mobility management (MM) and call control (CC) are defined in the existing GSM specifications. Even though MM and CC occur between the UE and the CN and are therefore not part of UTRAN specific signaling (see *Figure 15*), they demand basic support from the transfer service, which is offered by duplication avoidance (see 3G TS 23.110). This layer is responsible for in-sequence transfer and priority handling of messages. It belongs to UTRAN, even though its peer entities are located in the UE and CN.

Figure 13. Uu and Iub RRC Protocol Architecture



Transport Network Layer: Specific Layer-3 Signaling and Control Protocols

Two types of layer-3 signaling protocols are found in the transport network layer:

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- Iu, Iur: Signaling Connection Control Part (SCCP) [ITU-T Q.711–Q. 716] This provides connectionless and connection-oriented services. On a connection-oriented link, it separates each mobile unit and is responsible for the establishment of a connection-oriented link for each and every one of them.

- Iu–CS, Iur, Iub: ALCAP [ITU–T Q.2630.1, Q.2150.1, and Q.2150.2]. Layer-3 signaling is needed to set up the bearers to transmit data via the user plane. This function is the responsibility of the ALCAP, which is applied to dynamically establish, maintain, release, and control ATM adaptation layer (AAL)–2 connections. ALCAP also has the ability to link the connection control to another higher layer control protocol. This and additional capabilities were specified in ITU–T Q.2630.1. Because of the protocol layer specified in Q.2630.1, a converter is needed to correspond with underlying sublayers of the protocol stack. These converters are called (generically) signaling transport converter (STC). Two converters are defined and applied in UTRAN:
  - Iu–CS, Iur: AAL–2 STC on message transfer part (MTP) level 3 (broadband) for Q.2140 (MTP3b) [Q.2150.1]
  - Iub: AAL–2 STC on service-specific connection-oriented protocol (SSCOP) [Q.2150.2]

Transport Network Layer Specific Transmission Technologies

Now that we have a circuit-switched and packet-switched domain in the CN and a growing market for packet-switched network solutions, a new RAN must be open to both types of traffic in the long run. That network must also transmit the Layer-3 signaling and control information. ATM was selected as the Layer-2 technology, but higher-layer protocols used in the transport network layer demonstrate the UMTS openness to a pure IP solution.

Iu, Iur, Iub: ATM [ITU-T I.361]

Broadband communication will play an important role with UMTS. Not only voice but also multimedia applications such as videoconferencing, exploring the Internet, and document sharing are anticipated. We need a data link technology that can handle both circuit-switched and packet-switched traffic as well as isochronous and asynchronous traffic. In UMTS (Release '99), ATM was selected to perform this task.

An ATM network is composed of ATM nodes and links. The user data is organized and transmitted in each link with a stream of ATM cells. AALs are

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defined to enable different types of services with corresponding traffic behavior. Two of these are applied in UTRAN:

- **Iu–CS, Iur, Iub: AAL–2 [ITU-T I.363.2]**—With AAL–2, isochronous connections with variable bit rate and minimal delay in a connection-oriented mode are supported. This layer was designed to provide real-time service with variable data rates, such as video. Except for the Iu–PS interface, AAL–2 is always used to carry the user data-streams.

- **Iu–PS, Iur, Iub: AAL–5 [ITU-T I.363.5]**—With AAL–5, isochronous connections with variable bit rate in a connection-oriented mode are supported. This layer is used for Internet protocol (IP) local-area network (LAN) emulation, and signaling. In UTRAN, AAL–5 is used to carry the packet-switched user traffic in the Iu–PS-interface and the signaling and control data throughout.

In order to carry signaling and control data, the AAL–5 has to be enhanced. Here, UTRAN offers both a classical ATM solution and an IP–based approach:

- **Signaling AAL and MTP3b**—To make signaling AAL (SAAL) available in place of the AAL–5 service-specific convergence sublayer (SSCS), the SSCOP, which provides a reliable data transfer service, and the service-specific coordination function (SSCF), which acts as coordination unit, are defined.

- **Iu, Iur, Iub: SSCOP [ITU–T Q.2110]**—The SSCOP is located on top of the AAL. It is a common connection-oriented protocol that provides a reliable data transfer between peer entities. Its capabilities include the transfer of higher-layer data with sequence integrity, flow control, connection maintenance in case of a longer data transfer break, error correction by protocol control information, error correction by retransmission, error reporting to layer management, status report, and more.

Two versions of the SSCF are defined: one for signaling at the user-to-network interface (UNI), and one for signaling at the network to node interface (NNI):

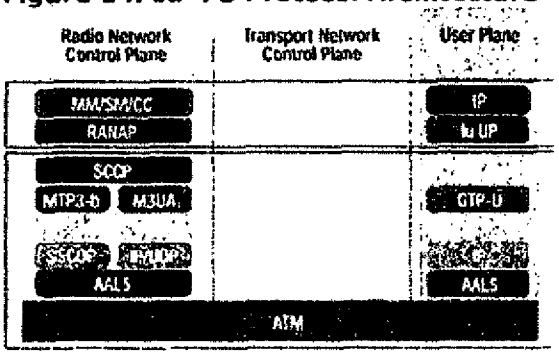
- **Iub: SSCF for at the UNI (SSCF) [ITU–T Q.2130]**—The SSCF–UNI receives Layer-3 signaling and maps it to the SSCOP and visa versa. The SSCF–UNI performs coordination between the higher and lower layers. Within UTRAN, it is applied in Iub with the NBAP and ALCAP on top of the SSCF–UNI.

- **Iu, Iur: SSCF at the NNI (SSCF-NNI) [ITU–T Q.2140]**—The SSCF-NNI receives the SS7 signaling of a Layer 3 and maps it to the

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SSCOP, and visa versa. The SSCF-NNI performs coordination between the higher and the lower layers. Within UTRAN, MTP3b has the higher Layer 3, which requires service from the SSCOP-NNI.

Figure 14. Iu–PS Protocol Architecture



Originally the SS7 protocol layer, SCCP relies on the services offered by MTP, so the Layer-3 part of the MTP must face the SCCP layer:

- **Iu, Iur: MTP3b [ITU–T Q.2210]**—Signaling links must be controlled in level 3 for: message routing, discrimination and distribution (for point-to-point link only), signaling link management, load sharing, etc. The specific functions and messages for these are defined by the MTP3b, which requires the SSCF–NNI to provide its service.

The Layer-3 signaling and control data can also be handled by an enhanced IP stack using a tunneling function (see *Figure 12*). Tunneling is also applied for packet-switched user data over the Iu–PS interface (see *Figure 14*).

- IP over ATM
  - Iu-PS, Iur: IP [IETF RFC 791, 2460, 1483, 2225], user datagram protocol (UDP) [IETF RFC 768] The IP can be encapsulated and then transmitted via an ATM connection, a process which is described in the RFC 1483 and RFC 2225. Both IP version 4 (IPv4) and IP version 6 (IPv6) are supported. IP is actually a Layer-3 protocol. UDP is applied on top of the unreliable Layer-4 protocol. The objective is to open this signaling link to future pure IP network solutions.

In order to tunnel SCCP or ALCAP signaling information, two protocols are applied:

- **Iu–PS and Iur: Simple Control Transmission Protocol (SCTP) [IETF SCTP]**—This protocol layer allows the transmission of

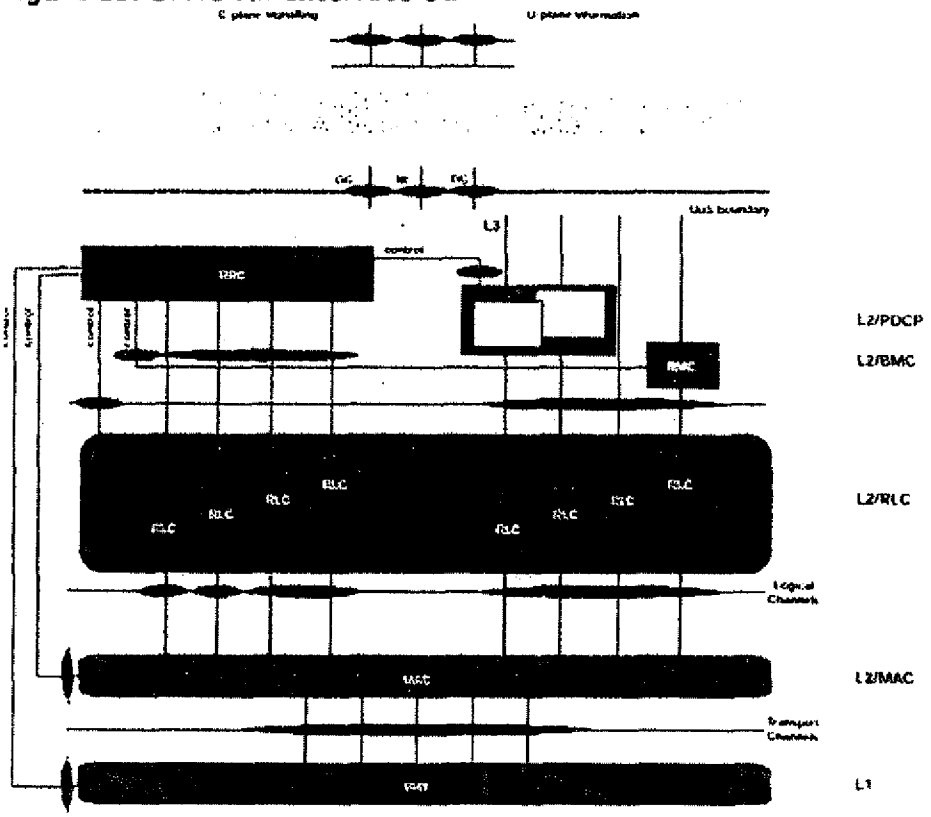
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signaling protocols over IP networks. Its tasks are comparable with MTP3b. On Iu–CS, SS7 must be tunneled between the CN and the RNC. The plan is that this is to be done with the Iu–PS and Iur [IETF M3UA].

The following does the tunneling of packet-switched user data:

- **Iu–PS: GPRS tunneling protocol (GTP) [3G TS 29.060]**—The GTP provides signaling through GTP–control (GTP–C) and data transfer through GTP–user (GTP–U) procedures. Only the latter is applied in the Iu–PS interface because the control function is handled by the RANAP protocol. The GTP–U is used to tunnel user data between the SGSN and the RNC.

Figure 15. UMTS Air Interface Uu



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Iu, Iur, Iub: The Physical Layers [3G TS 25.411]

The physical layer defines the access to the transmission media, the physical and electrical properties, and how to activate and deactivate a connection. It offers to the higher-layer physical service access points to support the transmission of a uniform bit stream. A huge set of physical-layer solutions is allowed in UTRAN, including ETSI synchronous transport module (STM)–1 (155 Mbps) and STM–4 (622 Mbps); synchronous optical network (SONET) synchronous transport signal (STS)–3c (155 Mbps) and STS–12c (622 Mbps); ITU STS–1 (51 Mbps) and STM–0 (51 Mbps); E-1 (2 Mbps), E-2 (8 Mbps), and E-3 (34 Mbps); T-1 (1.5 Mbps) and T-3 (45 Mbps); and J-1 (1.5 Mbps) and J-2 (6.3 Mbps).

With the above protocol layers, the interfaces Iu, Iur, and Iur are fully described. There is only the air interface left for a more detailed analysis:

The Air Interface Uu [3G TS 25.301]

The air interface solution is usually a major cause for dispute when specifying a new RAN. *Figure 15* shows the realization of the lower parts of the protocol stack in the UE. As can be seen, a physical layer, data link layer, and network layer (the part for the RRC) have been specified.

The physical layer is responsible for the transmission of data over the air interface. The FDD and TDD W–CDMA solutions have been specified in UMTS Rel. '99. The data link layer contains four sublayers:

- **Medium Access Control (MAC) [3G TS 25.321]**—The MAC layer is located on top of the physical layer. Logical channels are used for communication with the higher layers. A set of logical channels is defined to transmit each specific type of information. Therefore, a logical channel determines the kind of information it uses. The exchange of information with the physical layer is realized with transport channels. They describe how data is to be transmitted over the air interface and with what characteristics. The MAC layer is responsible for more than mapping the logical channels into the physical ones. It is also used for priority handling of UEs and the data flows of a UE, traffic monitoring, ciphering, multiplexing, and more.

- **Radio Link Control (RLC) [3G TS 25.322]**—This is responsible for acknowledged or unacknowledged data transfer, establishment of RLC connections, transparent data transfer, quality of service (QoS) settings, unrecoverable error notification, ciphering, etc. There is one RLC connection per radio bearer.

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The two remaining Layer-2 protocols are used only in the user plane:

- **Packet Data Convergence Protocol (PDCP) [3G TS 25.323]**—This is responsible for the transmission and reception of radio network layer protocol data units (PDUs). Within UMTS, several different network layer protocols are supported to transparently transmit protocols. At the moment, IPv4 and IPv6 are supported, but UMTS must be open to other protocols without forcing the modification of UTRAN protocols. This transparent transmission is one task of PDCP; another is to increase channel efficiency (by protocol header compression, for example).

- **Broadcast/Multicast Control (BMC) [3G TS 25.324]**—This offers broadcast/multicast services in the user plane. For instance, it stores SMS CB messages and transmits them to the UE.

4. UMTS and UTRAN Measurement Objectives

As noted in the preceding section, four new interfaces have been introduced with UMTS/UTRAN. With the new interfaces came a huge set of protocol layers for mobile communication networks. Dealing with these new protocols presents a demanding challenge to manufacturers, operators, and measurement equipment suppliers.

Tektronix Measurement Approaches

The following will present a case study of Tektronix's measurement approaches. For more information on specific test procedures, please see Tektronix's Virtual Exhibit. Nearly all measurement situations can be considered in three categories with related approaches. Even though there are situations where two or more approaches could be applied to the same interface, the first steps in protocol testing should always be to determine the characteristics of the system under test and the test objectives.

- Do you have a living network that you should not, or are not allowed, to disturb?
  *Use the nonintrusive **monitoring** approach.*

- Do you have a dead node or system that needs to be externally stimulated?
  *Use the **simulation/emulation** approach.*

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- Do you need to verify compatibility with standards or with other equipment?
  *Use the **conformance** approach.*

Monitoring [see also CCITT 880 and GSM 12.04]

Monitoring is the process of collecting data from the interface. The main reason for operators and manufacturers to collect data is to retrieve the necessary information for decision-making in relation to a specified objective. The item under investigation can be an individual network element, parts of the PLMN, or even the whole PLMN. The major objectives for monitoring data collections include the following:

- To get an overall view of the actual performance level
- To determine a possible need for an improvement
- To discover the differences between specified and predicted characteristics and its actual performance
- To improve predictions of behavior and potential problems

Interface monitoring can collect data and present results in two ways:

- **Measurement result collection**—Use of cumulative counters to capture the number of occurrences of an event and/or discrete event registers to capture and trace specified results such as overload situations and failures
- **Data review for evaluation**—The storage of measured data for subsequent review and analysis; the amount of data is normally reduced through the filtering of specified events (such as abnormal call termination), the use of statistical methods or the selection of specific conditions (tracing data at a defined address, tracing a call setup, etc.)

Simulation

Simulation is the representation or imitation of a process or system by another device. In a test environment, a simulator can be used in place of a network element or a part of the network to produce desired conditions. For instance, when testing an RNC, the test equipment can simulate the CN behavior, keeping the RNC independent of the network. Simulators are used to do the following:

- To get information about the dependability of a network element (NE); normal and abnormal situations are specified and simulated, and the

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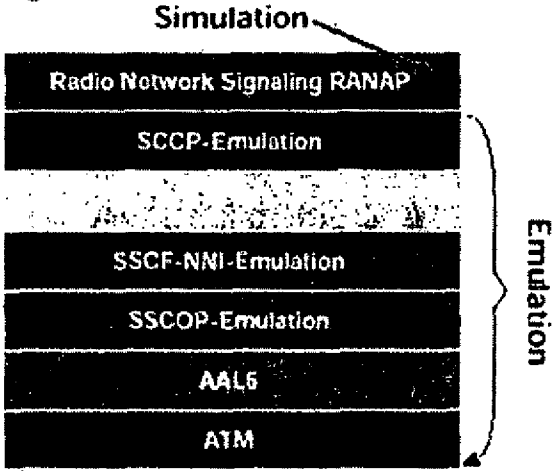
NE's ability to cope with the simulated environment allows the operator to predict how well the NE will perform in the field; simulations are also used for conformance testing where standardized conditions are applied to the NE.

- To substitute missing network elements or parts of a network during the development process; simulation creates a realistic operating environment for the item under development.
- To save development and installation costs; the strong and weak points of an item can be discovered in the development process, before introducing it to an operating network.

Emulation

Emulation is a higher form of simulation where the behaviors of selected layers of communication protocols are simulated automatically and in conformance with standards. For instance, the simulation of the Iu RANAP is based on an emulation of the corresponding lower layers. While the lower layers are defined to act as specified, the simulated layer can be used to deliberately add faults to test an element's ability to handle them.

Figure 16. Simulation and Emulation



Conformance Testing [ETSI ETR 021]

Standards allow different manufacturers to develop systems that can interoperate and exchange and handle information. A system or an implementation is declared conformant when its capabilities and external behavior meet those defined in the referenced standards. Conformance testing is the verification process that determines whether a system or an implementation is conformant.

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While specific conformance tests are defined in UMTS for the air interface (see 3G TS 34.xxx series), conformance tests of the remaining UTRAN interfaces are still dependent upon mutual agreement between manufacturers, operators, and measurement suppliers.

5. Appendix

Recommended Documents and Standards	
3G TS 23.110	UMTS Access Stratum Services and Functions
3G TS 25.301	Radio Interface Protocol Architecture
3G TS 25.321	Medium Access Control (MAC) Protocol Specification
3G TS 25.322	Radio Link Control (RLC) Protocol Specification
3G TS 25.323	Packet Data Convergence Protocol (PDCP) protocol
3G TS 25.324	Radio Interface for Broadcast/Multicast Services
3G TS 25.331	Radio Resource Control (RRC) Protocol Specification
3G TS 25.401	UTRAN Overall Description
3G TS 25.410	UTRAN Iu Interface: General Aspects and Principles
3G TS 25.411	UTRAN Iu interface Layer 1
3G TS 25.413	UTRAN Iu Interface: RANAP Signaling
3G TS 25.420	UTRAN Iur Interface: General Aspects and Principles
3G TS 25.423	UTRAN Iur interface RNSAP Signaling
3G TS 25.430	UTRAN Iub Interface: General Aspects and Principles
3G TS	UTRAN Iub interface NBAP Signaling

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25.433	
3G TS 29.060	GPRS tunneling protocol (GPT) across the Gn and Gp interface, CCITT Rec. E.880, field data collection and evaluation on the performance of equipment, network, and services
ETSI ETR 021	Advanced Testing Methods (ATM); tutorial on protocol conformance testing (especially OSI standards and profiles) (ETR/ATM-1002)
ETSI GSM 12.04	Digital cellular telecommunication system (Phase 2); performance data measurements
IETF M3UA	G. Sidebottom et al, "SS7 MTP3–User Adaptation Layer (M3UA draft-ietf-sigtran-m3ua-02.txt (Work In Progress), IETF, 10 March 2000
IETF SCTP	R. Stewart, et al, "Simple Control Transmission Protocol," draft-ieft-sigtran-sctp-v0.txt (work in progress), IETF, September 1999
IETF RFC 791	Internet Protocol
IETF RFC 768	User Datagram Protocol
IETF RFC 1483	Multiprotocol Encapsulation over ATM Adaptation Layer 5
IETF RFC 2225	Classical IP and ARP over ATM
IETF RFC 2460	"Internet Protocol version 6 (IPv6) Specification"
ITU-T I.361	B-ISDN ATM layer specification.
ITU-T I.363.2	B-ISDN ATM Adaptation Layer Type 2
ITU-T I.363.5	B-ISDN ATM Adaptation Layer Type 5
ITU-T Q.711	Functional Description of the Signaling Connection Control Part
ITU-T Q.712	Definition and Function of Signaling Connection Control Part Messages
ITU-T Q.713	Signaling Connection Control Part Formats and Codes
ITU-T Q.714	Signaling Connection Control Part Procedures

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ITU–T Q.715	Signaling Connection Control Part User Guide
ITU–T Q.716	Signaling Connection Control Part (SCCP) performance
ITU–T Q.2100	B–ISDN Signaling ATM Adaptation Layer (SAAL)—overview description.
ITU–T Q.2110	B–ISDN ATM Adaptation Layer—Service Specific Connection Oriented Protocol (SSCOP).
ITU–T Q.2130	B–ISDN Signaling ATM Adaptation Layer—Service Specific Coordination Function for Support of Signaling at the User Network Interface (SSCF at UNI)
ITU–T Q.2140	B–ISDN ATM adaptation Layer—Service Specific Coordination Function for Signaling at the Network Node Interface (SSCF AT NNI).
ITU–T Q.2150.1	B–ISDN ATM Adaptation Layer—Signaling Transport Converter for the MTP3b
ITU–T Q.2150.2	AAL Type 2 Signaling Transport Converter on SSCOP (Draft)
ITU–T Q.2210	Message Transfer Part Level 3 Functions and Messages Using the Services of ITU–T Recommendation Q.2140.
ITU–T Q.2630.1	AAL Type 2 Signaling Protocol (Capability Set 1)

Self-Test

1. Which of the following is **not** a characteristic of 3G systems?

    a. used worldwide

    b. support only data transmission

    c. offer high data rates

    d. offer high spectrum velocity

2. One of the most important IMT-2000 proposals is having UMTS as the successor to GSM.

    a. true

    b. false

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3. UMTS increases the transmission speed to _____ Mbps per mobile user.

   a. 0.5

   b. 1

   c. 2

   d. 3

4. Who is developing UMTS?

   a. ITU

   b. 3GPP

   c. IETF

   d. IEC

5. What does this tutorial cite as the most important revolutionary step of GSM toward UMTS?

   a. GPRS

   b. CAMEL

   c. GGSN

   d. SGSN

6. _____ enables worldwide access to operator-specific IN applications such as prepaid, call screening, and supervision.

   a. PLMN

   b. CAMEL

   c. CN

   d. BSC

7. SCCP is the physical unit for radio transmission/reception with cells.

   a. true

   b. false

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8. Which of the following is **not** one of the four new interfaces specified in UMTS?

    a. Uu

    b. Iub

    c. Iuc

    d. Iu

    e. Iur

9. Which of the following is **not** one of the five major UTRAN protocol blocks?

    a. transport signals

    b. data and signaling bearers

    c. data streams

    d. ALCAP

    e. application protocols

10. Based on the Tektronix measurement case study, which of the following is **not** one of the three measurement approaches?

    a. simulation

    b. conformance

    c. emulation

    d. investigation

Correct Answers

1. Which of the following is not a characteristic of 3G systems?

    a. used worldwide

    b. support only data transmission

    c. offer high data rates

    d. offer high spectrum velocity

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See Topic 1.

2. One of the most important IMT-2000 proposals is having UMTS as the successor to GSM.

   a. true

   b. false

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   a. 0.5

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   d. 3

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   a. ITU

   b. 3GPP

   c. IETF

   d. IEC

   See Topic 1.

5. What does this tutorial cite as the most important revolutionary step of GSM toward UMTS?

   a. GPRS

   b. CAMEL

   c. GGSN

   d. SGSN

   See Topic 2.

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6. _____ enables worldwide access to operator-specific IN applications such as prepaid, call screening, and supervision.

   a. PLMN

   b. CAMEL

   c. CN

   d. BSC

   See Topic 2.

7. SCCP is the physical unit for radio transmission/reception with cells.

   a. true

   b. false

   See Topic 2.

8. Which of the following is not one of the four new interfaces specified in UMTS?

   a. Uu

   b. Iub

   c. Iuc

   d. Iu

   e. Iur

   See Topic 3.

9. Which of the following is not one of the five major UTRAN protocol blocks?

   a. transport signals

   b. data and signaling bearers

   c. data streams

   d. ALCAP

   e. application protocols

   See Topic 3.

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10. Based on the Tektronix measurement case study, which of the following is not one of the three measurement approaches?

    a. simulation

    b. conformance

    c. emulation

    d. investigation

    See Topic 4.

Glossary

1G
first generation

2G
second generation

3G
third generation

3GPP
Third-Generation Partnership Project (of ETSI)

AAL
ATM adaptation layer

AAL2
ATM adaptation layer type 2

AAL5
ATM adaptation layer type 5

AC
authentication center

ALCAP
access link control application part

AMPS
Advanced Mobile Phone Service

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AMR
adaptive multirate

ANSI T1
American National Standards Institute Standards Committee T-1

ARIB/TTC
Association of Radio Industries and Business/Telecommunication Technology Committee

ATM
asynchronous transfer mode

BEC
backward error correction

BHCA
busy hour call attempt

BMC
broadcast/multicast control

BSC
base station controller

BSS
base station subsystem

BTS
base transceiver station

CAMEL
customized application for mobile enhanced logic

CAP
CAMEL application part

CATT
China Academy of Telecommunication Technology

CBR
constant bit-rate (data stream)

CC
call control

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CCITT
Comité Consultatif International Téléphonique et Telecommunication

CCS7
common control signaling system 7

CDMA
code division multiple access

CDMA2000
3rd Generation Code Division Multiple Access

CM
call management

CN
core network

CODEC
compression/decompression

CRNC
controlling RNC

CS
circuit switched

CS-CN
circuit-switched core network

CSE
CAMEL service environment

CT
conformance test

CWTS
Chinese Wireless Telecommunication Standard

D-AMPS
digital amps

DCH
dedicated channel

DECT
digital enhanced cordless telephone

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DL
downlink

DPC
destination point code

DRNC
drift radio network controller

DRNS
drift radio network subsystem

DTE
data terminal equipment

EDGE
enhanced data rates for GSM evolution

EFR
enhanced full rate

EIR
equipment identity register

ESE
emulation scenario editor

ETSI
European Telecommunications Standards Institute

FDD
frequency division duplex

FDMA
frequency division multiple access

FEC
forward error correction

FER
frame error rate

GGSN
gateway GPRS support node

GMM
GPRS mobility management (protocols)

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GMSC
gateway MSC

GPRS
general packet radio service

GSM
Global System for Mobile Communication

GSM-R
GSM railway

GsmSCF
GSM service control function

GsmSSF
GSM service switching function

GTP
GPRS tunneling protocol

GTP-C
GTP control

GTP-U
GTP user

HLR
home location register

HO/HoV
handover

HSCSD
high-speed circuit-switched data

ICO
intermediate circular orbits

IETF
Internet Engineering Task Force

IMEI
international mobile equipment identification

IMT-2000
International Mobile Telecommunications 2000

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IMUN
international mobile user number

IN
intelligent network

IP
Internet protocol

IPv4
IP version 4

IPv6
IP version 6

IS–95
interim standard '95

ISDN
integrated services digital network

ISP
Internet service provider

ISUP
ISDN user part

ITU
International Telecommunications Union

ITUN
SS7 ISUP tunneling

Iu
interface between RNC and CN

Iub
interface between Node B and RNC

Iu–CS
interface between RNC and the circuit-switched domain of the CN

Iu–PS
interface between RNC and the packet-switched domain of the CN

Iur
interface between two RNCs

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IUT
implementation under test

IWF
interworking function

kbps
kilobits per second

LAN
local-area network

MAC
medium access control

MAP
mobile application part

Mbps
megabits per second

MBS
message building system

MC
multicarrier

MC-CDMA
multicarrier CDMA

MCE
multiprotocol encapsulation

MDTP
multinetwork datagram transmission protocol

ME
mobile equipment

MM
mobility management (protocols)

MS
mobile station

MSC
mobile services switching center, message sequence chart

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MSS
mobile satellite system

MT
mobile telephone

MTP
message transfer part

MTP3b
message transfer part level 3 (broadband) for Q.2140

NAS
nonaccess stratum

NBAP
Node B application protocol

NE
network element

NMT
Nordic Mobile Telephone

NNI
network-node interface

Node B
UMTS base station

NSS
network and switching subsystem

O&M
operation and maintenance

OAM
operation, administration, and maintenance

OMC
operation and maintenance centers

OSA
open service architecture

OSS
operations support system

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PDC
personal digital communication

PDCP
packet data convergence protocol

PDH
plesiochronous digital hierarchy

PDN
packet data network

PDU
protocol data unit

PLMN
public land mobile network

PMR
private mobile radio

PS
packet switched

PS-CN
public switched core network

PSTN
public switched telephone network

QoS
quality of service (ATM network channels)

QPSK
quadrature phase shift keying (or quaternary phase shift keying)

RAB
radio access bearer

RAN
radio access network

RANAP
RAN application part

RLC
radio link control

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RLP
radio link protocol

RNC
radio network controller

RNS
radio network subsystem

RNSAP
radio network subsystem application part

RNTI
radio network temporary identity

RR
radio resource

RRC
radio resource control

RRM
radio resource management

RTT
radio transmission technology

SAAL
signaling ATM adaptation layer

SCCP
signaling connection control part

SCTP
simple control transmission protocol

SDH
synchronous digital hierarchy

SDO
standards developing organization

SGSN
serving GPRS support node

SIM
subscriber identity module

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SM
session management protocols

SONET
synchronous optical network

SRNC
serving radio network controller

SRNS
serving radio network subsystem

SS7
signaling system 7

SSCOP
service-specific connection-oriented protocol

SSCF
service-specific coordination function

SSCF–UNI
SSCF at the UNI

SSCS
service-specific convergence sublayer

SSCS–UNI
SSCS at the UNI

SSF
service switching function

STC
signaling transport converter

STM
synchronous transport module

STS
synchronous transport signal

STM1
synchronous transport module level 1

SUT
system under test

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TACS
Total Access Communication System

TC
transcoder

TD–CDMA
time division–code division multiple access

TDD
time division duplex

TDMA
time division multiple access

TD–SCDMA
time division–synchronous CDMA

TEID
tunneling endpoint I.D.

TETRA
terrestrial trunked radio access

TIA
telecommunications industry association

TN-CP
transport network-control plane

TPC
transmission power control

TRAU
transcoder and rate adapter unit

TS
technical specification

TTA
telecommunications technology association

UDP
user datagram protocol

UE
user equipment

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UL
uplink

Um
GSM air interface

UMTS
Universal Mobile Telecommunication System

UNI
user-to-network interface

UP
user plane

USIM
UMTS subscriber identity module

UTRA
UMTS terrestrial radio access

UTRAN
UMTS terrestrial radio access network

Uu
UMTS air interface

UWC–136
universal wireless communication

VBR
variable bit rate (data stream)

VHE
virtual home environment

VLR
visitor location register

VMSC
visited MSC

W–CDMA
wide-band code division multiple access

WLL
wireless local loop

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Tutorial: Medium Access Control (MAC) in 3G/UMTS Protocol Stack

Appln No. 11/646,692
Docket No. 562492007400

By Zahid Ghadialy

Last Updated: 03/03/2005



Introduction

MAC is a Layer 2 protocol and it resides between Physical Layer (L1) and RLC. The internal configuration of MAC is done by the RRC layer (L3). The interface between PHY and MAC are the transport channels where as the interface between RLC and MAC are the logical channels. MAC provides services to both User plane as well as Control plane. MAC takes care of circuit switched as well as packet switch traffic and signalling traffic as well.

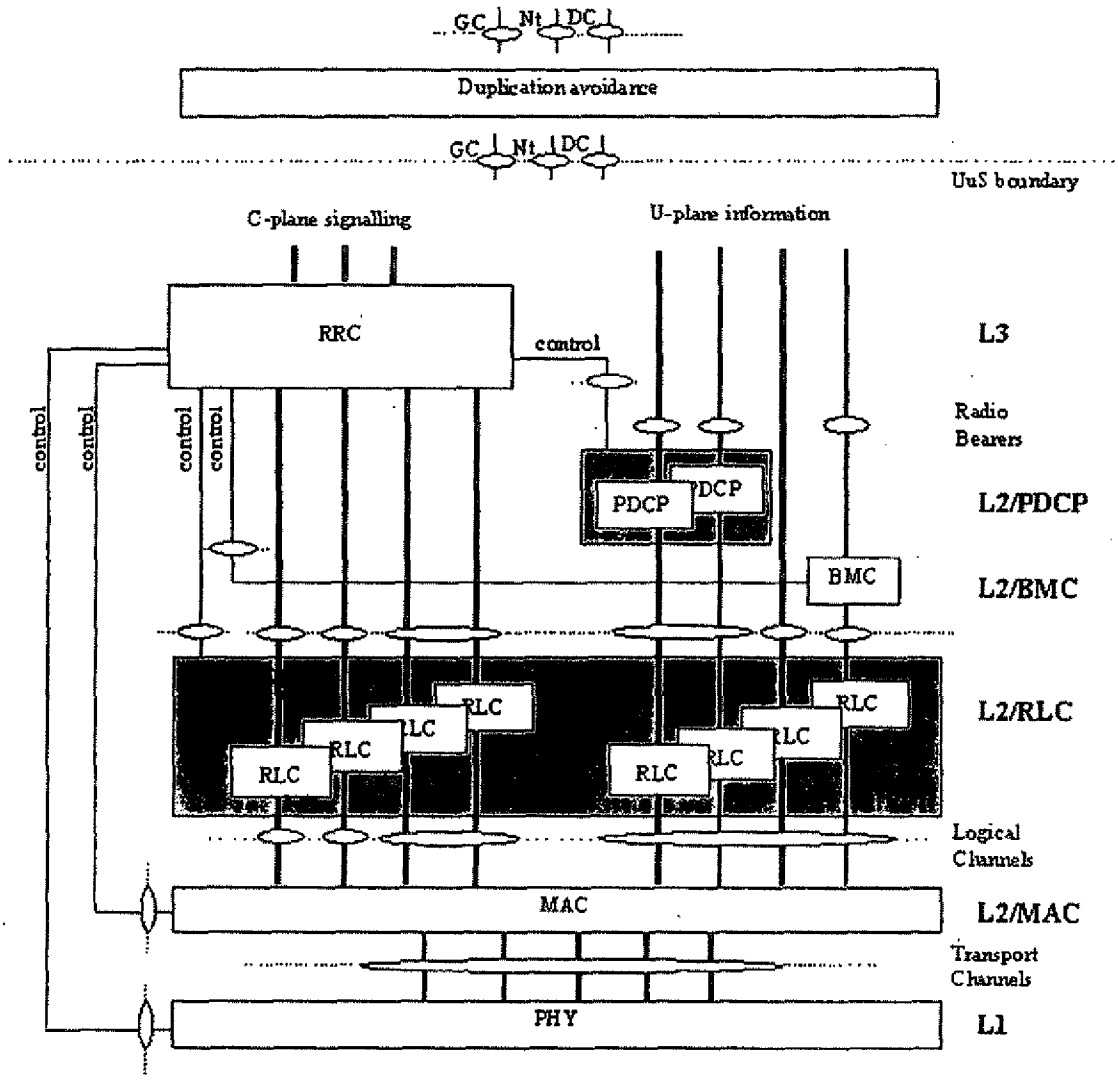


Fig 1: Radio Interface Protocol Architecture
(Taken from 25.301, figure 2)

One important thing to remember is that the MAC is not symmetrical protocol. It is different in UL and DL.

MAC Services

MAC sublayer provides following services to the upper layers:

- Data Transfer: This service provides unacknowledged transfer of MAC SDU's between peer MAC entities.
- Reallocation of radio resources and MAC parameters: On request by RRC, MAC can change the identity of the UE, change the transport format set, change the transport channel type, etc.
- Reporting of Measurements: Traffic volume measurements are performed in MAC and reported to RRC

MAC Functions

MAC Functions include:

- Mapping between logical channels and transport channels

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- Selection of appropriate Transport Format for each Transport channel depending on instantaneous source rate. Given the Transport Format Combination Set assigned by RRC, MAC selects the appropriate transport format within an assigned transport format set for each active transport channel depending on source rate. The control of transport formats ensures efficient use of transport channels.
- Priority handling between data flows of one UE. When selecting between the Transport Format Combinations in the given Transport Format Combination Set, priorities of the data flows to be mapped onto the corresponding Transport Channels can be taken into account.
- Priority handling between UEs by means of dynamic scheduling. In order to utilise the spectrum resources efficiently for bursty transfer, a dynamic scheduling function may be applied. MAC realises priority handling on common and shared transport channels.
- Identification of UEs on common transport channels. When a particular UE is addressed on a common downlink channel, or when a UE is using the RACH, there is a need for inband identification of the UE. Since the MAC layer handles the access to, and multiplexing onto, the transport channels, the identification functionality is naturally also placed in MAC.
- Multiplexing/demultiplexing of upper layer PDUs into/from transport blocks delivered to/from the physical layer on common transport channels. MAC should support service multiplexing for common transport channels, since the physical layer does not support multiplexing of these channels.
- Multiplexing/demultiplexing of upper layer PDUs into/from transport block sets delivered to/from the physical layer on dedicated transport channels. The MAC allows service multiplexing for dedicated transport channels. This function can be utilised when several upper layer services (e.g. RLC instances) can be mapped efficiently on the same transport channel. In this case the identification of multiplexing is contained in the MAC protocol control information.
- Traffic volume measurement. Measurement of traffic volume on logical channels and reporting to RRC. Based on the reported traffic volume information, RRC performs transport channel switching decisions.
- Transport Channel type switching. Execution of the switching between common and dedicated transport channels based on a switching decision derived by RRC.
- Ciphering. This function prevents unauthorised acquisition of data. Ciphering is performed in the MAC layer for transparent RLC mode.
- Access Service Class selection for RACH and CPCH transmission. The RACH resources (i.e. access slots and preamble signatures for FDD, timeslot and channelisation code for TDD) and CPCH resources (i.e. access slots and preamble signatures for FDD only) may be divided between different Access Service Classes in order to provide different priorities of RACH and CPCH usage. In addition it is possible for more than one ASC or for all ASCs to be assigned to the same access slot/signature space. Each access service class will also have a set of back-off parameters associated with it, some or all of which may be broadcast by the network. The MAC function applies the appropriate back-off and indicates to the PHY layer the RACH and CPCH partition associated to a given MAC PDU transfer.

Channel Structure

Before discussing anything further, we should look at the channel structures for Layer 1, MAC and RLC. The Transport Channels are interface between MAC and Layer 1, while Logical Channels are interface between MAC and RLC.

Transport channels can be further subdivided into Common Transport Channels (where there is need for inband identification of the UEs when particular UEs are addressed); and dedicated transport channels (where the UEs are identified by the physical channel, i.e. code and frequency for FDD and code, time slot and frequency for TDD).

Common transport channel types are:

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- Random Access Channel (RACH): A contention based uplink channel used for transmission of relatively small amounts of data, e.g. for initial access or non-real-time dedicated control or traffic data.
- Common Packet Channel (CPCH): A contention based channel used for transmission of bursty data traffic. This channel only exists in FDD mode and only in the uplink direction. The common packet channel is shared by the UEs in a cell and therefore, it is a common resource. The CPCH is fast power controlled.
- Forward Access Channel (FACH): Common downlink channel without closed-loop power control used for transmission of relatively small amount of data.
- Downlink Shared Channel (DSCH): A downlink channel shared by several UEs carrying dedicated control or traffic data.
- Uplink Shared Channel (USCH): An uplink channel shared by several UEs carrying dedicated control or traffic data, used in TDD mode only.
- Broadcast Channel (BCH): A downlink channel used for broadcast of system information into an entire cell.
- Paging Channel (PCH): A downlink channel used for broadcast of control information into an entire cell allowing efficient UE sleep mode procedures. Currently identified information types are paging and notification. Another use could be UTRAN notification of change of BCCH information.
- High Speed Downlink Shared Channel (HS-DSCH): A downlink channel shared between UEs by allocation of individual codes, from a common pool of codes assigned for the channel.

Dedicated transport channel types are:

- Dedicated Channel (DCH): A channel dedicated to one UE used in uplink or downlink.

A general classification of logical channels is into two groups; Control Channels (for the transfer of control plane information) and Traffic Channels (for the transfer of user plane information).

Control Channels:

- Broadcast Control Channel (BCCH): A downlink channel for broadcasting system control information.
- Paging Control Channel (PCCH): A downlink channel that transfers paging information. This channel is used when the network does not know the location cell of the UE, or, the UE is in the cell connected state (utilising UE sleep mode procedures).
- Common Control Channel (CCCH): Bi-directional channel for transmitting control information between network and UEs. This channel is commonly used by the UEs having no RRC connection with the network and by the UEs using common transport channels when accessing a new cell after cell reselection.
- Dedicated Control Channel (DCCH): A point-to-point bi-directional channel that transmits dedicated control information between a UE and the network. This channel is established through RRC connection setup procedure.
- Shared Channel Control Channel (SHCCH): Bi-directional channel that transmits control information for uplink and downlink shared channels between network and UEs. This channel is for TDD only.

Traffic Channels:

- Dedicated Traffic Channel (DTCH): A Dedicated Traffic Channel (DTCH) is a point-to-point channel, dedicated to one UE, for the transfer of user information. A DTCH can exist in both uplink and downlink.
- Common Traffic Channel (CTCH): A point-to-multipoint unidirectional channel for transfer of

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dedicated user information for all or a group of specified UEs.

The mappings of Logical channels to transport channels is shown in the diagram below.

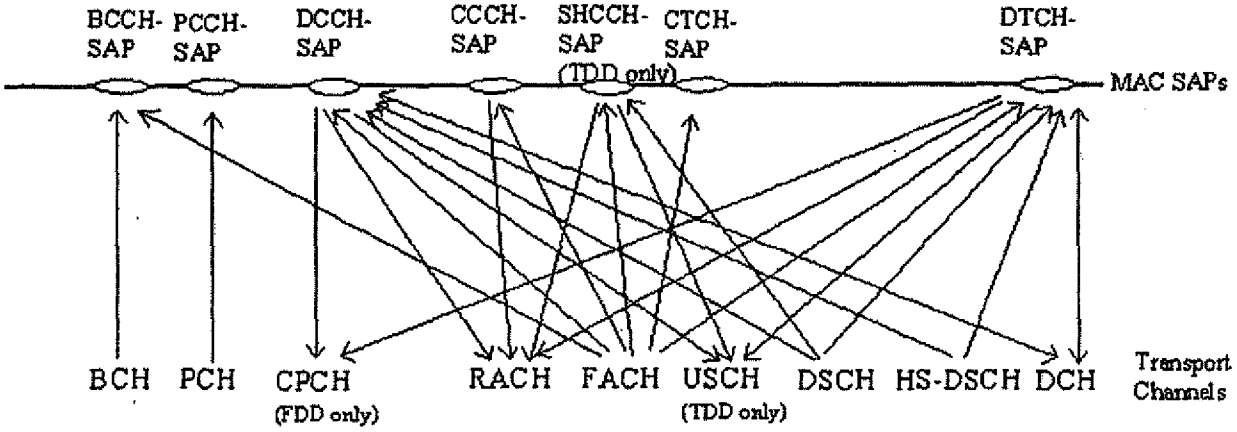


Fig. 2: Logical channels mapped onto transport channels, seen from the UE side (Taken from 25.301, figure 4)

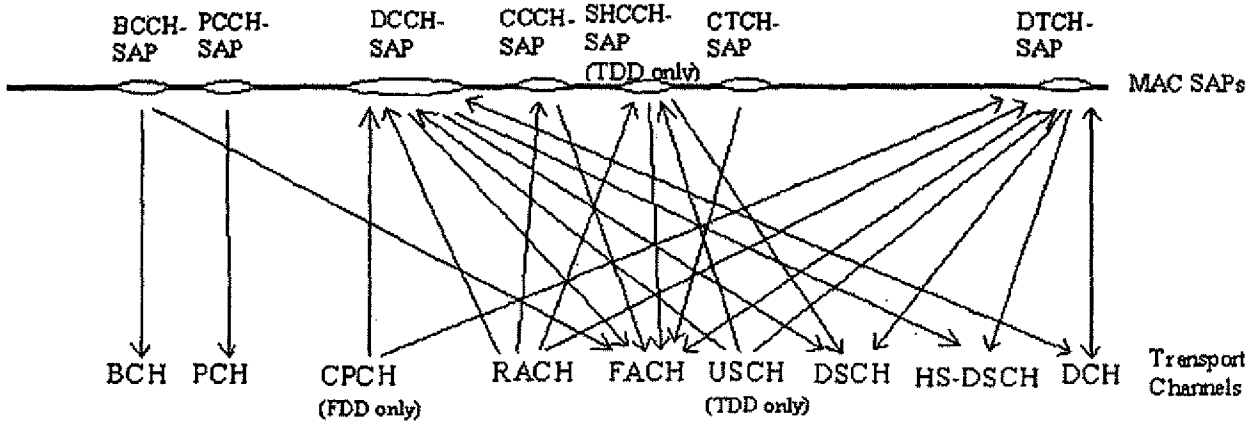


Fig. 3: Logical channels mapped onto transport channels, seen from the UTRAN side (Taken from 25.301, figure 5)

MAC Entities

As mentioned earlier, the MAC protocol is not symmetrical in UL and DL. The MAC entities might be present in the UL and/or DL. The functional entities are as follows:

- MAC-b: Mac-b represents the control entity for the broadcast channel (BCH). There is one (current cell) or multiple (current cell plus neighbouring cells) MAC-b entities in each UE and one MAC_b in the UTRAN for each cell. The MAC Control SAP is used to transfer Control information to MAC-b.
- MAC-c/sh: MAC-c/sh handles the paging channel (PCH), the forward access channel (FACH), the random access channel (RACH), common packet channel (UL CPCH) that exists in FDD mode, the downlink shared channel (DSCH) and the uplink shared channel that exists in TDD mode. There is one MAC-c/sh entity in each UE and one in UTRAN for each cell.
- MAC-d: MAC-d handles the dedicated transport channel (DCH). There is one MAC-d entity in the UE and one MAC-d entity in the UTRAN for each UE that has one or more dedicated logical channels to or from the UTRAN.

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- MAC-hs: MAC-hs handles the high speed downlink shared channel (HS-DSCH). There is one MAC-hs entity in the UTRAN for each cell that supports HS-DSCH transmission.

Discussion of Functions of MAC

1. Ciphering of Transparent Mode Radio Bearers

In case of TM RBs, RLC acts like a pipe that transfers the data to the MAC layer without adding any headers. Thus in this case Ciphering has to be performed in the MAC layer. In all other cases (AM and UM RBs), Ciphering is performed in the RLC layer. The part of MAC PDU that is ciphered is the MAC SDU as shown in the fig below.

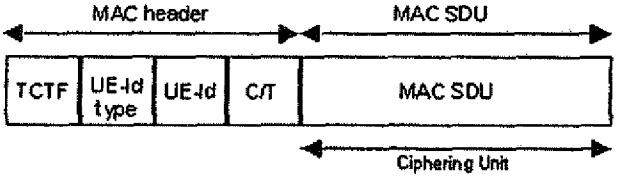
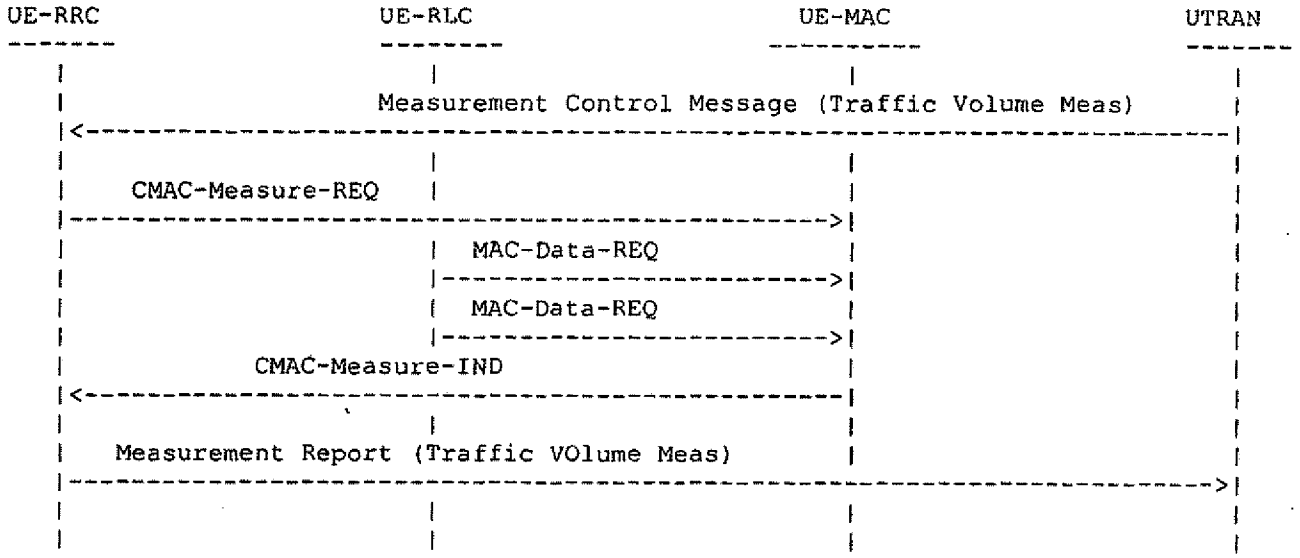


Fig. 4: Ciphered part of MAC PDU
(Taken from 25.321, figure 11.5.1)

2. Traffic Volume Measurement for Dynamic RB Control

Dynamic radio bearer control is performed by RRC, based on the traffic volume measurements reported by MAC. Traffic volume information is measured in MAC layer and the results are reported from MAC layer to RRC layer. This concept can be explained with the help of the diagram below.



At least every TTI, the MAC layer shall receive from each RLC entity the value of its Buffer Occupancy (BO), expressed in bytes. RRC can configure MAC to keep track of statistics (i.e. raw BO, average of BO and variance of BO) on the BO values of all Radio Bearers mapped onto a given transport channel. When the average or variance are requested, an averaging interval duration will also be provided.

Every time the BO values are reported to MAC, the UE shall verify whether an event was triggered or if a periodic report is required. If reporting is required (multiple reports may be triggered in a single TTI), the MAC shall deliver to RRC the reporting quantities required for the corresponding RBs. In the case of average and variance of BO, the averaging should be performed for the interval with the

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configured duration ending at the time when the event was triggered.

3. Access Service Class Selection for RACH Transmission

The physical RACH resources (i.e. access slots and preamble signatures for FDD) may be divided between different Access Service Classes in order to provide different priorities of RACH usage. It is possible for more than one ASC or for all ASCs to be assigned to the same access slot/signature space.

Access Service Classes are numbered in the range 0 £ i £ NumASC £ 7 (i.e. the maximum number of ASCs is 8). An ASC is defined by an identifier i that defines a certain partition of the PRACH resources and an associated persistence value Pi. A set of ASC parameters consists of NumASC+1 such parameters (i, Pi), i = 0, ..., NumASC. The PRACH partitions and the persistence values Pi are derived by the RRC protocol from system information. The set of ASC parameters is provided to MAC with the CMAC-Config-REQ primitive. The ASC enumeration is such that it corresponds to the order of priority (ASC 0 = highest priority, ASC 7 = lowest priority). ASC 0 shall be used in case of Emergency Call or for reasons with equivalent priority.

At radio bearer setup/reconfiguration each involved logical channel is assigned a MAC Logical channel Priority (MLP) in the range 1,...,8. When the MAC sublayer is configured for RACH transmission in the UE, these MLP levels shall be employed for ASC selection on MAC.

The following ASC selection scheme shall be applied, where NumASC is the highest available ASC number and MinMLP the highest logical channel priority assigned to one logical channel:

- in case all TBs in the TB set have the same MLP, select ASC = min(NumASC, MLP);
- in case TBs in a TB set have different priority, determine the highest priority level MinMLP and select ASC = min(NumASC, MinMLP).

When an RRC CONNECTION REQUEST message is sent RRC determines ASC by means of the access class. The ASC to be used in these circumstances is signalled to MAC by means of the CMAC-CONFIG-REQ message.

If MAC has knowledge of a U-RNTI then the ASC is determined in the MAC entity. If no U-RNTI has been indicated to MAC then MAC will use the ASC indicated in the CMAC-CONFIG-REQ primitive.

4. Transport format combination selection in UE

RRC can control the scheduling of uplink data by giving each logical channel a priority between 1 and 8, where 1 is the highest priority and 8 the lowest. TFC selection in the UE shall be done in accordance with the priorities indicated by RRC. Logical channels have absolute priority, i.e. the UE shall maximise the transmission of higher priority data. Hence higher priority data flows will be given higher bit rate combinations while lower priority data flows will have to use low bit rate combinations. Note that zero bit rate is a special case of low bit rate combination.

MAC has to derive the priority parameters from two sources:

- The buffer occupancy parameter received from RLC
- MAC logical channel priority received from RRC

A given TFC can be in any of the following states:

- Supported state;
- Excess-power state;

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- Blocked state.

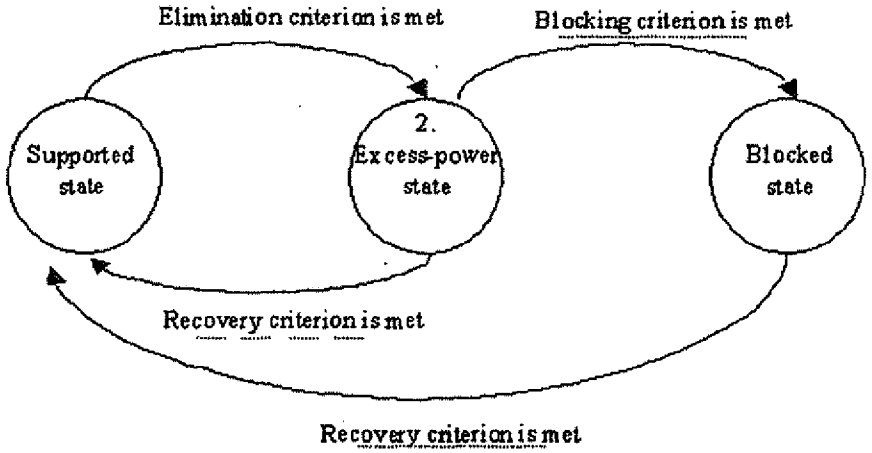


Fig. 5. State transitions for the state of a given TFC
(Taken from [1], fig. 11.4.1)

UEs in CELL_FACH state may estimate the channel path loss and set to excess power state all the TFCs requiring more power than the Maximum UE transmitter power. All other TFCs shall be set to Supported state.

Every time the set of supported TFCs changes, the available bitrate shall be indicated to upper layers for each logical channel in order to facilitate the adaptation of codec data rates when codecs supporting variable-rate operation are used. The details of the computation of the available bitrate and the interaction with the application layer are not further specified.

At Radio Bearer Setup (or Reconfiguration), each logical channel is assigned MAC logical channel prioroty (MLP) in rage 1-8 by RRC. MAC has to then select a TFC that can transmit as much as and as high priority data as possible. In a noisy cell, a high priority TFC can be blocked if its use would cause the UE to transmit more power than the UEs current maximum transmitter power.

References:

[1] 3GPP TS 25.321: Medium Access Control (MAC) protocol specification

[2] 3GPP TS 25.301: Radio Interface Protocol Architecture

[3] 3GPP TS 23.110: UMTS Access Stratum; Services and Functions

[4] 3GPP TS 25.401: RAN Overall Description

[5] Introduction to 3G Mobile Communications - Juha Korhonen

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Universal Mobile Telecommunications System (UMTS) Protocols and Protocol Testing

2. UMTS Network Architecture

UMTS (Rel. '99) incorporates enhanced GSM Phase 2+ Core Networks with GPRS and CAMEL. This enables network operators to enjoy the improved cost-efficiency of UMTS while protecting their 2G investments and reducing the risks of implementation.

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Definition and Overview
1. Evolution of Mobile Communications
2. UMTS Network Architecture
3. UMTS Interfaces
4. UMTS and UTRAN Measurement Objectives
5. Appendix
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In UMTS release 1 (Rel. '99), a new radio access network UMTS terrestrial radio access network (UTRAN) is introduced. UTRAN, the UMTS radio access network (RAN), is connected via the Iu to the GSM Phase 2+ core network (CN). The Iu is the UTRAN interface between the radio network controller (RNC) and CN; the UTRAN interface between RNC and the packet-switched domain of the CN (Iu–PS) is used for PS data and the UTRAN interface between RNC and the circuit-switched domain of the CN (Iu–CS) is used for CS data.

"GSM–only" mobile stations (MSs) will be connected to the network via the GSM air (radio) interface (Um). UMTS/GSM dual-mode user equipment (UE) will be connected to the network via UMTS air (radio) interface (Uu) at very high data rates (up to almost 2 Mbps). Outside the UMTS service area, UMTS/GSM UE will be connected to the network at reduced data rates via the Um.

Maximum data rates are 115 kbps for CS data by HSCSD, 171 kbps for PS data by GPRS, and 553 kbps by EDGE. Handover between UMTS and GSM is supported, and handover between UMTS and other 3G systems (e.g., multicarrier CDMA [MC–CDMA]) will be supported to achieve true worldwide access.

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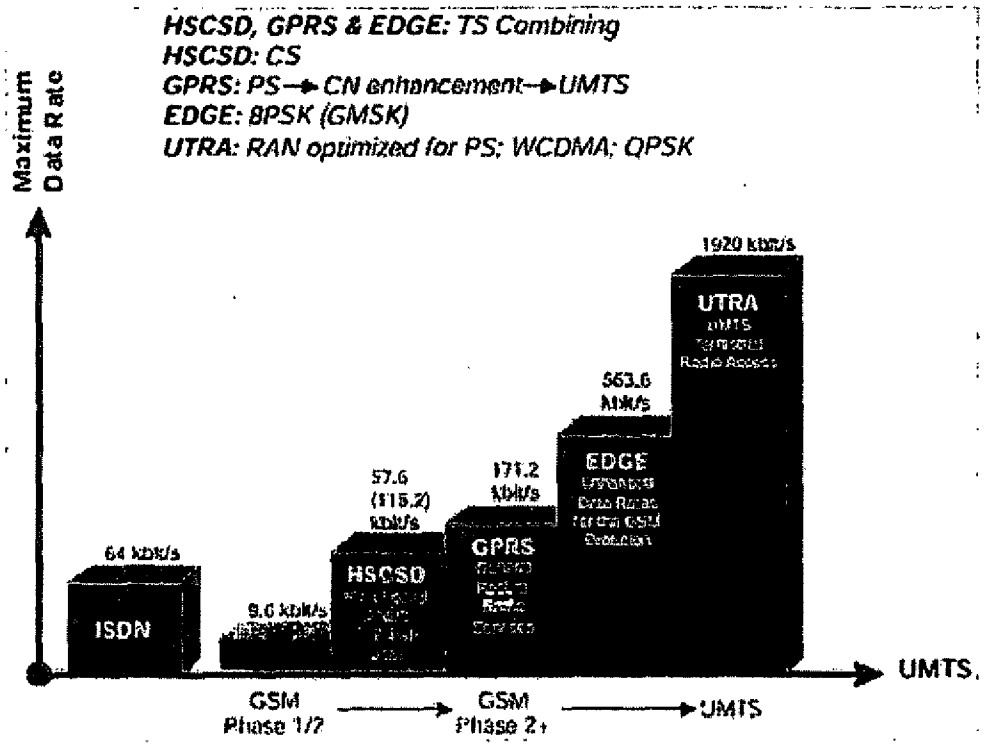


Figure 3. Transmission Rate

The public land mobile network (PLMN) described in UMTS Rel. '99 incorporates three major categories of network elements:

- GSM Phase 1/2 core network elements: mobile services switching center (MSC), visitor location register (VLR), home location register (HLR), authentication center (AC), and equipment identity register (EIR)
- GSM Phase 2+ enhancements: GPRS (serving GPRS support node [SGSN] and gateway GPRS support node [GGSN]) and CAMEL (CAMEL service environment [CSE])
- UMTS specific modifications and enhancements, particularly UTRAN

Network Elements from GSM Phase 1/2

The GSM Phase 1/2 PLMN consists of three subsystems: the base station subsystem (BSS), the network and switching subsystem (NSS), and the operations support system (OSS). The BSS consists of the functional units: base station controller (BSC), base transceiver station (BTS) and transcoder and rate adapter unit (TRAU). The NSS consists of the functional units: MSC, VLR, HLR, EIR, and the AC. The MSC provides functions such as switching, signaling, paging, and inter–MSC handover. The OSS consists of operation and maintenance centers (OMCs), which are used for remote and centralized operation, administration, and maintenance (OAM) tasks.

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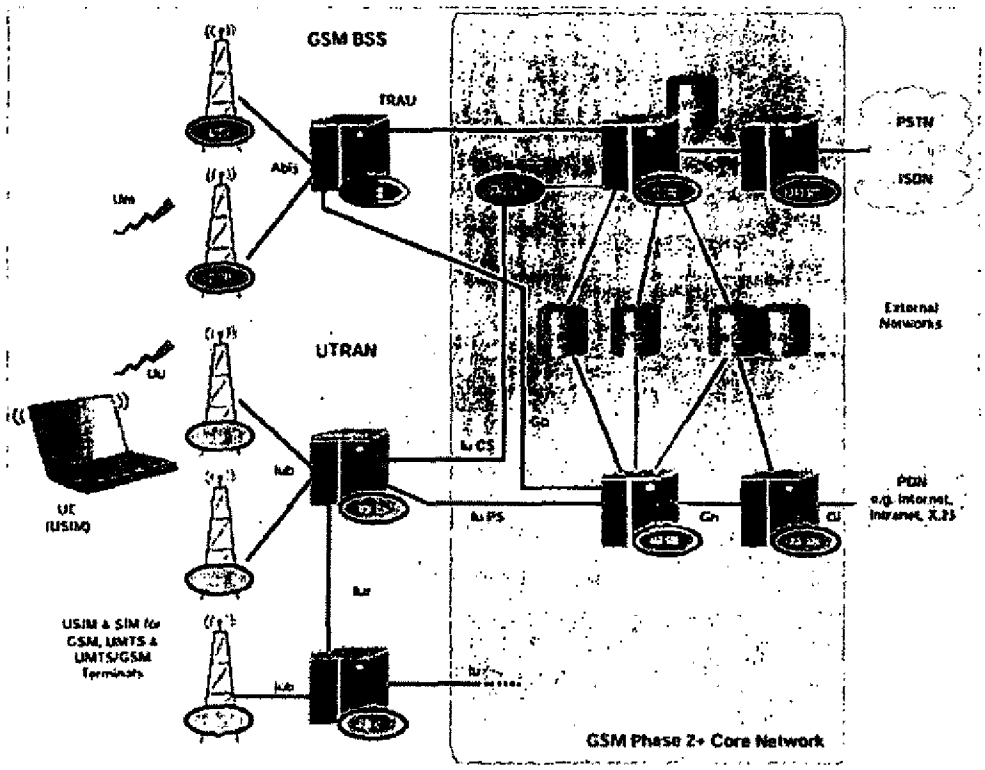


Figure 4. UMTS Phase 1 Network

Network Elements from GSM Phase 2+

GPRS
The most important evolutionary step of GSM toward UMTS is GPRS. GPRS introduces PS into the GSM CN and allows direct access to packet data networks (PDNs). This enables high–data rate PS transmission well beyond the 64 kbps limit of ISDN through the GSM CN, a necessity for UMTS data transmission rates of up to 2 Mbps. GPRS prepares and optimizes the CN for high–data rate PS transmission, as does UMTS with UTRAN over the RAN. Thus, GPRS is a prerequisite for the UMTS introduction.

Two functional units extend the GSM NSS architecture for GPRS PS services: the GGSN and the SGSN. The GGSN has functions comparable to a gateway MSC (GMSC). The SGSN resides at the same hierarchical level as a visited MSC (VMSC)/VLR and therefore performs comparable functions such as routing and mobility management.

CAMEL
CAMEL enables worldwide access to operator-specific IN applications such as prepaid, call screening, and supervision. CAMEL is the primary GSM Phase 2+ enhancement for the introduction of the UMTS virtual home environment (VHE) concept. VHE is a platform for flexible service definition (collection of service creation tools) that enables the operator to modify or enhance existing services and/or define new services. Furthermore, VHE enables worldwide access to these operator-specific services in every GSM and UMTS PLMN and introduces location-based services (by interaction with GSM/UMTS mobility management). A CSE and a new common control signaling system 7 (SS7) (CCS7) protocol, the CAMEL application part (CAP), are required on the CN to introduce CAMEL.

Network Elements from UMTS Phase 1
As mentioned above, UMTS differs from GSM Phase 2+ mostly in the new principles for air interface transmission (W–CDMA instead of time division multiple access [TDMA]/frequency division multiple access [FDMA]). Therefore, a new RAN called UTRAN must be introduced with UMTS. Only minor modifications, such as allocation of the transcoder (TC) function for speech compression to the CN, are needed in the CN to accommodate the change. The TC function is used together with an interworking function (IWF) for protocol conversion between the A and the Iu–CS interfaces.

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UTRAN

The UMTS standard can be seen as an extension of existing networks. Two new network elements are introduced in UTRAN, RNC, and Node B. UTRAN is subdivided into individual radio network systems (RNSs), where each RNS is controlled by an RNC. The RNC is connected to a set of Node B elements, each of which can serve one or several cells.

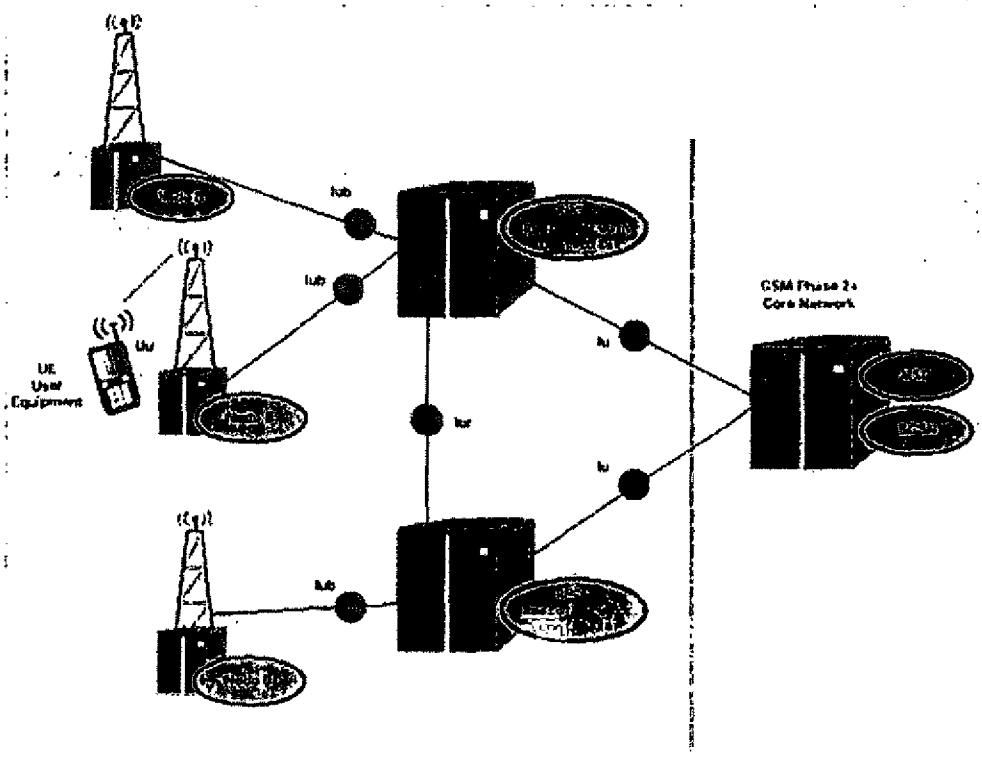


Figure 5. UMTS Phase 1: UTRAN

Existing network elements, such as MSC, SGSN, and HLR, can be extended to adopt the UMTS requirements, but RNC, Node B, and the handsets must be completely new designs. RNC will become the replacement for BSC, and Node B fulfills nearly the same functionality as BTS. GSM and GPRS networks will be extended, and new services will be integrated into an overall network that contains both existing interfaces such as A, Gb, and Abis, and new interfaces that include Iu, UTRAN interface between Node B and RNC (Iub), and UTRAN interface between two RNCs (Iur). UMTS defines four new open interfaces:

- Uu: UE to Node B (UTRA, the UMTS W–CDMA air interface
- Iu: RNC to GSM Phase 2+ CN interface (MSC/VLR or SGSN)
  - Iu-CS for circuit-switched data
  - Iu-PS for packet-switched data
- Iub: RNC to Node B interface
- Iur: RNC to RNC interface, not comparable to any interface in GSM

The Iu, Iub, and Iur interfaces are based on ATM transmission principles.

The RNC enables autonomous radio resource management (RRM) by UTRAN. It performs the same functions as the GSM BSC, providing central control for the RNS elements (RNC and Node Bs).

The RNC handles protocol exchanges between Iu, Iur, and Iub interfaces and is responsible for centralized operation and maintenance (O&M) of the entire RNS with access to the OSS. Because the interfaces are ATM–based, the RNC switches ATM cells between them. The user's circuit-switched and packet-switched data coming from Iu–CS and Iu–PS interfaces are

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multiplexed together for multimedia transmission via Iur, Iub, and Uu interfaces to and from the UE.

The RNC uses the Iur interface, which has no equivalent in GSM BSS, to autonomously handle 100 percent of the RRM, eliminating that burden from the CN. Serving control functions such as admission, RRC connection to the UE, congestion and handover/macro diversity are managed entirely by a single serving RNC (SRNC).

If another RNC is involved in the active connection through an inter–RNC soft handover, it is declared a drift RNC (DRNC). The DRNC is only responsible for the allocation of code resources. A reallocation of the SRNC functionality to the former DRNC is possible (serving radio network subsystem [SRNS] relocation). The term controlling RNC (CRNC) is used to define the RNC that controls the logical resources of its UTRAN access points.

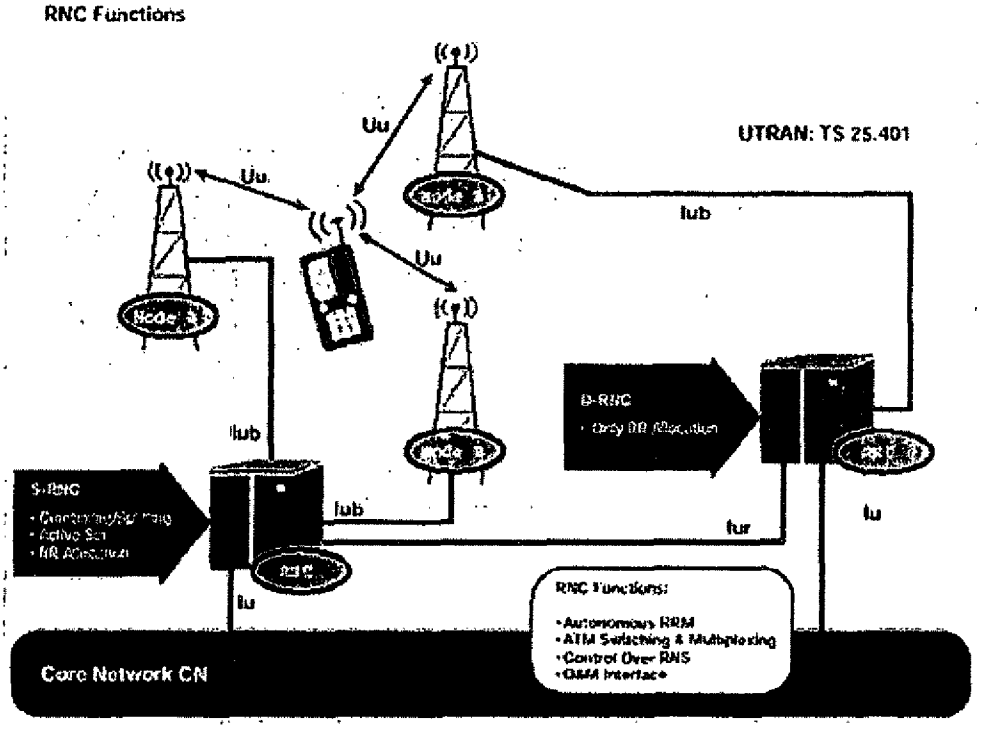


Figure 6. RNC Functions

Node B

Node B is the physical unit for radio transmission/reception with cells. Depending on sectoring (omni/sector cells), one or more cells may be served by a Node B. A single Node B can support both FDD and TDD modes, and it can be co-located with a GSM BTS to reduce implementation costs. Node B connects with the UE via the W–CDMA Uu radio interface and with the RNC via the Iub asynchronous transfer mode (ATM)–based interface. Node B is the ATM termination point.

The main task of Node B is the conversion of data to and from the Uu radio interface, including forward error correction (FEC), rate adaptation, W–CDMA spreading/despreading, and quadrature phase shift keying (QPSK) modulation on the air interface. It measures quality and strength of the connection and determines the frame error rate (FER), transmitting these data to the RNC as a measurement report for handover and macro diversity combining. The Node B is also responsible for the FDD softer handover. This micro diversity combining is carried out independently, eliminating the need for additional transmission capacity in the Iub.

The Node B also participates in power control, as it enables the UE to adjust its power using downlink (DL) transmission power control (TPC) commands via the inner-loop power control on the basis of uplink (UL) TPC information. The predefined values for inner-loop power control are derived from the RNC via outer-loop power control.

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