AO 120 (Rev. 08/10)

TO:	Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:22cv414	10/21/2022	Eastern District of Texas

PLAINTIFF	DEFENDANT
DALI WIRELESS, INC.	T-MOBILE US, INC., et al

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	10,750,382	8/18/2020	Dali Wireless, Inc.
2	9,197,358	11/24/2015	Dali Wireless, Inc.
3	11,026,232	6/1/2021	Dali Wireless, Inc.
4	10,334,499	6/25/2019	Dali Wireless, Inc.
5	8,682,338	3/25/2014	Dali Wireless, Inc.

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

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2:22cv414	10/21/2022	Eastern District of Texas

PLAINTIFF	DEFENDANT
DALI WIRELESS, INC.	T-MOBILE US, INC., et al

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	11,006,343	5/11/2021	Dali Wireless, Inc.
2	9,820,171	11/14/2017	Dali Wireless, Inc.
3			
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/661,368	08/18/2020	10750382	10333-41-CON	6065

167137 7590 07/29/2020

SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

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

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

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

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

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

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

Shawn Patrick Stapleton, Burnaby, CANADA;
DALI WIRELESS, INC., MENLO PARK, CA;
Seyed Amin Hejazi, Burnaby, CANADA;

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

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/661,368	10/23/2019	Shawn Patrick Stapleton	10333-41-CON	6065

167137 7590 07/14/2020

SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

EXAMINER	
SAMS, MATTHEW C	

ART UNIT	PAPER NUMBER
2646	

NOTIFICATION DATE	DELIVERY MODE
07/14/2020	ELECTRONIC

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

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

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jvick@sheridanross.com

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page004

Response to Rule 312 Communication	Application No.	Applicant(s)	
	16/661,368	Stapleton et al.	
	Examiner	Art Unit	AIA (FITF) Status
	MATTHEW C SAMS	2646	No

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

1. ☑ The amendment filed on 07 July 2020 under 37 CFR 1.312 has been considered, and has been:

a) ☐ entered.

b) ☑ entered as directed to matters of form not affecting the scope of the invention.

c) ☐ disapproved because the amendment was filed after the payment of the issue fee.

Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

d) ☐ disapproved. See explanation below.

e) ☐ entered in part. See explanation below.

Applicant amended the specification to change an application number to a patent number.

/Matthew C Sams/
Primary Examiner, Art Unit 2646

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page005

OK TO ENTER: /MS/

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Shawn Patrick Stapleton	)	Group Art Unit: 2646
Application No.: 16/661,368	)	Examiner: SAMS, MATTHEW C
Filed: October 23, 2019	)	Confirmation No.: 6065
Atty. File No.: 10333-41-CON	)	

For: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

AMENDMENT AFTER ALLOWANCE UNDER 37 C.F.R. 1.312

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

Dear Commissioner:

Applicants submit this Amendment After Allowance pursuant to 37 C.F.R. 1.312 in response to the Notice of Allowance having a mailing date of April 9, 2020. While Applicants believe that no fees are due with the filing of this response, the undersigned hereby authorizes the charge of any fees deemed necessary to Deposit Account No. 19-1970.

An amendment may be entered after the mailing of a Notice of Allowance but prior to payment of the issue fee upon recommendation of the primary Examiner. Therefore, it is respectfully requested that the above-referenced application be amended as follows:

Amendments to the Specification begin on page 2 of this paper.

Remarks begin on page 3 of this paper.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page006

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/661,368	10/23/2019	Shawn Patrick Stapleton	10333-41-CON	6065

7590 07/10/2020

SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

EXAMINER	
SAMS, MATTHEW C	

ART UNIT	PAPER NUMBER
2646	

NOTIFICATION DATE	DELIVERY MODE
07/10/2020	ELECTRONIC

NOTICE OF NON-COMPLIANT INFORMATION DISCLOSURE STATEMENT

An Information Disclosure Statement (IDS) filed 7.06.2020 in the above-identified application fails to meet the requirements of 37 CFR 1.97(d) for the reason(s) specified below. Accordingly, the IDS will be placed in the file, but the information referred to therein has not been considered.

The IDS is not compliant with 37 CFR 1.97(d) because:

☑ The IDS lacks a statement as specified in 37 CFR 1.97(e).

☐ The IDS lacks the fee set forth in 37 CFR 1.17(p).

☐ The IDS was filed after the issue fee was paid. Applicant may wish to consider filing a petition to withdraw the application from issue under 37 CFR 1.313(c) to have the IDS considered. See MPEP 1308.

N. Horne, for

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

FORM PTOM327-B (Rev. 02/08)

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page007

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
16/661,368	10/23/2019	Shawn Patrick Stapleton	10333-41-CON

CONFIRMATION NO. 6065

167137
SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

POA ACCEPTANCE LETTER

OC000000118244811

Date Mailed: 07/07/2020

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 07/02/2020.

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.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/cvorachack/

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page008

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
16/661,368	10/23/2019	2646	865	10333-41-CON	1	1

CONFIRMATION NO. 6065

CORRECTED FILING RECEIPT

167137
SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

OC000000118244832

Date Mailed: 07/07/2020

Receipt is acknowledged of this non-provisional utility 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 FIRST INVENTOR, 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 corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction 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 provided that the request is grantable.

Inventor(s)

Shawn Patrick Stapleton, Burnaby, CANADA;
Seyed Amin Hejazi, Burnaby, CANADA;

Applicant(s)

DALI WIRELESS, INC., MENLO PARK, CA;

Assignment For Published Patent Application

DALI WIRELESS, INC., MENLO PARK, CA

Power of Attorney: The patent practitioners associated with Customer Number 167137

Domestic Priority data as claimed by applicant

This application is a CON of 13/950,160 07/24/2013 PAT 10506454
which claims benefit of 61/678,016 07/31/2012

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 11/07/2019

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/661,368**

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

Preliminary Class

455

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page010

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 (1-866-999-4258).

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).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page011

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Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page012

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	16/661,368
				Filing Date	October 23, 2019
				First Named Inventor	Shawn Patrick Stapleton
				Art Unit	2646
				Examiner Name	SAMS, MATTHEW C
Sheet	1	of	5	Attorney Docket Number	10333-41-CON

U.S. PATENT DOCUMENTS					
Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	8958789	02-17-2015	Bauman et al.	
	2	2001/0052011	12-13-2001	Nagao	
	3	2003/0147353	08-07-2003	Clarkson et al.	
	4	2005/0153743	07-14-2005	Berra et al.	
	5	2006/0199595	09-07-2006	Halonen	
	6	2008/0119198	05-22-2008	Hettstedt et al.	
	7	2011/0122788	05-26-2011	Sombrutzki et al.	
	8	2012/0039329	02-16-2012	Sun et al.	
	9	2012/0039254	02-16-2012	Stapleton et al.	
	10	2012/0119772	05-17-2012	Hirako	
	11	2012/0149411	06-14-2012	Miyoshi et al.	
	12	2012/0327789	12-27-2012	Grenier et al.	

UNPUBLISHED U.S. PATENT DOCUMENTS					
Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] (if known)	Filing Date MM-DD-YYYY	Name of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	13	61/600530	02-17-2012	Hejazi et al.	
	14	61/669572	07-09-2012	Hejazi et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	15	JP 2001-203691 A	07-27-2001	NEC CORP		(Believed to correspond to US Publication No. 2001/0052011 cited herein)

Examiner Signature		Date Considered	

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

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	16/661,368
				Filing Date	October 23, 2019
				First Named Inventor	Shawn Patrick Stapleton
				Art Unit	2646
				Examiner Name	SAMS, MATTHEW C
Sheet	2	of	5	Attorney Docket Number	10333-41-CON

	16	JP 2012-124695 A	06-28-2012	HITACHI LTD		(Believed to correspond to US Publication No. 2012/0149411 cited herein)
	17	WO 2011/085514	07-21-2011	ALCATEL LUCENT SHANGHAI BELL		(Includes an English Translation of the Abstract)
	18	WO 2012/024349	02-23-2012	DALI SYSTEMS CO LTD		
	19	WO 2014/022211	02-06-2014	DALI SYSTEMS CO LTD		

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)		
Examiner Initials*	Cite No.[1]	
	20	International Search Report for International Application No. PCT/US2013/052206, mailed October 31, 2013 (Attorney Ref. No. 10333-41-PCT)
	21	Written Opinion for International Application No. PCT/US2013/052206, mailed October 31, 2013 (Attorney Ref. No. 10333-41-PCT)
	22	International Preliminary Report on Patentability for International Application No. PCT/US2013/052206, mailed June 11, 2015 (Attorney Ref. No. 10333-41-PCT)
	23	Examination and Search Report for UAE Application No. 125/2015, mailed November 14, 2018 (Attorney Ref. No. 10333-41-PAE)
	24	First Examination Report for Australian Patent Application No. 2013296819, mailed August 31, 2016 (Attorney Ref. No.: 10333-41-PAU)
	25	Second Examination Report for Australian Patent Application No. 2013296819, mailed June 7, 2017 (Attorney Ref. No.: 10333-41-PAU)
	26	Notice of Acceptance for Australian Patent Application No. 2013296819, mailed August 16, 2017 (Attorney Ref. No.: 10333-41-PAU)

Examiner Signature		Date Considered	

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

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	16/661,368
				Filing Date	October 23, 2019
				First Named Inventor	Shawn Patrick Stapleton
				Art Unit	2646
				Examiner Name	SAMS, MATTHEW C
Sheet	3	of	5	Attorney Docket Number	10333-41-CON

	27	First Examination Report for Australian Patent Application No. 2017268613, mailed February 8, 2019 (Attorney Ref. No.: 10333-41-PAU-DIV)
	28	English Translation of First Office Action for Chinese Patent Application No. 201380040757.7, mailed April 12, 2017 (Attorney Ref. No. 10333-41-PCN)
	29	First Office Action (Including Translation) for Eurasian Patent Application No. 201500184, mailed November 7, 2016 (Attorney Ref. No. 10333-41-PEA)
	30	Second Office Action (Including Translation) for Eurasian Patent Application No. 201500184, mailed November 7, 2018 (Attorney Ref. No. 10333-41-PEA)
	31	European Search Report for European Application No. 13825612.8, mailed June 24, 2016 (Attorney Ref. No. 10333-41-PEP)
	32	Office Action for European Application No. 13825612.8, mailed March 8, 2017 (Attorney Ref. No. 10333-41-PEP)
	33	Office Action for European Application No. 13825612.8, mailed August 7, 2018 (Attorney Ref. No. 10333-41-PEP)
	34	Intent to Grant for European Application No. 13825612.8, mailed December 20, 2019 (Attorney Ref. No. 10333-41-PEP)
	35	European Search Report for European Application No. 20172204.8, mailed May 20, 2020 (Attorney Ref. No. 10333-41-PEP-DIV)
	36	Substantive Examination Report (Including Translation) for Indonesian Application No. P00201500998, mailed May 30, 2018 (Attorney Ref. No.: 10333-41-PID)
	37	Office Action (Including Translation) for Israel Patent Application No. 236631, mailed September 24, 2017 (Attorney Ref. No. 10333-41-PIL)
	38	Notice of Acceptance for Israel Patent Application No. 236631, mailed June 4, 2018 (Attorney Ref. No. 10333-41-PIL)
	39	First Examination Report (Including Translation) for Indian Patent Application No. 244/CHENP/2015, mailed September 27, 2019 (Attorney Ref. No. 10333-41-PIN)
	40	Notice of Reasons for Refusal (Including Translation) for Japanese Patent Application No. 2015-525473, mailed August 28, 2017 (Attorney Ref. No. 10333-41-PJP)
	41	Decision to Grant a Patent (Including Translation) for Japanese Patent Application No. 2015-525473, mailed June 19, 2018 (Attorney Ref. No. 10333-41-PJP)
	42	Notification of Reason for Refusal (Including Translation) for Korean Application No. 10-2015-7004047, mailed June 19, 2019 (Attorney Ref. No. 10333-41-PKR)

Examiner Signature		Date Considered	

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

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	16/661,368
				Filing Date	October 23, 2019
				First Named Inventor	Shawn Patrick Stapleton
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Sheet	4	of	5	Attorney Docket Number	10333-41-CON

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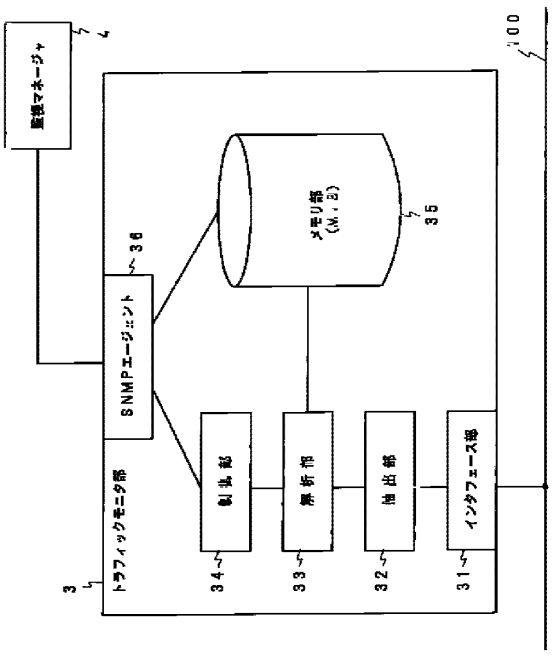
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最終頁に続く

(54)【発明の名称】　ネットワークトラフィック監視システム及びそれに用いる監視方法

(57)【要約】
【課題】　Ｄｉｆｆｓｅｒｖプロトコルを用いたＩＰネットワークにおいてネットワークの挙動を左右するサービス分布を把握し、大規模ネットワークにも対応可能なネットワークトラフィック監視システムを提供する。
【解決手段】　インタフェース部３１はＩＰパケットのキャプチャを行い、物理層及びデータリンク層の終端を行う。抽出部３２はＩＰヘッダから集計に必要となるＤＳＣＰと送出元ＩＰアドレスと宛先ＩＰアドレスとを抽出する。解析部３３は抽出された情報とネットマスクとからサービスクラス毎及びサブネットワーク毎のトラフィックを集計し、ＭＩＢの形式でメモリ部３５に蓄積する。制御部３４はサブネットワークアドレス算出のためのネットマスクを監視マネージャ４からＳＮＭＰエージェント３６経由で設定し、トラフィックモニタ部３全体の動作制御を行う。



Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page018

【特許請求の範囲】
【請求項１】　ＩＰ（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ）パケット毎にサービス単位に応じて優先度を変えて転送するＩＰネットワークにおいてトラフィック監視を行うネットワークトラフィック監視システムであって、前記トラフィック監視を前記サービス単位及び前記ＩＰネットワークのサブネットワーク単位で行う手段を有することを特徴とするネットワークトラフィック監視システム。
【請求項２】　ＩＰ（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ）ネットワークを構築するＩＰルータがリンクによって相互に接続され、ＩＰパケット転送の品質をクラス分けするＤｉｆｆｓｅｒｖ（ｄｉｆｆｅｒｅｎｔｉａｔｅｄ　ｓｅｒｖｉｃｅ）プロトコルに基づいてサービスクラス分けされたＩＰパケットの転送を行うネットワークにおいてトラフィック監視を行うネットワークトラフィック監視システムであって、前記リンク上を転送されるＩＰパケットを監視する手段と、その監視で検出されたＩＰパケットの前記サービスクラスを表す値と送出元ＩＰアドレス及び宛先ＩＰアドレスから割り出される送出元サブネットワークアドレスと宛先サブネットワークアドレスとに基づいてトラフィックを分類する手段と、その分類されたトラフィックを前記サービスクラス毎及び前記ＩＰネットワークのサブネットワーク毎に蓄積する手段とからなるトラフィックモニタ部を有することを特徴とするネットワークトラフィック監視システム。
【請求項３】　前記サービスクラスを表す値は、前記ＩＰパケットのヘッダ内フィールドの一部に前記サービスクラスを表す値を記録するためのフィールドとして割り当てられたＤＳＣＰ（Ｄｉｆｆｓｅｒｖ　Ｃｏｄｅ　Ｐｏｉｎｔ　）を用いるようにしたことを特徴とする請求項２記載のネットワークトラフィック監視システム。
【請求項４】　前記サービスクラス毎及び前記サブネットワーク毎に蓄積されたトラフィックデータに対して統計処理を施して前記トラフィックの表示と異常の監視とトレンドの把握とを行う監視マネージャを含むことを特徴とする請求項２または請求項３記載のネットワークトラフィック監視システム。
【請求項５】　前記監視マネージャは、前記サブネットワークのアドレス算出に必要なネットマスクを前記トラフィックモニタ部に供給するようにしたことを特徴とする請求項４記載のネットワークトラフィック監視システム。
【請求項６】　前記トラフィックモニタ部を前記ＩＰルータ内に配置したことを特徴とする請求項２から請求項５のいずれか記載のネットワークトラフィック監視システム。
【請求項７】　前記トラフィックは、ＭＩＢ（Ｍａｎａｇｅｍｅｎｔ　Ｉｎｆｏｒｍａｔｉｏｎ　Ｂａｓｅ）の形式で蓄積するようにしたことを特徴とする請求項２から請求項６のいずれか記載のネットワークトラフィック監視システム。
【請求項８】　ＩＰ（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ）パケット毎にサービス単位に応じて優先度を変えて転送するＩＰネットワークにおいてトラフィック監視を行うためのネットワークトラフィック監視方法であって、前記トラフィック監視を前記サービス単位及び前記ＩＰネットワークのサブネットワーク単位で行うようにしたことを特徴とするネットワークトラフィック監視方法。
【請求項９】　ＩＰ（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ）ネットワークを構築するＩＰルータがリンクによって相互に接続され、ＩＰパケット転送の品質をクラス分けするＤｉｆｆｓｅｒｖ（ｄｉｆｆｅｒｅｎｔｉａｔｅｄ　ｓｅｒｖｉｃｅ）プロトコルに基づいてサービスクラス分けされたＩＰパケットの転送を行うネットワークにおいてトラフィック監視を行うためのネットワークトラフィック監視方法であって、前記リンク上を転送されるＩＰパケットを監視し、その監視で検出されたＩＰパケットの前記サービスクラスを表す値と送出元ＩＰアドレス及び宛先ＩＰアドレスから割り出される送出元サブネットワークアドレスと宛先サブネットワークアドレスとに基づいてトラフィックを分類し、その分類されたトラフィックを前記サービスクラス毎及び前記ＩＰネットワークのサブネットワーク毎に蓄積するようにしたことを特徴とするネットワークトラフィック監視方法。
【請求項１０】　前記サービスクラスを表す値は、前記ＩＰパケットのヘッダ内フィールドの一部に前記サービスクラスを表す値を記録するためのフィールドとして割り当てられたＤＳＣＰ（Ｄｉｆｆｓｅｒｖ　Ｃｏｄｅ　Ｐｏｉｎｔ）を用いるようにしたことを特徴とする請求項９記載のネットワークトラフィック監視方法。
【請求項１１】　前記サービスクラス毎及び前記サブネットワーク毎に蓄積されたトラフィックデータに対して統計処理を施して前記トラフィックの表示と異常の監視とトレンドの把握とを行うようにしたことを特徴とする請求項９または請求項１０記載のネットワークトラフィック監視方法。
【請求項１２】　前記ＩＰルータ内において、前記分類されたトラフィックを前記サービスクラス毎及び前記ＩＰネットワークのサブネットワーク毎に蓄積するようにしたことを特徴とする請求項９から請求項１１のいずれか記載のネットワークトラフィック監視方法。
【請求項１３】　前記トラフィックは、ＭＩＢ（Ｍａｎａｇｅｍｅｎｔ　Ｉｎｆｏｒｍａｔｉｏｎ　Ｂａｓｅ）の形式で蓄積するようにしたことを特徴とする請求項９から請求項１２のいずれか記載のネットワークトラフィック監視方法。
【発明の詳細な説明】
【０００１】

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page019

【発明の属する技術分野】本発明はネットワークトラフィック監視システム及びそれに用いる監視方法に関し、特に大規模ＩＰ（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ）ネットワークにおけるトラフィック監視方法に関する。

【０００２】

【従来の技術】従来、トラフィック監視手法においては、一般に、ＩＰヘッダ内から送信元ＩＰアドレスと宛先ＩＰアドレスとを読出し、これらのＩＰアドレスペアと４層宛先ポート番号とから識別される上位アプリケーション種別によって集計を行っている。

【０００３】一方、ＩＥＴＦ（Ｉｎｔｅｒｎｅｔ　Ｅｎｇｉｎｅｅｒｉｎｇ　Ｔａｓｋ　Ｆｏｒｃｅ）によって新たなプロトコルとして、従来平等に転送されていたＩＰパケットに対して転送の優先度を設け、サービスに差別を設けるという技術が議論されるようになっている。これがＤｉｆｆｓｅｒｖ（ｄｉｆｆｅｒｅｎｔｉａｔｅｄ　ｓｅｒｖｉｃｅ）プロトコルである。

【０００４】Ｄｉｆｆｓｅｒｖプロトコルに対応した端末や、Ｄｉｆｆｓｅｒｖサービスの境界となるルータでは、転送するＩＰパケットの送信元ＩＰアドレスや宛先ＩＰアドレス、使用するポート番号等によってパケットを数種類（ＩＥＴＦのＲＦＣ２４７５では、１４種のクラス）のサービスクラスに分類し、ＤＳＣＰ（Ｄｉｆｆｓｅｒｖ　Ｃｏｄｅ　Ｐｏｉｎｔ）としてＩＰヘッダ内に情報を埋め込んでパケット転送を行う。

【０００５】Ｄｉｆｆｓｅｒｖプロトコルをサポートしたルータは、ＩＰヘッダ内に埋め込まれたＤＳＣＰの値を読込んで優先レベルを判断し、転送方法を決定するというアーキテクチャである。これによって、ＩＰパケットはクラス毎に分類された数種類のフローとして扱われ、特定のホストのＩＰパケットの廃棄率を低く設定したり、特定のアプリケーションパケットを低遅延で転送させたりすることが可能となる。

【０００６】

【発明が解決しようとする課題】以上のようなネットワークに対し、従来のトラフィック監視方式においては、４層プロトコルのポート番号によってアプリケーション毎に総トラフィック量を分類しているので、Ｄｉｆｆｓｅｒｖプロトコルによって生ずる転送優先度を把握することができず、ネットワークがどのようなサービスに割り当てられているかを監視することができない。

【０００７】また、Ｅｎｄ−ｔｏ−Ｅｎｄの端末同士でやりとりされるトラフィック量を分類しているので、ネットワークの規模が大きくなるにつれて扱うＩＰアドレス数が増加し、トラフィックモニタ部のメモリ容量圧迫や管理ネットワークへ負荷が増大するため、大規模ネットワークに対応しきれない。

【０００８】さらに、ＩＰｓｅｃ（ｓｅｃｕｒｉｔｙ　ａｒｃｈｉｔｅｃｔｕｒｅ　ｆｏｒｉｎｔｅｒｎｅｔ　ｐｒｏｔｏｃｏｌ）やＩＰｏｖｅｒＩＰのようなプロトコルを用いたネットワークでは４層プロトコルのポート番号を監視することができなくなるため、トラフィックをアプリケーション毎に分類することができない。

【０００９】そこで、本発明の目的は上記の問題点を解消し、Ｄｉｆｆｓｅｒｖプロトコルを用いたＩＰネットワークにおいてネットワークの挙動を左右するサービス分布を把握することができ、大規模ネットワークにも対応することができるネットワークトラフィック監視システム及びそれに用いる監視方法を提供することにある。

【００１０】

【課題を解決するための手段】本発明によるネットワークトラフィック監視システムは、ＩＰ（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ）パケット毎にサービス単位に応じて優先度を変えて転送するＩＰネットワークにおいてトラフィック監視を行うネットワークトラフィック監視システムであって、前記トラフィック監視を前記サービス単位及び前記ＩＰネットワークのサブネットワーク単位で行う手段を備えている。

【００１１】本発明による他のネットワークトラフィック監視システムは、ＩＰ（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ）ネットワークを構築するＩＰルータがリンクによって相互に接続され、ＩＰパケット転送の品質をクラス分けするＤｉｆｆｓｅｒｖ（ｄｉｆｆｅｒｅｎｔｉａｔｅｄ　ｓｅｒｖｉｃｅ）プロトコルに基づいてサービスクラス分けされたＩＰパケットの転送を行うネットワークにおいてトラフィック監視を行うネットワークトラフィック監視システムであって、前記リンク上を転送されるＩＰパケットを監視する手段と、その監視で検出されたＩＰパケットの前記サービスクラスを表す値と送出元ＩＰアドレス及び宛先ＩＰアドレスから割り出される送出元サブネットワークアドレスと宛先サブネットワークアドレスとに基づいてトラフィックを分類する手段と、その分類されたトラフィックを前記サービスクラス毎及び前記ＩＰネットワークのサブネットワーク毎に蓄積する手段とからなるトラフィックモニタ部を備えている。

【００１２】本発明によるネットワークトラフィック監視方法は、ＩＰ（ＩｎｔｅｒｎｅｔＰｒｏｔｏｃｏｌ）パケット毎にサービス単位に応じて優先度を変えて転送するＩＰネットワークにおいてトラフィック監視を行うためのネットワークトラフィック監視方法であって、前記トラフィック監視を前記サービス単位及び前記ＩＰネットワークのサブネットワーク単位で行うようにしている。

【００１３】本発明による他のネットワークトラフィック監視方法は、ＩＰ（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ）ネットワークを構築するＩＰルータがリンクによって相互に接続され、ＩＰパケット転送の品質をクラス分けするＤｉｆｆｓｅｒｖ（ｄｉｆｆｅｒｅｎｔｉａｔ

ｅｄ　ｓｅｒｖｉｃｅ）プロトコルに基づいてサービスクラス分けされたＩＰパケットの転送を行うネットワークにおいてトラフィック監視を行うためのネットワークトラフィック監視方法であって、前記リンク上を転送されるＩＰパケットを監視し、その監視で検出されたＩＰパケットの前記サービスクラスを表す値と送出元ＩＰアドレス及び宛先ＩＰアドレスから割り出される送出元サブネットワークアドレスと宛先サブネットワークアドレスとに基づいてトラフィックを分類し、その分類されたトラフィックを前記サービスクラス毎及び前記ＩＰネットワークのサブネットワーク毎に蓄積するようにしている。

【００１４】すなわち、本発明のネットワークトラフィック監視システムは、インタネットやイントラネットに代表されるＩＰネットワークにおいて、トラフィック監視をサービス単位及びサブネットワーク単位で行うことによって収集するデータを集約させてデータ量を削減し、大規模ネットワーク監視に適した監視システムを提供することを特徴としている。

【００１５】より具体的に、本発明のネットワークトラフィック監視システムは、ＩＰネットワークを構築するＩＰルータであるＮＥ（ネットワークエレメント）がリンクによって相互に接続されており、Ｄｉｆｆｓｅｒｖ（ｄｉｆｆｅｒｅｎｔｉａｔｅｄ　ｓｅｒｖｉｃｅ）プロトコルに基づいてクラス分けされたＩＰパケットの転送を行っている。

【００１６】ＤｉｆｆｓｅｒｖプロトコルはＩＥＴＦによって議論されているＩＰパケット転送の品質をクラス分けするプロトコルであり、ＩＰヘッダ内のフィールドの一部をサービスクラスを表すＤＳＣＰ（Ｄｉｆｆｓｅｒｖ　Ｃｏｄｅ　Ｐｏｉｎｔ）を記録するためのフィールドとして割り当て、このフィールドに設定される１４種のＤＳＣＰ値にしたがってパケット毎に優先度を変えて転送するという方式である。

【００１７】トラフィックモニタ部はリンク上を転送されるＩＰパケットを監視し、つまりパケットをキャプチャし、サービスクラスを表すＤＳＣＰの値と、送出元ＩＰアドレス及び宛先ＩＰアドレスから割り出される送出元サブネットワークアドレスと、宛先サブネットワークアドレスとに基づいてトラフィックを分類し、内部メモリに蓄積するための装置である。

【００１８】蓄積されたトラフィックデータはＳＮＭＰ（Ｓｉｍｐｌｅ　ＮｅｔｗｏｒｋＭａｎａｇｅｍｅｎｔ　Ｐｒｏｔｏｃｏｌ）等を用いて監視マネージャへ転送されて統計処理が施され、トラフィックの表示・異常の監視・トレンドの把握等に用いられる。監視マネージャではサブネットワークアドレス算出に必要なネットマスクを入力するためのユーザインタフェースも提供する。

【００１９】このようにして、本発明ではトラフィック監視の粒度としてサービスクラス毎及びサブネットワーク毎に集計を行っているので、ネットワーク上の全端末同士で交換されるトラフィック情報を全アプリケーション毎に把握する代わりに、サブネットワーク毎・サービスクラス毎のトラフィックとして集約させた形で捉えることが可能となり、トラフィックモニタ部に必要なメモリ量を節約したり、監視マネージャへの通信量を低くすることが可能となる。

【００２０】また、このようにして得られる集約されたトラフィックデータは、特に大規模ネットワークにおいてトラフィック管理をマクロ的に行う場合に有効な情報であることは言うまでもない。

【００２１】よって、Ｄｉｆｆｓｅｒｖプロトコルを用いたＩＰネットワークにおいて、トラフィック監視の集計をサービス単位及びサブネットワーク単位で収集することで情報を集約させて監視することによって、ネットワークの挙動を左右するサービス分布を把握し、かつ大規模ネットワークにも対応可能となる。

【００２２】

【発明の実施の形態】次に、本発明の実施例について図面を参照して説明する。図１は本発明の一実施例によるネットワークトラフィック監視システムの構成を示すブロック図である。図１において、ＮＥ（ネットワークエレメント）１，２はＩＰネットワークを構築するＩＰルータであり、リンク１００によって相互に接続されており、Ｄｉｆｆｓｅｒｖ（ｄｉｆｆｅｒｅｎｔｉａｔｅｄ　ｓｅｒｖｉｃｅ）プロトコルに基づいてクラス分けされたＩＰパケットの転送を行っている。

【００２３】ＤｉｆｆｓｅｒｖプロトコルはＩＥＴＦによって議論されているＩＰパケット転送の品質をクラス分けするプロトコルであり、ＩＰヘッダ内のフィールドの一部をサービスクラスを表すＤＳＣＰ（Ｄｉｆｆｓｅｒｖ　Ｃｏｄｅ　Ｐｏｉｎｔ）を記録するためのフィールドとして割り当て、このフィールドに設定される１４種のＤＳＣＰ値にしたがって、パケット毎に優先度を変えて転送するという方式である。

【００２４】トラフィックモニタ部（プローブ）３はリンク１００上を転送されるＩＰパケットを監視し、つまりパケットをキャプチャし、サービスクラスを表すＤＳＣＰの値と、送出元ＩＰアドレス及び宛先ＩＰアドレスから割り出される送出元サブネットワークアドレスと、宛先サブネットワークアドレスとに基づいてトラフィックを分類し、内部メモリ（図示せず）に蓄積するための装置である。

【００２５】蓄積されたトラフィックデータはＳＮＭＰ（Ｓｉｍｐｌｅ　ＮｅｔｗｏｒｋＭａｎａｇｅｍｅｎｔ　Ｐｒｏｔｏｃｏｌ）等を用いて監視マネージャ４へ転送されて統計処理が施され、トラフィックの表示・異常の監視・トレンドの把握等に用いられる。監視マネージャ４ではサブネットワークアドレス算出に必要なネットマスクを入力するためのユーザインタフェースも提供す

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page021

る。
【００２６】このようにして、本実施例ではトラフィック監視の粒度としてサービスクラス毎及びサブネットワーク毎に集計を行っているので、図示せぬネットワーク上の全端末同士で交換されるトラフィック情報を全アプリケーション毎に把握する代わりに、サブネットワーク毎・サービスクラス毎のトラフィックとして集約させた形で捉えることができ、トラフィックモニタ部３に必要なメモリ量を節約したり、監視マネージャ４への通信量を低くすることができる。
【００２７】また、このようにして得られる集約されたトラフィックデータは、特に大規模ネットワークにおいてトラフィック管理をマクロ的に行う場合に有効な情報である。
【００２８】図２は図１のトラフィックモニタ部３の構成を示すブロック図である。図２において、トラフィックモニタ部３はインタフェース部３１と、抽出部３２と、回析部３３と、制御部３４と、メモリ部（ＭＩＢ：Ｍａｎａｇｅｍｅｎｔ　Ｉｎｆｏｒｍａｔｉｏｎ　Ｂａｓｅ）３５と、ＳＮＭＰエージェント３６とから構成されている。
【００２９】インタフェース部３１はネットワークリンク１００と接続され、ＩＰパケットのキャプチャを行い、物理層及びデータリンク層の終端を行う部分である。抽出部３２は下位層の終端が行われたＩＰヘッダから、集計に必要となるＤＳＣＰと送出元ＩＰアドレスと宛先ＩＰアドレスとをそれぞれ抽出する。
【００３０】解析部３３は抽出された情報と制御部３４から受け渡されるネットマスクとからサービスクラス毎及びサブネットワーク毎のトラフィックを集計し、ＭＩＢの形式でメモリ部３５に蓄積を行う部分である。制御部３４はサブネットワークアドレス算出のためのネットマスクを監視マネージャ４からＳＮＭＰエージェント３６経由で設定したり、トラフィックモニタ部３全体の動作制御を行う部分である。ＳＮＭＰエージェント３６はトラフィックモニタ部３と監視マネージャ４との間のデータ交換に用いられる。
【００３１】監視マネージャ４はＳＮＭＰプロトコルを用いてトラフィックモニタ部３にネットマスクを設定したり、定期的にトラフィックモニタ部３内のメモリ部３５にＭＩＢの形式で保存された収集データにアクセスを行って、このデータをさらに統計・加工処理してトラフィック状態を表示したり、データを蓄積して異常状態の監視やトレンドの把握を行う装置である。
【００３２】以上、本実施例の構成について述べたが、監視マネージャ４は当業者にとってよく知られており、また本発明とは直接関係しないので、その詳細な構成及び動作についての説明は省略する。
【００３３】図３は図２の抽出部３２へ送られるヘッダ情報の詳細を示す図である。図３（ａ）はＩＰｖ４（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ　ｖｅｒｓｉｏｎ　４）フォーマットのヘッダ情報を示し、図３（ｂ）はＩＰｖ６（ＩｎｔｅｒｎｅｔＰｒｏｔｏｃｏｌ　ｖｅｒｓｉｏｎ　６）フォーマットのヘッダ情報を示している。
【００３４】図４は図２の解析部３３にて行う集計動作を説明するための図である。これら図１～図４を参照して本発明の一実施例によるネットワークトラフィック監視システムの動作について説明する。
【００３５】まず、トラフィック監視に先立ち、監視マネージャ４からトラフィックモニタ部３に対してサブネットワーク算出に用いるネットマスクが設定される。ネットマスクはＩＰアドレスのホストアドレスを隠蔽するためのビット列であり、設定はビットを指定しても良いし、例えば（２５５．２５５．２５５．０）や（２５５．２５５．０．０）、（２５５．０．０．０）といったアドレスの形式としても良い。トラフィックモニタ部３はこれを制御部３４に記録しておく。
【００３６】次に、トラフィックモニタ部３がリンク１００上を流れるＩＰパケットを受信した場合、インタフェース部３１では受信したＩＰパケットの物理層及びデータリンク層を終端し、ヘッダ情報を抽出部３２へ送る。
【００３７】ここで、抽出部３２へ送られるヘッダ情報の詳細を図３に示す。図３（ａ）はＩＰｖ４フォーマットのヘッダ情報を示しており、ＩＰヘッダの先頭から２バイト目にＴＯＳ（Ｔｙｐｅ　ｏｆ　Ｓｅｒｖｉｃｅ）フィールド１１が、３バイト目にＬｅｎｇｔｈフィールド１３が、１３バイト目に宛先ＩＰアドレスフィールド１４が、１７バイト目に送出元ＩＰアドレスフィールド１５がそれぞれ位置している。ＤＳＣＰはＴＯＳフィールド１１にマッピングされている。
【００３８】また、図３（ｂ）はＩＰｖ６フォーマットのヘッダ情報を示しており、５ビット目にＴｒａｆｆｉｃ　Ｃｌａｓｓフィールド１２が、５バイト目にＬｅｎｇｔｈフィールド１３が、９バイト目に宛先ＩＰアドレスフィールド１４が、２５バイト目に送出元ＩＰアドレスフィールド１５がそれぞれ位置している。ＤＳＣＰはＴｒａｆｆｉｃ　Ｃｌａｓｓフィールド１２にマッピングされている。抽出部３２はこれらの情報を読取って解析部３３へと送る。
【００３９】解析部３３は制御部３４から受け渡されたネットマスクと、ＩＰヘッダから抽出された宛先ＩＰアドレス及び送出元ＩＰアドレスとの和をとることによって、宛先サブネットワークと送出元サブネットワークとを算出し、このサブネットワークのペアと、同様にＩＰヘッダから抽出されたＤＳＣＰ値（すなわち、サービスクラス）毎にエントリを作成し、該当エントリについてＬｅｎｇｔｈフィールド１３で示されたＩＰパケット長、エントリを確認した回数（すなわち、該当ＩＰパケットの受信回数）それぞれの累積を、メモリ部３５にＭ

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page022

ＩＢ情報として蓄積する。

【００４０】次に、解析部３３にて行う集計動作について例を挙げて説明する。現在、監視マネージャ４からトラフィックモニタ部３に、（２５５．２５５．０．０）というネットマスクが設定されているものとする。

【００４１】この状態において、トラフィックモニタ部３が送出元ＩＰアドレス（１０．２４．３２．１０１）から宛先アドレス（２０．３２．５２．２１１）に対して送られたＤＳＣＰ値（１０１１１０）のパケット長ＬのＩＰパケットを受信したとする。

【００４２】このとき、トラフィックモニタ部３の解析部３３では、図４に示すようなエントリ２１ａを作成する。作成されたエントリ２１ａはパケット長Ｌとともにメモリ部３５内にレングスカウンタ３５ｂ、エントリカウンタ３５ｃとともに１つのレコード３５ａとして格納される。

【００４３】エントリカウンタ３５ｃはレコード３５ａが生成された時に「１」であり、該当エントリが収集される毎に１ずつインクリメントされるカウンタで、すなわち該当ＩＰパケット通信個数を表す。レングスカウンタ３５ｂはキャプチャされる毎にパケットレングスが加算されるカウンタで、すなわち該当ＩＰパケットの通信オクテット数を表す。

【００４４】続いて、送出元ＩＰアドレス（１０．２４．３３．１０）から宛先アドレス（２０．３２．５２．２００）に対して送られたＤＳＣＰ値（１０１１１０）のパケット長MのＩＰパケットを受信したとする。このパケットのエントリは先に作られたエントリ２１ａのものと一致するので、エントリカウンタ３５ｃは「２」となり、レングスカウンタ３５ｂは「Ｌ＋Ｍ」となる。

【００４５】また、送出元ＩＰアドレス（１０．２４．３３．１０）から宛先アドレス（２０．３２．５２．．２１１）に対して送られたＤＳＣＰ値（００１０１０）のパケット長MのＩＰパケットを受信したとする。この場合、サブネットアドレスは先に送られているＩＰパケットと一致するが、ＤＳＣＰが異なるため、新たなエントリ２１ｂとしてメモリ部３５に格納される。

【００４６】このように、従来方式のように個々のＩＰアドレスでエントリを作成した場合、ｎ台のホストがある状況では最大でｎ×（ｎ－１）個のエントリを作成しなければならず、また４層ポート番号によってプロトコルの識別を行っているため、使用されるポート番号の個数に比例したエントリがさらに必要となる。

【００４７】一方、本実施例のようにサービス毎・サブネットワーク毎に集計を行えば、プロトコルは１４種のサービスのいずれかに分類されるため、サブネットワークがｍ個（ｍ＜ｎ）である場合、エントリは最大でもｍ×（ｍ－１）×１４個だけ作成されることになる。

【００４８】よって、本実施例ではサービス毎・サブネットワーク毎に集計を取っているので、プロトコル毎・Ｅｎｄ－ｔｏ－Ｅｎｄの端末毎に情報を蓄積する場合に比べて情報量が少なくなり、トラフィックモニタ部３のメモリを節約することができる。

【００４９】また、本実施例ではサービス毎・サブネットワーク毎に集計を取っているので、大規模ネットワークに対しても監視の適用が可能となる。エントリ数はｎやｍの２乗に比例するので、ｎとｍとの差が大きければ大きいほど、つまり大規模ネットワークほど効果が大きく表れる。

【００５０】さらに、本実施例ではサービス毎・サブネットワーク毎に集計を取っているので、監視マネージャ４へ転送する情報も少なくなるため、管理ネットワーク上の通信負荷を削減することができる。

【００５１】さらにまた、抽出する情報が全てＩＰヘッダ上にあるため、ＩＰｓｅｃ（ｓｅｃｕｒｉｔｙ ａｒｃｈｉｔｅｃｔｕｒｅ ｆｏｒｉｎｔｅｒｎｅｔ ｐｒｏｔｏｃｏｌ）のＥＳＰ（Ｅｎｃａｐｓｕｌａｔｉｏｎ Ｓｅｃｕｒｉｔｙ Ｐａｙｌｏａｄ）やＩＰｏｖｅｒＩＰのようなカプセル化プロトコルを用いたネットワークに対しても、サービスレベルでのトラフィック監視が可能となる。

【００５２】従来方式では上記のＩＰｓｅｃやＩＰｏｖｅｒＩＰプロトコルが用いられたネットワークにおいて、４層ポート番号が暗号化されたり、ヘッダ先頭からの位置が変化してしまうので、情報を抽出することができず、トラフィックをプロトコル毎に分類することができない。

【００５３】一方、本実施例のようにＤＳＣＰに基づいたサービス毎のトラフィック集計はカプセル化外部のＩＰヘッダ内にその情報が含まれるため、その監視を行うことができる。また、Ｄｉｆｆｓｅｒｖプロトコルを用いたネットワークにおいては、各種アプリケーションによって分類されたトラフィック情報よりも、転送優先度に基づいて分類されたトラフィック情報の方が、ネットワークのＱｏＳ（Ｑｕａｌｉｔｙ ｏｆ Ｓｅｒｖｉｃｅ）を端的に表現することができるため、付加価値の高い情報として扱うことができる。本実施例では以上の効果から、監視システム全体としての監視性能向上が見込まれる。

【００５４】上記の監視マネージャ４からトラフィックモニタ部３に設定するネットマスクは自由に設定可能であるため、（２５５．２５５．２５５．２５５）のようなマスクを設定した場合、サブネットワークアドレスがホストＩＰアドレスと等しくなり、従来のようなＥｎｄ－ｔｏ－Ｅｎｄ毎のトラフィック監視も可能となる。

【００５５】図５は本発明の他の実施例によるルータの構成を示すブロック図である。図５においては本発明の他の実施例によるルータ５内部にトラフィックモニタ部５１を組込んだ例を示している。

【００５６】ルータ５のインタフェース＃１～＃ｎからなるインタフェース部３１に到着したパケットのヘッダ情報はフォワーディングエンジン部５２へ転送され、宛先ＩＰアドレスからハードウェア的に送出先が検索される。このヘッダ情報を抽出部３２にもフォワーディングエンジン部５２と同様に受け渡すことによって、ルータ５のインタフェース部３１に関わらずトラフィックを収集することができるようになる。よって、ノードにおけるトラフィック監視が可能となる。

【００５７】この形態において、（０．０．０．０）のようなマスクを設定した場合には、図示せぬネットワーク内のサービス分布（どのノードにどのサービスが集中しているか等）を把握することも可能となる。

【００５８】また、上記の形態において、トラフィックモニタ部５１と監視マネージャ（図示せず）との間の通信にＣＯＰＳ（Ｃｏｍｍｏｎ　Ｏｐｅｎ　Ｐｏｌｉｃｙ　Ｓｙｓｔｅｍ）プロトコルを用いた場合には、トラフィックモニタ５１部と監視マネージャ部との信頼性の高い通信や、監視ポリシーの設定を実現することができる。ＣＯＰＳプロトコルを利用する場合にはポリシー受け渡しのためのクライアントタイプを予め設定しなければならないが、トラフィックモニタのためのクライアントタイプはＩＥＴＦでも決定はされていないため、新たなクライアントタイプとして登録を行う。

【００５９】

【発明の効果】以上説明したように本発明によれば、ＩＰ（Ｉｎｔｅｒｎｅｔ　Ｐｒｏｔｏｃｏｌ）パケット毎にサービス単位に応じて優先度を変えて転送するＩＰネットワークにおいてトラフィック監視を行うネットワークトラフィック監視システムにおいて、トラフィック監視をサービス単位及びＩＰネットワークのサブネットワーク単位で行うことによって、Ｄｉｆｆｓｅｒｖプロトコルを用いたＩＰネットワークにおいてネットワークの挙動を左右するサービス分布を把握することができ、大規模ネットワークにも対応することができるという効果がある。

【図面の簡単な説明】

【図１】本発明の一実施例によるネットワークトラフィック監視システムの構成を示すブロック図である。

【図２】図１のトラフィックモニタ部の構成を示すブロック図である。

【図３】（ａ）はＩＰｖ４フォーマットのヘッダ情報を示す図、（ｂ）はＩＰｖ６フォーマットのヘッダ情報を示す図である。

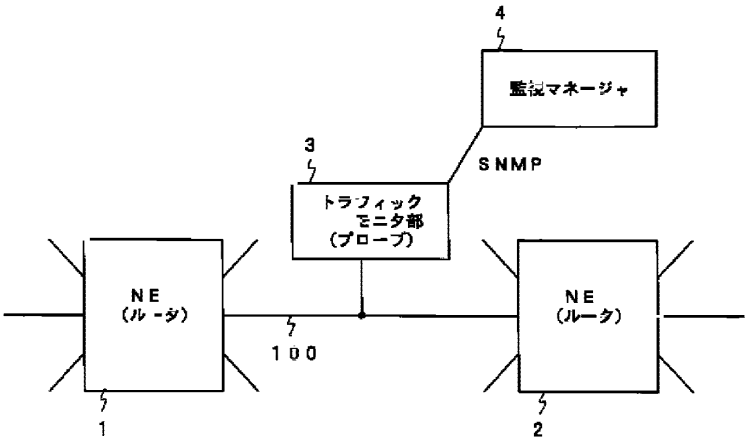
【図４】図２の解析部にて行う集計動作を説明するための図である。

【図５】本発明の他の実施例によるルータの構成を示すブロック図である。

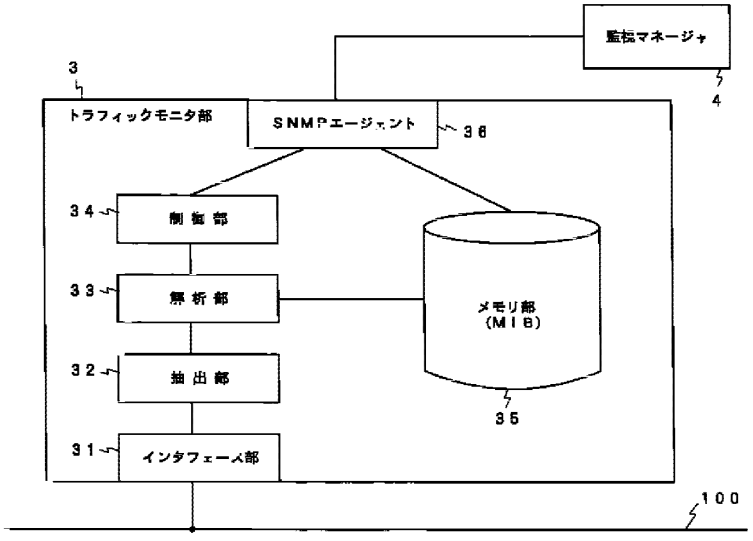
【符号の説明】

１，２　ＮＥ
３，５１　トラフィックモニタ部
４　監視マネージャ
５　ルータ
１１　ＴＯＳフィールド
１２　Ｔｒａｆｆｉｃ　Ｃｌａｓｓフィールド
１３　Ｌｅｎｇｔｈフィールド
１４　宛先ＩＰアドレスフィールド
１５　送出元ＩＰアドレスフィールド
２１ａ，２１ｂ　エントリ
３１　インタフェース部
３２　抽出部
３３　回析部
３４　制御部
３５　メモリ部
３５ａ　レコード
３５ｂ　レングスカウンタ
３５ｃ　エントリカウンタ
３６　ＳＮＭＰエージェント
５２　フォワーディングエンジン部
１００　リンク

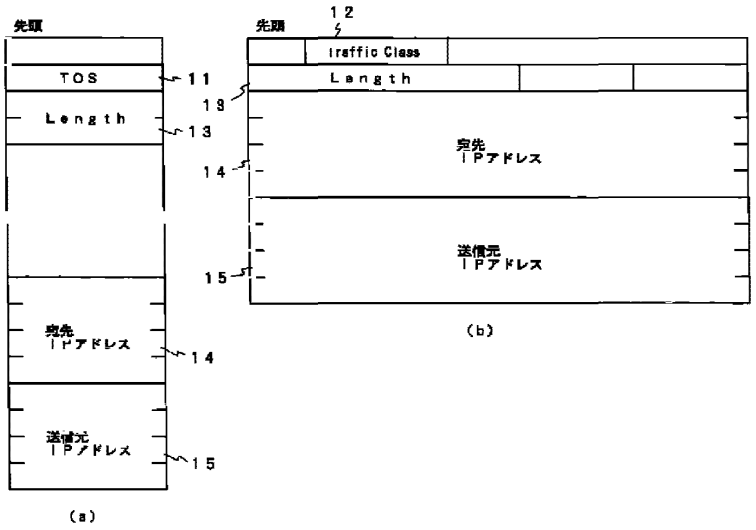
【図１】


4
監視マネージャ
SNMP
3
トラフィック
モニタ部
(プローブ)
NE
(ルータ)
NE
(ルータ)
100
1
2

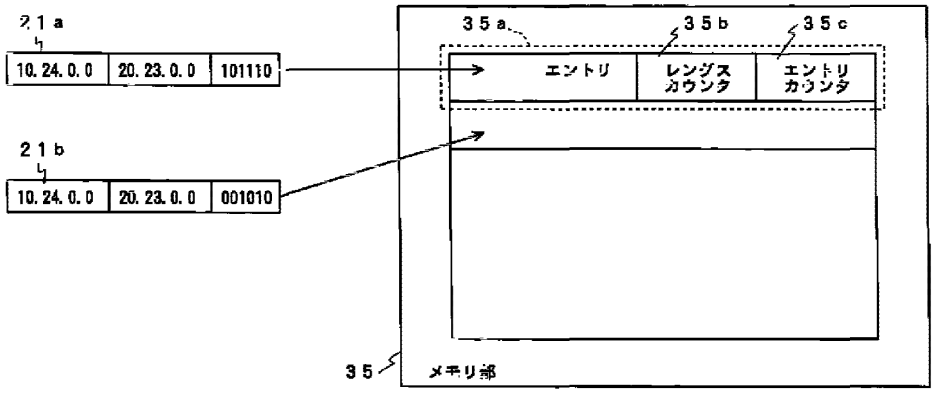
【図２】


監視マネージャ
4
3
トラフィックモニタ部
SNMPエージェント
36
34
制御部
33
解析部
32
抽出部
31
インタフェース部
メモリ部
(MIB)
35
100

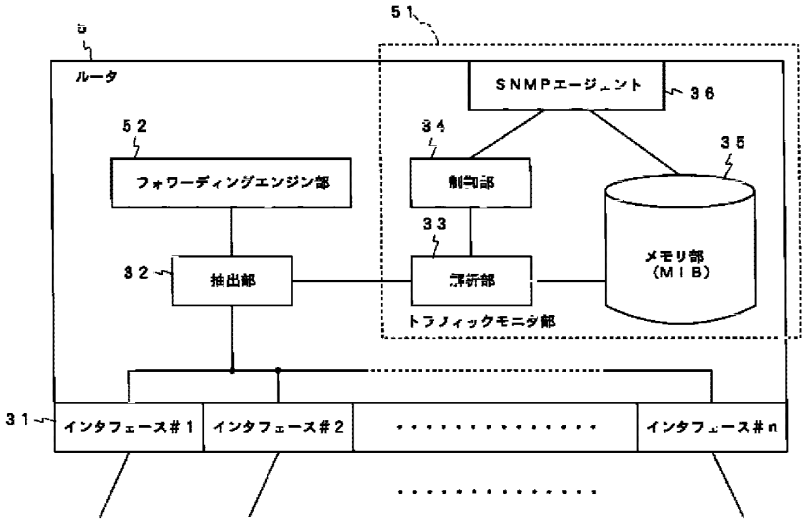
【図３】


先頭
TOS
11
Length
13
宛先
IPアドレス
14
送信元
IPアドレス
15
(a)
12
先頭
Traffic Class
Length
19
宛先
IPアドレス
14
送信元
IPアドレス
15
(b)

【図４】


21a
10.24.0.0
20.23.0.0
101110
21b
10.24.0.0
20.23.0.0
001010
35a
35b
35c
エントリ
レングス
カウンタ
エントリ
カウンタ
35
メモリ部

【図５】



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MC08 MD10
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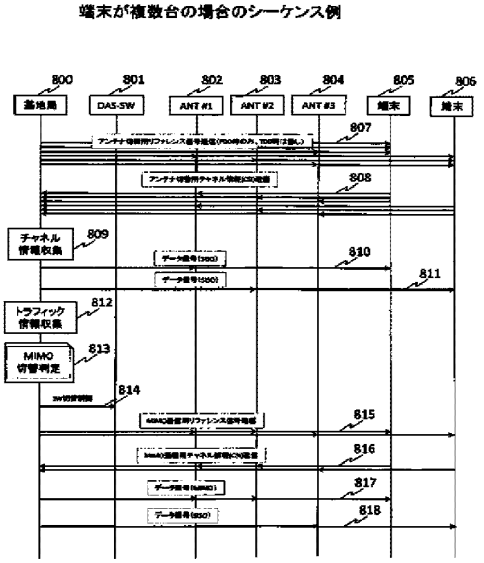
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最終頁に続く

(54)【発明の名称】分散アンテナシステム、基地局装置、アンテナ選択制御方法

(57)【要約】
【課題】　端末のトラフィックと無線伝搬状況に応じて、最適な通信モードと最適なアンテナを選択する。
【課題を解決するための手段】　基地局と端末の間のトラフィック情報を用いて８１２、トラフィックが小さい場合はＳＩＳＯ通信もしくはＳＩＭＯ通信を行い、トラフィックが大きい場合はＭＩＭＯ通信をすべきかどうか判定を行い８１３、基地局の分散アンテナと端末のアンテナ間の無線伝搬チャネル情報を用いてＭＩＭＯ通信として効果が発揮できるアンテナを選択する。また、ＭＩＭＯ通信を行うことによって、アンテナの選択が変わるため、ＳＩＳＯ通信やＳＩＭＯ通信を行っている端末への干渉影響を考慮して、ＳＩＳＯ通信やＳＩＭＯ通信を行っている端末にとって最適なアンテナを再選択する。
【選択図】　図１６



Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page028

【特許請求の範囲】
【請求項１】
複数のアンテナポートを持つ基地局装置と、複数のアンテナを持つ端末と、複数の分配装置を空間的に分散配置して分配装置のアンテナと基地局装置のアンテナポートの接続を上り下り通信で切り替えるアンテナスイッチを備えた分散アンテナシステムにおいて、
前記基地局装置は、
上り下り通信のトラフィック情報を収集するトラフィック情報収集部と、
分散アンテナから端末のアンテナまでの無線伝搬チャネルの情報を収集するチャネル情報収集部と、
前記トラフィック情報収集部及び前記チャネル情報収集部からの情報に基づき、ひとつの端末との通信に複数のアンテナを用いる第１通信と、ひとつの端末との送信又は受信にひとつのアンテナを用いる第２通信との切り替え判定を行う切替判定部と
を備え、
前記切替判定部は、
端末のトラフィック量が予め定められた第１閾値以上でない場合には、第２通信を行うこととし、
端末のトラフィック量が第１閾値以上の場合には、
端末が第１の通信の適用中であり、且つ、現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上である場合、第１の通信を適用するという第１判定を行い、
端末が第１の通信の適用中であり且つ現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上でない場合、又は、端末が第１の通信の適用中でない場合、
（ｉ）複数のアンテナを組み合わせた場合に通信速度又はスループットが、予め定められた第３閾値以上であれば第１通信を適用し、第３閾値以上でなければ第２通信を適用するという第２判定を行う、又は、
（ｉｉ）該端末が利用しているアンテナを利用している他の端末の端末数が、第４閾値以上であれば第１通信を適用し、第４閾値以上でなければ第２通信を適用するという第３判定を行う
ことを特徴とする分散アンテナシステム。

【請求項２】
請求項１に記載の分散アンテナシステムにおいて、
前記第２判定において、
分散アンテナシステムの各アンテナと端末の間のチャネル情報（ＣＳＩ）から、各アンテナのチャネル容量を算出し、
算出したチャネル容量に基づいて、各アンテナの見込み通信速度又はスループットを推定し、
全アンテナを対象として、見込み通信速度又はスループットの速いアンテナ順にリストアップし、
そのリスト上位Ｎ組（Ｎは、１以上の整数）のアンテナを組み合わせた場合、見込み通信速度又はスループットが、前記第３閾値以上である場合は第１通信を適用し、前記第３閾値以上でないである場合は第２通信を適用する
ことを特徴とする分散アンテナシステム。

【請求項３】
請求項２に記載の分散アンテナシステムにおいて、
Ｎは、予め定められた固定値、又は、通信速度又はスループットが所定閾値以上のアンテナ数であることを特徴とする分散アンテナシステム。

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page029

【請求項４】
請求項１乃至３のいずれかに記載の分散アンテナシステムにおいて、
前記第２判定により前記端末が第１通信を適用するとした場合に、第２通信を適用している他の端末が別のアンテナを選択するかどうかをさらに判断して最適なアンテナを選び直すことを特徴とする分散アンテナシステム。

【請求項５】
請求項１乃至４のいずれかに記載の分散アンテナシステムにおいて、
前記第２判定により前記端末が第１通信を適用するとした場合に、
第１通信をする端末が利用するアンテナに繋がっている第２通信を行っている他の端末を選択し、
前記他の端末と各アンテナ間のＣＩＮＲ（Ｃａｒｒｉｅｒ Ｉｎｔｅｒｆｅｒｅｎｃｅ Ｎｏｉｓｅ Ｒａｔｉｏ）又はＳＮＲ（Ｓｉｇｎａｌ Ｎｏｉｓｅ Ｒａｔｉｏ）を測定し、
該ＣＩＮＲ又はＳＮＲが閾値以上かを判別し、
該ＣＩＮＲ又はＳＮＲが閾値以上であれば、現在のアンテナを継続使用し、一方、
該ＣＩＮＲ又はＳＮＲが閾値以上でなければ、第２通信をしている他の端末にとってＣＩＮＲ又はＳＮＲが最も良い又は所定値より良いアンテナを再選択する
ことを特徴とする分散アンテナシステム。

【請求項６】
請求項１乃至５のいずれかに記載の分散アンテナシステムにおいて、
前記基地局装置は、
アンテナ切替用リファレンス信号を各アンテナから送信し、
各アンテナが端末から受信したＣＳＩ又はＳＮＲに基づいて、各アンテナの通信速度又はスループットを計算する
ことを特徴とする分散アンテナシステム。

【請求項７】
請求項１乃至５のいずれかに記載の分散アンテナシステムにおいて、
前記基地局装置は、
各アンテナが端末から受信したサウンディング信号又は他の参照信号からチャネル推定処理を行うことでチャネル情報（ＣＳＩ）又はＳＮＲを求め、
求めたＣＳＩ又はＳＮＲに基づいて、各アンテナの通信速度又はスループットを計算する
ことを特徴とする分散アンテナシステム。

【請求項８】
請求項１乃至７のいずれかに記載の分散アンテナシステムにおいて、
前記第１通信は、ＭＩＭＯ（Ｍｕｌｔｉｐｌｅ Ｉｎｐｕｔ Ｍｕｌｔｉｐｌｅ Ｏｕｔｐｕｔ）であり、
前記第２通信は、ＳＩＳＯ（Ｓｉｇｌｅ Ｉｎｐｕｔ Ｓｉｎｇｌｅ Ｏｕｔｐｕｔ）通信もしくはＳＩＭＯ（Ｓｉｎｇｌｅ Ｉｎｐｕｔ Ｍｕｌｔｉｐｌｅ Ｏｕｔｐｕｔ）である
ことを特徴とする分散アンテナシステム。

【請求項９】
複数のアンテナポートを持つ基地局装置と、複数のアンテナを持つ端末と、複数の分配装置を空間的に分散配置して分配装置のアンテナと基地局装置のアンテナポートの接続を上り下り通信で切り替えるアンテナスイッチを備えた分散アンテナシステムにおける前記

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page030

基地局装置であって、
上り下り通信のトラフィック情報を収集するトラフィック情報収集部と、
分散アンテナから端末のアンテナまでの無線伝搬チャネルの情報を収集するチャネル情報収集部と、
前記トラフィック情報収集部及び前記チャネル情報収集部からの情報に基づき、ひとつの端末との通信に複数のアンテナを用いる第１通信と、ひとつの端末との送信又は受信にひとつのアンテナを用いる第２通信との切り替え判定を行う切替判定部と
を備え、
前記切替判定部は、
端末のトラフィック量が予め定められた第１閾値以上でない場合には、第２通信を行うこととし、
端末のトラフィック量が第１閾値以上の場合には、
端末が第１の通信の適用中であり、且つ、現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上である場合、第１の通信を適用するという第１判定を行い、
端末が第１の通信の適用中であり且つ現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上でない場合、又は、端末が第１の通信の適用中でない場合、
（ｉ）複数のアンテナを組み合わせた場合に通信速度又はスループットが、予め定められた第３閾値以上であれば第１通信を適用し、第３閾値以上でなければ第２通信を適用するという第２判定を行う、又は、
（ｉｉ）該端末が利用しているアンテナを利用している他の端末の端末数が、第４閾値以上であれば第１通信を適用し、第４閾値以上でなければ第２通信を適用するという第３判定を行う
ことを特徴とする基地局装置。

【請求項１０】
複数のアンテナポートを持つ基地局装置と、複数のアンテナを持つ端末と、複数の分配装置を空間的に分散配置して分配装置のアンテナと基地局装置のアンテナポートの接続を上り下り通信で切り替えるアンテナスイッチを備えた分散アンテナシステムにおけるアンテナ選択制御方法であって、
前記基地局装置は、
上り下り通信のトラフィック情報を収集するトラフィック情報収集部と、
分散アンテナから端末のアンテナまでの無線伝搬チャネルの情報を収集するチャネル情報収集部と、
前記トラフィック情報収集部及び前記チャネル情報収集部からの情報に基づき、ひとつの端末との通信に複数のアンテナを用いる第１通信と、ひとつの端末との送信又は受信にひとつのアンテナを用いる第２通信との切り替え判定を行う切替判定部と
を備え、
前記切替判定部は、
端末のトラフィック量が予め定められた第１閾値以上でない場合には、第２通信を行うこととし、
端末のトラフィック量が第１閾値以上の場合には、
端末が第１の通信の適用中であり、且つ、現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上である場合、第１の通信を適用するという第１判定を行い、
端末が第１の通信の適用中であり且つ現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上でない場合、又は、端末が第１の通信の適用中でない場合、
（ｉ）複数のアンテナを組み合わせた場合に通信速度又はスループットが、予め定められ

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page031

た第３閾値以上であれば第１通信を適用し、第３閾値以上でなければ第２通信を適用するという第２判定を行う、又は、
（ｉｉ）該端末が利用しているアンテナを利用している他の端末の端末数が、第４閾値以上であれば第１通信を適用し、第４閾値以上でなければ第２通信を適用するという第３判定を行う
ことを特徴とするアンテナ選択制御方法。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、分散アンテナシステム、基地局装置、アンテナ選択制御方法に係り、特に、ＤＡＳ（分散アンテナシステム）スイッチを用いたＭＩＭＯ向けの分散アンテナシステム、基地局装置、アンテナ選択制御方法に関する。
【背景技術】
【０００２】
電波が届きにくい建物内部の無線環境をよくするために、アンテナを建物内部に分散配置する分散アンテナシステム（ＤＡＳ：　Ｄｉｓｔｒｉｂｕｔｅｄ　Ａｎｔｅｎｎａ　Ｓｙｓｔｅｍ）が知られている。従来の分散アンテナシステムでは、基地局装置から漏洩同軸ケーブルを引きまわして、敷設したケーブルの周囲に電波を輻射する方法が知られている。また、基地局装置が入出力するアナログ伝送信号を分岐結合する装置を介して複数のアンテナに同軸ケーブルで分配する方法が知られている。従来の分散アンテナシステムにおいては、基地局装置の入出力信号を複数のアンテナに分配しているため、すべてのアンテナから同じ信号が入出力されている。近年、ＬＴＥ（Ｌｏｎｇ　Ｔｅｒｍ　Ｅｖｏｌｕｔｉｏｎ）やＷｉＭＡＸ（Ｗｏｒｌｄｗｉｄｅ　Ｉｎｔｅｒｏｐｅｒａｂｉｌｉｔｙ　ｆｏｒ　Ｍｉｃｒｏｗａｖｅ　Ａｃｃｅｓｓ）といった高速無線通信インフラが整備されようとしている。これらの通信方式では、周波数利用効率向上の観点から、複数アンテナからデータを送信して複数アンテナで受信するＭＩＭＯ（Ｍｕｌｔｉｐｌｅ　Ｉｎｐｕｔ　Ｍｕｌｔｉｐｌｅ　Ｏｕｔｐｕｔ）技術が採用されている。このＭＩＭＯ技術では、複数のアンテナから異なる信号を送受信することが必要となるため、分散アンテナシステムにおいても複数のアンテナから異なる信号を送受信することが求められている。
【０００３】
ＭＩＭＯ技術を分散アンテナシステムに適用する場合の背景技術として、特開２０１０－０６８４９６（特許文献１）がある。この文献には、「端末の電力測定部が、分散アンテナシステムの各アンテナから送信されているパイロット信号の受信電力を長期間測定する。端末は、受信電力が強い所定数個のアンテナを通信アンテナ候補として選択し通信アンテナ候補及びそれに対応する受信電力を無線基地局装置に通知する。端末のチャネル推定部は、無線基地局装置から、通信可能アンテナとそれに付与されるアンテナインデックス情報とを受信して、通信可能なアンテナに関してチャネル推定を行う。ＭＩＭＯ通信を行うためには基地局装置の送信信号に対して演算を行うプリコーディングマトリクスを決定する必要があるが、端末のチャネル推定に基づいて通信可能なアンテナに関するプリコーディングマトリックスインデックス（ＰＭＩ）を求め、アンテナインデックス情報を使って無線基地局装置に通信して通知することによって、データ通信を実行するアンテナ毎の位相回転量、電力比率等を制御する。」　ことが開示されている。
【０００４】
また、特開２００７－５３７６８号公報（特許文献２）がある。この文献には、「無線アクセスユニットからの上り情報を推定することにより、各無線アクセスユニットと該ユーザ間の距離減衰を取得し、距離減衰を取得する。距離減衰推定器は、各距離減衰及び無線アクセスユニットの番号を対応付けて記憶する。リソース割当器は、前記記憶された距離減衰及び無線アクセスユニットの番号に基づいて、該ユーザが採用する無線アクセスユニットを含むリソース割当情報を取得する。送信処理器は、前記リソース割当情報に基づいて、該ユーザデータに対して、対応する送信信号処理を行い、該ユーザが採用する無線

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page032

アクセスユニットの各無線アクセスユニットに対するベースバンド信号ストリームを生成する。無線アクセスユニット選択器は、前記リソース割当情報に基づいて、中央処理ユニットに接続されたすべての無線アクセスユニットから、対応する無線アクセスユニットを選択して、前記送信処理器により処理された各ベースバンド信号ストリームを送信する。そして、無線アクセスユニット選択器から出力したベースバンド信号ストリームに対してそれぞれアップコンバート処理を行い、アップコンバート処理後のベースバンド信号ストリームを、下り情報として、伝送リンクを介して、それぞれ対応する無線アクセスユニットへ送信する」ことが開示されている。

【先行技術文献】

【特許文献】

【０００５】

【特許文献１】特開２０１０－０６８４９６号公報

【特許文献２】特開２００７－０５３７６８号公報

【非特許文献】

【０００６】

【非特許文献１】ｈｔｔｐ：／／ｗｗｗ．ｊｐｏ．ｇｏ．ｊｐ／ｓｈｉｒｙｏｕ／ｓ＿ｓｏｎｏｔａ／ｈｙｏｕｊｕｎ＿ｇｉｊｕｔｓｕ／ｍｉｍｏ／１－２－２．ｐｄｆ＃ｐａｇｅ＝１

【非特許文献２】ｈｔｔｐ：／／ｗｗｗ．ｊｐｏ．ｇｏ．ｊｐ／ｓｈｉｒｙｏｕ／ｓ＿ｓｏｎｏｔａ／ｈｙｏｕｊｕｎ＿ｇｉｊｕｔｓｕ／ｍｉｍｏ／１－２－２．ｐｄｆ＃ｐａｇｅ＝３

【発明の概要】

【発明が解決しようとする課題】

【０００７】

上述の分散アンテナシステム（以下、ＤＡＳ）において、すべてのアンテナから同一の無線信号が送信されるように運用すると、エリアを広くカバーするメリットがある一方で、ある特定の端末にのみ送信すればよい信号を不要なアンテナから送信することになる。また、ある特定の端末がＭＩＭＯ通信を行う場合において、上述の特開２０１０－０６８４９６（特許文献１）を適用した場合、ＭＩＭＯ通信用のアンテナが選択されても、それ以外のアンテナを通信に用いるかどうかについての開示がなされていない。ＭＩＭＯ通信以外のアンテナは干渉となるため、用いないことが考えられるが、ある程度、離れたアンテナであれば他のユーザに向けての通信が可能な場合もある。また、特許文献１では、ＭＩＭＯ通信を常にすることを前提としており、ＰＭＩの情報を端末から基地局に常にフィードバックする必要がある。もし、端末と基地局間の通信トラフィック量が少ないときは、ＭＩＭＯ通信を行わずに１本の送受信アンテナでＳＩＳＯ（Ｓｉｎｇｌｅ Ｉｎｐｕｔ Ｓｉｎｇｌｅ Ｏｕｔｐｕｔ）通信もしくはＳＩＭＯ（Ｓｉｎｇｌｅ Ｉｎｐｕｔ Ｍｕｌｔｉｐｌｅ Ｏｕｔｐｕｔ）通信をしていれば十分であり、ＭＩＭＯ通信を続けるとＰＭＩフィードバックのために無線リソースを消費したり、複数アンテナに対するチャネル推定処理など不必要な信号処理を行うことになる。

【０００８】

また、前記の特許文献２では、端末と基地局の間の距離減衰を基準としてアンテナ等の物理リソースを選択することが開示されている。これによれば、端末に近いアンテナが選ばれることになるが、ＭＩＭＯ通信で例えば２本のアンテナを選択した場合、端末と選ばれた２本のアンテナの距離減衰が小さくても、相関の高い無線伝搬路であればＭＩＭＯ通信として効果を発揮できない場合がある。

【０００９】

本発明は、以上の点に鑑み、端末のトラフィックの大きさに応じてＭＩＭＯ通信、ＳＩＳＯ通信、ＳＩＭＯ通信等の通信方式を最適に選択することを可能とし、常にＭＩＭＯ通信等の複数アンテナを用いる通信を行う場合に比べてＰＭＩ情報などのフィードバックによる無線リソースの消費を節約することを可能とし、及び／又は、効率的な無線通信を実

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page033

現することを目的とする。また、本発明は、ＳＩＳＯ通信やＳＩＭＯ通信等のひとつのアンテナを送信又は受信に用いる通信を行う端末を選ぶことによって、トラフィックに応じて必要な信号処理量とし、常にＭＩＭＯ通信等の複数アンテナを用いる通信を行う場合に比べて端末の消費電力を低減することを目的とする。

【００１０】

また、本発明は、ＭＩＭＯ通信等の複数アンテナを用いる通信を行うために、無線伝搬チャネル情報に基づいてアンテナを再選択するため、ＭＩＭＯ通信等の複数アンテナを用いる通信で効果を発揮することのできるアンテナを選択することを目的とする。

また、本発明によれば、ある特定の端末がＭＩＭＯ通信等の複数アンテナを用いる通信を行うことになった場合には、ＭＩＭＯ通信の複数アンテナを用いる通信で用いるアンテナを共用する端末でＳＩＳＯ通信やＳＩＭＯ通信等のひとつのアンテナを送信又は受信に用いる通信を行っている端末への干渉の影響を考慮し、信号対干渉雑音電力比が大きな品質のよいアンテナを再選択することによって、システム全体のスループットを向上することを目的とする

【課題を解決するための手段】

【００１１】

本発明では、上記課題を解決するために、例えば、基地局と端末の間のトラフィック情報を用いて、トラフィックが小さい場合はＳＩＳＯ通信、もしくはＳＩＭＯ通信を行い、トラフィックが大きい場合はＭＩＭＯ通信をすべきかどうか判定を行い、基地局の分散アンテナと端末のアンテナ間の無線伝搬チャネル情報を用いてＭＩＭＯ通信として効果が発揮できるアンテナを選択する分散アンテナシステムを提供する。また、ＭＩＭＯ通信を行うことによって、アンテナの選択が変わるため、ＳＩＳＯ通信やＳＩＭＯ通信を行っている端末への干渉影響を考慮して、ＳＩＳＯ通信やＳＩＭＯ通信を行っている端末にとって最適なアンテナを再選択することを特徴とすることができる。

【００１２】

本発明における分散アンテナシステムでは、例えば、複数のアンテナポートを持つ基地局装置と、複数のアンテナを持つ端末と、複数の分配装置を空間的に分散配置して分配装置のアンテナと基地局装置のアンテナポートの接続を上り下り通信で切り替えるアンテナスイッチとを備えており、基地局装置では、上り下り通信のトラフィック情報を収集する手段と、分散アンテナから端末のアンテナまでの無線伝搬チャネルの情報を収集する手段と、ＭＩＭＯ（Ｍｕｌｔｉｐｌｅ Ｉｎｐｕｔ Ｍｕｌｔｉｐｌｅ Ｏｕｔｐｕｔ）通信を行うか否かを判定する手段と、ある端末がＭＩＭＯ通信を行うとした場合に、ＳＩＳＯ（Ｓｉｇｌｅ Ｉｎｐｕｔ Ｓｉｎｇｌｅ Ｏｕｔｐｕｔ）通信もしくはＳＩＭＯ（Ｓｉｎｇｌｅ Ｉｎｐｕｔ Ｍｕｌｔｉｐｌｅ Ｏｕｔｐｕｔ）通信をしている端末のアンテナを選択する手段を有し、端末のトラフィック量がある閾値以上でない場合には、トラフィック量の大きさによってＳＩＳＯ通信、もしくはＳＩＭＯ通信を行うこととし、端末のトラフィック量が閾値以上の場合には、ＭＩＭＯ通信を行うかどうかを判定して、もし、前記端末がＭＩＭＯ通信を行うとした場合に、他のＳＩＳＯ通信もしくはＳＩＭＯ通信を行っている端末が別のアンテナを選択するかどうかを判断して最適なアンテナを選び直すことを特徴とすることができる。

【００１３】

上記のＭＩＭＯ通信を行うか否かを判定する手段においては、端末のトラフィックがある閾値を超えた場合、分散アンテナシステムの各アンテナと端末の間のチャネル情報（ＣＳＩ）から、各アンテナのチャネル容量を算出して、各アンテナの見込み通信速度を推定し、全アンテナを対象として、見込み通信速度の速いアンテナ順にリストアップし、そのリスト上位Ｎ組のアンテナを組み合わせた場合に、見込み通信速度が閾値以上となる場合にＭＩＭＯを適用し、当該リスト上位Ｎ組のアンテナを組み合わせた場合、見込み推定速度が閾値未満である場合はＭＩＭＯを適用しない。これによって、チャネル情報に基づいてＭＩＭＯ通信の効果が発揮できる場合にのみＭＩＭＯ通信を行うことになる。

【００１４】

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page034

なお、チャネル容量の計算は、例えば、非特許文献１及び２に記載の計算式を参照するものとする。

もしくは、上記のＭＩＭＯ通信を行うか否かを判定する手段において、端末のトラフィックがある閾値を超えた場合に、その端末が利用しているアンテナを利用している他の端末数が閾値以上の場合に、ＭＩＭＯ通信を行うものとし、他の端末数が閾値以上でない場合にはＭＩＭＯ通信を行わなくてもよい。

【００１５】

また、上記で、ある特定の端末がＭＩＭＯ通信を行うと決定した場合に、ＳＩＳＯ通信もしくはＳＩＭＯ通信をしている端末のアンテナを選択する手段において、ＭＩＭＯ通信をする端末が利用するアンテナに繋がっているその他のＳＩＳＯもしくはＳＩＭＯ通信を行っている端末を選択し、前記端末と各アンテナ間のＣＩＮＲ（Ｃａｒｒｉｅｒ Ｉｎｔｅｒｆｅｒｅｎｃｅ Ｎｏｉｓｅ Ｒａｔｉｏ）を測定し、当該ＣＩＮＲが閾値以上のアンテナに対して、ＳＩＳＯもしくはＳＩＭＯ通信をしている端末にとってＣＩＮＲが最も良いアンテナを再選択することができる。

ＣＩＮＲは、例えば、ＣＳＩを取得後、そのタイミングでその都度ＣＩＮＲを計算するものとする。なお、ＣＩＮＲ以外のパラメータとして、ＳＮＲ（Ｓｉｇｎａｌ Ｎｏｉｓｅ Ｒａｔｉｏ）がアンテナ再選択に使用される場合もある。

【００１６】

本発明の第１の解決手段によると、

複数のアンテナポートを持つ基地局装置と、複数のアンテナを持つ端末と、複数の分配装置を空間的に分散配置して分配装置のアンテナと基地局装置のアンテナポートの接続を上り下り通信で切り替えるアンテナスイッチを備えた分散アンテナシステム、及び、アンテナ選択制御方法であって、

前記基地局装置は、

上り下り通信のトラフィック情報を収集するトラフィック情報収集部と、

分散アンテナから端末のアンテナまでの無線伝搬チャネルの情報を収集するチャネル情報収集部と、

前記トラフィック情報収集部及び前記チャネル情報収集部からの情報に基づき、ひとつの端末との通信に複数のアンテナを用いる第１通信と、ひとつの端末との送信又は受信にひとつのアンテナを用いる第２通信との切り替え判定を行う切替判定部と

を備え、

前記切替判定部は、

端末のトラフィック量が予め定められた第１閾値以上でない場合には、第２通信を行うこととし、

端末のトラフィック量が第１閾値以上の場合には、

端末が第１の通信の適用中であり、且つ、現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上である場合、第１の通信を適用するという第１判定を行い、

端末が第１の通信の適用中であり且つ現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上でない場合、又は、端末が第１の通信の適用中でない場合、

（ｉ）複数のアンテナを組み合わせた場合に通信速度又はスループットが、予め定められた第３閾値以上であれば第１通信を適用し、第３閾値以上でなければ第２通信を適用するという第２判定を行う、又は、

（ｉｉ）該端末が利用しているアンテナを利用している他の端末の端末数が、第４閾値以上であれば第１通信を適用し、第４閾値以上でなければ第２通信を適用するという第３判定を行う

ことを特徴とする分散アンテナシステム、及び、アンテナ選択制御方法が提供される。

【００１７】

本発明の第２の解決手段によると、

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page035

複数のアンテナポートを持つ基地局装置と、複数のアンテナを持つ端末と、複数の分配装置を空間的に分散配置して分配装置のアンテナと基地局装置のアンテナポートの接続を上り下り通信で切り替えるアンテナスイッチを備えた分散アンテナシステムにおける前記基地局装置であって、

上り下り通信のトラフィック情報を収集するトラフィック情報収集部と、

分散アンテナから端末のアンテナまでの無線伝搬チャネルの情報を収集するチャネル情報収集部と、

前記トラフィック情報収集部及び前記チャネル情報収集部からの情報に基づき、ひとつの端末との通信に複数のアンテナを用いる第１通信と、ひとつの端末との送信又は受信にひとつのアンテナを用いる第２通信との切り替え判定を行う切替判定部と

を備え、

前記切替判定部は、

端末のトラフィック量が予め定められた第１閾値以上でない場合には、第２通信を行うこととし、

端末のトラフィック量が第１閾値以上の場合には、

端末が第１の通信の適用中であり、且つ、現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上である場合、第１の通信を適用するという第１判定を行い、

端末が第１の通信の適用中であり且つ現在のアンテナの組み合わせによる通信速度又はスループットが予め定められた第２閾値以上でない場合、又は、端末が第１の通信の適用中でない場合、

（ｉ）複数のアンテナを組み合わせた場合に通信速度又はスループットが、予め定められた第３閾値以上であれば第１通信を適用し、第３閾値以上でなければ第２通信を適用するという第２判定を行う、又は、

（ｉｉ）該端末が利用しているアンテナを利用している他の端末の端末数が、第４閾値以上であれば第１通信を適用し、第４閾値以上でなければ第２通信を適用するという第３判定を行う

ことを特徴とする基地局装置が提供される。

【発明の効果】

【００１８】

本発明によれば、端末のトラフィックの大きさに応じてＭＩＭＯ通信、ＳＩＳＯ通信、ＳＩＭＯ通信等の通信方式を最適に選択することが可能となり、常にＭＩＭＯ通信等の複数アンテナを用いる通信を行う場合に比べてＰＭＩ情報などのフィードバックによる無線リソースの消費を節約することが可能であり、及び／又は、効率的な無線通信を実現することができる。また、本発明によれば、ＳＩＳＯ通信やＳＩＭＯ通信等のひとつのアンテナを送信又は受信に用いる通信を行う端末を選ぶことによって、トラフィックに応じて必要な信号処理量となり、常にＭＩＭＯ通信等の複数アンテナを用いる通信を行う場合に比べて端末の消費電力を低減することができる。

【００１９】

また、本発明によれば、ＭＩＭＯ通信等の複数アンテナを用いる通信を行うために、無線伝搬チャネル情報に基づいてアンテナを再選択するため、ＭＩＭＯ通信等の複数アンテナを用いる通信で効果を発揮することのできるアンテナを選択することができる。

また、本発明によれば、ある特定の端末がＭＩＭＯ通信等の複数アンテナを用いる通信を行うことになった場合には、ＭＩＭＯ通信の複数アンテナを用いる通信で用いるアンテナを共用する端末でＳＩＳＯ通信やＳＩＭＯ通信等のひとつのアンテナを送信又は受信に用いる通信を行っている端末への干渉の影響を考慮し、信号対干渉雑音電力比が大きな品質のよいアンテナを再選択することによって、システム全体のスループットを向上することができる。

【図面の簡単な説明】

【００２０】

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page036

【図１】ＤＡＳの構成例である。
【図２】ＤＡＳの他の構成例（ＤＡＳ－ＳＷから直接アンテナを分配）である。
【図３】基地局の構成ブロック図の例である。
【図４】ＤＡＳスイッチ構成ブロックの例である。
【図５】基地局内ＭＩＭＯ切替判定部のフローチャート例（その１）である。
【図６】基地局内トラフィック情報収集部におけるトラフィック量判定図の例である。
【図７】基地局内ＭＩＭＯ切替判定部のフローチャート例（その２）である。
【図８】ＤＡＳスイッチの例である。
【図９】ＤＡＳスイッチ例（ＳＩＳＯ時）である。
【図１０】ＤＡＳスイッチ例（ＭＩＭＯ時）である。
【図１１】端末が１台の場合のシーケンスの例である。
【図１２】ＤＡＳスイッチ実施の形態（ＳＩＭＯ時）である。
【図１３】ＤＡＳスイッチ実施の形態（ＭＩＭＯ時）である。
【図１４】ＤＡＳスイッチ実施の形態（複数台ＳＩＭＯ時）である。
【図１５】ＤＡＳスイッチ実施の形態（ＭＩＭＯ、ＳＩＳＯ共存時）である。
【図１６】端末が複数台の場合のシーケンスの例である。
【図１７】ＤＡＳスイッチ実施の形態（その３）である。
【図１８】基地局内ＭＩＭＯ切替判定部のフローチャートの例（その３）である。
【図１９】基地局内ＭＩＭＯ切替判定部のフローチャートの例（その６）である。
【図２０】チャネル情報（ＣＳＩ）のデータベース配列である。
【図２１】基地局内ＭＩＭＯ切替判定部のフローチャートの例（その４）である。
【図２２】基地局内ＭＩＭＯ切替判定部のフローチャートの例（その５）である。
【発明を実施するための形態】
【００２１】
以下に、本発明における実施の形態について説明する。

Ａ．実施の形態１

１．システム構成

図１に、本実施の形態におけるＤＡＳの構成例を示す。ダウンリンクについて、高速バックホールからのデータ信号は、高速バックホール回線終端装置１００を経由し、基地局装置１０１で無線通信方式に従った符号化・変調・増幅等の処理が行われる。ＤＡＳスイッチ１０２は、入力端は基地局装置１０１のアンテナポートと接続され、出力端はＤＡＳ親機１０３に接続されており、基地局装置１０１のアンテナポートと分散アンテナシステムのアンテナ間をスイッチによって切替制御が行われる。ＤＡＳ親機１０３で終端・中継された信号は、建物の各階に設置されたＤＡＳ子機１０４ａ～１０４ｃへ中継され、ＤＡＳスイッチ１０２の切替制御に従って、分配装置１０５ａ～１０５ｉへ信号が送信される。その後、分配装置１０５ａ～１０５ｉ内の各アンテナから適宜、データ信号が送信される。アップリンクについては、上記と逆の過程となる。図１のＤＡＳスイッチは、基地局装置とＤＡＳ親機の間に設置する形態であるが、ＤＡＳスイッチのその他の形態としては、基地局装置内に組み込むものや、ＤＡＳ親機内に組み込まれている場合がある。
【００２２】
図２に、ＤＡＳの他の構成例を示す。図２は、図１の構成例で想定した建物よりも小規模な場合におけるＤＡＳの構成例である。ダウンリンクについて、高速バックホール回線からのデータ信号が、高速バックホール回線終端装置２００、基地局装置２０１を経由する部分は図１と同様であるが、図１と異なる部分は、ＤＡＳスイッチ２０２が直接アンテナ２０３ａ～２０３ｈへ直接接続されていることである。この場合、ＤＡＳスイッチ２０２は切替制御のみならず、図１のＤＡＳ親機１０３の機能である信号終端・中継等の機能を有する場合もある。アップリンクについては、上記と逆の過程となる。

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page037

【００２３】
図３に、基地局構成ブロック図の例を示す。基地局３００は、大きく、基地局と高速バックバックホール間のデータの送受信経路となる高速バックホール回線３０１と、バックホール回線を終端するバックホール回線インタフェース３０２と、制御部３０７と、信号の生成、変調、増幅およびその他信号処理を行うベースバンド／ＲＦ（Ｒａｄｉｏ Ｆｒｅｑｕｅｎｃｙ）部３０９と、ＲＦ外部インタフェース３１３と、アンテナポート３１４を備える。制御部３０７では、データのトラフィック情報を収集するトラフィック情報収集部３０３と、トラフィック情報のデータベースであるトラフィック情報３０４と、スイッチの切替制御やＭＩＭＯ等の通信に必要なチャネル情報（ＣＳＩ：Ｃｈａｎｎｅｌ Ｓｔａｔｅ Ｉｎｆｏｒｍａｔｉｏｎ）を収集するチャネル情報収集部３０５と、チャネル情報のデータベースであるチャネル情報３０６と、トラフィック情報３０４及びチャネル情報３０６を利用してＭＩＭＯを実施するか否かを判定するＭＩＭＯ切替判定部３０７と、ＭＩＭＯ切替判定部３０７で決定されたフローに従って、スイッチ切替を制御するための信号処理を行う制御信号処理部３０８を備える。ベースバンド／ＲＦ部３０９は、ベースバンド信号処理及びＲＦ信号処理以外に、アンテナ切替用やＭＩＭＯ通信用のリファレンス信号生成３１０と、ＳＩＳＯ信号処理３１１と、ＭＩＭＯ信号処理３１２の機能が含まれる。ベースバンド／ＲＦ部３０９で処理された信号はＲＦ信号へ変調・増幅された後、ＲＦ外部インタフェース３１３を経由し、アンテナポート３１４から送信される。ここで、本発明に係る全ての実施の形態において、トラフィックとはダウンリンクにおけるトラフィック量を指すが、別の形態として、アップリンクのトラフィック量の場合もある。また、ＳＩＳＯ信号処理３１１では、受信にダイバーシティ受信を考慮して複数のアンテナで受信するＳＩＭＯ信号処理３１１であってもよい。

【００２４】
図４に、ＤＡＳスイッチ構成ブロック図の例を示す。ＤＡＳスイッチ３１５は、基地局アンテナポートと接続される入力ポート３１６と、基地局からのスイッチ切替制御信号を処理する制御部３１７と、制御部３１７の制御に従って切替を行うスイッチ３１８と、ＤＡＳ親機もしくはＤＡＳアンテナと接続される出力ポート３１９を備える。

【００２５】
２．ＭＩＭＯ切替判定フロー

図５に、基地局内ＭＩＭＯ切替判定部のフローチャート例（その１）を示す。このフローチャートは、図３の基地局３００内のＭＩＭＯ切替判定部３０７の内部処理を説明するものであり、ある特定の端末１台にフォーカスしたものである。端末へのトラフィックがある閾値を超えた場合（Ｓｔｅｐ１）、各チャネル情報（ＣＳＩ）から、各ＤＡＳアンテナのチャネル容量を計算する（Ｓｔｅｐ２）。このＣＳＩは、アンテナ切替用として用いられる。次に、計算されたチャネル容量に基づき、各アンテナの見込み通信速度を推定する。見込み通信速度は、例えば、チャネル容量からそのアンテナにつながっている端末数で除したもの等から算定される。その後、全アンテナを対象として、見込み通信速度の速いアンテナ順にリストアップを実施する（Ｓｔｅｐ４）。さらに、そのリスト上位Ｎ組のアンテナを組合せた場合、見込み通信速度が閾値以上である場合（Ｓｔｅｐ５）、ＭＩＭＯ適用（Ｓｔｅｐ６）となる。Ｓｔｅｐ１でトラフィック量が閾値以上でない、あるいは、Ｓｔｅｐ５で見込み通信速度が閾値以上でない場合は、ＭＩＭＯ適用しない（Ｓｔｅｐ７）。Ｓｔｅｐ６またはＳｔｅｐ７の後は、Ｓｔｅｐ１へ戻る。このＭＩＭＯ切替判定は定期的あるいは周期的に実施されるものとし、その都度、データ（ＣＳＩ情報等）が更新される為、見込み通信速度リストの上位のアンテナがＭＩＭＯ通信に採用される。なお、Ｓｔｅｐ１における閾値は、ＳＩＳＯ通信もしくはＳＩＭＯ通信からＭＩＭＯ通信に切り替わる際に用いる閾値とは別に、ＭＩＭＯ通信からＳＩＳＯ通信もしくはＳＩＭＯ通信に切り替わる閾値を設定してもよい。

【００２６】
図６に、トラフィック量判定図の例を示す。縦軸はトラフィック量であり、横軸は時間

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page038

である。トラフィック量判定には図３の基地局３００内のトラフィック情報３０４のデータが使用される。このトラフィック量が閾値１以上でない場合は、ＭＩＭＯ通信が実施されることはなく、ＳＩＳＯまたはＳＩＭＯのみ実施される。ある時間t_1において、閾値１以上となった場合、ＭＩＭＯ切替判定の次のステップへ進む。後述の図５または図７または図２２のフローチャートであれば、Ｓｔｅｐ１からＳｔｅｐ２のフローに該当し、後述の図１８または図１９または図２１のフローチャートであれば、Ｓｔｅｐ２からＳｔｅｐ３のフローに該当する。

【００２７】

３．ＤＡＳスイッチ

図８に、ＤＡＳスイッチの動作例を示す。ＤＡＳスイッチ４００は、一例として入力端に４ポート、出力端に８ポートを有しており、入力端は、図１の基地局装置１０１または図２の基地局装置２０１のアンテナポートと接続され、出力端は、図１のＤＡＳ親機１０３または図２のアンテナ２０３ａ～２０３ｈと接続される。図８では、入力端（つまり、基地局装置のアンテナポート）＜１＞～＜４＞が出力端の各アンテナ番号＃３～６と各々接続されている様子を示している。この場合は、アンテナ番号＃３～＃６の４本のアンテナが基地局装置１０１にとって４本の独立したアンテナとして動作することになる。

【００２８】

図９に、ＳＩＳＯ適用時におけるＤＡＳスイッチの動作例を示す。この図では、ＤＡＳスイッチ５０１において、基地局装置のアンテナポート＜１＞とアンテナ＃１が接続されている。基地局装置の他のアンテナポートはＤＡＳスイッチ５０１内において接続されていない。従って、端末５００とアンテナ＃１の間でＳＩＳＯ通信が行われる。

【００２９】

図１０に、ＭＩＭＯ適用時におけるＤＡＳスイッチの動作例を示す。この図では、ＤＡＳスイッチ５０３において、基地局装置のアンテナポート＜１＞とアンテナ＃１、基地局装置のアンテナポート＜２＞とアンテナ＃２が各々接続されている。基地局装置の他のアンテナ番号はＤＡＳスイッチ５０１内において接続されていない。従って、端末５００とアンテナ＃１及び＃２の間で送受信アンテナ２本でのＭＩＭＯ通信が行われる。

上記の例では、ＳＩＳＯ通信やＭＩＭＯ通信の接続の例を示したが、使用していない基地局のアンテナポートを他のアンテナに接続して、他のユーザ端末と通信を行ってもよい。

【００３０】

４．シーケンス１（端末が１台の場合）

図１１に、端末が１台の場合における基地局装置と端末間のシーケンスを示す。

基地局６００から送信されたアンテナ切替用リファレンス信号６０６はＤＡＳスイッチ６０１を経て、アンテナ６０２～６０４から各々送信され、端末６０５で受信される。その後、端末６０５は、リファレンス信号からチャネル推定処理によってチャネル情報（ＣＳＩ）を求め、アンテナ切替用チャネル情報（ＣＳＩ）６０７をフィードバック信号として送信し、各アンテナ６０２～６０４で受信され、ＤＡＳスイッチ６０１を経て、基地局６００で受信される。但し、ＴＤＤ（Ｔｉｍｅ　Ｄｉｖｉｓｉｏｎ　Ｄｕｐｌｅｘ）システムにおいては、アンテナ切替用リファレンス信号の送信は行わなくてもよく、アップリンクに既知のサウンディング信号を送信することによって、基地局側で受信したサウンディング信号からチャネル推定処理を行うことでチャネル情報（ＣＳＩ）を求め、求めたチャネル情報をダウンリンクのチャネル情報として活用してもよい。

【００３１】

その後、チャネル情報収集６０８において、チャネル情報収集部３０５は、取得したチャネル情報をデータベース化する。例えば、データベースとしては、使用するアンテナ本数に対応したアンテナ番号と対象となる端末のチャネル情報（ＣＳＩ）が対応づけで記憶される。この時、基地局６００から端末６０５へはデータ信号（ＳＩＳＯ）６０９が送信

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page039

されているが、その際にトラフィック情報収集６１０にて、トラフィック情報収集部３０３により、データトラフィック量が集計される。なお、この例では、ＳＩＳＯを前提としたが、これ以外にもＳＩＭＯ、ＭＩＭＯ等の適宜の通信方式によりデータ信号を送信する場合を前提とすることができる。

【００３２】

以上のトラフィック情報とチャネル情報により、ＭＩＭＯ切替判定６１１にて、ＭＩＭＯ切替判定部３０７により、ＭＩＭＯを実施するか否かが判定され、ＭＩＭＯが実施される場合には、チャネル情報によって最適なアンテナが選択され、選択されたアンテナを基地局６００からＤＡＳスイッチ６０１に対して、スイッチ切替制御６１２が制御信号処理部３０８により行われる。スイッチ切替制御が完了すると、基地局６００からＭＩＭＯ通信用リファレンス信号６１３がＤＡＳスイッチ６０１を経て、アンテナ６０２及びアンテナ６０３から送信され、端末６０５で受信される。その後、端末６０５からＭＩＭＯ通信用チャネル情報（ＣＳＩ）６１４を送信し、アンテナ６０２及び６０３、ＤＡＳスイッチ６０１を経て、基地局６００で受信される。その後、基地局６００から送信されたデータ信号（ＭＩＭＯ）６１５が、ＤＡＳスイッチ６０１を経て、アンテナ６０２及びアンテナ６０３を使用して、端末６０５で受信される。このようにして、ＭＩＭＯ通信に最適なアンテナが選択され、選択されたアンテナを用いてＭＩＭＯ通信が行われる。

【００３３】

図１２に、ＳＩＭＯ適用時におけるＤＡＳスイッチの動作例を示す。横軸を時間として、各アンテナ＃１～８のダウンリンク（ＤＬ）及びアップリンク（ＵＬ）での基地局装置のアンテナポート＜１＞～＜４＞との対応を表している。図の左側から説明すると、最初のＤＬでは、アンテナ＃１、＃２、＃３、＃４には基地局装置のアンテナポート＜１＞、＜２＞、＜３＞、＜４＞が繋がっており、各々アンテナ切替用リファレンス信号送信のために使用されている。図中のＳｌｏｔ１は、スイッチング時間及び基地局装置がアンテナ切替用リファレンス信号を送信する期間である。アンテナ＃５～８とは基地局装置のいずれのアンテナとも接続されていない。最初のＵＬではＤＬと同じスイッチング状態を保持しているが、端末のアンテナ切替用チャネル情報（ＣＳＩ）送信に使用されている。図中のＳｌｏｔ２は、スイッチング時間及び端末がアンテナ切替用チャネル情報（ＣＳＩ）を送信する期間である。２番目のＤＬでは、アンテナ＃５、＃６、＃７、＃８には基地局装置のアンテナポート＜１＞、＜２＞、＜３＞、＜４＞が繋がっており、各々アンテナ切替用リファレンス信号送信のために使用されている。図中のＳｌｏｔ３は、スイッチング時間及び基地局装置がアンテナ切替用リファレンス信号を送信する期間である。アンテナ＃１～４とは基地局装置のいずれのアンテナとも接続されていない。２番目のＵＬでは２番目ＤＬと同じスイッチング状態を保持しているが、端末のアンテナ切替用チャネル情報（ＣＳＩ）送信時間として使用されている。図中のＳｌｏｔ４は、スイッチング時間及び端末がチャネル情報（ＣＳＩ）を送信する期間である。以上の＃１～８の全アンテナについてのアンテナ切替用チャネル情報の収集プロセスは、例えば、周期的または定期的に実施されるものとする。

【００３４】

Ｓｌｏｔ１からＳｌｏｔ４にて、基地局装置からリファレンス信号を送信して、端末からチャネル情報をフィードバックして得る例を示したが、上記のように端末からサウンディング信号を送信して、サウンディング信号からチャネル情報を基地局で求め、このチャネル情報を下りのチャネル情報として活用するＴＤＤシステムでは、アップリンクでの受信のみ切り替えればよい。

Ｓｌｏｔ４以降では、アンテナ＃１にはＤＬ／ＵＬいずれも基地局装置のアンテナポート＜１＞が、アンテナ＃２にはＵＬのみ基地局装置のアンテナポート＜２＞が割り当てられており、ある期間、ＳＩＭＯ通信を実施している例を示している。

【００３５】

図１３に、ＭＩＭＯ適用時におけるＤＡＳスイッチの動作例を示す。この図では、図１２と異なり、Ｓｌｏｔ１～Ｓｌｏｔ４の期間を終えると、アンテナ＃１及び＃２には、基

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page040

地局装置のアンテナポート＜１＞、＜２＞が常に割り当てられ、ＭＩＭＯ通信が実施される。

【００３６】

５．アンテナの移動動作

図１４に、複数端末が繋がっており、いずれもＳＩＳＯ通信中のＤＡＳスイッチの実施の形態を示す。この図では、ＤＡＳスイッチ７０２において、基地局装置のアンテナポート＜１＞、＜２＞が各々アンテナ＃１、＃４と接続されている。またアンテナ＃１、＃４と端末７００、７０１間で各々ＳＩＳＯ通信が行われている例を示している。

【００３７】

図１５は、図１４の状態から、端末７００の１台がＭＩＭＯを適用した時のアンテナ再割当の様子を示している。この図では、ＤＡＳスイッチ７０５において、基地局装置のアンテナポート＜１＞、＜２＞とアンテナ＃１、＃２が各々接続されており、アンテナ＃１、＃２と端末７００でＭＩＭＯが開始されると、ＳＩＳＯ通信を行っている端末７０１はＭＩＭＯ通信への干渉が少ないアンテナ、即ち、この例ではアンテナ＃６へ移動する。具体的には、ＣＩＮＲを判定パラメータとし、アンテナ＃４からアンテナ＃６へ再割当が実施される。ここで、アンテナ＃６は、基地局装置のアンテナポート＜３＞と接続されている。

【００３８】

このように、ある端末がＭＩＭＯ開始した際、例えばＳＩＳＯやＳＩＭＯを行っている端末はＣＩＮＲ値をパラメータとして、ＭＩＭＯ通信への干渉が少ないアンテナへ移動することができる。

【００３９】

ここで、既知のパイロット信号を基地局装置側のアンテナ＃ｉから送信し、端末側のアンテナ＃ｊで受信した信号に対してチャネル推定した結果のチャネル情報をh_{ij}とすると、基地局装置のアンテナ＃４と端末７０１間のＳＩＳＯ通信において、各所望波、各干渉波、ノイズはそれぞれ以下となる。但し、基地局装置の全送信電力をＰとすると、アンテナ＃１および＃２の送信電力は各Ｐ／４、アンテナ＃４の送信電力は、Ｐ／２に配分されたケースであり、その他の電力配分も同様の手法で算出できる。

【数１】

所望波（＃ｃ）：$\frac{P}{2}|h_{4c}|^2$ （数式１）

所望波（＃ｄ）：$\frac{P}{2}|h_{4d}|^2$ （数式２）

干渉波（アンテナ＃ｃ）：$\frac{P}{4}|h_{1c}|^2+\frac{P}{4}|h_{2c}|^2$ （数式３）

干渉波（アンテナ＃ｄ）：$\frac{P}{4}|h_{1d}|^2+\frac{P}{4}|h_{2d}|^2$ （数式４）

したがって、

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page041

【数２】

$$\mathrm{CINR}\text{（アンテナ＃c）}:\frac{\frac{P}{2}|h_{4c}|^2}{\sigma^2+\frac{P}{4}|h_{1c}|^2+\frac{P}{4}|h_{2c}|^2} \qquad \text{（数式５）}$$

$$\mathrm{CINR}\text{（アンテナ＃d）}:\frac{\frac{P}{2}|h_{4d}|^2}{\sigma^2+\frac{P}{4}|h_{1d}|^2+\frac{P}{4}|h_{2d}|^2} \qquad \text{（数式６）}$$

$$\mathrm{CINR}\text{（端末７０１）}:\frac{\frac{P}{2}|h_{4c}|^2+\frac{P}{2}|h_{4d}|^2}{2\sigma^2+\frac{P}{4}|h_{1c}|^2+\frac{P}{4}|h_{2c}|^2+\frac{P}{4}|h_{1d}|^2+\frac{P}{4}|h_{2d}|^2} \qquad \text{（数式７）}$$

ここで、σ^2は、熱雑音電力である。端末７０１のＣＩＮＲを表すものには、アンテナ＃ｃと＃ｄ間での合成ダイバーシティを示す数式７のほかに、数式５と数式６の平均をとったもの、もしくは数式５と数式６のどちらか値の大きな方を選ぶ方法（選択ダイバーシティ）が挙げられる。

【００４０】

６．シーケンス２（端末が複数台の場合）

図１６に、端末が複数台の場合における基地局装置と端末間のシーケンスを示す。基地局８００から送信されたアンテナ切替用リファレンス信号８０７はＤＡＳスイッチ８０１を経て、アンテナ８０２～８０４から各々送信され、端末８０５及び８０６で受信される。その後、端末８０５及び８０６では、リファレンス信号からチャネル推定処理によってチャネル情報（ＣＳＩ）を求め、アンテナ切替用チャネル情報（ＣＳＩ）８０８を送信する。このアンテナ切替用チャネル情報（ＣＳＩ）８０８は、各アンテナ８０２～８０４で受信され、ＤＡＳスイッチ８０１を経て、基地局８００で受信される。その後、チャネル情報収集８０９において、チャネル情報収集部３０５は、取得したチャネル情報をデータベース化する。なお、データベースの詳細については、図２０で後述する。但し、ＴＤＤシステムにおいては、上述のように端末が送信するサウンディング信号を基地局装置で受信してチャネル推定処理を行うことでチャネル情報を収集し、このチャネル情報を下りのチャネル情報として活用する。この時、基地局８００から端末８０５及び８０６へはデータ信号（ＳＩＳＯ）８１０及び８１１が送信されているが、その際にトラフィック情報収集８１２にて、トラフィック情報収集部３０３により、データトラフィック量が集計される。なお、この例では、ＳＩＳＯを前提としたが、これ以外にもＳＩＭＯ、ＭＩＭＯ等の適宜の通信方式によりデータ信号を送信する場合を前提とすることができる。

【００４１】

以上のトラフィック情報とチャネル情報より、ＭＩＭＯ切替判定８１３にて、ＭＩＭＯ切替判定部３０７が、ＭＩＭＯを実施するか否かの判定後、基地局８００からＤＡＳスイッチ８０１に対して、スイッチ切替制御８１４が制御信号処理部３０８により行われる。

スイッチ切替制御が完了すると、基地局８００からＭＩＭＯ通信用リファレンス信号８１５がＤＡＳスイッチ８０１を経て、アンテナ８０２～８０４から送信され、端末８０５及び８０６で受信される。その後、端末８０５及び８０６では、リファレンス信号からチャネル情報を求め、ＭＩＭＯ通信用チャネル情報（ＣＳＩ）８１６を送信する。ＭＩＭＯ通信用チャネル情報（ＣＳＩ）８１６は、アンテナ８０２～８０４、ＤＡＳスイッチ８０１を経て、基地局８００で受信される。基地局８００から送信されたデータ信号（ＭＩＭＯ）８１７は、ＤＡＳスイッチ８０１を経て、アンテナ８０２及び８０３から端末８０５

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page042

へ送信される。また基地局８００から送信されたデータ信号（ＳＩＳＯ）は、ＤＡＳスイッチ８０１を経て、アンテナ８０４から端末８０６へ送信される。なお、この例では、端末８０５がＭＩＭＯ通信を行い、端末８０６がＳＩＭＯ通信を行うようにした場合を示すが、これに限らず、ＭＩＭＯ切替判定により設定された適宜の通信方式により各端末が通信することができる。

【００４２】

図１７に、ＭＩＭＯ通信が開始された場合に、ＳＩＳＯを行っている他の端末と繋がっているアンテナが、ＭＩＭＯ通信への干渉が少ないアンテナへと再割当が実施される際のＤＡＳスイッチの動作例を示す。Ｓｌｏｔ１～Ｓｌｏｔ４の期間までは、図１２と同様である。Ｓｌｏｔ４の後、アンテナ＃１にはＤＬ／ＵＬいずれも基地局装置のアンテナポート＜１＞が、アンテナ＃４にはＤＬ／ＵＬいずれも基地局装置のアンテナポート＜２＞が割り当てられており、２台の端末がＳＩＳＯ通信を行っている。ある時点でトラフィックが増大したため、端末の１台（ユーザ１）がアンテナ＃１、＃２を使用してＭＩＭＯ通信を開始したとする。この時、アンテナ＃１、＃２には、各々、基地局装置のアンテナポート＜１＞、＜２＞が割り当てられたとする。ＭＩＭＯ開始前は、残りの１台（ユーザ２）は、アンテナ＃４に基地局装置のアンテナポート＜２＞を使用して通信をしていたが、基地局装置のアンテナポート＜２＞がＭＩＭＯ通信を開始した端末（ユーザ１）に使用されるため、干渉が少ないアンテナ＃６が再割当されている様子を示している。この図では、ユーザ２に対しては、基地局装置のアンテナポート＜３＞と接続されたアンテナ＃６が再割当されている。図１２と同様、＃１～８の全アンテナについてのアンテナ切替用チャネル情報の収集プロセスは、周期的または定期的に実施されるものとする。

【００４３】

このように、ある端末がＭＩＭＯ開始した際、ＳＩＳＯやＳＩＭＯを行っている端末はＣＩＮＲ値をパラメータとして、ＭＩＭＯ通信への干渉が少ないアンテナへ移動することができる（なお、具体的なＭＩＭＯ切替判定フローは、「Ｃ．実施の形態３」図１８及びその説明箇所等参照。）。

【００４４】

図２０に、チャネル情報（ＣＳＩ）のデータベース配列を示す。

本データベースは、チャネル情報３０６に有するものであって、使用するアンテナ本数に対応したアンテナ番号とエリア内の端末のチャネル情報（ＣＳＩ）が対応づけて記憶される。図２０では一例としてアンテナ数８本の例を示している。

【００４５】

Ｂ．実施の形態２

図７は、基地局内ＭＩＭＯ切替判定部のフローチャート例（その２）である。この図は、実施の形態１における図５のフローチャートの別の実施の形態を示す。ＭＩＭＯ適用後のアンテナの取り扱いが図５と一部異なっている。

端末へのトラフィックがある閾値を超えた場合（Ｓｔｅｐ１）、現在ＭＩＭＯを適用中かの判別を行う（Ｓｔｅｐ２）。ＭＩＭＯ適用中であって、現在のアンテナの組合せで、見込み通信速度が閾値以上の場合（Ｓｔｅｐ３）、現状のアンテナを継続使用し、ＭＩＭＯ通信を実施する（Ｓｔｅｐ８）。Ｓｔｅｐ２において、ＭＩＭＯ適用中でない場合、もしくはＳｔｅｐ３において、見込み通信速度が閾値以上でない場合は、Ｓｔｅｐ４に進む。

【００４６】

Ｓｔｅｐ４以降では、図５と同様に、アンテナ切替用チャネル情報（ＣＳＩ）から、各アンテナのチャネル容量が算出され、その値をもとに、Ｓｔｅｐ５において、見込み通信速度を推定する。見込み通信速度は、例えば、チャネル容量からそのアンテナにつながっている端末数で除したもの等から算定される。その後、全アンテナを対象として、見込み通信速度の速いアンテナ順にリストアップを実施する（Ｓｔｅｐ６）。さらに、そのリスト上位Ｎ組のアンテナを組合せた場合、見込み通信速度が閾値以上である場合（Ｓｔｅｐ

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page043

７）、ＭＩＭＯ適用（Ｓｔｅｐ８）となる。Ｓｔｅｐ１でトラフィック量が閾値以上でない、あるいは、Ｓｔｅｐ７で見込み通信速度が閾値以上でない場合は、ＭＩＭＯ適用しない（Ｓｔｅｐ９）。Ｓｔｅｐ８またはＳｔｅｐ９の後は、Ｓｔｅｐ１へ戻る。このＭＩＭＯ切替判定は定期的あるいは周期的に実施されるものとし、その都度、データ（ＣＳＩ情報等）が更新される為、見込み通信速度リストの上位のアンテナがＭＩＭＯ通信に採用される。

【００４７】

Ｃ．実施の形態３

図１８は、基地局内ＭＩＭＯ切替判定部のフローチャートの例（その３）である。この図は、実施の形態１における図５のフローチャートの別の実施の形態を示す。図１８では、ある特定の端末に対してＭＩＭＯ通信が開始された場合に、ＳＩＳＯ通信又はＳＩＭＯ通信を行っている他の端末に対して、ＭＩＭＯ通信に対する干渉が少ないアンテナへと再割当が実施される際のＭＩＭＯ切替判定部のフローチャートを示している。

【００４８】

まず、図５と同様に、対象となる端末を選択後（Ｓｔｅｐ１）、端末のトラフィック量が閾値以上か否かを判定する（Ｓｔｅｐ２）。Ｓｔｅｐ２で閾値以上であれば、チャネル情報（ＣＳＩ）から、各アンテナのチャネル容量を算出する（Ｓｔｅｐ３）。その後、各アンテナの見込み通信速度を推定する（Ｓｔｅｐ４）。見込み通信速度の推定方法の一つとして、チャネル容量をアンテナに繋がっているユーザ数で除したものなどがある。その後、全アンテナについて見込み通信速度順にリストアップされると（Ｓｔｅｐ５）、リスト上位Ｎ組のアンテナを組み合わせた場合、見込み通信速度が閾値以上かの判別を行う（Ｓｔｅｐ６）。Ｓｔｅｐ６で、閾値以上であれば、ＭＩＭＯ適用となる（Ｓｔｅｐ７）。

【００４９】

ＭＩＭＯ適用後、周囲でＳＩＳＯもしくはＳＩＭＯ通信を行っている端末をサーチ・選択する（Ｓｔｅｐ８）。当該端末に対して、ＭＩＭＯ通信を開始した端末との干渉度合いを調べるため、ＣＩＮＲを測定し（Ｓｔｅｐ９）、ＣＩＮＲが閾値以上かを判別する（Ｓｔｅｐ１０）。もし、現在通信しているアンテナに対するＣＩＮＲが閾値以上でない場合には、他のアンテナの中でＣＩＮＲが最も高い他のアンテナを選択する（Ｓｔｅｐ１１）。もし、現在通信しているアンテナに対するＣＩＮＲが閾値以上であれば、ＭＩＭＯ通信を行っている端末との干渉の影響が少ないと判断し、当該端末は現在繋がっているアンテナを継続使用して、ＳＩＳＯ通信もしくはＳＩＭＯ通信を行う（Ｓｔｅｐ１３）。ここで、Ｓｔｅｐ２もしくはＳｔｅｐ６で各々閾値以上でないである場合、ＭＩＭＯ適用しない（Ｓｔｅｐ１２）。なお、Ｓｔｅｐ１１、Ｓｔｅｐ１２、Ｓｔｅｐ１３の処理が完了すると、Ｓｔｅｐ１へ戻る。

【００５０】

なお、ＣＩＮＲの代わりにＳＮＲを用いてもよい。

このように、ある端末がＭＩＭＯ開始した際、ＳＩＳＯやＳＩＭＯを行っている端末はＣＩＮＲ値又はＳＮＲ値をパラメータとして、ＭＩＭＯ通信への干渉が少ないアンテナへ移動することができる。

【００５１】

Ｄ．実施の形態４

図２１は、基地局内ＭＩＭＯ切替判定部のフローチャートの例（その４）である。この図は、実施の形態１における図５のフローチャートの別の実施の形態を示す。図２１では、ある特定の端末のトラフィック量が増えた場合に、その端末と同じアンテナにつながっている端末数が上限を超えた場合、ＭＩＭＯが適用されるというＭＩＭＯ切替判定部のフローチャートの例を示している。

【００５２】

まず対象となる端末を選択後（Ｓｔｅｐ１）、端末のトラフィック量が閾値以上かを判

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page044

別する（Ｓｔｅｐ２）。Ｓｔｅｐ２において、トラフィック量が閾値以上だった場合、対象となる端末が利用しているアンテナと同じアンテナに繋がっている他の端末数を計測する（Ｓｔｅｐ３）。その後、計測した端末数が閾値以上かを判別し（Ｓｔｅｐ４）、端末数が閾値以上であれば、ＭＩＭＯ適用となる（Ｓｔｅｐ５）。一方、Ｓｔｅｐ２でトラフィック量が閾値より小さい場合、又は、Ｓｔｅｐ４で端末数が閾値より小さい場合、ＭＩＭＯ適用しない（Ｓｔｅｐ１０）。

【００５３】

Ｅ．実施の形態５

図２２は、基地局内ＭＩＭＯ切替判定部のフローチャート例（その５）である。この図は、実施の形態１における図５のフローチャート又は実施の形態４における図２１のフローチャートの別の実施の形態を示す。ＭＩＭＯ適用後のアンテナの取り扱いが図２１と一部異なっている。

【００５４】

端末へのトラフィックがある閾値を超えた場合（Ｓｔｅｐ１）、現在ＭＩＭＯを適用中かの判別を行う（Ｓｔｅｐ２）。ＭＩＭＯ適用中であって、現在のアンテナの組合せで、見込み通信速度が閾値以上の場合（Ｓｔｅｐ３）、現状のアンテナを継続使用し、ＭＩＭＯ通信を実施する（Ｓｔｅｐ８）。Ｓｔｅｐ２において、ＭＩＭＯ適用中でない場合、もしくはＳｔｅｐ３において、見込み通信速度が閾値以上でない場合は、Ｓｔｅｐ４に進む。

【００５５】

Ｓｔｅｐ４以降では、図２１と同様に、対象となる端末が利用しているアンテナと同じアンテナに繋がっている他の端末数を計測する（Ｓｔｅｐ４）。その後、計測した端末数が閾値以上かを判別し（Ｓｔｅｐ７）、端末数が閾値以上であれば、ＭＩＭＯ適用となる（Ｓｔｅｐ８）。Ｓｔｅｐ１でトラフィック量が閾値以上でない、あるいは、Ｓｔｅｐ７で端末数が閾値以上でない場合は、ＭＩＭＯ適用しない（Ｓｔｅｐ９）。Ｓｔｅｐ８またはＳｔｅｐ９の後は、Ｓｔｅｐ１へ戻る

【００５６】

Ｆ．実施の形態６

図１９は、基地局内ＭＩＭＯ切替判定部のフローチャートの例（その６）である。この図は、実施の形態１における図５のフローチャート又は実施の形態４における図２１のフローチャートの別の実施の形態を示す。図１９では、ある特定の端末に対してＭＩＭＯ通信が開始された場合に、ＳＩＳＯ通信又はＳＩＭＯ通信を行っている他の端末に対して、ＭＩＭＯ通信に対する干渉が少ないアンテナへと再割当が実施される際のＭＩＭＯ切替判定部のフローチャートを示している。

【００５７】

まず対象となる端末を選択後（Ｓｔｅｐ１）、端末のトラフィック量が閾値以上かを判別する（Ｓｔｅｐ２）。Ｓｔｅｐ２において、トラフィック量が閾値以上だった場合、対象となる端末が利用しているアンテナと同じアンテナに繋がっている他の端末数を計測する（Ｓｔｅｐ３）。その後、計測した端末数が閾値以上かを判別し（Ｓｔｅｐ４）、端末数が閾値以上であれば、ＭＩＭＯ適用となる（Ｓｔｅｐ５）。一方、Ｓｔｅｐ２でトラフィック量が閾値より小さい場合、又は、Ｓｔｅｐ４で端末数が閾値より小さい場合、ＭＩＭＯ適用しない（Ｓｔｅｐ１０）。

【００５８】

ＭＩＭＯ適用後、図１８と同様に、周囲でＳＩＳＯ通信もしくはＳＩＭＯ通信を行っている端末をサーチ・選択する（Ｓｔｅｐ６）。当該端末に対して、ＭＩＭＯ通信を開始した端末との干渉度合いを調べるため、ＣＩＮＲを測定し（Ｓｔｅｐ７）、ＣＩＮＲが閾値以上かを判別する（Ｓｔｅｐ８）。もし、現在通信しているアンテナに対するＣＩＮＲが閾値以上でない場合には、ＣＩＮＲが最も高い他のアンテナを選択する（Ｓｔｅｐ９）。

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page045

もし、現在通信しているアンテナに対するＣＩＮＲが閾値以上であれば、ＭＩＭＯ通信を行っている端末との干渉の影響が少ないと判断し、当該端末は現在繋がっているアンテナを継続使用して、ＳＩＳＯもしくはＳＩＭＯを行う（Ｓｔｅｐ１１）。ここで、Ｓｔｅｐ２もしくはＳｔｅｐ４で各々閾値以上でないである場合、ＭＩＭＯ適用しない（Ｓｔｅｐ１０）。なお、Ｓｔｅｐ９、Ｓｔｅｐ１０、Ｓｔｅｐ１１の処理が完了すると、Ｓｔｅｐ１へ戻る。

【００５９】

なお、ＣＩＮＲの代わりにＳＮＲを用いてもよい。

このように、ある端末がＭＩＭＯ開始した際、ＳＩＳＯやＳＩＭＯを行っている端末はＣＩＮＲ値又はＳＮＲ値をパラメータとして、ＭＩＭＯ通信への干渉が少ないアンテナへ移動することができる。

【産業上の利用可能性】

【００６０】

本発明は、いわゆるＤＡＳ以外にも、複数のアンテナを分散配置した様々な分散アンテナシステムに適用することができる。また、通信速度を例に処理を説明したが、これに限らず、スループット又はこれらに類似のデータ等の適宜のデータを用いて処理を行うことができる。

【符号の説明】

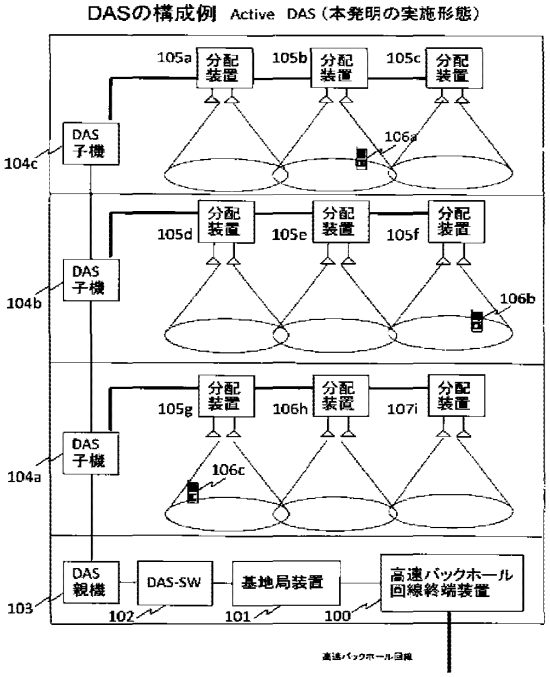
【００６１】

１００　高速バックホール回線終端装置
１０１　基地局装置
１０２　分散アンテナシステム（以下、ＤＡＳ）切替スイッチ
１０３　ＤＡＳ親機
１０４ａ～１０４ｃ　ＤＡＳ子機
１０５ａ～１０５ｉ　分配装置
１０６ａ～１０６ｃ　端末
２００　高速バックホール回線終端装置
２０１　基地局装置
２０２　ＤＡＳスイッチ
２０３ａ～２０３ｈ　ＤＡＳアンテナ
２０４ａ～２０４ｂ　端末
３００　基地局装置
３０１　バックホール回線
３０２　バックホール回線インタフェース
３０３　トラフィック情報収集部
３０４　トラフィック情報
３０５　チャネル情報収集部
３０６　チャネル情報
３０７　ＭＩＭＯ切替判定部
３０８　制御信号処理部
３０９　ベースバンド／ＲＦ部
３１０　リファレンス信号生成部
３１１　ＳＩＳＯ信号処理部
３１２　ＭＩＭＯ信号処理部
３１３　ＲＦ外部インタフェース
３１４　アンテナポート
３１５　ＤＡＳスイッチ
３１６　ＤＡＳスイッチ入力ポート
３１７　ＤＡＳスイッチ制御部
３１８　ＤＡＳスイッチング部

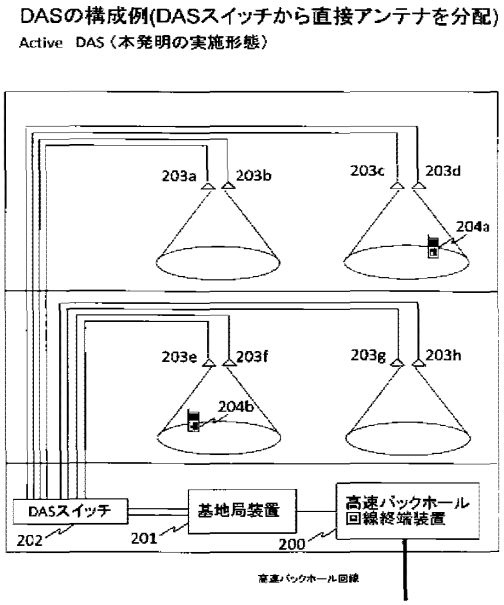
３１９　ＤＡＳスイッチ出力ポート
４００　ＤＡＳスイッチ
５００　端末
５０１　ＤＡＳスイッチ
５０２　端末
５０３　ＤＡＳスイッチ
６００　基地局装置
６０１　ＤＡＳスイッチ
６０２　アンテナ＃１
６０３　アンテナ＃２
６０４　アンテナ＃３
６０５　端末
６０６　アンテナ切替用リファレンス信号送信
６０７　アンテナ切替用チャネル情報（ＣＳＩ）送信
６０８　チャネル情報収集
６０９　データ信号（ＳＩＳＯ）
６１０　トラフィック情報収集
６１１　ＭＩＭＯ切替判定
６１２　スイッチ切替制御
６１３　ＭＩＭＯ通信用リファレンス信号送信
６１４　ＭＩＭＯ通信用チャネル情報（ＣＳＩ）送信
６１５　データ信号（ＭＩＭＯ）
７００　端末１
７０１　端末２
７０２　ＤＡＳスイッチ
７０３　端末１
７０４　端末２
７０５　ＤＡＳスイッチ
８００　基地局装置
８０１　ＤＡＳスイッチ
８０２　アンテナ＃１
８０３　アンテナ＃２
８０４　アンテナ＃３
８０５　端末
８０６　端末
８０７　アンテナ切替用リファレンス信号送信
８０８　アンテナ切替用チャネル情報（ＣＳＩ）送信
８０９　チャネル情報収集
８１０　データ信号（ＳＩＳＯ）
８１１　データ信号（ＳＩＳＯ）
８１２　トラフィック情報収集
８１３　ＭＩＭＯ切替判定
８１４　スイッチ切替制御
８１５　ＭＩＭＯ通信用リファレンス信号送信
８１６　ＭＩＭＯ通信用チャネル情報（ＣＳＩ）送信
８１７　データ信号（ＭＩＭＯ）
８１８　データ信号（ＳＩＳＯ）

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page047

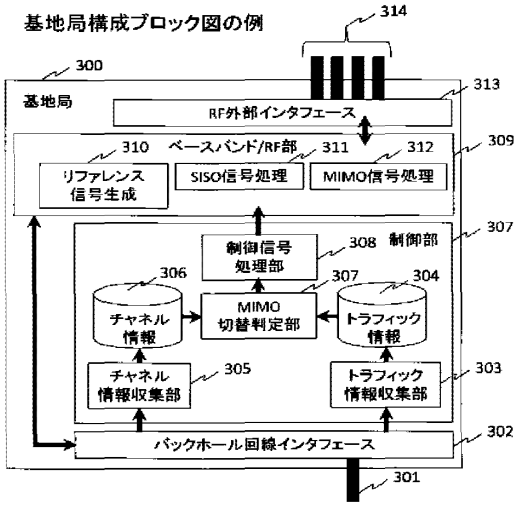
【図１】


DASの構成例 Active DAS（本発明の実施形態）
105a
分配装置
105b
分配装置
105c
分配装置
DAS子機
104c
106a
105d
分配装置
105e
分配装置
105f
分配装置
DAS子機
104b
106b
105g
分配装置
106h
分配装置
107i
分配装置
DAS子機
104a
106c
DAS親機
103
DAS-SW
102
基地局装置
101
高速バックホール回線終端装置
100
高速バックホール回線

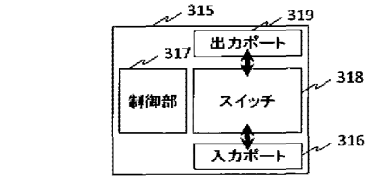
【図２】


DASの構成例(DASスイッチから直接アンテナを分配)
Active DAS（本発明の実施形態）
203a
203b
203c
203d
204a
203e
203f
203g
203h
204b
DASスイッチ
202
基地局装置
201
高速バックホール回線終端装置
200
高速バックホール回線

【図３】

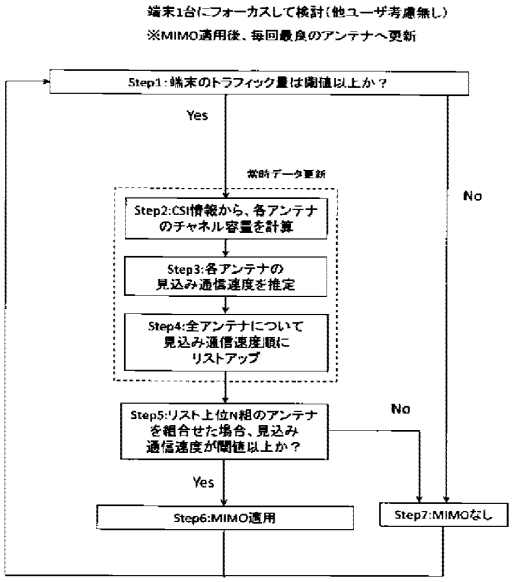

基地局構成ブロック図の例
314
300
基地局
313
RF外部インタフェース
309
310
ベースバンド/RF部
311
312
リファレンス信号生成
SISO信号処理
MIMO信号処理
307
制御部
制御信号処理部
308
306
307
304
チャネル情報
MIMO切替判定部
トラフィック情報
チャネル情報収集部
305
トラフィック情報収集部
303
バックホール回線インタフェース
302
301

【図４】


DASスイッチ構成ブロック図の例
315
319
出力ポート
317
制御部
スイッチ
318
入力ポート
316

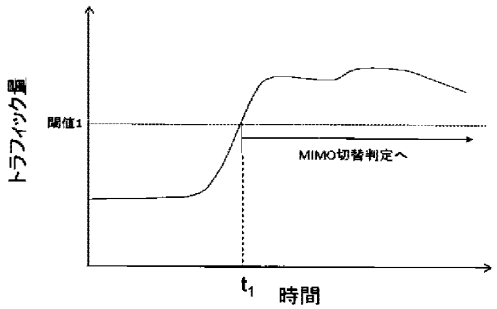
【図５】

基地局内MIMO切替判定部のフローチャート例(その1)



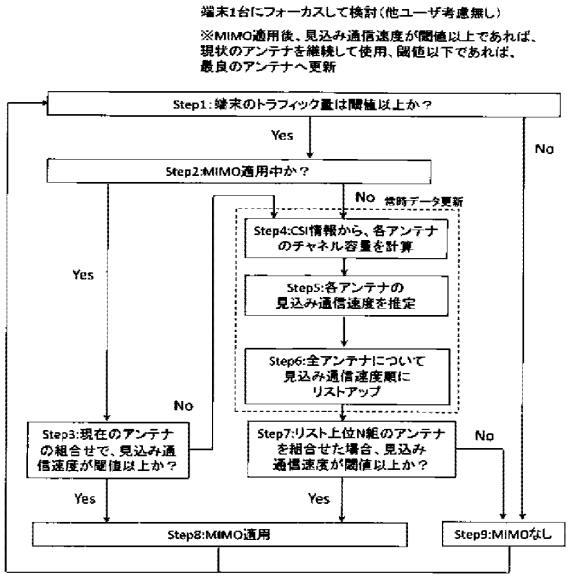
【図６】

トラフィック量判定図の例



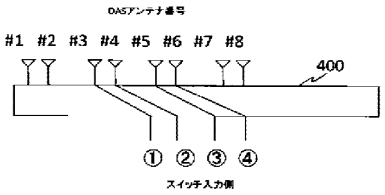
【図７】

基地局内MIMO切替判定部のフローチャート例(その2)

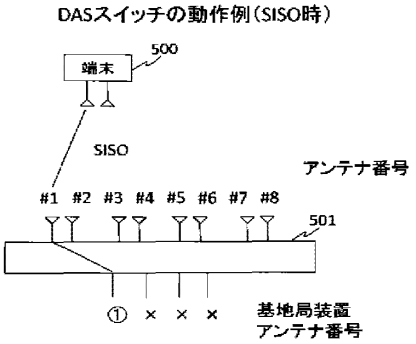


【図８】

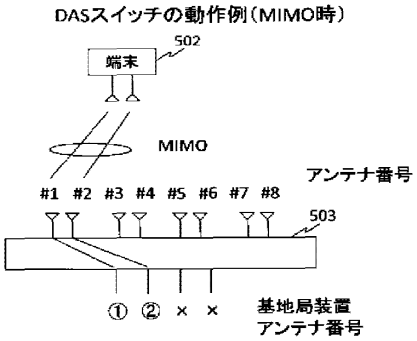
DASスイッチの動作例



【図９】

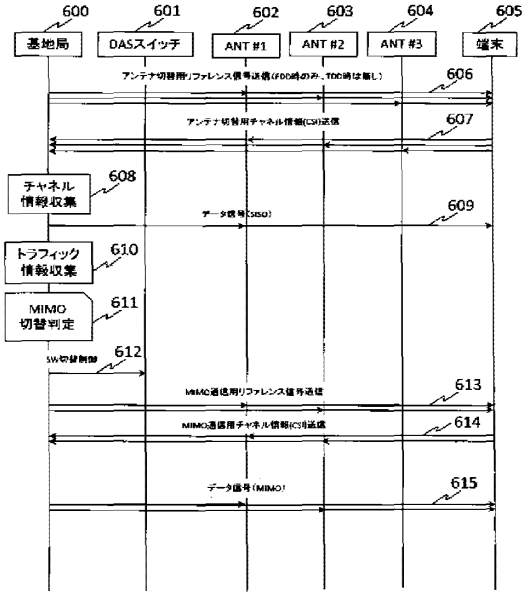


【図１０】



【図１１】

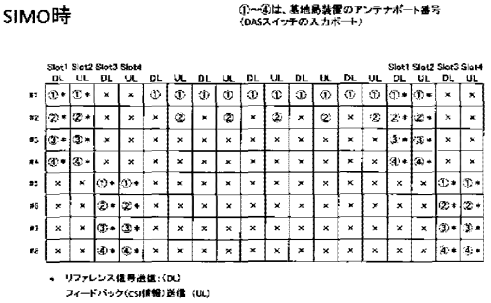
端末が1台の場合のシーケンス例



【図１２】

DASスイッチの動作例(SIMO時)

SIMO時



【図１３】

DASスイッチの動作例（MIMO時）

MIMO時

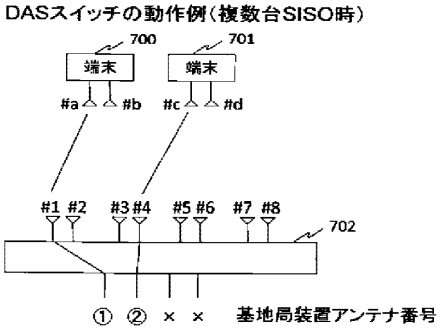
①～④は、基地局装置のアンテナポート番号
（DASスイッチの入力ポート）

	Slot1 DL	Slot1 UL	Slot2 DL	Slot2 UL	Slot3 DL	Slot3 UL	Slot4 DL	Slot4 UL	Slot1 DL	Slot1 UL	Slot2 DL	Slot2 UL	Slot3 DL	Slot3 UL	Slot4 DL	Slot4 UL
#1	①*	①*	×	×	①	①	①	①	①	①	①	①	①	①	①*	①*	×	×
#2	②*	②*	×	×	②	②	②	②	②	②	②	②	②	②	②*	②*	×	×
#3	③*	③*	×	×	×	×	×	×	×	×	×	×	×	×	③*	③*	×	×
#4	④*	④*	×	×	×	×	×	×	×	×	×	×	×	×	④*	④*	×	×
#5	×	×	①*	①*	×	×	×	×	×	×	×	×	×	×	①*	①*		
#6	×	×	②*	②*	×	×	×	×	×	×	×	×	×	×	②*	②*		
#7	×	×	③*	③*	×	×	×	×	×	×	×	×	×	×	③*	③*		
#8	×	×	④*	④*	×	×	×	×	×	×	×	×	×	×	④*	④*		

* リファレンス信号送信（DL）
フィードバック（CSI情報）送信：（UL）

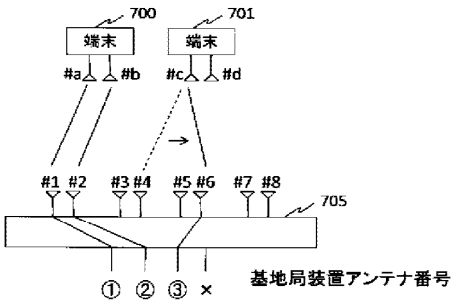
【図１４】

DASスイッチの動作例（複数台SISO時）



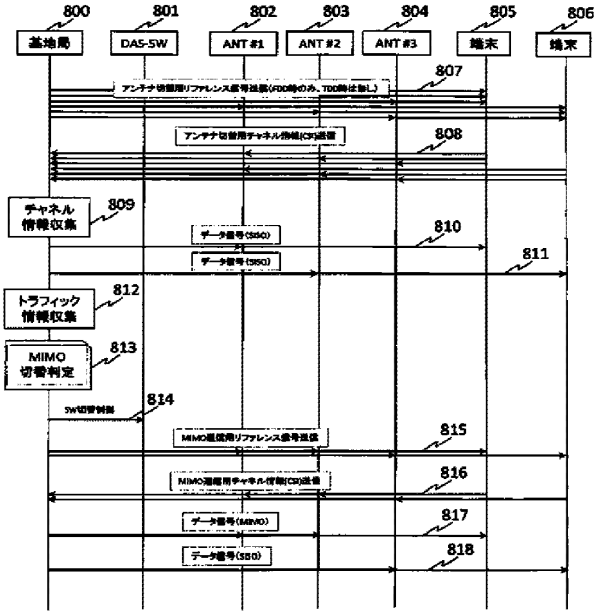
【図１５】

DASスイッチの動作例（MIMO、SISO共存時）



【図１６】

端末が複数台の場合のシーケンス例

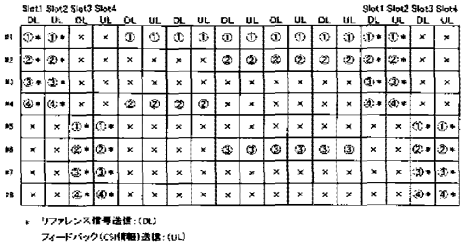


【図１７】

DASスイッチの動作例(その3)

①～④は、基地局装置のアンテナポート番号
(DASスイッチの入力ポート)

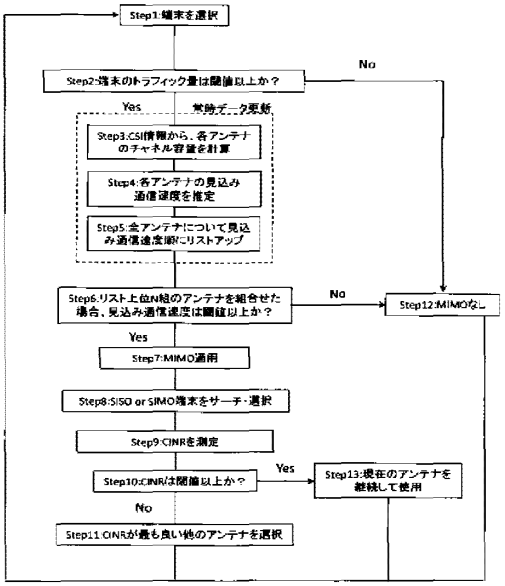
SIMO時



＊ リファレンス信号送信：(DL)
フィードバック(CSI情報)送信：(UL)

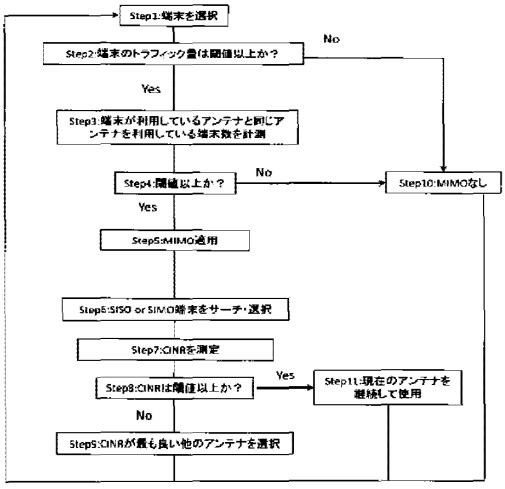
【図１８】

基地局内MIMO切替判定部の
フローチャートの例(その3)



【図１９】

基地局内MIMO切替判定部の
フローチャートの例(その6)



【図２０】

チャネル情報(CSI)のデータベース配列

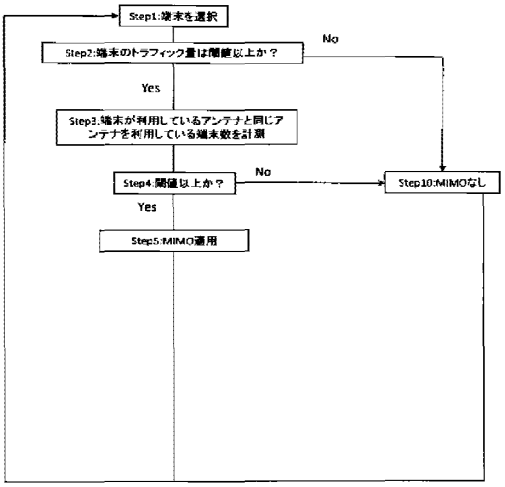
注:一例として、図15を基に作成

アンテナ番号	端末700	端末701
#1	h1a,h1b	h1c,h1d
#2	h2a,h2b	h2c,h2d
#3	h3a,h3b	H3c,h3d
#4	h4a,h4b	h4c,h4d
#5	h5a,h5b	h5c,h5d
#6	h6a,h6b	h6c,h6d
#7	h7a,h7b	h7c,h7d
#8	h8a,h8b	h8c,h8d
・・・	・・・	・・・
#n	h1na,h12b	h12c,h12d

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page052

【図２１】

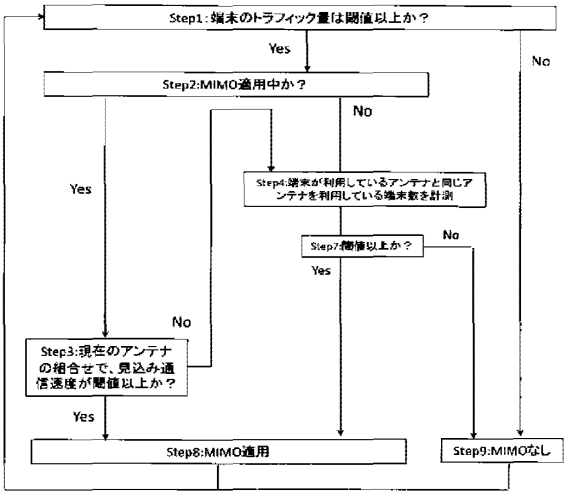
基地局内MIMO切替判定部の
フローチャートの例(その4)



【図２２】

基地局内MIMO切替判定部の
フローチャート例(その5)

端末1台にフォーカスして検討(他ユーザ考慮無し)



Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page053

フロントページの続き

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[见续页]

(54) **Title**: METHOD AND EQUIPMENT FOR INTER-CELL INTERFERENCE COORDINATION IN RELAY-ASSISTED CELLULAR SYSTEM

(54) **发明名称** : 中继辅助蜂窝系统中用于小区间干扰协调的方法和设备

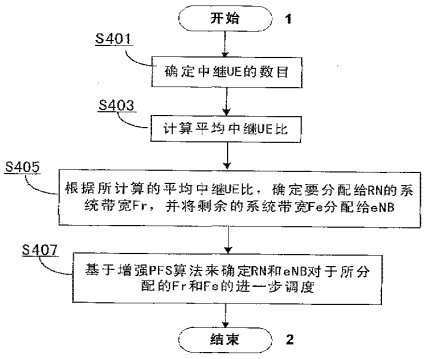


图 4 /Fig.4

1 START
S401 DETERMINING THE NUMBER OF RELAY UES
S403 CALCULATING THE MEAN PERCENTAGE OF RELAY UES
S405 ACCORDING TO THE CALCULATED MEAN PERCENTAGE OF RELAY UES, DETERMINING THE SYSTEM BANDWIDTH FR WHICH WILL BE DISTRIBUTED TO RNS, AND DISTRIBUTING THE REST SYSTEM BANDWIDTH FE TO ENB;
S407 DETERMINING THE FURTHER SCHEDULING OF RNS AND ENB TO THE DISTRIBUTED FR AND FE BASED ON THE REINFORCED PFS ALGORITHM
2 END

(57) **Abstract**: A method for inter-cell interference coordination (ICIC) in a relay-assisted network is provided in the present invention, and in the relay-assisted network, user equipments (UE) are divided into macro UEs which are directly serviced by base stations, and relay UEs which are indirectly serviced by the base stations through relay nodes. The method includes the following steps: calculating the mean percentage of relay UEs, wherein the mean percentage of relay UEs is the mean percentage of the number of relay UEs serviced by a single relay node in the cell to the total number of UEs; according to the calculated mean percentage of relay UEs, determining the system bandwidth to be distributed to the relay nodes, and distributing the rest system bandwidth to the base station; and determining the further scheduling of the relay nodes and base station to the distributed system bandwidth based on the scheduling algorithm. An equipment for inter-cell interference coordination ICIC in the relay-assisted network is also provided in the present invention.

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WO 2011/085514 A1

SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW。

(84) **指定国** (除另有指明，要求每一种可提供的地区保护): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), 欧亚 (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 欧洲 (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)。

本国际公布:

— 包括国际检索报告(条约第 21 条(3))。

(57) **摘要**:

本发明提供了一种中继辅助网络中进行小区间干扰协调 ICIC 的方法，在所述中继辅助网络中，用户设备 UE 被划分为由基站直接服务的宏 UE 和经由中继节点间接由基站服务的中继 UE，所述方法包括以下步骤：计算平均中继 UE 比，其中所述平均中继 UE 比是小区中的单个中继节点所服务的中继 UE 数目占所有 UE 数目的平均百分比；根据所计算的平均中继 UE 比，确定要分配给中继节点的系统带宽，并将剩余的系统带宽分配给基站；以及基于调度算法来确定中继节点和基站对于所分配的系统带宽的进一步调度。本发明还提供了一种中继辅助网络中的小区间干扰协调 ICIC 设备。

中继辅助蜂窝系统中用于小区间干扰协调的方法和设备

技术领域

本发明涉及蜂窝系统中的干扰协调方法和设备，更具体地讲，涉及在中继辅助蜂窝网络中进行小区间干扰协调的方法和设备。

背景技术

正交频分多址接入（OFDMA）已被第三代伙伴计划长期演进（3GPP LTE）接受为用于下一代系统的有前景的下行链路空中接口技术（参见 S. Sesia, I. Toufik, and M. Baker, "LTE – the UMTS long term evolution: from theory to practice," Wiley Press, 2009，在此一并引入作为参考）。OFDMA 为无线电资源分配和避免小区内干扰提供了固有的灵活性。然而，由密集资源复用导致的强小区间干扰限制了充分利用 OFDMA 方案的可能。因而，为减小小区间干扰，提供适合的无线电资源管理（RRM）是十分必要的。

目前，主要考虑以下三种降低小区间干扰（ICIM）的技术：1）干扰随机化，2）干扰消除，3)干扰协调(参见 M. Rahman, H. Yanikomeroglu, and W. Wong, "Interference avoidance with dynamic inter-cell coordination for downlink LTE system," Proc. IEEE WCNC' 09, April 2009，在此一并引入作为参考)。，然而，干扰随机化并没有从本质上降低干扰，而干扰消除仅能够消除主要干扰，因此以协调的方式对下行链路资源管理进行限制以实现最佳网络性能的干扰协调被视为 3GPP LTE 中最有前景的 ICIM 方式。

大量的可用小区间干扰协调（ICIC）技术基于如图 1 所示的分数频率复用（FFR）原理。FFR 考虑复用分割，其中向小区边缘用户设备（UE）分配具有比小区中心 UE 高的复用因子的资源（一部分频谱），分配给小区中心 UE 的资源（整个频带或一部分频谱）仅以比至小区边缘 UE 的增强型节点 B（eNB）传输的功率低的受限功率进行复用。然而，基于各种考虑（尤其是下行链路功率控制可能使下行链路信道质量指示符（CQI）测量混乱，因而影响下行链路自适应和调度的有效性），最终在 LTE 中的数据信道上并不支持下行链路功率控制，这使得 FFR 对于 ICIC 是无效或无意义的。

近来，在 LTE 和 LTE-A 中广泛地对多跳中继技术进行了讨论，并将其引入了 3GPP

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page057

版本 9 及更高版本(参见 3GPP TR 36.814, "Further Advancements for E-UTRA Physical Layer Aspects," v1.2.1, June 2009，在此一并引入作为参考)。在中继辅助系统中，每个 UE 可以主动或被动地访问 eNB 或中继节点（RN)。通过在小区边缘部署 RN，小区边缘 UE 可以体验来自服务 RN 的提高的接收信号功率。这样，使得在不降低小区中心频率资源处的 eNB 传输功率的情况下，FFR 在 LTE 中可用。基于上述考虑完成了本发明。

发明内容

为了解决现有技术中存在的问题，本发明提出了在中继辅助网络中进行小区间干扰协调 ICIC 的方法和设备。

根据本发明的一方面，提供了一种在中继辅助网络中进行小区间干扰协调 ICIC 的方法，在所述中继辅助网络中，用户设备 UE 被划分为由基站直接服务的宏 UE 和经由中继节点间接由基站服务的中继 UE，所述方法包括以下步骤：计算平均中继 UE 比，其中所述平均中继 UE 比是小区中的单个中继节点所服务的中继 UE 数目占所有 UE 数目的平均百分比；根据所计算的平均中继 UE 比，确定要分配给中继节点的系统带宽，并将剩余的系统带宽分配给基站；以及基于调度算法来确定中继节点和基站对于所分配的系统带宽的进一步调度。

优选地，所述调度算法是依赖于缓冲器队列状态因素的增强比例公平调度算法。

其中，分配给中继节点的系统带宽和分配给基站的系统带宽是相互正交的。

其中确定进一步调度的步骤包括：基于第一增强比例公平调度算法来计算针对中继节点的第一调度准则，以确定将所分配的系统带宽进一步分配给中继 UE 的调度优先级。通过下式实现第一增强比例公平调度算法，

$$M_r(t) = \arg\max_m \frac{\min\{R^m_{inst}(t), R^m_{buffer}(t)\}}{R^m_{aver}(t)},$$

其中，t 表示时间索引，$R^m_{inst}(t)$ 表示中继 UE m 的瞬时可支持数据速率，$R^m_{aver}(t)$ 表示针对某一时间常量 τ 的中继 UE m 的指数滤波平均服务速率，以及 $R^m_{buffer}(t)$ 表示中继 UE m 的期望缓冲速率。

其中确定进一步调度的步骤还包括：基于第二增强比例公平调度算法来计算针对基站的第二调度准则，以确定将所分配的系统带宽进一步分配给宏 UE 和中继回程链路的调度优先级。通过下式实现第二增强比例公平调度算法，

$$M_e(t) = \arg\max_{n,l_m}\left\{\frac{R^n_{inst}(t)}{R^n_{aver}(t)}, \frac{R^{l_m}_{imp}(t)}{R^{l_m}_{aver}(t)}\right\},$$

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page058

其中，t 表示时间索引，$R_{inst}^{n}(t)$ 表示宏 UE n 的瞬时可支持数据速率，$R_{aver}^{n}(t)$ 表示针对某一时间常量 τ 的宏 UE n 的指数滤波平均服务速率，$R_{aver}^{l_m}(t)$ 表示中继 UE m 所对应的回程链路的平均速率，以及 $R_{imp}^{l_m}(t)$ 表示考虑了中继缓冲器队列状态的改进型回程链路速率

该方法还包括，根据当前的 UE 关联方案和业务量负载信息，确定 UE 是中继 UE 还是宏 UE。

根据本发明的另一方面，提供了一种中继辅助网络中进行小区间干扰协调 ICIC 的设备，在所述中继辅助网络中，用户设备 UE 被划分为由基站直接服务的宏 UE 和经由中继节点间接由基站服务的中继 UE，所述设备包括：计算装置，用于计算平均中继 UE 比，其中所述平均中继 UE 比是小区中的单个中继节点所服务的中继 UE 数目占所有 UE 数目的平均百分比；分配装置，用于根据所计算的平均中继 UE 比，确定要分配给中继节点的系统带宽，并将剩余的系统带宽分配给基站；以及调度装置，用于基于调度算法来确定中继节点和基站对于所分配的系统带宽的进一步调度。

优选地，所述调度算法是依赖于缓冲器队列状态因素的增强比例公平调度算法。

其中，分配给中继节点的系统带宽和分配给基站的系统带宽是相互正交的。

所述调度装置包括：第一调度装置，用于基于第一增强比例公平调度算法来计算针对中继节点的第一调度准则，以确定将所分配的系统带宽进一步分配给中继 UE 的调度优先级。通过下式实现第一增强比例公平调度算法，

$$M_r(t) = \arg\max_{m} \frac{\min\{R_{inst}^{m}(t), R_{buffer}^{m}(t)\}}{R_{aver}^{m}(t)},$$

其中，t 表示时间索引，$R_{inst}^{m}(t)$ 表示中继 UE m 的瞬时可支持数据速率，$R_{aver}^{m}(t)$ 表示针对某一时间常量 τ 的中继 UE m 的指数滤波平均服务速率，以及 $R_{buffer}^{m}(t)$ 表示中继 UE m 的期望缓冲速率。

所述调度装置还包括：第二调度装置，用于基于第二增强比例公平调度算法来计算针对基站的第二调度准则，以确定将所分配的系统带宽进一步分配给宏 UE 和中继回程链路的调度优先级。通过下式实现第二增强比例公平调度算法，

$$M_e(t) = \arg\max_{n,l_m} \left\{ \frac{R_{inst}^{n}(t)}{R_{aver}^{n}(t)}, \frac{R_{imp}^{l_m}(t)}{R_{aver}^{l_m}(t)} \right\},$$

其中，t 表示时间索引，$R_{inst}^{n}(t)$ 表示宏 UE n 的瞬时可支持数据速率，$R_{aver}^{n}(t)$ 表示针对某一时间常量 τ 的宏 UE n 的指数滤波平均服务速率，$R_{aver}^{l_m}(t)$ 表示中继 UE m 所对应的回程链路的平均速率，以及 $R_{imp}^{l_m}(t)$ 表示考虑了中继缓冲器队列状态的改进型回程链路速率。

该设备还包括，确定装置，用于根据当前的 UE 关联方案和业务量负载信息，确

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page059

定 UE 是中继 UE 还是宏 UE。

本发明针对中继辅助蜂窝网络中的 LTE 下行链路传输，提出了一种利用相应的增强型 PFS 算法的新的基于 FFR 的 ICIC 方案。在该 FFR 模型中，将整个系统带宽分为两个正交部分，一个用于由 eNB 直接服务的宏 UE，另一个用于由小区边缘 RN 服务的中继 UE。用于中继 UE 的资源可以由所有 RN 复用，因为 RN 具有有限的传输功率；类似地，用于宏 UE 的资源也可以由所有 eNB 复用，因为这些资源是用于小区中心 UE 的。该频谱划分并不需要在 eNB 处的功率控制功能，而是非常容易实现的。通过根据当前的 UE 关联和业务量负载确定中继 UE 的数目，继而根据所计算的平均中继 UE 比确定中继 UE 资源的量，以进行半静态调整。同时，为了完全利用该 FFR 模型，提出了在调度优先级准则中考虑中继缓冲器状态的增强型 PFS，以提供一种资源使用的均衡方式。本发明可以显著地提高部署了中继节点的蜂窝系统的系统性能。

附图说明

结合附图，本发明的上述和其它方面、特征和优点将从以下对于本发明的非限制性实施例的详细描述中变得更加清楚，其中：

图 1 示出了根据本发明示意性实施例的典型的 FFR 配置；

图 2 示出了根据本发明示意性实施例的中继辅助传输示意图；

图 3 示出了根据本发明示意性实施例的小区间干扰协调设备的结构框图；

图 4 示出了根据本发明示意性实施例的小区间干扰协调方法的流程图；

图 5 示出了根据本发明示意性实施例的多小区六边形的布局以及相应的频谱划分；

图 6 示出了根据本发明示意性实施例的 LTE FDD 下行链路帧结构；

图 7 示出了根据本发明示意性实施例的半静态资源分配；以及

图 8 示出了根据本发明示意性实施例的基于 FRR 的 ICIC 方案的吞吐量增益。

具体实施方式

以下将结合附图，对本发明的示意性实施例进行描述。在该示意性实施例中，以 LTE 系统为例。但是本领域技术人员应当理解，本发明的范围并不限于此，该示意性实施例仅用于描述目的，应将其看作本发明的示例而非对本发明的任何限制，任何利用了本发明实施例的方案均落入本发明的保护范围内。

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page060

本发明提出了一种新的针对中继辅助蜂窝网络中的小区间干扰协调 ICIC 的分数频率复用 FFR 方案。本发明的基本思想是，通过基于中继 UE 关联比的半静态正交资源分配、和经由增强比例公平调度（PFS）算法的动态资源调度，来避免从 eNB 至 RN 的小区内和小区间干扰，其包括以下主要的几点：

（1）在小区边缘部署中继节点；

（2）将每个小区中的所有 UE 分为两类：直接由 eNB 访问和服务的 UE 被称为宏 UE；以及经由 RN 间接由 eNB 服务的 UE 被称为中继 UE；

（3）将整个系统频谱分为两个正交子频带，例如 Fe 和 Fr，其中 Fe 被分配给 eNB，并由 eNB 最终利用 PFS 分配给宏 UE 和中继回程（backhaul）链路；以及 Fr 被相应地分配给 RN，并由 RN 最终利用 PFS 分配给中继 UE。这样的划分保证了在 eNB 与 RN 之间没有干扰；

（4）网络中的所有小区遵循相同的频谱划分，即，Fe 可以由所有施主 eNB 复用，以及 Fr 可以由所有 RN 复用。由于 Fe 用于小区中心 UE，因而期望来自相邻 eNB 的干扰功率远小于来自施主 eNB 的信号功率。同时，也可以假设小区间 RN 干扰处于可以接受的范围内，因为 RN 具有非常有限的覆盖范围（RN 的传输功率比 eNB 的传输功率低得多）；

（5）Fr 的宽度与平均中继 UE 比成正比，并且以半静态方式进行调整以与当前的网络状态相匹配；

（6）平均中继 UE 比是单个 RN 所服务的中继 UE 数目占单个小区平均 UE 总数目的平均百分比，具体地，是全网总的中继 UE 数目除以全网总 UE 数目后再除以全网总的 RN 数目。因为每个小区可能分布不同的 UE 总数，也可能包含不同数量的 RN 数目，而每个 RN 也可能服务不同数目的中继 UE。为了计算该平均中继 UE 比，一方面，将中继 UE 数目经由 Un 接口从每个下级 RN 报告给施主 eNB；另一方面，通过 X2 接口，在不同的 eNB 中互相交换中继 UE 数目。本领域技术人员应当理解，Un 接口是 Rn 与 eNB 之间的接口；以及 X2 接口是 eNB 与 eNB 之间的接口；

（7）为了充分利用该 FFR 方案，资源分配是基于增强 PF 调度（PFS）算法的。通过将缓冲器队列状态的因素引入调度准则来获得该增强，从而实现更加适合的资源分配。

参见图 3，图 3 示出了根据本发明示意性实施例的小区间干扰协调设备 300 的结构框图。如图 3 所示，小区间干扰协调设备 300 包括：计算装置 301、用于计算平均

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page061

中继 UE 比，其中所述平均中继 UE 比是小区中的单个 RN 所服务的中继 UE 数目占所有 UE 数目的平均百分比；分配装置 303，用于根据所计算的平均中继 UE 比，确定要分配给 RN 的系统带宽，并将剩余的系统带宽分配给 eNB；调度装置 305，用于基于增强比例公平调度算法来确定 RN 和 eNB 对于所分配的系统带宽的进一步调度。

该调度装置 305 包括：第一调度装置（未示出），用于基于第一增强 PFS 算法来计算 RN 处的第一调度结果，以确定将所分配的系统带宽进一步分配给中继 UE 的调度优先级；以及第二调度装置（未示出），用于基于第二增强 PFS 算法来计算 eNB 处的第二调度结果，以确定将所分配的系统带宽进一步分配给宏 UE 和中继回程链路的调度优先级，其中，所述第一和第二增强 PFS 算法依赖于缓冲器队列状态因素。

此外，小区间干扰协调设备 300 还可以包括设置在计算装置 301 之前的确定装置（未示出），用于根据当前的 UE 关联方案和业务量负载信息，确定 UE 是中继 UE 还是宏 UE，以便确定中继 UE 的数目。

以下参照图 4-7，对根据本发明示意性实施例的小区间干扰协调方法进行描述，在该示意性实施例中，以 LTE FDD 下行链路传输为例。可以理解，本发明不限于此，而是可以应用于其它无线领域。

图 5 示意性地示出了多小区六边形的布局以及相应的频谱划分。如图 5 所示，在每个小区边缘可以部署，例如，两个 RN。以 LTE FDD 系统为例，典型地，LTE FDD 系统中的每个下行链路帧长 10ms，包括 20 个长度为 0.5ms 的时隙，标记为 0-19，如图 6 所示。将子帧定义为两个连续的时隙，其中子帧 i 包括时隙 2i 和 2i+1。

在 10MHz 系统带宽的情况下，在每个子帧中存在总数为 50 的物理资源块（PRB）。假设平均 25 个 UE 均匀地分布在每个小区中，并根据当前适合的 UE 关联方案（例如，考虑最大接收信号功率、或最短距离等）以及实际的业务量负载，由 eNB 或 RN 之一服务。如前所述，直接由 eNB 服务的 UE 称为宏 UE，通过 RN 间接由 eNB 服务的 UE 称为中继 UE。

在步骤 401 中，确定装置根据当前的 UE 关联方案和业务量负载信息，确定 UE 是中继 UE 还是宏 UE，以便确定中继 UE 的数目。

然后，每个 RN 通过 Un 接口向 eNB 报告中继 UE 数目，并通过 X2 接口在不同的 eNB 中互相交换该 UE 关联信息（即中继 UE 数目）。

在步骤 S403 中，通过计算装置 301 计算平均中继 UE 比。

在步骤 S405 中，分配装置 303 根据所计算的平均中继 UE 比，确定要分配给 RN

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page062

的系统带宽，并将剩余的系统带宽分配给 eNB。

例如，假设在特定持续时间内，平均地，每个 RN 间接地服务 3 个 UE，即，中继 UE，（由此可知平均中继 UE 比为 3/25=12%），以及施主 eNB 直接服务 19 个 UE。因此，可以根据平均中继 UE 比 12%，将整个系统带宽划分为以下两个部分：Fr，1-6 个 PRB；以及 Fe，7-50 个 PRB，即，将前 12%的资源分配给 RN 以便服务于中继 UE，以及将剩余资源分配给 eNB 以便服务于宏 UE 和中继回程链路，如图 7 所示。

由于资源调度算法极大地影响着 FFR 的性能，为此，本发明提出了增强 PFS，通过在调度准则中引入涉及缓冲器队列状态的因素来获得该增强，从而实现更加适合的资源分配。

在步骤 S407 中，调度装置 305 基于增强 PFS 算法来确定 RN 和 eNB 对于分配装置 303 所分配的 Fr 和 Fe 的进一步调度。

具体地讲，在步骤 S407 中，由第一调度装置基于第一增强 PFS 算法来计算 RN 处的第一调度结果，以确定将所分配的系统带宽进一步分配给中继 UE 的调度优先级。第二调度装置基于第二增强 PFS 算法来计算 eNB 处的第二调度结果，以确定将所分配的系统带宽进一步分配给宏 UE 和中继回程链路的调度优先级。其中，

1）实现第一增强 PFS 算法如下面的表达式（1）—（3）给出：

针对 Fr 频带的每个 PRB 的 RN PFS，调度优先级准则为

$$M_r(t) = \arg\max_m \frac{\min\{R^m_{inst}(t), R^m_{buffer}(t)\}}{R^m_{aver}(t)} \qquad (1)$$

其中，t是时间索引，$R^m_{inst}(t)$ 是中继UE m的瞬时可支持数据速率，以及 $R^m_{aver}(t)$ 是根据下式进行更新的针对某一时间常量 τ 的中继UE m的指数滤波平均服务速率

$$R^m_{aver}(t+1) = \begin{cases} (1-\tau)R^m_{aver}(t) + \tau \cdot \min\{R^m_{inst}(t), R^m_{buffer}(t)\}, & 若 M_r(t) = m \\ (1-\tau)R^m_{aver}(t), & 若\ M_r(t) \neq m \end{cases} \qquad (2)$$

。以及 $R^m_{buffer}(t)$ 是中继UE m的期望缓冲速率，被定义为：

$$R^m_{buffer}(t) = \frac{\text{UE } m\text{的缓冲器队列总长度(以比特为单位)}}{\text{TTI}} \qquad (3)$$

其中，TTI 等于 1ms，即，一个子帧的传输时间间隔。通过新到达的数据队列长度和服务 RN 处的重传数据队列长度二者来确定缓冲器队列的总长度。

与现有技术中的 PFS 算法 $M(t) = \arg\max_m \frac{R^m_{inst}(t)}{R^m_{aver}(t)}$ 相比，本发明所提出的调度优先级准则考虑了 UE 的缓冲器状态，从而避免了以空的缓冲器来调度 UE。

2）实现第二增强 PFS 算法如下面的表达式（4）和（5）给出：

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page063

假设 eNB 处的业务量加载模型是无限负载模型（infinitely-backlogged model），也称为满负荷模型，针对 Fe 频带的每个 RPB 处的 eNB PFS，在每个时间步骤中，调度优先级准则为

$$M_e(t) = \arg\max_{n,l_m}\left\{\frac{R^n_{inst}(t)}{R^n_{aver}(t)}, \frac{R^{l_m}_{imp}(t)}{R^{l_m}_{aver}(t)}\right\} \quad (4)$$

其中，t 表示时间索引，$R^n_{inst}(t)$ 表示宏 UE n 的瞬时可支持数据速率，$R^n_{aver}(t)$ 表示针对某一时间常量 τ 的宏 UE n 的指数滤波平均服务速率，$R^{l_m}_{aver}(t)$ 表示中继 UE m 所对应的回程链路的平均速率，以及 $R^{l_m}_{imp}(t)$ 表示考虑了中继缓冲器队列状态的改进型回程链路速率。其中宏 UE n 的 PF 优先级的计算（$R^n_{inst}(t)/R^n_{aver}(t)$）、以及中继 UE m 所对应的回程链路的平均速率（$R^{l_m}_{aver}(t)$）的计算与现有技术中相同。然而，对于与中继 UE m 对应的中继回程链路 l_m，$R^{l_m}_{imp}(t)$ 表示考虑了中继缓冲器队列状态的改进型回程链路速率：

$$R^{l_m}_{imp}(t) = \begin{cases} 0, & \text{如果链路 } l_m \text{的缓冲器队列长度大于特定阈值S1} \\ +\infty, & \text{如果链路 } l_m \text{的缓冲器为空,且总的RN缓冲器队列长度小于特定阈值S2} \\ R^{l_m}_{inst}(t), & \text{其它情况} \end{cases} \quad (5)$$

其中，$R^{l_m}_{inst}(t)$ 是回程链路 l_m 的瞬时可支持信道速率。

通过采用 $R^{l_m}_{imp}(t)$ 而非 $R^{l_m}_{inst}(t)$，中继回程链路不会耗费过多的 Fe 频带资源，同时可以向中继 UE 提供均衡的数据流。于是，可以在宏 UE 和中继回程链路中更恰当地使用 Fe 频带。

因而，将半静态资源分配和增强 PFS 相结合，可以在中继辅助蜂窝网络中有效地实现基于 FFR 的 ICIC，而不用限制 eNB 处的功率控制。

本发明针对中继辅助蜂窝网络中的 LTE 下行链路传输，提出了一种利用相应的增强 PFS 算法的新的基于 FFR 的 ICIC 方案。在该 FFR 模型中，将整个系统带宽分为两个正交部分，一个用于由 eNB 直接服务的宏 UE，另一个用于由小区边缘 RN 服务的中继 UE。用于中继 UE 的资源可以由所有 RN 复用，因为 RN 具有有限的传输功率。类似地，用于宏 UE 的资源也可以由所有 eNB 复用，因为这些资源是用于小区中心 UE 的。该频谱划分并不需要在 eNB 处的功率控制功能，而是非常容易实现的。通过根据当前的 UE 关联和业务量负载确定中继 UE 的数目，继而根据所计算的平均中继 UE 比确定中继 UE 资源的量，以进行半静态调整。同时，为了完全利用该 FFR 模型，提出了在调度优先级准则中考虑中继缓冲器状态的增强型 PFS，以提供一种资源使用的均衡方式。

此外，所提出的方法可以用于类型 I 和类型 II 中继节点，非常有利于在 3GPP LTE-A 标准中的应用。

根据本发明的基于 FFR 的 ICIC 方案可以在小区平均和小区边缘频谱效率方面提

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page064

供更好的系统性能。

图 8 示出了所提出的方法的显著性能增益（归一化用户吞吐量）示意图。下面的表 1 记录了针对图 8 中每种情况的相应小区平均和小区边缘(5%)用户吞吐量增益(表 1 中已对吞吐量进行了归一化)。经过计算可以得知，通过采用 RN 复用，在小区平均和小区边缘吞吐量上分别有 9.4%和 4.0%的增加；通过在每个小区内采用正交 RN 传输，在小区平均和小区边缘吞吐量上分别有 3.0%和 16.0%的增加。

表 1

	在没有 RN 的情况下的基线	*RN 正交*	*RN 复用*
小区平均(bps/Hz/小区)	1.741	1.794 (+3.0%)	1.905 (+9.4%)
小区边缘(bps/Hz)	0.025	0.029(+16.0%)	0.026 (+4.0%)

下面的表 2 给出了在无线蜂窝系统中利用本发明的方法和设备进行仿真时所采用的参数。

表 2

参数	值
蜂窝布局	单层 7 eNB 站点的环绕（wrap-round）布局，每个 eNB 站点包含 3 个小区，小区成六边形结构
系统带宽	10MHz, 下行链路
ISD（基站间距）	500 m (3GPP 场景 1)
最大 eNodeB 功率	46 dBm
RN 传输功率	30 dBm
每个小区的 RN 数目	2
每个小区的 UE 数目	25
调度方案	增强比例公平
调度中继	6ms
调度粒度	5PRB
下行链路 HARQ	具有 CC 的异步 HARQ, 最大三次重传，以及中继网络中的逐跳 HARQ
信道	针对 3GPP 场景 1 的 SCM 室内宏蜂窝高扩展模型
eNodeB 天线配置	具有在 3GPP TS 36.814 V1.2.1 中定义的天线模式的 1 个传输天线
RN 天线配置	具有在 3GPP TS 36.814 V1.2.1 中定义的天线模式的 1 个传输天线和 2 个接收天线
UE 天线配置	2 个传输天线(0 dBi 天线增益, 全向的)
下行链路接收类型	MRC
路径损失模型	参见 3GPP TS 36.814 V1.2.1
业务量模型	满负荷模型
控制信道开销, ACK 等	LTE：用于 DL CCH 的 L=3 个符号，用于解调参考信号的开销

表 2. 系统级仿真参数

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page065

通过上面给出的数据可知，本发明可以显著地改进部署了中继节点的蜂窝系统的系统性能。根据本发明的方案具有以下特性：

- eNB 和它的下级 RN 使用正交频率资源；
- 以半静态方式执行小区内的资源分配；
- 通过 Un 接口，将 UE 关联信息从 RN 报告给施主 eNB；
- 不同的 eNB 彼此交互，以通过 X2 接口交换它们相应的 UE 关联结果等。

本发明主要涉及基于 FFR 的 ICIC 解决方案，满足 3GPP LTE 中继定义，因而可以直接基于现有的技术来实现。

本领域技术人员应该很容易认识到，可以通过编程，利用计算机来实现上述方法的不同步骤。在此，一些实施方式同样包括机器可读或计算机可读的程序存储设备（如，数字数据存储介质）以及编码机器可执行或计算机可执行的程序指令，其中，该指令执行上述方法的一些或全部步骤。例如，程序存储设备可以是数字存储器、磁存储介质（如磁盘和磁带）、硬件或光可读数字数据存储介质。实施方式同样包括执行存储介质上记录的程序以执行上述方法的所述步骤的计算机。

上面结和附图所做的描述只是为了说明本发明而示例性给出的。本领域技术人员可以理解，能够基于上面所描述的本发明的原理提出不同的结构，虽然这些不同的结构未在此处明确描述或示出，但体现了本发明的原理并包括在其精神和范围之内。此外，所有此处提到的示例明确地主要只用于教学目的以帮助读者理解本发明的原理以及发明人所贡献的促进本领域的构思，并应被解释为不是对这些特定提到的示例和条件的限制。此外，此处所有提到本发明的原则、方面和实施方式的陈述及其特定的示例包含其等同物在内。

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page066

权 利 要 求

1. 一种在中继辅助网络中进行小区间干扰协调 ICIC 的方法，在所述中继辅助网络中，用户设备 UE 被划分为由基站直接服务的宏 UE 和经由中继节点间接由基站服务的中继 UE，所述方法包括以下步骤：

计算平均中继 UE 比，其中所述平均中继 UE 比是小区中的单个中继节点所服务的中继 UE 数目占所有 UE 数目的平均百分比；

根据所计算的平均中继 UE 比，确定要分配给中继节点的系统带宽，并将剩余的系统带宽分配给基站；以及

基于调度算法来确定中继节点和基站对于所分配的系统带宽的进一步调度。

2. 根据权利要求 1 所述的方法，其中，所述调度算法是依赖于缓冲器队列状态因素的增强比例公平调度算法。

3. 根据权利要求 1 所述的方法，其中，分配给中继节点的系统带宽和分配给基站的系统带宽是相互正交的。

4. 根据权利要求 2 所述的方法，其中确定进一步调度的步骤包括：

基于第一增强比例公平调度算法来计算针对中继节点的第一调度准则，以确定将所分配的系统带宽进一步分配给中继 UE 的调度优先级。

5. 根据权利要求 4 所述的方法，其中通过下式实现第一增强比例公平调度算法，

$$M_r(t) = \arg\max_m \frac{\min\{R^m_{inst}(t),\ R^m_{buffer}(t)\}}{R^m_{aver}(t)},$$

其中，t 表示时间索引，$R^m_{inst}(t)$ 表示中继 UE m 的瞬时可支持数据速率，$R^m_{aver}(t)$ 表示针对某一时间常量 τ 的中继 UE m 的指数滤波平均服务速率，以及 $R^m_{buffer}(t)$ 表示中继 UE m 的期望缓冲速率。

6. 根据权利要求 2 所述的方法，其中确定进一步调度的步骤还包括： 基于第二增强比例公平调度算法来计算针对基站的第二调度准则，以确定将所分配的系统带宽进一步分配给宏 UE 和中继回程链路的调度优先级。

7. 根据权利要求 6 所述的方法，其中通过下式实现第二增强比例公平调度算法，

$$M_e(t) = \arg\max_{n,l_m}\left\{\frac{R^n_{inst}(t)}{R^n_{aver}(t)}, \frac{R^{l_m}_{imp}(t)}{R^{l_m}_{aver}(t)}\right\},$$

其中，t 表示时间索引，$R^n_{inst}(t)$ 表示宏 UE n 的瞬时可支持数据速率，$R^n_{aver}(t)$ 表示针对某一时间常量 τ 的宏 UE n 的指数滤波平均服务速率，$R^{l_m}_{aver}(t)$ 表示中继 UE m 所对应的回程链路的平均速率，以及 $R^{l_m}_{imp}(t)$ 表示考虑了中继缓冲器队列状态的改进型回程链路速率。

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page067

8. 根据权利要求 1 所述的方法，还包括，根据当前的 UE 关联方案和业务量负载信息，确定 UE 是中继 UE 还是宏 UE。

9. 一种中继辅助网络中进行小区间干扰协调 ICIC 的设备，在所述中继辅助网络中，用户设备 UE 被划分为由基站直接服务的宏 UE 和经由中继节点间接由基站服务的中继 UE，所述设备包括：

计算装置，用于计算平均中继 UE 比，其中所述平均中继 UE 比是小区中的单个中继节点所服务的中继 UE 数目占所有 UE 数目的平均百分比；

分配装置，用于根据所计算的平均中继 UE 比，确定要分配给中继节点的系统带宽，并将剩余的系统带宽分配给基站；以及

调度装置，用于基于调度算法来确定中继节点和基站对于所分配的系统带宽的进一步调度。

10. 根据权利要求 9 所述的设备，其中，所述调度算法是依赖于缓冲器队列状态因素的增强比例公平调度算法。

11. 根据权利要求 9 所述的设备，其中，分配给中继节点的系统带宽和分配给基站的系统带宽是相互正交的。

12. 根据权利要求 10 所述的设备，其中所述调度装置包括：

第一调度装置，用于基于第一增强比例公平调度算法来计算针对中继节点的第一调度准则，以确定将所分配的系统带宽进一步分配给中继 UE 的调度优先级。

13. 根据权利要求 12 所述的设备，其中通过下式实现第一增强比例公平调度算法，

$$M_r(t) = \arg\max_m \frac{\min\{R^m_{inst}(t), R^m_{buffer}(t)\}}{R^m_{aver}(t)},$$

其中，t 表示时间索引，$R^m_{inst}(t)$ 表示中继 UE m 的瞬时可支持数据速率，$R^m_{aver}(t)$ 表示针对某一时间常量 τ 的中继 UE m 的指数滤波平均服务速率，以及 $R^m_{buffer}(t)$ 表示中继 UE m 的期望缓冲速率。

14. 根据权利要求 10 所述的设备，其中所述调度装置还包括：第二调度装置，用于基于第二增强比例公平调度算法来计算针对基站的第二调度准则，以确定将所分配的系统带宽进一步分配给宏 UE 和中继回程链路的调度优先级。

15. 根据权利要求 14 所述的设备，其中通过下式实现第二增强比例公平调度算法，

$$M_e(t) = \arg\max_{n,l_m} \left\{ \frac{R^n_{inst}(t)}{R^n_{aver}(t)}, \frac{R^{l_m}_{imp}(t)}{R^{l_m}_{aver}(t)} \right\},$$

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page068

其中，t 表示时间索引，$R^{n}_{inst}(t)$ 表示宏 UE n 的瞬时可支持数据速率，$R^{n}_{aver}(t)$ 表示针对某一时间常量 τ 的宏 UE n 的指数滤波平均服务速率，$R^{l_m}_{aver}(t)$ 表示中继 UE m 所对应的回程链路的平均速率，以及 $R^{l_m}_{imp}(t)$ 表示考虑了中继缓冲器队列状态的改进型回程链路速率。

16. 根据权利要求 9 所述的设备，还包括，确定装置，用于根据当前的 UE 关联方案和业务量负载信息，确定 UE 是中继 UE 还是宏 UE。

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page069

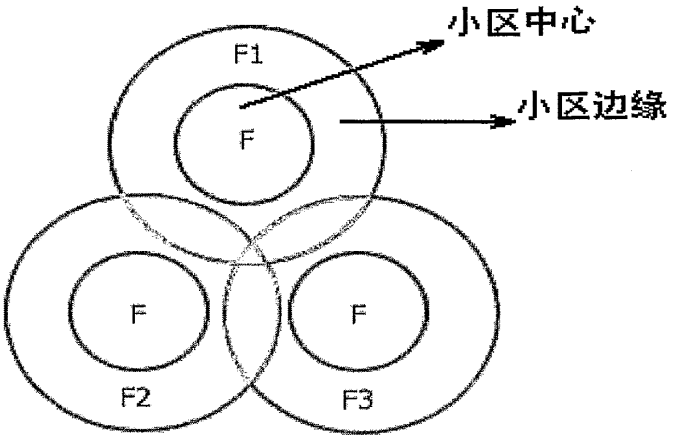


图 1

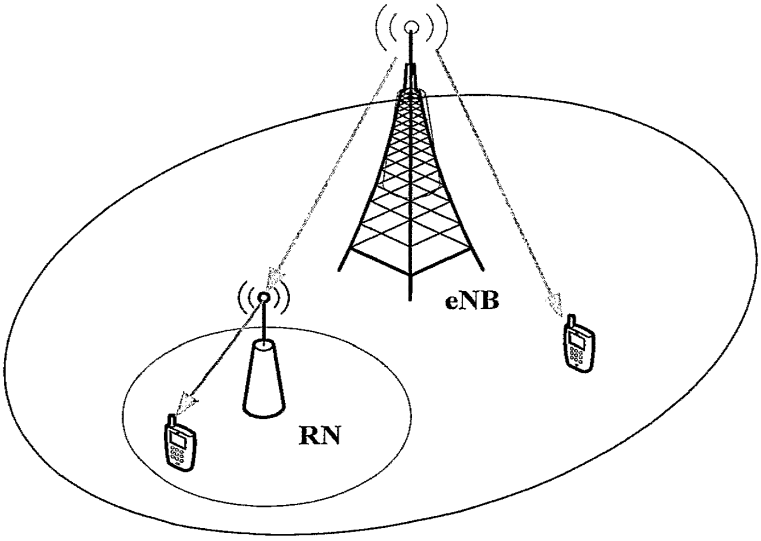


图 2

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page070

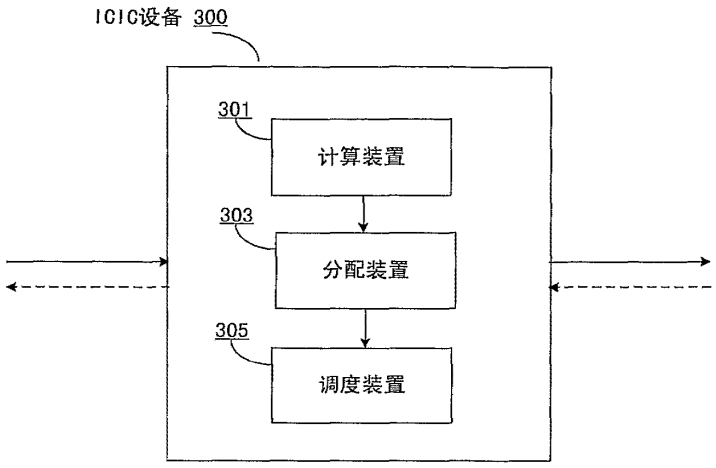


图 3

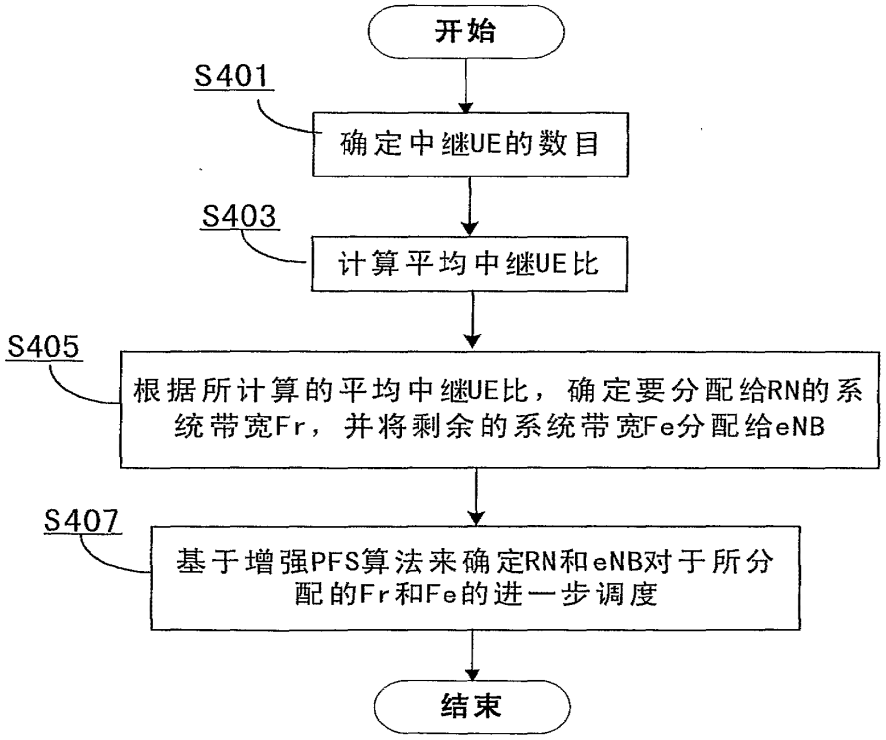


图 4

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page071

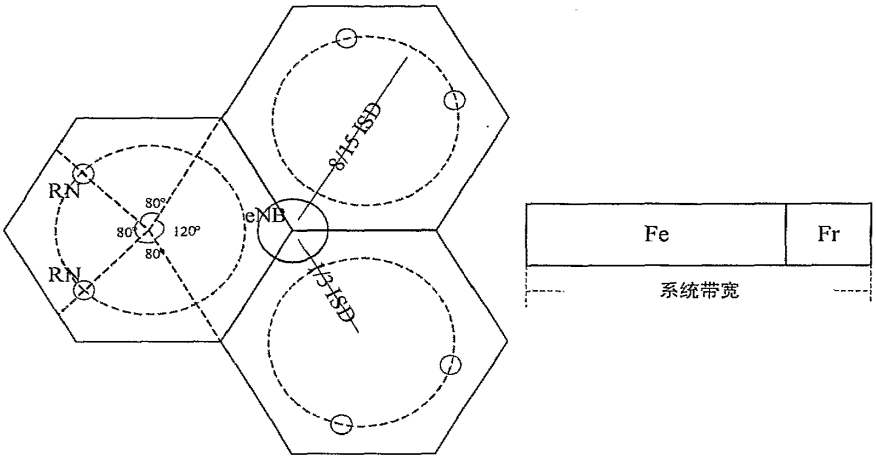


图 5

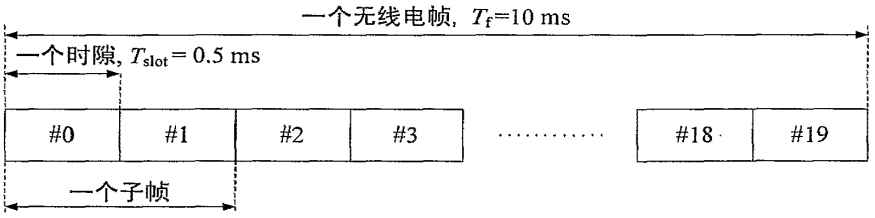


图 6

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page072

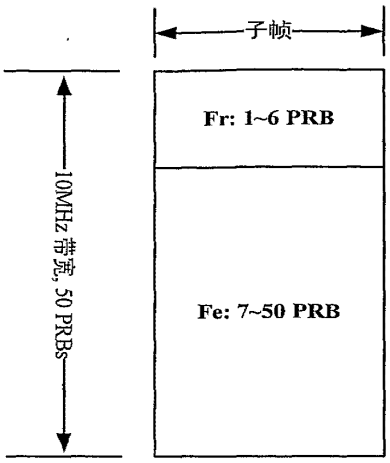


图 7

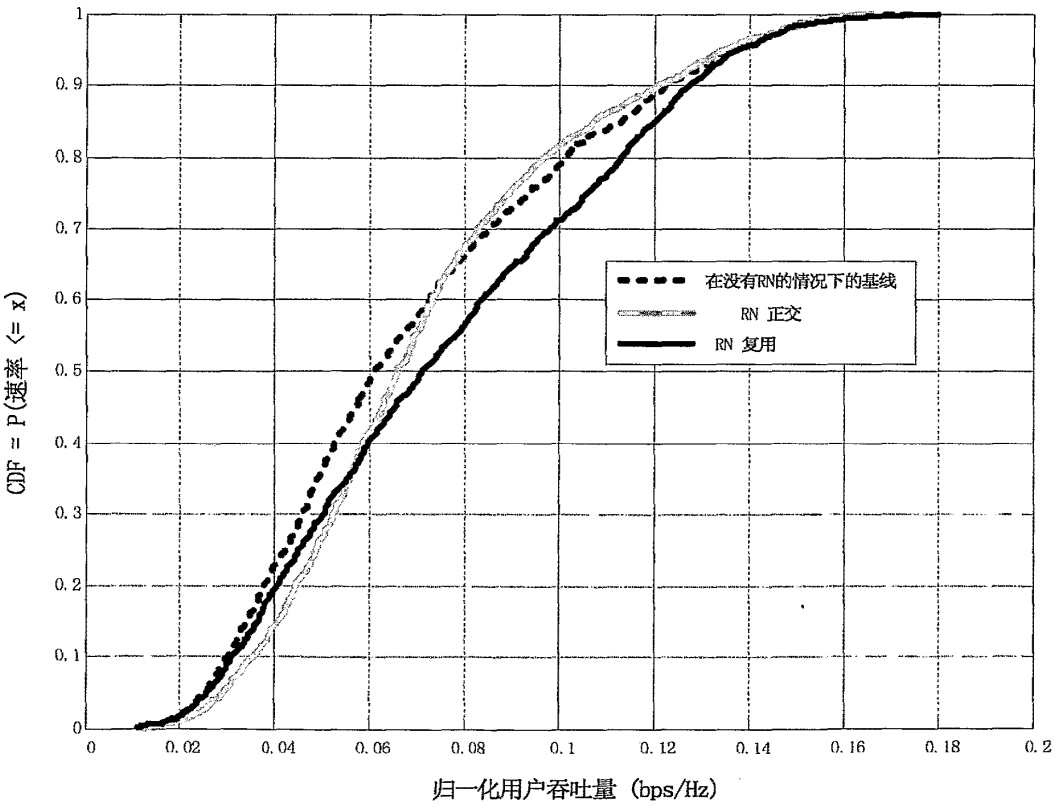


图 8

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page073

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2010/000055

A. CLASSIFICATION OF SUBJECT MATTER

H04W72/00 (2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W72/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CPRSABS,CNKI,WPI,EPODOC: INTERFERENCE W COORDINATION, RELAY, BANDWIDTH, RESOURCE, SCHEDULE, DISTRIBUTE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN101610518A (INTEL CORP)23 Dec.2009 (23.12.2009) See the whole document	1-16
A	CN101009622A (ALCATEL LUCENT)01 Aug.2007 (01.08.2007) See the whole document	1-16
A	CN101335971A(LENOVO BEIJING LTD)31Dec.2008 (31.12.2008) See the whole document	1-16
A	WO2009129413A2 (QUALCOMM INC) 22 Oct.2009 (22.10.2009) See the whole document	1-16

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 Oct.2010(12.10.2010)	**21 Oct. 2010 (21.10.2010)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer JIANG, Jingjing Telephone No. (86-10)62411430

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2010/000055

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN101610518A	23.12.2009	EP2101528A1	16.09.2009
		US2009233544A1	17.09.2009
CN101009622A	01.08.2007	CN100534057C	26.08.2009
		EP1806942A1	11.07.2007
		US2007155431A1	05.07.2007
CN101335971A	31.12.2008	US2009003260A1	01.01.2009
WO2009129413A2	22.10.2009	WO2009129413A3	25.03.2010
		US2009264077A1	22.10.2009

Form PCT/ISA /210 (patent family annex) (July 2009)

国际检索报告

国际申请号
PCT/CN2010/000055

A. 主题的分类

H04W72/00 (2009.01)i

按照国际专利分类(IPC)或者同时按照国家分类和 IPC 两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

IPC：H04W72/-

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CPRSABS,CNKI:干扰协调,中继,带宽,资源,调度,分配,

WPI,EPODOC: INTERFERENCE W COORDINATION, RELAY, BANDWIDTH, RESOURCE, SCHEDULE, DISTRIBUTE

C. 相关文件

类　型*	引用文件，必要时，指明相关段落	相关的权利要求
A	CN101610518A (英特尔公司)23.12 月 2009 (23.12.2009) 全文	1-16
A	CN101009622A (阿尔卡特朗讯公司)01.8 月 2007 (01.08.2007) 全文	1-16
A	CN101335971A(联想有限公司)31.12 月 2008 (31.12.2008) 全文	1-16
A	WO2009129413A2 (QUALCOMM INC) 22.10 月 2009 (22.10.2009) 全文	1-16

☐ 其余文件在 C 栏的续页中列出。　　☒ 见同族专利附件。

* 引用文件的具体类型：
"A" 认为不特别相关的表示了现有技术一般状态的文件
"E" 在国际申请日的当天或之后公布的在先申请或专利
"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）
"O" 涉及口头公开、使用、展览或其他方式公开的文件
"P" 公布日先于国际申请日但迟于所要求的优先权日的文件
"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件
"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性
"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性
"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
12.10 月 2010 (12.10.2010)	**21.10 月 2010 (21.10.2010)**
ISA/CN 的名称和邮寄地址： 中华人民共和国国家知识产权局 中国北京市海淀区蓟门桥西土城路 6 号 100088 传真号：　(86-10)62019451	受权官员 **江婧敬** 电话号码：(86-10) **62411430**

PCT/ISA/210 表(第 2 页) (2009 年 7 月)

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page076

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2010/000055

检索报告中引用的专利文件	公布日期	同族专利	公布日期
CN101610518A	23.12.2009	EP2101528A1	16.09.2009
		US2009233544A1	17.09.2009
CN101009622A	01.08.2007	CN100534057C	26.08.2009
		EP1806942A1	11.07.2007
		US2007155431A1	05.07.2007
CN101335971A	31.12.2008	US2009003260A1	01.01.2009
WO2009129413A2	22.10.2009	WO2009129413A3	25.03.2010
		US2009264077A1	22.10.2009

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page077

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(19) World Intellectual Property Organization
International Bureau

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PCT

(10) International Publication Number
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(51) International Patent Classification:
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(21) International Application Number:
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16 August 2011 (16.08.2011)

(25) Filing Language: English

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(54) Title: DAISY-CHAINED RING OF REMOTE UNITS FOR A DISTRIBUTED ANTENNA SYSTEM

(57) Abstract: The present disclosure is a novel utility of a software defined radio (SDR) based Distributed Antenna System (DAS) that is field reconfigurable and support multi-modulation schemes (modulation-independent), multi-carriers, multi-frequency bands and multi-channels. More specifically, the present invention relates to a DAS utilizing one or more Daisy-Chained Rings of Remote Units. The present invention enables a high degree of flexibility to manage, control, enhance, facilitate the usage and performance of a distributed wireless network such as Flexible Simulcast, automatic traffic load-balancing, network and radio resource optimization, network calibration, autonomous/assisted commissioning, carrier pooling, automatic frequency selection, frequency carrier placement, traffic monitoring, traffic tagging, pilot beacon, etc. As a result, a DAS in accordance with the present invention can increase the efficiency and traffic capacity of the operators' wireless network.

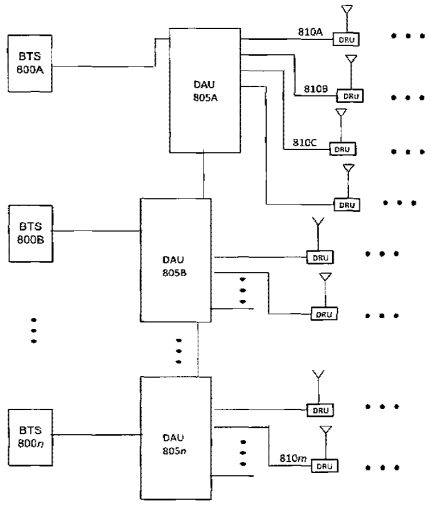


Figure 8

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Daisy-Chained Ring of Remote Units for a Distributed Antenna System

SPECIFICATION

Related Applications

[001] This application claims the benefit of the following U.S. Patent applications, all of which are incorporated herein by reference:

Serial Number	Filing Date	Title
61/374,593	8/17/2010	Neutral Host Architecture for a Distributed Antenna System
61/382,836	9/14/2010	Remotely Reconfigurable Distributed Antenna System and Methods
12/928,931	12/21/2010	Modulation Agnostic Digital Hybrid Mode Power Amplifier System and Method
12/928,933	12/21/2010	Remote Radio Head Unit System with Wideband Power Amplifier and Method
12/928,934	12/21/2010	Multi-Band Wideband Power Amplifier Digital Predistortion System and Method

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page080

12/928,943	12/21/2010	High Efficiency, Remotely Reconfigurable Remote Radio Head Unit System and Method for Wireless Communications
61/439,940	2/7/2011	Daisy Chained Ring of Remote Units for a Distributed Antenna System
[not assigned yet]	8/16/2011	Neutral Host Architecture for a Distributed Antenna System
[not assigned yet]	8/16/2011	Remotely Reconfigurable Distributed Antenna System and Methods
[not assigned yet]	8/16/2011	Daisy Chained Ring of Remote Units for a Distributed Antenna System

FIELD OF THE INVENTION

[002] The present invention generally relates to wireless communication systems employing Distributed Antenna Systems (DAS) as part of a distributed wireless network. More specifically, the present invention relates to a DAS utilizing one or more remotely monitored and controlled digital access units configured to assign particular packet transmissions to selected ones of a plurality of remote units, which can in some embodiments be configured in a daisy-chained rings.

BACKGROUND OF THE INVENTION

[003] Wireless and mobile network operators face the continuing challenge of building networks that effectively manage high data-traffic growth rates.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page081

Mobility and an increased level of multimedia content for end users requires end-to-end network adaptations that support both new services and the increased demand for broadband and flat-rate Internet access. One of the most difficult challenges faced by network operators is maximizing the capacity of their DAS networks while ensuring cost-effective DAS deployments and at the same time providing a very high degree of DAS remote unit availability.

[004] In order to provide DAS network capacity which is high enough to meet short-term needs of network subscribers in specific locations yet also avoid costly and inefficient deployment of radio resources, DAS network planners prefer to employ DAS architectures and solutions which provide a high degree of dynamic flexibility. Therefore, it would be advantageous for wireless network operators to employ a DAS solution which has a high degree of flexibility to implement dynamic rearrangements based on ever-changing network conditions and subscriber needs. Also, the more future-proof a DAS deployment can be, generally the lower its life cycle cost.

[005] DAS network planners and system integrators employ a wide range of innovative approaches for helping to ensure that a particular DAS deployment is as cost-effective as possible. The types of costs considered by network planners and integrators include DAS deployment or DAS installation cost, as well as operational costs including maintenance costs, emergency restoration costs and network re-arrangement costs. Rearrangement costs are particularly significant for indoor DAS applications, due to frequent changes in building use and facility needs changes. Therefore, it would be advantageous to employ DAS systems and methods which are based on as few DAS transport facilities as possible to minimize

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page082

installation and/or lease costs and have self-healing capabilities to avoid the need for costly emergency restoration services.

[006] In order to obtain a high degree of DAS remote unit availability, two primary conditions must be satisfied. First, the DAS remote unit itself must be inherently reliable. Second, the transport media e.g., optical fiber, must be very reliable. It is well known that electronic and/or optical connections themselves are a significant root cause of failure or reduced availability in a DAS network. Companies who maintain outdoor DAS networks have reported that a failure of outside plant optical fiber facilities is not as rare as would be desirable. Therefore, it would be advantageous to employ systems and methods which offer higher redundancy and/or self-healing features in the event of failure of a transport media connection.

SUMMARY OF THE INVENTION

[007] The present invention substantially achieves the advantages and benefits discussed above and overcomes the limitations of the prior art discussed above by providing a distributed antenna system responsive to one or more base stations and having at least one but in some embodiments a plurality of Digital Access Units ("DAU's"), each operating to control the packet traffic of an associated plurality of Digital Remote Units ("DRU's"). In embodiments employing multiple DAU's, the DAU's can be daisy-chained linearly or in a ring configuration. Likewise, depending upon the implementation, the DRU's associated with a given DAU can be configured in either a linear or ring Daisy chain configuration.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page083

[008] The data received from the base stations is down-converted, digitized and converted to baseband with the DAU. The data streams are then I/Q mapped and framed and independently serialized, such that multiple data streams are available in parallel from the DAU. In at least some embodiments, the DAU communicates with the associated DRU's via an optical transport arrangement. It will be appreciated by those skilled in the art that, using the present invention, it is possible to configure a distributed antenna system having *n* base stations, each providing *m* RF outputs for transmission by one or more associated DAU's to *o* DRU's, where the only limits are imposed by the technical performance specifications of the particular DAS, such as delay.

[009] By the use of a ring configuration for connecting, in at least some embodiments, the DRU's and/or the DAU's, fault tolerance is built into the system, with resulting high availability. In single DAU embodiments, each DRU is accessible through two paths, and therefore remains available even in the event of a line break. In multi-DAU embodiments, where the DAU's are linearly daisy-chained, each DRU is accessible from multiple DRU's such that even some DAU failures will not prevent system operation. In embodiments employing a ring connection for the DAU's, multiple paths exist to each DAU, and thus provide an additional level of fault tolerance as well as dynamic load balancing and resource management as discussed in greater detail hereinafter.

[0010] Thus, the configuration of the advanced system architecture of the present invention provides a high degree of flexibility to manage, control, enhance and facilitate the radio resource efficiency, usage, availability, and overall performance of the distributed wireless network. The present

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page084

invention enables specialized applications and enhancements including Flexible Simulcast, automatic traffic load-balancing, network and radio resource optimization, network calibration, autonomous/assisted commissioning, carrier pooling, automatic frequency selection, radio frequency carrier placement, traffic monitoring, traffic tagging, and indoor location determination using pilot beacons. The present invention can also serve multiple operators, multi-mode radios (modulation-independent) and multi-frequency bands per operator to increase the efficiency and traffic capacity of the operators' wireless networks.

[0011] Further the present invention provides a high degree of dynamic flexibility, supports dynamic re-arrangements, and provides a low life cycle cost. This advanced system architecture enables deployment of DAS networks using fewer DAS transport facilities to reduce costs, while providing self-healing features. The present invention also offers redundancy and enhanced system availability.

[0012] It is an object of the present invention to provide Flexible Simulcast capabilities, as disclosed in U.S. Provisional Application S.N. 61/382,836, entitled "Remotely Reconfigurable Distributed Antenna System and Methods," filed September 14, 2010, incorporated herein by reference and attached as Appendix A, in a high-availability ring configuration using, for example, optical fiber transport. As discussed above, the ring configuration insures that a break in any optical fiber cable will not shut down the daisy-chained network, because the downlink and uplink signals can be rerouted around the cable break to the respective DRUs.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page085

[0013] It is a further object of the present invention to balance the bidirectional data rate on the optical fibers so as to increase the maximum achievable data rate during operation on the ring network of DRUs.

[0014] It is a further object of the present invention to provide higher transport network capacity in the event the data transport is asymmetrical between the downlink and uplink, as is typically the case for mobile broadband networks.

[0015] It is a further object of the present invention to provide an adaptive and automatic control for optimizing the transport media capacity on the ring.

[0016] It is a further object of the present invention to provide a method of summing co-channel users' uplink signals in the DRU daisy chain.

[0017] Applications of the present invention are suitable to be employed with distributed base stations, distributed antenna systems, distributed repeaters, mobile equipment and wireless terminals, portable wireless devices, and other wireless communication systems such as microwave and satellite communications. The present invention is also field upgradable through a link such as an Ethernet connection to a remote computing center.

[0018] Appendix I is a glossary of terms used herein, including acronyms.

THE FIGURES

[0019] Further objects and advantages of the present invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

[0020] Figure 1 is a block diagram according to one embodiment of the invention showing the basic structure and an example of a unidirectional,

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page086

channelized downlink transport, one ring scenario based on having one DAU and four DRUs.

[0021] Figure 2 is a block diagram in accordance with an embodiment of the invention showing the basic structure and an example of a unidirectional, channelized uplink transport, one ring scenario based on having one DAU and four DRUs.

[0022] Figure 3 is a block diagram in accordance with an embodiment of the invention showing the basic structure and an example of a unidirectional, channelized uplink transport, two ring scenario based on having one DAU and eight DRUs.

[0023] Figure 4 is a block diagram in accordance with an embodiment of the invention showing the basic structure and an example of a unidirectional channelized uplink or downlink transport. This example of a five ring scenario comprises two DAUs and twenty DRUs.

[0024] Figure 5 illustrates an embodiment of a cellular network system employing multiple DRUs according to the present invention.

[0025] Figure 6 illustrates an embodiment of a multi-band system employing six different services operating in different frequency channels with multiple DRUs according to the present invention.

[0026] Figure 7 illustrates in block diagram form the interaction between the DAU embedded software control module and the DRU embedded software control module.

[0027] Figure 8 illustrates in block diagram form an embodiment of a DAS according to an aspect of the invention, including daisy-chained DAU's.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page087

DETAILED DESCRIPTION OF THE INVENTION

[0028] The present invention is a novel Reconfigurable Distributed Antenna System that provides a high degree of flexibility to manage, control, re-configure, enhance and facilitate the radio resource efficiency, usage and overall performance of the distributed wireless network. Figure 1 illustrates an embodiment of the Distributed Antenna System 100 in accordance with the present invention. The system employs a Digital Access Unit functionality 105 (hereinafter "DAU"). The DAU 105 serves as an interface between associated base stations (BTS) 110A-B and a plurality of digital remote units (DRU) 125A-n, although only four DRU's are shown in Figure 1. In the present description, "DRU" will be used interchangeably with Remote Radio Head Unit, or "RRU", because of the similarity of the functions discussed herein, although those skilled in the art will recognize that a DRU communicates with a DAU, whereas an RRU communicates with a base station. In addition, those skilled in the art will recognize that a DAU is monitored and controlled by a remote network operations center ("NOC"), as indicated at bidirectional link 115 in Figure 1. Such links are typically Ethernet connections or external modems, but can be any form of link suitable for remote monitoring and control. The NOC has the capability to remotely configure the DAU parameter settings which in turn configures the DRU's parameter settings. The NOC can request information from the DAUs. The DAUs can subsequently request information from the DRUs. The information requested includes but is not limited to uplink power, downlink power, optical error rate, gain settings, active carriers, etc.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page088

[0029] For the downlink (DL) path, RF input signals 120A through 120*n* are received at the DAU 105 from one or more base station units (BTS) indicated at 110A through 110p. The RF input signals are separately down-converted, digitized, and converted to baseband (using a Digital Down-Converter) by the DAU. Data streams are then I/Q mapped and framed and specific parallel data streams are then independently serialized and translated to optical signals using pluggable SFP modules, again by the DAU 105. The independently serialized, parallel data streams are then delivered to different DRU's 125A-125*k*, typically over optical fiber cable arranged, in at least some embodiments, in a ring configuration indicated at connection pairs 140A-145A, or, in other embodiments, a daisy chain configuration. In addition, each DAU can support a plurality of rings with associated DRU's, where the additional rings are indicated by fiber optic pairs up through 140*o*-145*o*. . It will be appreciated by those skilled in the art that the number of RF inputs, DAU's and DRU's and rings is limited only by network performance factors, such as delay. In addition, as discussed in connection with Figure 4 herein, the DAS can be further extended by using a ring or daisy-chain of DAU's, each of which supports an arrangement of DRU's and rings as shown in Figure 1.

[0030] One function of the DAU 105 is to determine the direction in which downlinked channels are propagated around the ring. As just one example, the embodiment shown in Figure 1 is configured to have downlink channels A, B, C and D propagate in a first direction, for example clockwise, and channels E, F, G, and H propagate in the counter direction, although it will be understood that the number of channels propagating in each direction need not be equal, nor adjacent, nor sequential. Likewise, the number of channels

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page089

received at each DRU is assigned by the DAU and need not be equal, adjacent or sequential, but instead will typically be any configuration that optimizes network utilization.

[0031] Referring next to Figure 2, an embodiment of an uplink (UL) path in accordance with the invention can be better appreciated. Channels received at the antenna associated with each DRU are converted into optical signals by each DRU 125A-125*k*. Optical signals received from the DRU's are de-serialized and de-framed by the DAU 105, and are also up-converted digitally using a Digital Up-Converter implemented within the DAU 105. Each data stream is then independently converted to the analog domain and up-converted to the appropriate RF frequency band, still within the DAU 105 in the illustrated implementation, although this functionality can be separate. The RF signals are then delivered to the appropriate one of a plurality of BTS' 110A-110*p*. As with the arrangement shown in Figure 1, the direction of propagation of each channel is controlled by the DAU, with some channels propagating in a clockwise direction and others in a counterclockwise direction. Also as discussed in connection with Figure 1, while adjacent channels are shown as propagating in the same direction in Figure 2, this is not required and any channel can be selected to propagate in either direction.

[0032] Referring again to Figure 1, it will be appreciated by those skilled in the art that, in some implementations of a DAS, more than one carrier can exist in each channel, and, as such, a DRU may receive a channel comprising a signal containing two or more carriers, or a wireless operator may have more than one RF carrier per channel allocated to a single base station. This is referred to as a "composite signal". The manner in which a composite downlink signal is managed by the present invention can be better

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page090

understood with reference to Figure 1. In such instances, the DAU will receive a composite downlink input signal 130 from, e.g., a first base station 110A belonging to one wireless operator, enters the DAU 105 at the RF input port 120A. Composite signal 130 comprises carriers A-D. A second composite downlink input signal from e.g., a *p*th base station 110*p* belonging to the same wireless operator enters DAU1 at the DAU1 RF input port 120*n*. Composite signal 135 comprises carriers E-H. The functionality of the DAU 105, and DRU's 125A-125*k*, respectively, are explained in detail in U.S. Provisional Application S.N. 61/374,593, entitled "Neutral Host Architecture for a Distributed Antenna System," filed August 17, 2010, incorporated herein by reference and attached hereto as Appendix B.

[0033] One optical output of DAU 105 is fed to DRU 125A, via bidirectional optical cable 140A. A second optical output of DAU 105 is fed via bidirectional optical cable 145A to DRU3. Similarly, bidirectional optical cables 150, 155 and 160 connect DRU's 125A-n in a ring configuration, such that DRU 125A connects to DRU 125B via cable 150A, DRU 125B connects to DRU 125n via cable 150B, and DRU 125*k* connects to DRU 125C, or the *k*th-1 DRU, via cable 150*m*. This connection facilitates networking of DAU 105, which means that all of Carriers A-H are available within DAU 105 to transport data to DRU's 125A-*k* depending on software settings within the networked DAU system. Depending upon the embodiment, the software settings within DRU 125A are configured either manually or automatically, such that carriers A-H are present in the downlink output signal 155A at the antenna port of DRU 125A. The presence of all eight carriers means that DRU 125A is potentially able to access the full capacity of both base stations feeding DAU 105. A possible application for DRU125A is a cafeteria in an

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page091

enterprise building during the lunch hour where a large number of wireless subscribers are gathered.

[0034] DRU 125B is fed by a second optical port of DRU 125A via bidirectional optical cable 150A. The optical cable 150A performs the function of daisy chaining DRU 125A with DRU125B. As with DRU 125A, the software settings within DRU 125B are configured either manually or automatically such that Carriers A, C, D and F are present in downlink output signal 155B at the antenna port of DRU 125B. The capacity of DRU 125B is set to a much lower value than DRU 125A by virtue of its specific channel settings as controlled by DAU 105. The individual Digital Remote Units have integrated frequency selective DUCs and DDCs with gain control for each carrier. The DAU's can remotely turn on and off the individual carriers via the gain control parameters.

[0035] In a similar manner as described previously for DRU 125A, the software settings within DRU 125C are configured either manually or automatically such that Carriers B and F are present in downlink output signal 155C at the antenna port of DRU 125C. Compared to the downlink signal 155B at the antenna port of DRU 125B, the capacity of DRU 125C, which is also configured via its software settings, is much less than the capacity of DRU 125B. DRU 125n is fed by the optical cable 150m connected to the second optical port of the n^{th}-1 DRU, shown for simplicity in Figure 1 as DRU 125C. The software settings within DRU 125n are configured either manually or automatically such that carriers A, D, E and H are present in downlink output signal 155D at the antenna port of DRU 125n. Typically, the capacity of DRU 125n is set to a much lower value than DRU 125A, however, the relative capacity settings of each of DRU's 125A-n can

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page092

be adjusted dynamically to meet the capacity needs within the coverage zones determined by the physical positions of antennas connected to those DRU's. As noted above, the ring connection is completed by interconnecting DRU 125B and DRU 125n through optical cable 150B. The ring configuration insures that any optical cable breaks will not shut down the daisy chained network. The downlink and uplink signals will be rerouted around the cable break to the respective DRUs.

[0036] The present invention facilitates conversion and transport of several discrete relatively narrow RF bandwidths. This approach allows conversion of only those multiple specific relatively narrow bandwidths which carry useful or specific information. This approach also allows more efficient use of the available optical fiber transport bandwidth for neutral host applications, and allows transport of more individual operators' band segments over the optical fiber. As disclosed in U.S. Provisional Application S.N. 61/374593, entitled "Neutral Host Architecture for a Distributed Antenna System," filed August 17, 2010 together with U.S. Provisional Application S.N. 61/382,836, entitled "Remotely Reconfigurable Distributed Antenna System and Methods", filed September 14, 2010, both assigned to the assignee of the present invention, and also referring to Figure 1 of the instant patent application, Digital Up Converters located within the DRU can be dynamically reconfigured as the result of commands from the NOC to transport from the DAU input to any specific DRU output any specific narrow frequency band or bands, RF carriers or RF channels which are available at the respective RF input port of either DAU. This capability is illustrated in Figure 1 where only specific frequency bands or RF carriers appear at the output of a given DRU. More specifically, through commands received from the NOC, the FPGA's in the

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page093

DAU and one or more of the associated DRU's can be reprogrammed or reconfigured to convert and transport only the desired narrow bandwidths.

[0037] A related capability of the present invention is that not only can the Digital Up Converters located within each DRU be configured to transport any specific narrow frequency band from the DAU input to any specific DRU output, but also the Digital Up Converters within each DRU can be configured to transport any specific time slot or time slots of each carrier from the DAU input to any specific DRU output. The carriers and time slots are monitored by the DAU by filtering the signals and performing power detection of the individual time slots, which information can be conveyed to the NOC as desired. Then, as with the Digital Up Converters, the Field Programmable Gate Arrays (FPGA) in the DAU or DRU can be dynamically reconfigured by commands received from the NOC in a manner analogous to software programmability. The DAU detects which carriers and corresponding time slots are active. This information is relayed to the individual DRUs via the management control and monitoring protocol software. This information is then used, as appropriate, by the DRUs for turning off and on individual carriers and their corresponding time slots.

[0038] Data transport between the Base Station and the subscribers is typically asymmetrical, whereby the downlink data rate is higher than the uplink rate. The ring network configuration of Daisy Chained DRUs can exploit this data rate asymmetry to maximize the data transport on the optical fibers 150A-150*m*.

[0039] The present invention balances the bidirectional data rate on the optical fibers so as to increase the maximum achievable data rate on the ring network of DRUs. The individual downlink channels are transmitted in a

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page094

unidirectional sense along the ring network. Referring to Figure 1, downlink channels A, B, C, and D are transmitted in a clockwise sense around the ring of DRU's 125A-*k*. On the other hand, downlink channels E, F, G and H are transmitted in a counterclockwise sense around the ring of DRU's. Referring to Figure 2, the uplink channels J, K, L and M are transmitted in a counterclockwise sense whereas uplink channels N, O, P and Q are transmitted in a clockwise sense around the ring of DRUs. If the downlink and uplink data rates were the same, there would be no advantage in the transport mechanism. However, if the data transport is asymmetrical between the downlink and uplink then a significant advantage can be gained. For example, for a factor of two difference between the downlink and uplink data rates, a 4/3 factor increase in data transport can be achieved. The larger the asymmetry between the downlink and uplink data rates, the larger will be the increase in data transport using the unidirectional channel transport mechanism around the ring.

[0040] Referring again to Figure 1, a further embodiment in accordance with another aspect of the present invention may be better understood. In the event that there is a significant change in asymmetry between the downlink and uplink data rates and/or if there is a change in channel complement at the BTS, the Management Control module [discussed in connection with Figure 7 herein] which is typically comprised within each DAU is able to automatically and adaptively re-allocate data transport resources on the clockwise direction of the ring and on the counter-clockwise direction of the ring to maximize the overall transport capacity. As stated previously, the larger the degree of asymmetry between uplink and downlink data rates for a particular DAU, the higher the increase in data transport using the

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page095

unidirectional channel transport mechanism around the ring. If there is more than one DAU present, in an embodiment one DAU is designated a Master DAU by the NOC, and the Management Control module located in the Master DAU makes decisions to optimize the overall transport capacity. In the event the master DAU fails, the NOC can designate another DAU as master. Alternatively, any suitable failover algorithm can be implemented.

[0041] Referring to Figure 3, an alternative embodiment of the present invention wherein a single DAU controls a plurality of rings, each comprising a plurality of daisy-chained DRU's, can be better understood. In Figure 3, two daisy-chained rings, indicated at 300 and 305, are shown although the number of rings could be greater and is determined mainly as a matter of design preference up to limits imposed by network performance. The rings each link a plurality of DRU's 310A-*n* and 315A-*m*, to a single DAU 320. The directional flow of the data transport is shown as the dashed lines 325 and dotted lines 330. The downlink channels available from the plurality of DRU's are divided into two subsets which flow in opposite directions around the two daisy-chained rings. The uplink channels are transported in a similar fashion. The channels are grouped into the two subsets so as to maximize the data transport to and from the DRUs. The DAU in turn communicates with one or more BTS's via RF Ports 335A-*p*.

[0042] Heuristic algorithms may be used to allocate RF channel data in a Dual-ring DAS. For Figure 3, there are two fibre rings R1, R2 (clockwise and counter clockwise) and a set T of $n \geq 2$ independent RF channels K*i*, $1 \leq i \leq n$ (including uplink and downlink). A channel K*i* requires a bandwidth of b(K*i*) to transport on a fibre ring. A time-bounded algorithm exists which obtains a schedule having the optimal bandwidth allocation (i.e. the maximum

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page096

aggregate bandwidth of each ring is as small as possible). A large number of advanced heuristic algorithms have been developed to solve such scheduling optimization problems. Some examples are genetic algorithm, evolutionary algorithm, greedy search, Tabu search, harmony search, simulated annealing, ant colony optimization, etc. For purposes of simplicity and clarity, a simple heuristic algorithm for two rings is described here, although the number of rings is not limited to two.

[0043] The algorithm begins by sorting the channels K*i* decreasingly by bandwidth b(K*i*). Then it schedules the channel in such a way that each channel is assigned to the ring which has the smaller aggregate bandwidth. The formal description of the algorithm follows.

[0044] Input: T = set of *n* independent channels K*i* with required bandwidth b(K*i*), $1 \le i \le n$.

[0045] Output: L_1, L_2 and D_1, D_2. L*j* is the set of channels schedule on ring R*j* , and D_j is the maximum aggregate bandwidth of ring R*j*, D*j* = ($\sum b(J)$, $J \epsilon L_j$), $1 \le j \le 2$.

[0046] ALGORITHM (T, L, D)

[0047] Step 1 (initialize K*i* and D_1, D_2) Sort K*i* such that $b(Ki) \le b(Ki_{+1})$, $1 \le i \le n-1$. $D_1 \leftarrow 0$, $D_2 \leftarrow 0$.

[0048] Step 2 (Schedule a channel)

[0049] For *i* =1 to *n,* step 1 do

[0050] If $D_1 \le D_2$, then [assign K*i* onto L_1, $D_1 \leftarrow D_1 + b(Ki)$] .

[0051] else [assign K*i* onto L_2, $D_2 \leftarrow D_2 + b(Ki)$] .

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page097

[0052] Referring next to Figure 4, a still further an alternative embodiment of the present invention may be understood. The arrangement illustrated in Figure 1 comprised downlink signals from two separate base stations belonging to the same wireless operator entering the DAU 105 at input ports 110A and 110p, respectively. In the embodiment of Figure 4, a first composite signal enters a first DAU 400 at that DAU's RF input port from a base station 405, and a second composite downlink input signal from, e.g., a second base station 410 belonging to a different wireless operator enters DAU 415 at that second DAU's RF input port. DAU 400 directly supports two rings 420 and 425, DAU 415 directly supports two rings 430 and 435, and a ring 440 is shared between DAU 400 and DAU 405. Each of the rings comprises daisy-chained DRU's generally indicated at 445 and connected via, for example, fiber optic links, as discussed in connection with Figure 1. It will be noted that channels A are transported in the opposite sense as channels B. The downlink channels in subset A are transported counterclockwise around each ring, whereas the channels in subset B are transported in a clockwise sense around each ring. In this embodiment, signals belonging to both the first operator and the second operator are converted and transported to the DRU's 445 on ring 440 because DAU 400 and DAU 405 are daisy-chained through the fiber optic cable 440. This embodiment provides an example of a neutral host wireless system, where multiple wireless operators share a common infrastructure comprised of DAU 400, DAU 415, and DRU's 445. All the previously mentioned features and advantages accrue to each of the two wireless operators. It will further be appreciated that, while Figure 4 illustrates only two DAU's linked in daisy-chain style, it is possible to daisy chain a larger plurality of DAU's, and the

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page098

daisy-chained DAU's can also be configured in a ring configuration similar to the manner in which the DRU's are connected. This arranged is illustrated in Figure 8, below.

[0053] As disclosed in U.S. Provisional Application S.N. 61/374,593, entitled "Neutral Host Architecture for a Distributed Antenna System," filed August 17, 2010 and again referring to Figure 1 of the instant patent application, the Digital Up Converters present in the DRU's of the present invention can be programmed to process various signal formats and modulation types including FDMA, CDMA, TDMA, OFDMA and others. Also, the Digital Up Converters present in the respective DRUs can be programmed to operate with signals to be transmitted within various frequency bands subject to the capabilities and limitations of the system architecture disclosed in U.S. Provisional Application S.N. 61/374593, mentioned above. In one embodiment of the present invention where a wideband CDMA signal is present within, e.g., the bandwidth corresponding to a first carrier at the input port to DAU 105, the transmitted signal at the antenna ports of DRU 125A, DRU 125B and DRU*k* will be a wideband CDMA signal which is virtually identical to the signal present within the bandwidth corresponding to that first carrier at the input port to DAU 105.

[0054] As disclosed in U.S. Provisional Application S.N. 61/374,593, again identified above, and also referring to Figure 1 of the instant patent application, it is to be understood that the Digital Up Converters present in the respective DRUs can be programmed to transmit any desired composite signal format to each of the respective DRU antenna ports. As an example, the Digital Up Converters present in DRU 125A and DRU 125B can be dynamically software-reconfigured as described previously so that the signal

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page099

present at the antenna port of DRU 125A would correspond to the spectral profile shown in Figure 1 as 155A and also that the signal present at the antenna port of DRU 125B would correspond to the spectral profile shown in Figure 1 as 155B. The application for such a dynamic re-arrangement of DRU capacity would be e.g., if a company meeting were suddenly convened in the area of the enterprise corresponding to the coverage area of DRU 125B.

[0055] Referring again to Figure 2, another embodiment of the Distributed Antenna System of the present invention can be better understood. As disclosed in the aforementioned U.S. Provisional Application S.N. 61/374,593, and also as shown in Figure 2, the optical ring transport mechanism can be implemented with regard to uplink signals. As discussed previously with regard to downlink signals and by referring to Figure 1, the uplink system shown in Figure 2 is mainly comprised of DAU 105, together with DRU's 125A-125k. In a manner similar to the downlink operation explained by referring to Figure 1, the operation of the uplink system shown in Figure 2 can be understood as follows.

[0056] The Digital Down Converters present in each of DRU's 125A-*k* are dynamically software-configured as described previously so that uplink signals of the appropriate desired signal format(s) present at the receive antenna ports of the respective DRU's 125A-125k are selected based on the desired uplink band(s) to be processed and filtered, converted and transported to the appropriate uplink output port of DAU 105. The DAU and DRUs frame the individual data packets corresponding to their respective radio signature using the Common Public Interface Standard (CPRI). Other Interface standards are applicable provided they uniquely identify data

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page100

packets with respective DRUs. Header information is transmitted along with the data packet which indentifies the DRU and DAU that corresponds to the individual data packet.

[0057] In one example for the embodiment shown in Figure 2, DRU's 125A and 125C are configured to receive uplink signals within the Channel K bandwidth, whereas DRU 125B and DRU 125*n* are both configured to reject uplink signals within the Channel K bandwidth. When DRU 125C receives a strong enough signal at its receive antenna port within the Channel K bandwidth to be properly filtered and processed, the Digital Down Converters within DRU 125C facilitate processing and conversion. Similarly, when DRU 125A receives a strong enough signal at its receive antenna port within the Channel K bandwidth to be properly filtered and processed, the Digital Down Converters within DRU 125A facilitate processing and conversion. The signals from DRU 125A and DRU 125C are combined based on the active signal combining algorithm, and are fed to the base station connected to the uplink output port of DAU 105. The term simulcast is frequently used to describe the operation of DRU125A and DRU 125C with regard to uplink and downlink signals within Channel K bandwidth. The term Flexible Simulcast refers to the fact that the present invention supports dynamic and/or manual rearrangement of which specific DRU are involved in the signal combining process for each Channel bandwidth.

[0058] Referring still to Figure 2, the Digital Down Converters present in DRU 125A are configured to receive and process signals within Channel J-Q bandwidths. The Digital Down Converters present in DRU 125B are configured to receive and process signals within Channel J, L, M and O bandwidths. The Digital Down Converters present in DRU 125C are

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page101

configured to receive and process signals within Channel K and O bandwidths. The Digital Down Converters present in DRU 125*n* are configured to receive and process signals within Channel J, M, N and Q bandwidths. The respective high-speed digital signals resulting from processing performed within each of the four DRU are routed to the DAU. As described previously, the uplink signals from the four DRUs are combined within the respective DAU corresponding to each base station.

[0059] In summary, the Reconfigurable Distributed Antenna System of the present invention described herein efficiently conserves resources and reduces costs. The reconfigurable system is adaptive or manually field-programmable, since the algorithms can be adjusted like software in the digital processor at any time.

[0060] Referring next to Figure 5, a alternative embodiment of the present invention may be better understood. Each DRU has a coverage radius that can be adjusted based on the power transmission from that particular remote unit. The DAU controls the various DRU's transmission power and can optimize the overall coverage zone. In the illustrated embodiment, DAU 502, again under the control of a NOC (not shown), is associated with a base station 501 and in turn interfaces with three DRU's 503, 504 and 505. A user 506 with a mobile device is provided relatively uniform coverage throughout the area covered by the three DRU's.

[0061] Referring next to Figure 6, a still further alternative embodiment may be better appreciated. The input frequency bands 605-630 (here denoted as six frequency bands at 700, 800, 850, 1900, 2100 and 2600 MHz) are input into the DAU 600 from the BTS's (not shown). The DAU includes, among other functionalities discussed herein, an RF IN portion for each band, and a

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page102

digital distribution matrix for distributing the frequency bands to a plurality of DRU's, indicated as DRU1-DRU60, daisy-chained along three separate rings 635, 640 and 645 for achieving the desired coverage. The frequency bands are transported to either all or a subset of DRUs. The particular number of frequency bands, DAU's, DRU's and rings is exemplary only, and can, in practice, be any number appropriate to the performance capabilities and needs of the network.

[0062] Referring next to Figure 7, the software embedded in the DAU and DRU, which controls the operation of keys functions of these devices, can be better understood. In particular, the DAU embedded software control module 700 comprises a DAU Management Control Module 705 and a DAU monitoring module 710. The DAU Management Control Module 705 communicates with the NOC 715, and also the DAU monitoring module 710. One such key function is determining and/or setting the appropriate amount of radio resources (such as RF carriers, CDMA codes or TDMA time slots) assigned to a particular DRU or group of DRUs to meet desired capacity and throughput objectives. As noted previously, the NOC 715 monitors the DAS operation and sends commands to the DAU's for configuring various functions of the DRU's as well as the DAU, in at least some embodiments.

[0063] The DAU Monitoring module, in addition to other functions, detects which carriers and corresponding time slots are active for each DRU. The DAU Management Control module communicates with the DRU Embedded Software Control module 720 over a fiber optic link control channel via a control protocol. In an embodiment, the control protocol comprises headers together with packets of data, such that both control information and data are transmitted to the DRU's together as a message. DRU functions or features

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page103

that the header would control in the DRU are typically implementation specific and can include, among other things, measuring uplink and downlink power, measuring gain of uplink and downlink, and monitoring alarms in the DRU.

[0064] In turn, the DRU Management Control module 725 within the DRU Embedded Software Control Module sets the individual parameters of all the DRU Digital Up-Converters 730 to enable or disable specific radio resources from being transmitted by a particular DRU or group of DRUs, and also sets the individual parameters of all the DRU Digital Down-Converters 735 to enable or disable specific radio resources from being transmitted by a particular DRU or group of DRUs. In addition, the DRU Embedded Software Control Module comprises a DRU Pilot Beacon Control Module 740, which communicates with a DRU Pilot Beacon 745.

[0065] Referring next to Figure 8, an embodiment of a daisy-chained configuration of DAU's is illustrated, together with a daisy-chained configuration of DRU's. In an embodiment, a plurality of base stations 800A-800*n* are each associated with one of DAU's 805A-*n*. The DAU's are daisy-chained, and each DAU communicates with one or more daisy-chains 810A-810*m* of DRU's which may or may not be arranged in a ring configuration. It will be appreciated that the DAU's can also be configured in a ring configuration, as discussed above.

[0066] An algorithm operating within the DAU Monitoring module which detects which carriers and corresponding time slots for each carrier are active for each DRU provides information to the DAU Management Control module to help identify when, e.g., a particular downlink carrier is loaded by a percentage greater than a predetermined threshold whose value is

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page104

communicated to the DAU Management Control module by the DAU's Remote Monitoring and Control function 715. If that occurs, the DAU Management Control module can adaptively modify the system configuration to begin to deploy, typically although not necessarily slowly, additional radio resources (such as RF carriers, CDMA codes or TDMA time slots) for use by a particular DRU which need those radio resources within its coverage area. At the same time, usually the DAU Management Control module adaptively modifies the system configuration to begin to remove, again typically slowly, certain radio resources (such as RF carriers, CDMA codes or TDMA time slots) for use by a particular DRU where that DRU no longer needs those radio resources within its coverage area.

[0067] Although the present invention has been described with reference to the preferred embodiments, it will be understood that the invention is not limited to the details described thereof. Various substitutions and modifications have been suggested in the foregoing description, and others will occur to those of ordinary skill in the art. Therefore, all such substitutions and modifications are intended to be embraced within the scope of the invention as defined in the appended claims.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page105

What is Claimed is:

1. A method for routing and switching operator RF signals comprising

providing one or more remote radio units, each configured to receive one or more downlink radio frequencies and to transmit one or more uplink radio frequencies,

providing at least one digital access unit configured to communicate with at least some remote radio units,

linking in a loop configuration the one or more remote radio units and the at least one digital access unit whereby each remote radio unit can be accessed in either direction around the loop, and

routing and switching packetized signals among the one or more radio units and the at least one digital access units.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page106

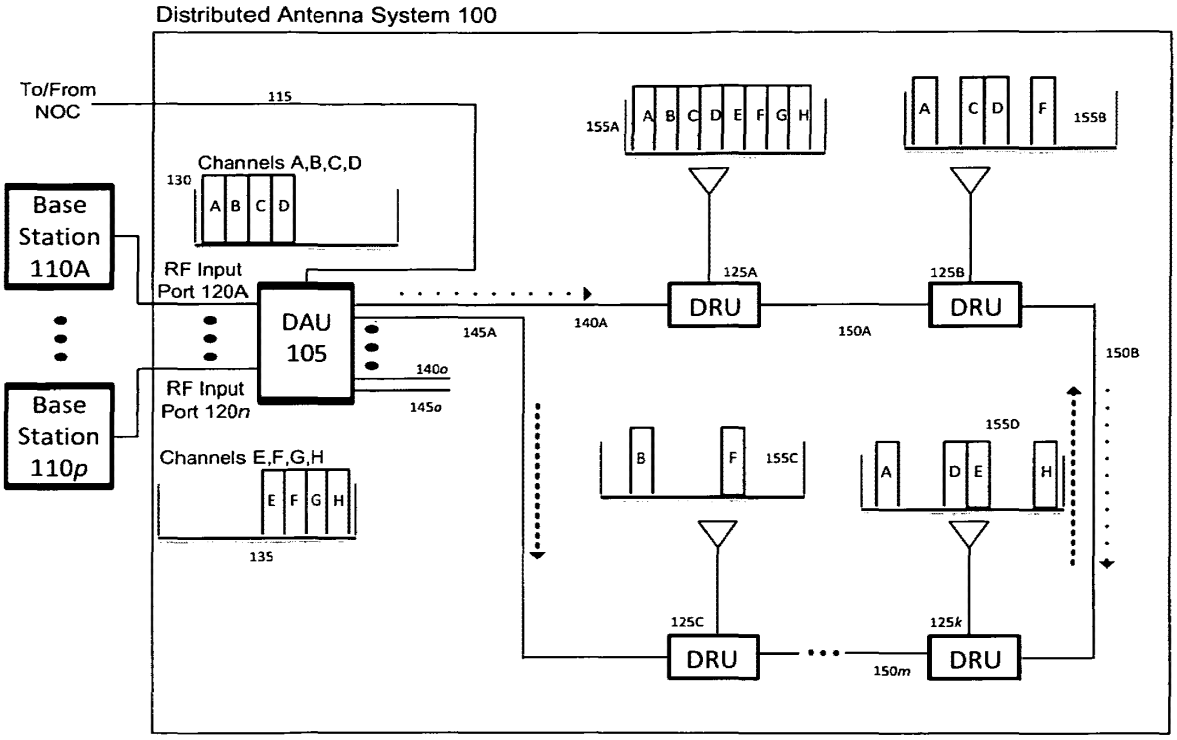


Figure 1

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page107

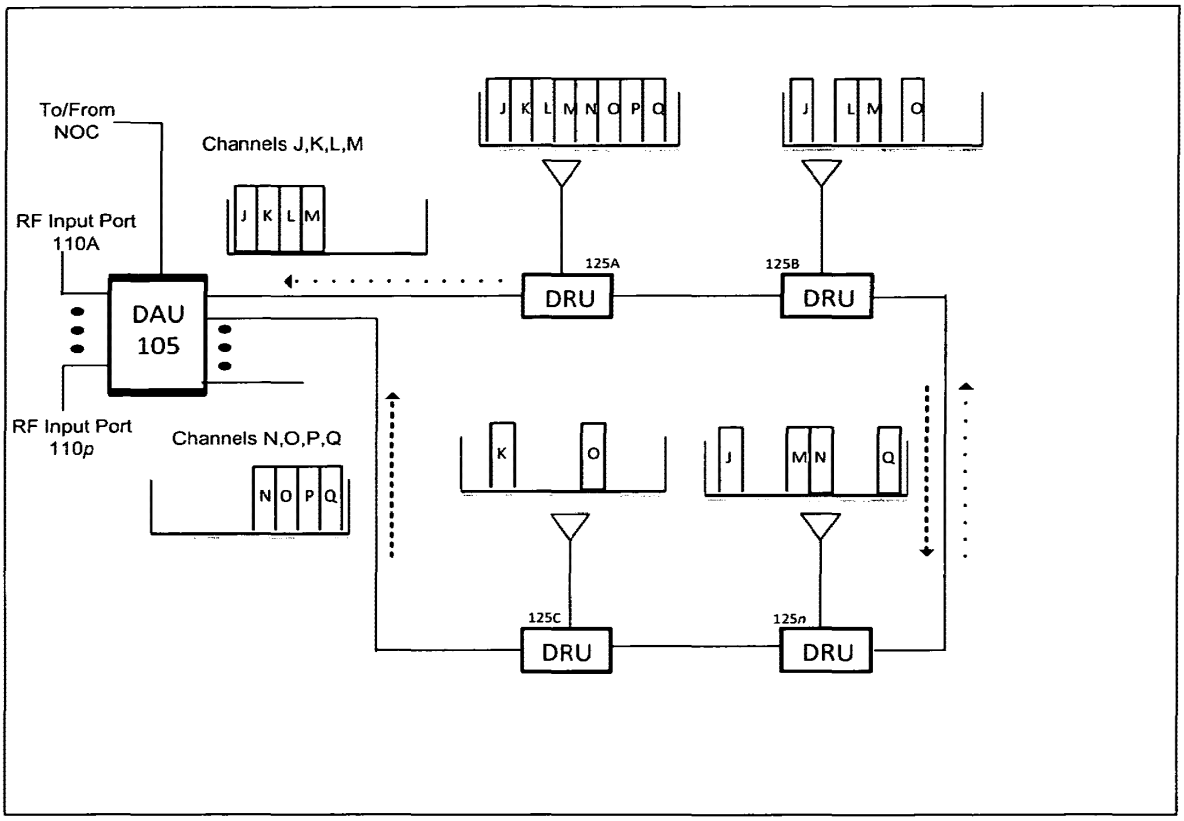


Figure 2

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page108

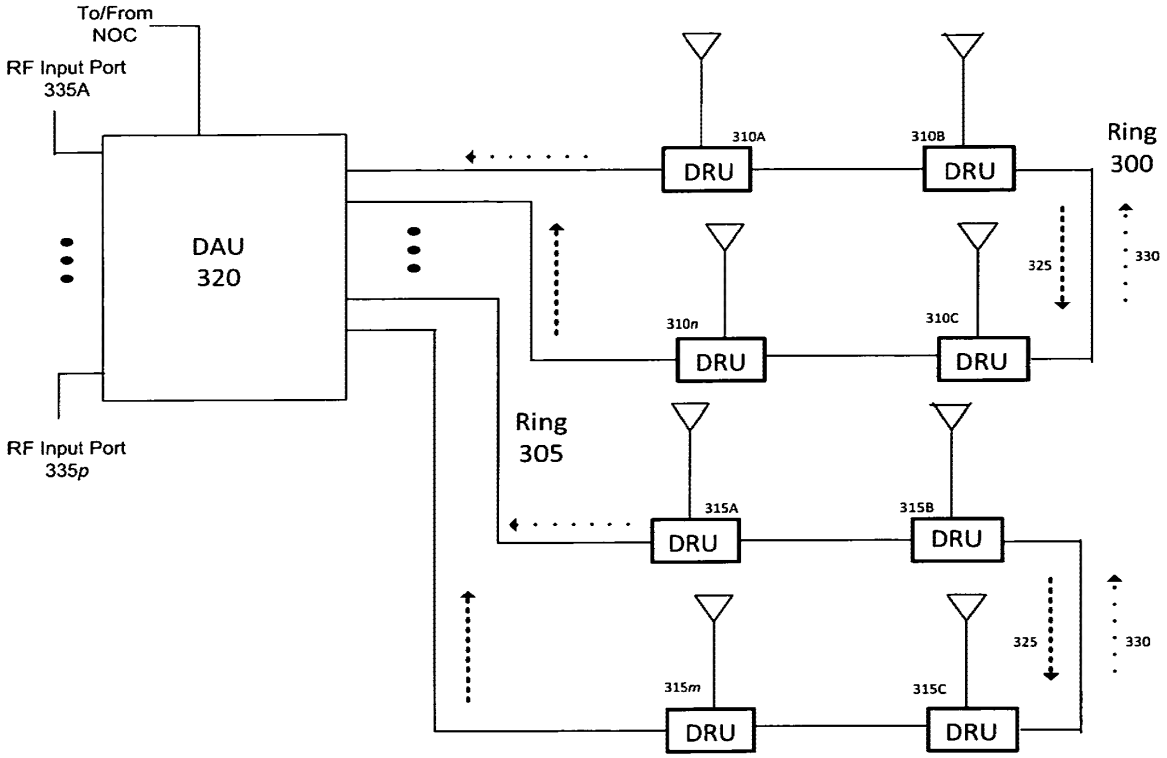


Figure 3

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page109

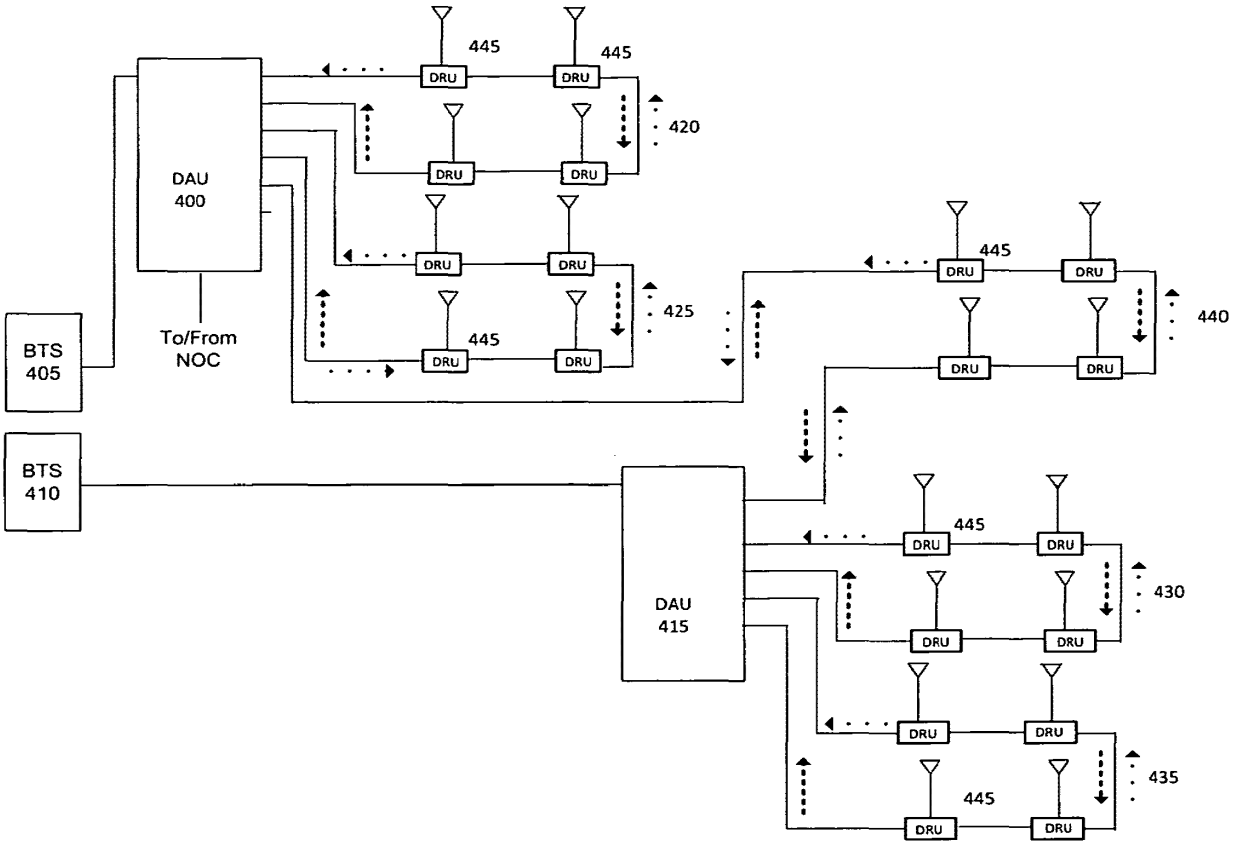


Figure 4

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page110

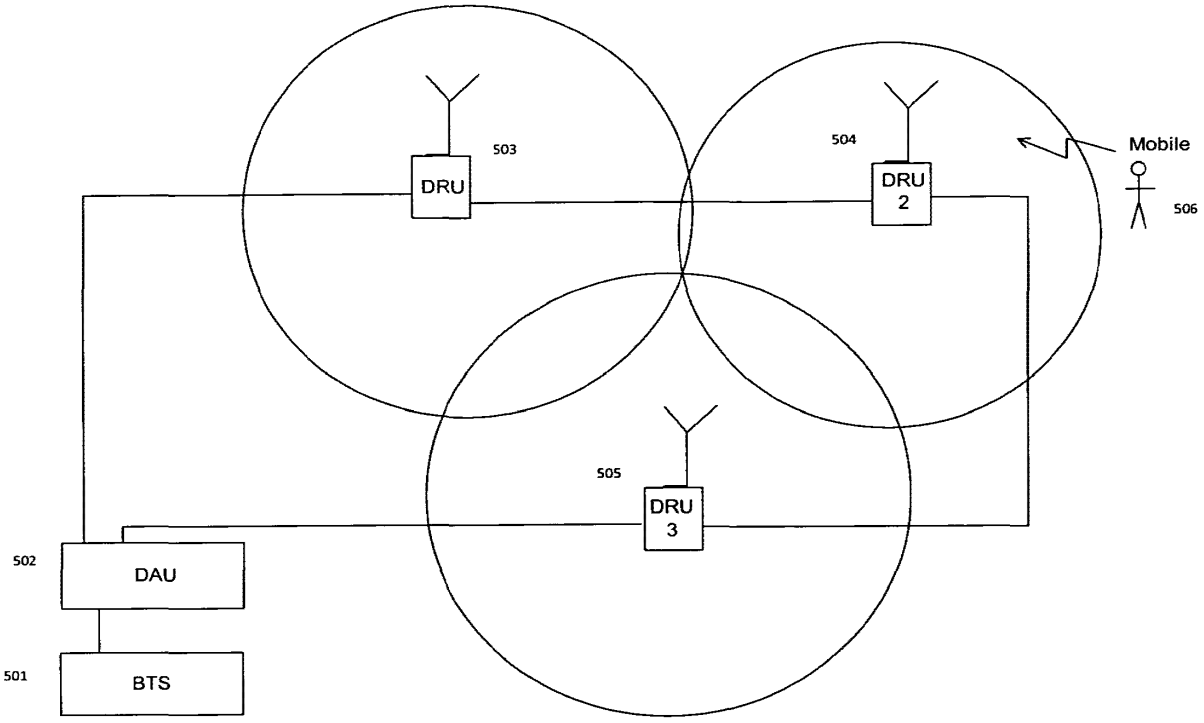


Figure 5

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page111

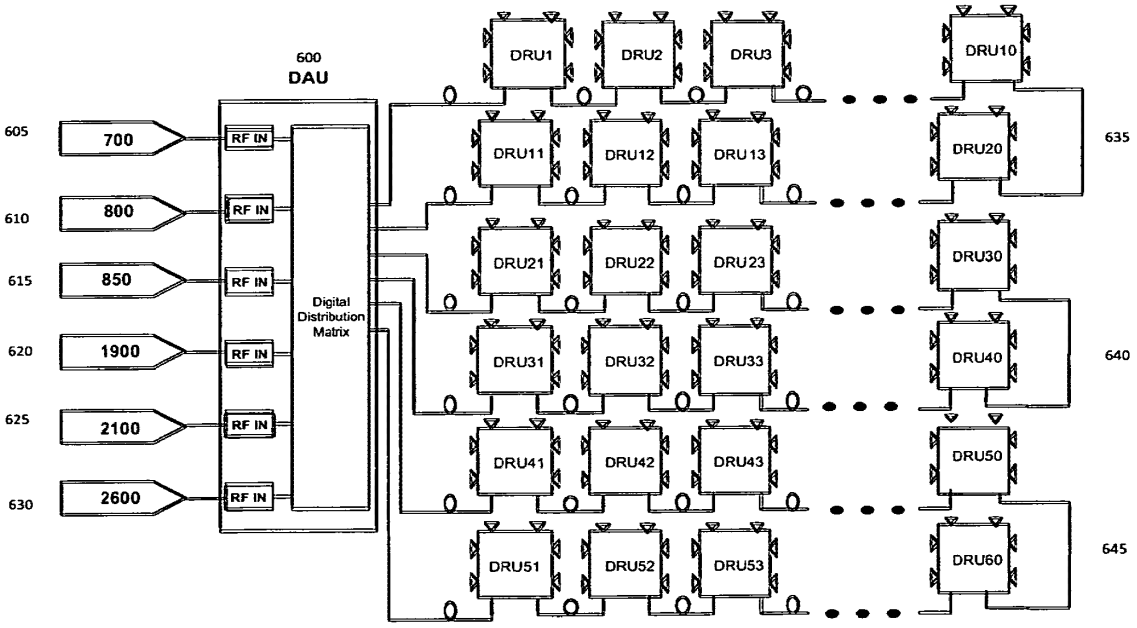


Figure 6

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page112

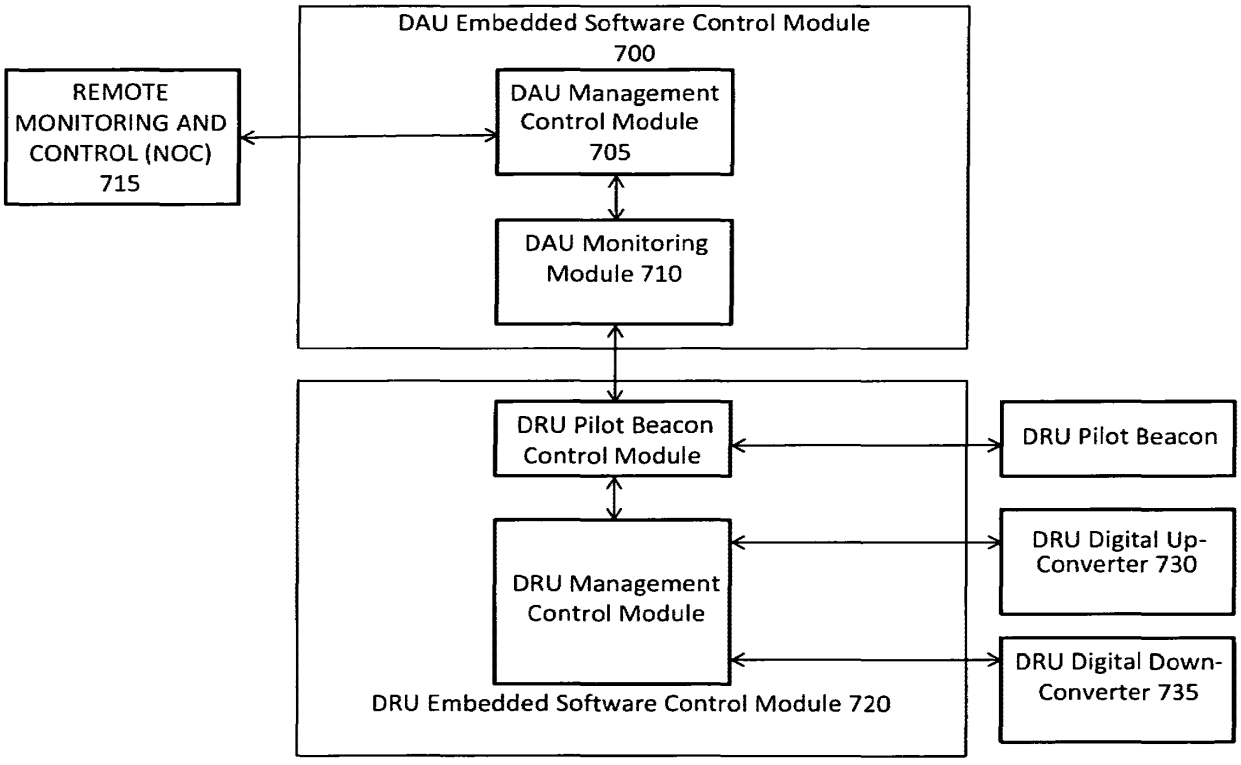


Figure 7

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page113

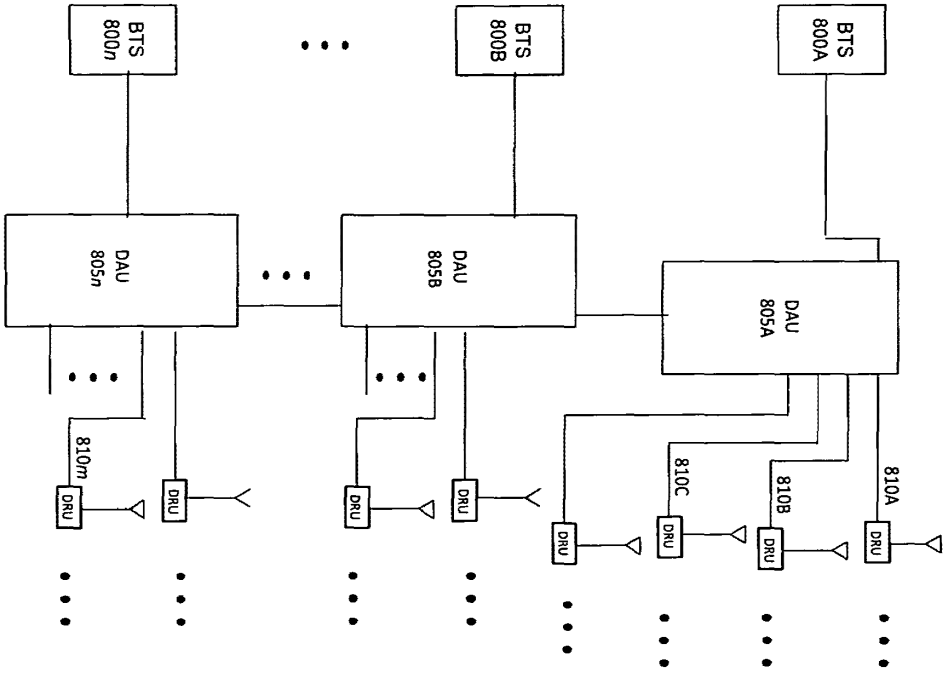


Figure 8

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page114

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 11/48004

A. CLASSIFICATION OF SUBJECT MATTER
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USPC - 375/219
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC: 375/219

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 375/219, 221; 370/277 (keyword limited - see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST (PGPB, USPT, USOC, EPAB, JPAB); GOOGLE; Google Scholar
Search Terms: antenna, packet, uplink, downlink, remote, radio, digital, frequency, configure, switching, route, loop, daisy-chained

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2002/0093926 A1 (Kilfoyle) 18 July 2002 (18.07.2002), entire document, especially; abstract, para. [0015], [0065]-[0067]	1
Y	US 2003/0181221 A1 (Nguyen) 25 September 2003 (25.09.2003), entire document, especially; abstract, para. [0003]-[0005], [0027], [0028]	1
A	US 2008/0146146 A1 (Binder et al.) 19 June 2008 (19.06.2008), entire document	1

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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[Continued on next page]

(54) **Title**: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

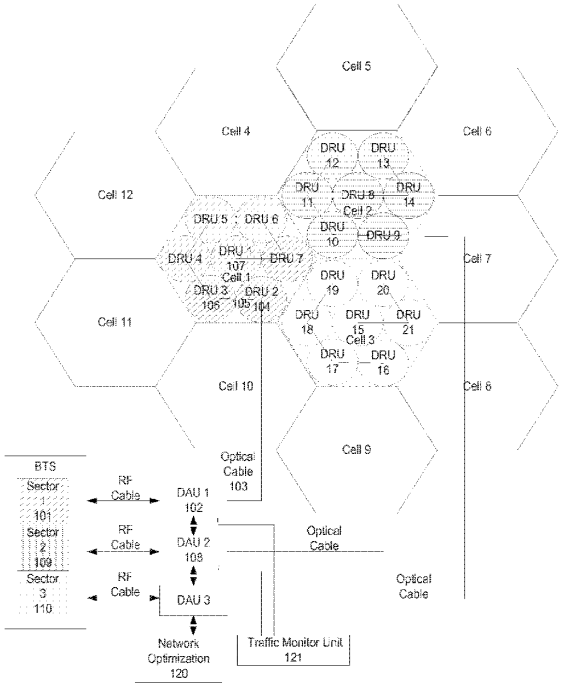


FIG. 1

(57) **Abstract**: A system for dynamically routing signals in a Distributed Antenna. System includes a plurality of Digital Access Units (DAUs). The plurality of DAUs are coupled and operable to route signals between the plurality of DAUs. The system also includes a. plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs and a plurality of Base Transcei ver Stations (BTS). The system further includes a pluraiity of traffic monitoring modules and a network optimization goaf and optimization algorithm.

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TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/678,016, filed on July 31, 2012, entitled "Optimization of Traffic Load in a Distributed Antenna System," the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

SUMMARY OF THE INVENTION

[0002] The present invention generally relates to wireless communication systems employing Distributed Antenna Systems (DAS) as part of a distributed wireless network. More specifically, the present invention relates to a DAS utilizing traffic monitoring and optimization. Wireless network operators faces the continuing challenge of building networks that effectively manage high data-traffic growth rates. Mobility and an increased level of multimedia content for end users typically employs end-to-end network adaptations that support new services and the increased demand for broadband and flat-rate Internet access. One of the most difficult challenges faced by network operators is caused by the physical movement of subscribers from one location to another, and particularly when wireless subscribers congregate in large numbers at one location. A notable example is a business enterprise facility during lunchtime, when a large number of wireless subscribers visit a lunch room or cafeteria location in the building. At that time, a large number of subscribers have moved away from their offices and usual work areas. It's likely that during lunchtime, there are many locations throughout the facility where there are very few subscribers. If the indoor wireless network resources were properly sized during the design process for subscriber loading as it is during normal working hours when subscribers are in their normal work areas, it is very likely that the lunchtime scenario will present some unexpected challenges with regard to available wireless capacity and data throughput.

[0003] According to an embodiment of the present invention, a system for dynamically routing signals in a Distributed Antenna System is provided. The system includes a plurality of Digital Access Units (DAUs). The plurality of DAUs are coupled and operable to route signals between the plurality of DAUs. The system also includes a plurality of Digital

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page118

Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs. The system further includes one or more Base Transceiver Stations (BTSs) and one or more traffic monitoring units.

[0004] According to another embodiment of the present invention, a system for dynamically routing signals in a Distributed Antenna System is provided. The system includes a plurality of Digital Access Units (DAUs). The plurality of DAUs are coupled and operable to route signals between the plurality of DAUs. The system also includes a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs and a plurality of Base Transceiver Stations (BTS). The system further includes a plurality of traffic monitoring modules and a network optimization goal and optimization algorithm.

[0005] In an embodiment, a system for dynamically routing signals in a Distributed Antenna System is provided and includes a plurality of Digital Access Units (DAUs). The plurality of DAUs are coupled and operable to route signals between the plurality of DAUs. The system also includes a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs and one or more Base Transceiver Stations (BTSs). The system further includes a traffic monitoring unit.

[0006] Numerous benefits are achieved by way of the present invention over conventional techniques. For example, embodiments of the present invention provide for traffic monitoring in a DAS network, improving network performance and user experience. These and other embodiments of the invention along with many of its advantages and features are described in more detail in conjunction with the text below and attached figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a block diagram according to one embodiment of the invention showing the basic structure and an example of the transport routing, traffic monitoring and network optimization based on having a single 3 sector BTS with 3 DAUs and 7 DRUs daisy chained together for each cell.

[0008] FIG. 2 is a block diagram according to one embodiment of the invention showing the basic structure for a frequency reuse pattern of N=1 and an example of the transport routing, traffic monitoring and network optimization based on having a single 3 sector BTS with 3 DAUs and 7 DRUs daisy chained together for each cell.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page119

[0009] FIG. 3 is a block diagram according to one embodiment of the invention showing the basic structure and an example of the transport routing, traffic monitoring and network optimization based on having multiple 3 sector BTSs with 3 DAUs and 7 DRUs daisy chained together for each cell. In this embodiment, multiple three sector base stations are connected to a daisy chained DAS network.

[0010] FIG. 4 is a block diagram of a Digital Access Unit (DAU), which contains Physical Nodes, a Local Router, and Port Traffic Monitoring capability according to an embodiment of the present invention.

[0011] FIG. 5 is a block diagram of a Digital Remote Unit (DRU), which contains Physical Nodes, a Remote Router, and Port Traffic Monitoring capability according to an embodiment of the present invention.

[0012] FIG. 6 depicts a typical topology where multiple Local Routers are interconnected with multiple Remote Routers along with Traffic monitoring and Network Optimization functionality according to an embodiment of the present invention.

[0013] FIG. 7 depicts a typical topology where multiple Local Routers are interconnected with multiple Remote Routers along with Traffic monitoring at each Picocell and Network Optimization functionality according to an embodiment of the present invention.

[0014] FIG. 8 depicts a typical topology where multiple Local Routers are interconnected with multiple Remote Routers along with Traffic monitoring at each Picocell and Network Optimization functionality according to an embodiment of the present invention.

[0015] FIG. 9 is a simplified flowchart illustrating a method of optimizing the DAS network according to an embodiment of the present invention.

[0016] FIG. 10 is a simplified flowchart illustrating a method of calculating KPIs and QoS for a DAS network according to an embodiment of the present invention.

[0017] FIG. 11 is a simplified flowchart illustrating an optimization algorithm according to an embodiment of the present invention .

DETAILED DESCRIPTION OF THE INVENTION

[0018] To accommodate variations in wireless subscriber loading at wireless network antenna locations at various times of day and for different days of the week, there are several candidate conventional approaches.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page120

[0019] One approach is to deploy many low-power high-capacity base stations throughout the facility. The quantity of base stations is determined based on the coverage of each base station and the total space to be covered. Each of these base stations is provisioned with enough radio resources, i.e., capacity and broadband data throughput to accommodate the maximum subscriber loading which occurs during the course of the workday and work week. Although this approach typically yields a high quality of service for wireless subscribers, the notable disadvantage of this approach is that many of the base stations' capacity is being wasted for a large part of the time. Since a typical indoor wireless network deployment involves capital and operational costs which are assessed on a per-subscriber basis for each base station, the typically high total life cycle cost for a given enterprise facility is far from optimal.

[0020] A second candidate approach involves deployment of a DAS along with a centralized group of base stations dedicated to the DAS. A conventional DAS deployment falls into one of two categories. The first type of DAS is "fixed", where the system configuration doesn't change based on time of day or other information about usage. The remote units associated with the DAS are set up during the design process so that a particular block of base station radio resources is thought to be enough to serve each small group of DAS remote units. A notable disadvantage of this approach is that most enterprises seem to undergo frequent re-arrangements and re-organizations of various staff groups within the enterprise. Therefore, it's highly likely that the initial DAS setup will need to be changed from time to time, requiring deployment of additional direct staff and contract resources with appropriate levels of expertise regarding wireless networks.

[0021] The second type of DAS is equipped with a type of network switch which allows the location and quantity of DAS remote units associated with any particular centralized base station to be changed manually. Although this approach would appear to support dynamic DAS reconfiguration based on the needs of the enterprise or based on time of day, it frequently implies that additional staff resources would need to be assigned to provide real-time management of the network. Another issue is that it's not always correct or best to make the same DAS remote unit configuration changes back and forth on each day of the week at the same times of day. Frequently it is difficult or impractical for an enterprise IT manager to monitor the subscriber loading on each base station. And it is almost certain that the enterprise IT manager has no practical way to determine the loading at a given time of day for each DAS remote unit; they can only guess the percentage loading.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page121

[0022] Another major limitation of conventional DAS deployments is related to their installation, commissioning and optimization process. Some challenging issues which must be overcome include selecting remote unit antenna locations to ensure proper coverage while minimizing downlink interference from outdoor macro cell sites, minimizing uplink interference to outdoor macro cell sites, and ensuring proper intra-system handovers while indoors and while moving from outdoors to indoors (and vice-versa). The process of performing such deployment optimization is frequently characterized as trial-and-error. Therefore, the results may not be consistent with a high quality of service.

[0023] Based on the conventional approaches described herein, it is apparent that a highly efficient, easily deployed and dynamically reconfigurable wireless network is not achievable with conventional systems and capabilities. Embodiments of the present invention substantially overcome the limitations of the conventional approach discussed above. The advanced system architecture provided by embodiments of the present invention provides a high degree of flexibility to manage, control, enhance and facilitate radio resource efficiency, usage and overall performance of the distributed wireless network. This advanced system architecture enables specialized applications and enhancements including, but not limited to, flexible simulcast, automatic traffic load-balancing, network and radio resource optimization, network calibration, autonomous/assisted commissioning, carrier pooling, automatic frequency selection, radio frequency carrier placement, traffic monitoring, and/or traffic tagging. Embodiments of the present invention can also serve multiple operators, multi-mode radios (modulation-independent) and multiple frequency bands per operator to increase the efficiency and traffic capacity of the operators' wireless networks.

[0024] Accordingly, embodiments of this architecture provide a capability for Flexible Simulcast. With Flexible Simulcast, the amount of radio resources (such as RF carriers, LTE Resource Blocks, CDMA codes or TDMA time slots) assigned to a particular DRU or group of DRUs can be set via software control to meet desired capacity and throughput objectives or wireless subscriber needs. Applications of the present invention are suitable to be employed with distributed base stations, distributed antenna systems, distributed repeaters, mobile equipment and wireless terminals, portable wireless devices, and other wireless communication systems such as microwave and satellite communications.

[0025] According to an embodiment of the present invention, a traffic monitoring unit is provided as a component of one or more elements of the system, enabling measurement of the network traffic in the network. A network optimization goal and optimization algorithm is also provided so that based on traffic measurements, which is typically a function of the

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page122

number of users on the system, performance of the network is optimized using the goal and associated algorithm.

[0026] As an example of traffic monitoring, the system could track the power of the down link or the power of the uplink. Another example, would include some signal processing, including examining certain control signals, for example, pilot signals sent by mobile devices. By locking onto these control signals, the traffic monitor can obtain information on the number of users using various components of the system.

[0027] A distributed antenna system (DAS) provides an efficient means of utilization of base station resources. The base station or base stations associated with a DAS can be located in a central location and/or facility commonly known as a base station hotel. The DAS network comprises one or more digital access units (DAUs) that function as the interface between the base stations and the digital remote units (DRUs). The DAUs can be collocated with the base stations. The DRUs can be daisy chained together and/or placed in a star configuration and provide coverage for a given geographical area. The DRUs are typically connected with the DAUs by employing a high-speed optical fiber link. This approach facilitates transport of the RF signals from the base stations to a remote location or area served by the DRUs. A typical base station comprises 3 independent radio resources, commonly known as sectors. These 3 sectors are typically used to cover 3 separate geographical areas without creating co-channel interference between users in the 3 distinct sectors.

[0028] Traffic monitoring in a DAS network is provided by embodiments of the present invention, which has not been performed in conventional systems. As described herein, the traffic monitoring unit can be implemented as a stand-alone unit in conjunction with one or more system components, including DAUs, DRUs, a BTS, a BTS hotel, or the like.

[0029] Once traffic resources are aggregated into eNodeB hotels, the discrete resources of a single eNodeB are still allocated to a specific set of antennas associated with that eNodeB and providing coverage to a specific geographic area. The traffic resources are fixed, i.e., only the resources associated with a specific eNodeB can be allocated to the antennas associated with that eNodeB. However, because the eNodeBs are collocated in an eNodeB hotel, the system can use the aggregated traffic resources of the discrete eNodeBs as a single, pooled traffic resource that can be allocated according to various algorithms. Assumptions are typically predicated on worst-case traffic assets in all areas, network design is wasteful 99 percent of the time, inevitably resulting in over- or under-provisioning of fixed resources.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page123

Traffic resources either go unused (idle channels), or are under-provisioned and are insufficient to handle the offered traffic. Both circumstances give rise to the same outcome: lost revenue and lost opportunity. When a site's traffic resources are idle and unused, the traffic asset fails to provide an optimal return on investment. But a site that lacks sufficient capacity to support the offered traffic at any point during the day garners dropped calls, lost revenue opportunity, and dissatisfied customers. The traffic information derived from an extensive sensor network will be used to dynamically allocate the traffic resources to the required geographical areas only for the time period the service is needed. Once the service is supplied and the traffic sensor network determines that the traffic resources are no longer required, they are returned to the resource pool for reallocation. The entire network automatically reconfigures itself based on the perceived (sensed) need or in the event of disruption due to natural or manmade events. Geographic load balancing using DAS is recognized as a new approach for traffic load balancing which provides dynamic load redistribution in real time according to the current geographic traffic conditions. It can be used to improve the performance for any distributed systems containing non-uniformly distributed traffic, especially for resolving traffic hot spots.

[0030] The network's performance (expressed by the number of KPIs (Key Performance Indicators) from different parts of the network) determines the QoS values. Different operators may have different defined business goals and different services of interest. Based on these considerations, efficient and cost effective network performance management varies from operator to operator. Therefore, QoS metrics could be defined and mapped to a set of KPIs.

[0031] An embodiment shown in FIG. 1 illustrates a basic DAS network architecture according to an embodiment of the present invention and provides an example of a data transport network, traffic monitoring and network optimization scenario between a 3 sector Base Station and multiple DRUs. In this embodiment, the DRUs are daisy chained together to achieve coverage in a specific geographical area. Each individual sector covers an independent geographical area, which is identified as a Cell. Although embodiments are discussed in terms of optimization of DAS networks, the term optimization is properly understood to include performance improvements in comparison to conventional systems, even if complete optimization is not achieved. Thus, optimization does not require the maximum values for traffic management metrics, but also includes distribution of traffic that improves system performance while remaining short of maximum performance.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page124

[0032] FIG. 1 depicts a DAS system employing multiple Digital Remote Units (DRUs) and multiple Digital Access Units (DAUs). In accordance with the present invention, each DRU provides unique information associated with each DRU which uniquely identifies uplink data received by that particular Digital Remote Unit.

[0033] One feature of embodiments of the present invention is the ability to route Base Station radio resources among the DRUs or group(s) of DRUs. In order to route radio resources available from one or more Base Stations, it is desirable to configure the individual router tables of the DAUs and DRUs in the DAS network. This functionality is provided by embodiments of the present invention.

[0034] The DAUs are networked together to facilitate the routing of DRU signals among multiple DAUs. The DAUs support the transport of the RF downlink and RF uplink signals between the Base Station and the DRUs. This architecture enables the various Base Station signals to be transported to and from multiple DRUs. PEER ports are used for interconnecting DAUs and interconnecting DRUs.

[0035] The DAUs have the capability to control the gain (in small increments over a wide range) of the downlink and uplink signals that are transported between the DAU and the base station (or base stations) connected to that DAU. This capability provides flexibility to simultaneously control the uplink and downlink connectivity of the path between a particular DRU (or a group of DRUs via the associated DAU or DAUs) and a particular base station sector.

[0036] Embodiments of the present invention use router tables to configure the networked DAUs. The local router tables establish the mapping of the inputs to the various outputs. Internal Merge blocks are utilized for the Downlink Tables when the inputs from an External Port and a PEER Port need to merge into the same data stream. Similarly, Merge blocks are used in the Uplink Tables when the inputs from the LAN Ports and PEER Ports need to merge into the same data stream.

[0037] The remote router tables establish the mapping of the inputs to the various outputs. Internal Merge blocks are utilized for the Downlink Tables when the inputs from a LAN Port and a PEER Port need to merge into the same data stream. Similarly, Merge blocks are used in the Uplink Tables when the inputs from the External Ports and PEER Ports need to merge into the same data stream.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page125

[0038] As shown in FIG. 1, the individual base station sector's radio resources are transported to a daisy-chained network of DRUs. Each individual sector's radio resources provide coverage to an independent geographical area via the networked DRUs. FIG. 1 demonstrates how three cells, each cell comprising an independent network of 7 DRUs, provide coverage to a given geographical area. A server is utilized to control the switching function provided in the DAS network. Referring to FIG. 1 and by way of example, DAU 1 (102) receives downlink signals from BTS Sector 1 (101). DAU 1 translates the RF signals to optical signals and the optical fiber cable 103 transports the desired signals to DRU 2 (104). Optical cable 105 transports all the optical signals to DRU 3 (106). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 1 (107). DAU 1 (102) is networked with DAU 2 (108) to allow the downlink signals from Sector 2 (109) and Sector 3 (110) to be transported to all the DRUs in Cell 1. The system's switching and routing functions enable the selection of which sectors' signals are transmitted and received by each DRU.

[0039] An embodiment illustrating a Traffic monitoring unit (121) at the DAUs is included to track the traffic load at each DAU in the network. The traffic load associated with each DAU is collected and stored in the Network Optimization Unit (120). The optimization unit (120) calculates the overall DAS network performance and determines the optimum reconfigured network to improve or maximize performance. Utilizing the traffic monitoring unit 121 in conjunction with the DAUs provides for optimization of the DAS network through a traffic monitoring unit external to the DAUs. Thus, embodiments of the present invention provide for traffic monitoring in a DAS network. Optimization of the DAS network can then be performed using information related to the traffic monitoring.

[0040] Referring to FIG. 1, the traffic monitor unit 121 can be a server determining the number of users on each DAU, with each DAU having multiple ports in some embodiments. Data from the traffic monitor unit 121 is then provided to the network optimization unit 120, which can be the same server including the traffic monitor unit or a different server. The network optimization unit 120 (which can be software running on a server) can model the rebalancing of the traffic load and, after determining that the performance will be acceptable, implements the load rebalancing by communicating with the DAUs and shifting traffic between sectors. Although the network optimization unit 120 is illustrated as coupled to the DAUs in FIG. 1, this is not required by embodiments of the present invention and the network optimization could be performed at one of the DRUs, with data regarding network optimization being transmitted back to the DAUs using, for example, using an Ethernet

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page126

backhaul connecting the DRUs to the DAUs. Thus, the network optimization server could be located at one of the DRUs, controlling the entire network from that location. One of ordinary skill in the art would recognize many variations, modifications, and alternatives.

[0041] The network optimization unit can implement a network optimization goal, which may relate to the number of users per sector, for example, that each sector carry a percentage of traffic less than 50% of the total traffic, less than 40% of the total traffic, or less than 35% of the total traffic, that each sector have less than 50% of the users, less than 40% of the users, less than 35% of the users, or that each sector have 33% of the users, or the like. Thus, the optimization goals can include metrics of the system performance. Although the system may not reach the goals, progress toward the goals can be provided, improving the user experience.

[0042] FIG. 2 shows an embodiment illustrating how a single base station can be used to provide coverage for a larger geographical area when a frequency reuse pattern of N=1 is used. Referring to FIG. 2, cell 1 and cell 8 would share the radio resources of sector 1 of the base station. Similarly, cell 2 and cell 10 would share the radio resources of sector 2.

[0043] The DAUs control the routing of data between the base station and the DRUs. Each individual data packet is provided with a header that uniquely identifies which DRU it is associated with. The DAUs are interconnected to allow transport of data among multiple DAUs. This feature provides the unique flexibility in the DAS network to route signals between the sectors and the individual DRUs. A server is utilized to control the switching function provided in the DAS network. Referring to FIG. 2, and by way of example, DAU 1 (202) receives downlink signals from BTS 1 Sector 1 (201). DAU 1 translates the RF signals to optical signals and the optical fiber cable 203 transports the desired signals to DRU 2 (204). Optical cable 205 transports all the optical signals to DRU 3 (206). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 1 (207). DAU 1 (202) is networked with DAU 2 (208) to allow the downlink signals from Sector 2 and Sector 3 to be transported to all the DRUs in Cell 1. Optical fiber cable 209 transports the desired signals to DRU 23 (210). Optical cable 211 transports all the optical signals to DRU 24 (212). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 22 (213). An embodiment illustrating a Traffic monitoring unit (221) at the DAUs is included to track the traffic load at each DAU in the network. The traffic load associated with each DAU is collected and stored in the Network Optimization Unit (220). The optimization unit (220) calculates the overall DAS network performance and determines the optimum reconfigured network to maximize performance.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page127

[0044] FIG. 3 shows an embodiment illustrating an application employing a base station hotel where N BTSs are interconnected to serve a given geographical area. The base stations may represent independent wireless network operators and/or multiple standards (WCDMA, LTE, etc.) or they may represent provision of additional RF carriers. The base station signals may be combined before they are connected to a DAU, as may be the case for a Neutral Host application. Referring to FIG. 3 and by way of example, DAU 1 (302) receives downlink signals from BTS Sector 1 (301). DAU 1 translates the RF signals to optical signals and the optical fiber cable 303 transports the desired signals to DRU 2 (304). Optical cable 305 transports all the optical signals to DRU 3 (306). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 1 (307). DAU 1 (302) is networked with DAU 2 (308) to allow the downlink signals from BTS 1 Sector 2 to be transported to all the DRUs in Cell 1. DAU 1 (302) receives downlink signals from BTS Sector N (309). DAU 1 translates the RF signals to optical signals and the optical fiber cable 303 transports the desired signals to DRU 2 (304). Optical cable 305 transports all the optical signals to DRU 3 (306). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 1 (307). The additional base stations provide the capability to add capacity for Cell 1.

[0045] In order to efficiently utilize the limited base station resources, the network of DRUs should have the capability of re-directing their individual uplink and downlink signals to and from any of the BTS sectors. Because the DRUs data traffic has unique streams, the DAU Router has the mechanism to route the signal to different sectors. An embodiment illustrating a Traffic monitoring unit (321) at the DAUs is included to track the traffic load at each DAU in the network. The traffic load associated with each DAU is collected and stored in the Network Optimization Unit (320). The optimization unit (320) calculates the overall DAS network performance and determines the optimum reconfigured network to maximize performance.

[0046] FIG. 4 shows the two primary elements in a DAU, the Physical Nodes (400) and the Local Router (401). The Physical Nodes translate the RF signals to baseband for the Downlink and from baseband to RF for the Uplink. The Local Router directs the traffic between the various LAN Ports, PEER Ports and the External Ports. The physical nodes connect to the BTS at radio frequencies (RF). The physical nodes can be used for different operators, different frequency bands, different channels, or the like. The physical nodes can combine the downlink and uplink signals via a duplexer or they can keep them separate, as would be the case for a simplex configuration. In one embodiment, Traffic monitoring (416)

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page128

capability is provided in each DAU for determining the traffic load at each of the DAU ports. In this embodiment, the traffic monitoring function is performed in each DAU in comparison with other implementations in which the traffic monitoring is performed externally.

[0047] FIG. 4 shows an embodiment whereby the physical nodes have separate outputs for the uplinks (405) and separate inputs for the downlink paths (404). The physical node translates the signals from RF to baseband for the downlink path and from baseband to RF for the uplink path. The physical nodes are connected to a Local Router via external ports (409,410)). The router directs the uplink data stream from the LAN and PEER ports to the selected External U ports. Similarly, the router directs the downlink data stream from the External D ports to the selected LAN and PEER ports.

[0048] In one embodiment, the LAN and PEER ports are connected via an optical fiber to a network of DAUs and DRUs. The network connection can also use copper interconnections such as CAT 5 or 6 cabling, or other suitable interconnection equipment. The DAU is also connected to the internet network using IP (406). An Ethernet connection (408) is also used to communicate between the Host Unit and the DAU. The DRU can also connect directly to the Remote Operational Control center (407) via the Ethernet port.

[0049] FIG. 5 shows the two primary elements in a DRU, the Physical Nodes (501) and the Remote Router (500). The DRU includes both a Remote Router and Physical Nodes. The Remote Router directs the traffic between the LAN ports, External Ports and PEER Ports. The physical nodes connect to the BTS at radio frequencies (RF). The physical nodes can be used for different operators, different frequency bands, different channels, etc. FIG. 5 shows an embodiment whereby the physical nodes have separate inputs for the uplinks (504) and separate outputs for the downlink paths (503). The physical node translates the signals from RF to baseband for the uplink path and from baseband to RF for the downlink path. The physical nodes are connected to a Remote Router via external ports (506,507). The router directs the downlink data stream from the LAN and PEER ports to the selected External D ports. Similarly, the router directs the uplink data stream from the External U ports to the selected LAN and PEER ports. The DRU also contains a Ethernet Switch (505) so that a remote computer or wireless access points can connect to the internet.

[0050] In one embodiment, the traffic monitoring (516) capability is provided in each DRU for determining the traffic load at each of the DRU ports. In this embodiment, the traffic monitoring function is performed in each DRU in comparison with other implementations in which the traffic monitoring is performed externally.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page129

[0051] As shown in FIG. 6, the base station hotel (610) is comprised of multiple Picocells. The Picocells are typically wireless operator dependent and frequency band dependent. Picocells that operate in the same frequency band are combined at RF and input to the respective DAUs. The DAU radio resources from the combined Picocells are transported to a daisy-chained network of DRUs. Each individual DAUs radio resources provide coverage to an independent geographical area via the networked DRUs. FIG. 6 demonstrates how multiple DAUs, each cell comprising an independent network of 7 DRUs, provide coverage to a given geographical area. In one embodiment, the traffic monitoring functionality is located in an external Traffic Monitoring Unit (621), which is connected to the network of DAUs.

[0052] As shown in FIG. 7, the base station hotel (710) is comprised of multiple Picocells. The Picocells are typically wireless operator dependent and frequency band dependent. Picocells that operate in the same frequency band are combined at RF and input to the respective DAUs. The DAU radio resources from the combined Picocells are transported to a daisy-chained network of DRUs. Each individual DAUs radio resources provide coverage to an independent geographical area via the networked DRUs. FIG. 7 demonstrates how multiple DAUs, each cell comprising an independent network of 7 DRUs, provide coverage to a given geographical area. In one embodiment, the traffic monitoring functionality is located in an external Traffic Monitoring Unit (721), which is connected to the Picocells. The BTS Hotel 710 includes a plurality of Picocells that are coupled to traffic monitoring unit 720. The traffic information flows from the Picocells to the traffic monitoring unit, which uses this traffic information to optimize the DAS network. The traffic monitoring unit 820 works in conjunction with network optimization unit 721, which can include traffic management algorithms used to distribute traffic efficiently throughout the DAS network.

[0053] FIG. 8 shows an embodiment of a base station hotel (810), which is comprised of multiple picocells that are interconnected to a network of DAUs via a digital interface (830).

[0054] FIG. 9 illustrates one embodiment of the DAS network optimization flow diagram. The Key Performance Indicators (KPIs) of the network traffic are collected at the various network nodes (910). KPI may comprise information such as: number of blocked calls, number of active calls, average power of uplink channels, average power of downlink channels, traffic on each sector, failed calls, number of satisfied users, number of unsatisfied users, number of users operating through a given DRU, and the like.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page130

[0055] The DAS network performance is then analyzed in the context of the available DAS network radio resources (912). An optimization algorithm is applied to the existing DAS network with the objective to determine the optimum routing of network traffic (914). Once an optimum DAS network has been determined then an estimate of the reconfigured DAS network performance is determined (916). The reconfigured DAS network is evaluated prior to an implementation to insure that the performance will be acceptable. If the reconfigured DAS network has been determined to be acceptable then the reconfigured DAS network is implemented (918) and the entire process is repeated. In an embodiment, the load on the sectors prior to reconfiguration and after the proposed reconfiguration can be compared to determine if the shifting of the DRUs to the other sectors improves the system performance.

[0056] Thus, using the KPIs of the network traffic, the DAS network can be modified to improve system performance. As an example, if a particular DRU has a higher load than other adjacent DRUs, traffic can be routed to the adjacent DRUs in order to reduce the load on the particular DRU. Additional description related to load balancing is provided in U.S. Patent Application No. 61/600,530, filed on February 17, 2012, entitled "Evolutionary Algorithms for Geographic Load Balancing Using a Distributed Antenna System," the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

[0057] As an example of optimizing network performance, a base station typically has three sectors. The DRU can be allocated to different sectors in order to improve performance by shifting traffic from a first sector (e.g., a high traffic sector) to a second sector (e.g., a low traffic sector) by shifting a DRU allocated to the first sector to the second sector. Although some embodiments of the present invention will not optimize performance of the system, the system performance can be improved using the techniques described herein, for example, by measuring the traffic load on the DRUs, performing load balancing of the traffic on the DRUs, to reduce the load on a first DRU characterized by a first traffic load by shifting the load to a second DRU characterized by a second traffic load less than the first traffic load. In the optimization process, system performance can be measured against a predetermined threshold, with the optimization process terminating once the predetermined threshold has been reached. One of ordinary skill in the art would recognize many variations, modifications, and alternatives.

[0058] As another example, power settings for the DRUs can be modified to improve system performance as discussed in additional detail in U.S. Patent Application No. 61/669,572, filed on July 9, 2012 and entitled, "A Self-Optimizing Distributed Antenna

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page131

System Using Soft Frequency Reuse," the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

[0059] FIG. 10 illustrates one embodiment of the DAS network calculation of the KPIs and QoS. The important parameters for determining the DAS network QoS include the number of users allocated to a given DRU, the spatial distance between the various DRUs, as well as identifying which DRUs are assigned to which BTS sector.

[0060] FIG. 11 illustrates one embodiment of the flow chart for the optimization algorithm. In this embodiment an Estimation Distribution Algorithm (EDA) is used. Various DRU allocation scenarios are investigated to determine the optimum DRU scenario that achieves the highest QoS. In an embodiment, the initial population is generated (1110). The traffic information (KPIs) is analyzed and traffic performance (QoS) for all sectorization is analyzed (1112). A sort procedure is performed (1114) and a determination is made if the convergence criterion are satisfied (1116). If so, the process is terminated. If not, then the generation counter is updated (1118), a sort operation is performed (1120), the parameter Γ is computed (1122) and a new population is generated (1124). Then the method proceeds to the traffic information and performance analysis (1112).

[0061] Network Optimization

[0062] The network's performance (expressed by the number of KPIs from different parts of the network) determines the QoS values. Different operators may have different defined business goals and different services of interest. Based on these considerations, efficient and cost effective network performance management varies from operator to operator. Therefore, QoS metrics could be defined and mapped to a set of KPIs. When a set of KPIs is used, then the mapping needs to be represented by a weighted normalized function.

[0063] In this section we formulate the sectorization problem with mixed integer programming to balance traffic among sectors and to minimize handoffs with connected and compact sectors. Given the sectorization of DRUs at time period t, our problem is to obtain new sectorization at time period $t+1$ that adaptively balances the change in traffic demands.

[0064] In order to formulate the problem, we consider a service coverage area with N DRUs. Each DRU is assumed to have traffic demand T_i $i = 1,...,N$. Note that, UE_A belongs to DRU_B if the received uplink power from UE_A at DRU_B is greater than the other $DRUs$. Let p_{ij} be the transition probability of mobiles from DRU_i to DRU_j. Then, the handoff calls from DRU_i to DRU_j become $h_{ij} = p_{ij}T_i$. The distance between DRU_i and DRU_j is inversely

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page132

proportional to p_{ij} . Assume that an eNodeB hotel has M VBSs. Let SOS_m and SOD_k be the set of sectors in VBS_m and the set of DRUs allocated to $Sector_k$, respectively, such that $|SOS_m| = 3$ (if each eNodeB/VBS has three sectors), $m=1,\ldots, M$ and $k=1,\ldots, K$. We consider the following three cost factors (KPIs) in the sectorization problem:

[0065] *KPI_{BC} (Inverse of the number of Blocked Calls) :* The penalty of the blocked calls caused by hard capacity and soft capacity. Let HC_m and SC_k be the hard capacity of VBS_m and soft capacity of $Sector_k$ respectively such that $HC_m = \sum_{k \in SOS_m} SC_k$. The binary variable $x_{ik} = 1$, when DRU_i belongs to $Sector_k$. $y_{im} = \sum_{k \in SOS_m} x_{ik}$, then $y_{im} = 1$ when DRU_i belongs to VBS_m .

$$sc_k = \begin{cases} 0 & if \quad \sum_i T_i x_{ik} < SC_k \\ \sum_i T_i x_{ik} - SC_k & otherwise \end{cases}$$

$$\begin{aligned} hc_m &= \sum_i T_i y_{im} - HC_m = \sum_i T_i \sum_{k \in SOS_m} x_{ik} - \sum_{k \in SOS_m} SC_k \\ &= \sum_{k \in SOS_m} \sum_i T_i x_{ik} - SC_k \\ &= \sum_{k \in SOS_m} sc_k \end{aligned}$$

(1)

Since a penalty occurs only when the calls are blocked, we apply just sc_k to the objective function, because the hc_m is a function of sc_k and there is no need to add it as another term to the objective function. sc_k is a nonnegative real variable. So,

$$KPI_{BC} = \left[\sum_{k \in SOS_m} sc_k \right]^{-1}$$

(2)

[0066] KPI_{HO} (Inverse of the number of Handoffs): we consider three different types of Handoffs :

[0067] **A. *Inter-eNodeB Handoff:*** When user equipment (UE) with an ongoing call moves from one VBS to another VBS, then the UE needs an inter-eNodeB handoff. Inter-eNodeB handoff is executed using the X2 interface (as long as the UE does not leave the LTE

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page133

coverage area) or S1 interface (when the UE leaves the serving cell). The X2 handoff includes establishing a signaling connection using the X2 Application Part (X2AP) from the source to the target eNodeB. The target eNodeB updates the MME (Mobility Management Entity) with the new geographic position of the UE. To enable this procedure, the MME needs to communicate with S-GW (Serving Gateway) to negotiate the new endpoint. During the S1 handoff, the MME receives the relocation preparation request of the source eNodeB, it starts the handoff resource allocation procedure to request the necessary radio resource from the target eNodeB. After the target eNodeB sends the required radio interface parameters embedded in a handoff command message; the MME forwards this handoff command message transparently to the UE, which executes the handoff. The main procedure is triggered by the MME and executed by S-GW.

[0068] Let the binary variable $z_{ijm} = 1$, when DRU_i and DRU_j belong to VBS_m. Then the inter-eNodeB handoff cost is computed by using the variable $z_{ij} = 1 - \sum_m z_{ijm}$, the cost becomes $\sum_i \sum_j h_{ij} z_{ij}$.

[0069] Note that inter-eNodeB handoff occurs when DRU_i and DRU_j belong to different VBS, i.e., $z_{ijm} = 0$.

[0070] *B. **Intra-eNodeB Handoff:*** When a UE with an ongoing call moves from one sector to another in a VBS, then the mobile needs an intra-eNodeB handoff. This procedure doesn't need to involve MME or S-GW because it can be handled entirely within that VBS. Now by letting the binary variable $w_{ijk} = 1$ when DRU_i and DRU_j belong to sector k, the intra-eNodeB handoff cost is computed by using two variables $w_{ij} - z_{ij}$ where $w_{ij} = 1 - \sum_k w_{ijk}$, the cost becomes $\sum_i \sum_j h_{ij}(w_{ij} - z_{ij})$.

[0071] An intra-eNodeB handoff occurs when DRU_i and DRU_j belong to different sectors of the same VBS.

[0072] *C. **Forced Handoff:*** When a DRU changes its sector, all ongoing calls in the cell have to change their pilot PN offsets for WCDMA. The cost of forced handoff is computed by employing the current sectorization a_{ik}, which is equal to zero when DRU_i is in $Sector_k$.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page134

Since the cost occurs when DRU_i currently in another sector moves into $Sector_k$, the cost becomes $\sum_i \sum_k a_{ik} T_i x_{ik}$.

[0073] The weighted combination of these three handoff cost would be:

$$KPI_{HO} = \left[c_1 \sum_i \sum_j h_{ij} z_{ij} + c_2 \sum_i \sum_j h_{ij} (w_{ij} - z_{ij}) + c_3 \sum_i \sum_k a_{ik} T_i x_{ik} \right]^{-1}$$

(3)

[0074] ***KPI_{CI} (Inverse of the Compactness Index):*** we will try to minimize the length of handoff border with the compactness index CI which is introduced in Section II.B. In Equation (4) the numerator term represents the number of handoff DRU sides between two different sectors.

$$KPI_{CI} = [CI]^{-1} = \left[\frac{\sum_i \sum_{i<j} w_{ij} B_{ij}}{\sum_i \sum_{i<j} B_{ij}} \right]^{-1}$$

(4)

Where $B_{ij} = 1$, if DRU_i and DRU_j are adjacent.

Now we consider the following constraints required in the formulation:

1. each DRU has to belong to a sector, that is,

$$\sum_k x_{ik} = 1 \qquad \text{for all } i$$

(5)

2. The relationship between any two DRUs in a $Sector_k$ has to satisfy $w_{ijk} = 1$ if and only if $x_{ik} = x_{jk} = 1$. Thus we have:

$$w_{ijk} \le x_{ik}, w_{ijk} \le x_{jk} \text{ and } w_{ijk} \ge x_{ik} + x_{jk} - 1 \qquad \text{for all } i,j \text{ and } k$$

(6)

[0075] The relationship between two DRUs in a VBS_m. $z_{ijm} = 1$ if and only if $y_{im} = y_{jm} = 1$ which leads to:

$$z_{ijm} \le y_{im}, z_{ijm} \le y_{jm} \text{ and } z_{ijm} \ge y_{im} + y_{jm} - 1 \qquad \text{for all } i,j \text{ and } k$$

(7)

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page135

3. Connected sectorization, if a sector has more than one DRU, then the DRUs of the sector have to be connected. For the formulation of connected sectors we employ the cut theorem [26] on SOD_k. If $Sector_k$ is connected, then any cut that separates cells in SOD_k has at least one common side of the hexagonal cells. Let $S1_k$ be a proper subset of SOD_k, that is, $S1_k \subset SOD_k$, $S1_k \neq \phi$, and $S1_k \neq SOD_k$. Also let $S2_k$ be the opposite set of $S1_k$, that is, $S2_k = SOD_k - S1_k$. Because two subsets are connected, there exists at least one common side of the DRUs separated by the subsets. Thus we have

$$\sum_{i \in S1_k} \sum_{j \in S2_k} B_{ij} \geq 1 \quad (8)$$

[0076] Now, our QoS function is the weighted combination of three KPIs (cost factors) which we have already introduced. Obviously our objective function is to maximize the QoS function. They are penalties of blocked calls by hard and soft capacities and handoff calls. The DRU sectorization can be formulated as the following mixed integer linear programming.

Minimize

$$QoS^{-1} = w_1.KPI_{BC}^{-1} + w_2.KPI_{HO}^{-1} + w_3.KPI_{CI}^{-1} \quad (9)$$

Subject to:

$$\sum_k x_{ik} = 1 \qquad for\ all\ \ i$$

$$w_{ijk} \leq x_{ik}, w_{ijk} \leq x_{jk}\ and\ w_{ijk} \geq x_{ik} + x_{jk} - 1 \qquad for\ all\ i, j\ and\ k$$

$$w_{ij} = 1 - \sum_k w_{ijk} \qquad for\ all\ i, j$$

$$y_{im} = \sum_{k \in SOS_m} x_{ik} \qquad for\ all\ \ m$$

$$z_{ijm} \leq y_{im}, z_{ijm} \leq y_{jm}\ and\ z_{ijm} \geq y_{im} + y_{jm} - 1 \qquad for\ all\ i, j\ and\ m$$

$$z_{ij} = 1 - \sum_k z_{ijk} \qquad for\ all\ i, j$$

$$\sum_{i \in S1_k} \sum_{j \in S2_k} B_{ij} \geq 1$$

$$for\ all\ S1_k \subset SOD_k\ \ where\ \ S1_k \neq \phi\ \ \ and\ \ \ S1_k \neq SOD_k\ \ \ and\ \ \ S2_k = SOD_k - S1_k$$

$$h_{ij} = p_{ij} T_i \qquad for\ all\ \ i\ and\ \ j$$

$$hc_m = \sum_i T_i y_{im} - HC_m \qquad for\ all\ \ m$$

$$sc_k = \begin{cases} 0 & if \quad \sum_i T_i x_{ik} < SC_k \\ \sum_i T_i x_{ik} - SC_k & otherwise \end{cases} \qquad for\ all\ \ k$$

$$x_{ik}, w_{ijk}, z_{ijm}, P_k \in \{0,1\} \qquad for\ all\ i, j, k\ and\ \ m$$

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page136

[0077] Note that many grouping problems which are special cases of the sectorization problem are well-known NP-hard problems. Since our problem is NP hard, the time it takes to execute the algorithm is exponentially increasing with the size of the problem. Such an algorithm is thus in most cases unusable for real-world size problem. As an encouraging result on NP-hard problems, we investigate evolutionary algorithms to solve the sectorization problem and compare the performance with the solutions obtained by the mixed integer programming.

[0078] Estimation distribution algorithm (EDA)

[0079] Unlike other evolutionary algorithms, in EDA a new population of individuals in each generation is generated without crossover and mutation operators. Instead, in EDA a new population is generated based on a probability distribution, which is estimated from the best selected individuals of previous generation. We introduce each main-vector as an individual for our EDA approach, and also our fitness function is objective function that we mentioned it in section III. In general, conventional EDAs can be characterized by parameters and notations:

$$(I_s, F, \Delta_l, \eta_l, \beta_l, p_s, \Gamma, I_{Ter}) \quad (11)$$

where

1) I_s is the space of all potential solutions (entire search space of individuals).

2) F denotes a fitness function.

3) Δ_l is the set of individuals (population) at the l_{th} generation.

4) η_l is the set of best candidate solutions selected from set Δ_l at the l_{th} generation.

5) We denote $\beta_l \equiv \Delta_l - \eta_l \equiv \Delta_l \cap \eta_l^C$ .where η_l^C is the complement of η_l.

6) p_s is the selection probability. The EDA algorithm selects $p_s|\Delta_l|$ individuals from set Δ_l to make up set η_l.

7) We denote by Γ the distribution estimated from η_l (the set of selected candidate solutions) at each generation.

8) I_{Ter} are the maximum number of generation

In conventional EDAs, each individual is designated by a string. A typical EDA is described in the following steps:

Step 0: Generate initial population Δ_0. The initial population ($|\Delta_0|$ individuals) is typically obtained by sampling according the uniform (equally likely) distribution:

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page137

$$(\theta_1,\theta_2,\cdots,\theta_n)=\prod_{i=1}^{n}p_i(\theta_i),$$

$$i=1,2,...,n,\ \text{and}\ p_i(\theta_i=S_{11})=p_i(\theta_i=S_{21})=...=p_i(\theta_i=S_{|SOS_M|M})=\frac{1}{\sum_{n=1}^{M}|SOS_n|} \quad (12)$$

For generation l = 1,2, ..., follow steps 1 through 6

***Step 1*:** Evaluate the individuals in the current population Δ_{l-1} according to the fitness function *F*. Sort the candidate solutions (individuals in the current population) according to their fitness orders.

***Step 2*:** If the best candidate solution satisfies the convergence criterion or the number of generation exceeds its limit I_{Ter} , then terminate; else go to step 3.

Step 3: Select the best $p_s\Delta_{l-1}$ candidate solutions (individuals) from current population Δ_{l-1}. This selection is accomplished according to the sorted candidate solutions.

Step 4: Estimate the probability distribution $p(\theta_1,\theta_2,\cdots,\theta_n)$ on the basis of $|\eta_{l-1}|$ best candidate solutions. We denote this estimation by

$$=P(\theta_1,\theta_2,\cdots,\theta_n|\eta_{l-1}) \quad (13)$$

Step 5: Generate new $|\Delta_{l-1}|-|\eta_{l-1}|$ individuals on the basis of this new estimated probability distribution Γ . Replace the bad $|\beta_{l-1}|$ individuals with newly generated $|\Delta_{l-1}|-|\eta_{l-1}|$ individuals.

Step 6: Go to step 1 and repeat the steps

We followed the steps of the above pseudo code for our EDA implementation. In our experimentation, for estimation (13), we used a simple scheme of estimating the marginal distributions separately and using product form

$$=p(\theta_1,\theta_2,\cdots,\theta_n|\eta_{l-1})=\prod_{i=1}^{n}p_i(\theta_i|\eta_{l-1})$$
$$=\prod_{i=1}^{n}\left(\frac{\sum_{j=1}^{|\eta_{l-1}|}\delta\left(x_i^j=\theta_i|\eta_{l-1}\right)}{|\eta_{l-1}|}\right) \quad (14)$$

Where δ is an indicator function and it can be expressed as

$$\delta\left(x_i^j=\theta|\eta_{l-1}\right)=\begin{cases}1 & \text{if } x_i^j=\theta\\ 0 & \text{otherwise}\end{cases} \quad (15)$$

[0080] It is also understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and scope of the appended claims.

[0081] Appendix I is a glossary of terms used herein, including acronyms.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page138

APPENDIX I

Glossary of Terms

ACLR	Adjacent Channel Leakage Ratio
ACPR	Adjacent Channel Power Ratio
ADC	Analog to Digital Converter
AQDM	Analog Quadrature Demodulator
AQM	Analog Quadrature Modulator
AQDMC	Analog Quadrature Demodulator Corrector
AQMC	Analog Quadrature Modulator Corrector
BPF	Bandpass Filter
CDMA	Code Division Multiple Access
CFR	Crest Factor Reduction
DAC	Digital to Analog Converter
DET	Detector
DHMPA	Digital Hybrid Mode Power Amplifier
DDC	Digital Down Converter
DNC	Down Converter
DPA	Doherty Power Amplifier
DQDM	Digital Quadrature Demodulator
DQM	Digital Quadrature Modulator
DSP	Digital Signal Processing
DUC	Digital Up Converter
EER	Envelope Elimination and Restoration
EF	Envelope Following
ET	Envelope Tracking
EVM	Error Vector Magnitude
FFLPA	Feedforward Linear Power Amplifier
FIR	Finite Impulse Response
FPGA	Field-Programmable Gate Array
GSM	Global System for Mobile communications
I-Q	In-phase / Quadrature
IF	Intermediate Frequency
LINC	Linear Amplification using Nonlinear Components
LO	Local Oscillator
LPF	Low Pass Filter
MCPA	Multi-Carrier Power Amplifier
MDS	Multi-Directional Search
OFDM	Orthogonal Frequency Division Multiplexing
PA	Power Amplifier
PAPR	Peak-to-Average Power Ratio
PD	Digital Baseband Predistortion
PLL	Phase Locked Loop
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RRH	Remote Radio Head
RRU	Remote Radio Head Unit
SAW	Surface Acoustic Wave Filter
UMTS	Universal Mobile Telecommunications System
UPC	Up Converter

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page139

WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page140

WHAT IS CLAIMED IS:

1. A system for dynamically routing signals in a Distributed Antenna System, the system comprising:

a plurality of Digital Access Units (DAUs), wherein the plurality of DAUs are coupled and operable to route signals between the plurality of DAUs;

a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs;

a plurality of Base Transceiver Stations (BTS);

a plurality of traffic monitoring modules; and

a network optimization goal and optimization algorithm.

2. The system of claim 1 wherein the Base Transceiver Station comprises a plurality of small cells.

3. The system of claim 1 wherein the Base Transceiver Station comprises a plurality of small cells.

4. The system of claim 1 wherein the wherein the network optimization goal comprises a percentage of users associated with each of a plurality of sectors.

5. A system for dynamically routing signals in a Distributed Antenna System, the system comprising:

a plurality of Digital Access Units (DAUs), wherein the plurality of DAUs are coupled and operable to route signals between the plurality of DAUs;

a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs;

one or more Base Transceiver Stations (BTSs); and

one or more traffic monitoring units.

6. The system of claim 5 wherein the one or more traffic monitoring units is external to the plurality of DAUs and coupled to each of the plurality of DAUs.

7. The system of claim 5 wherein the one or more traffic monitoring units comprise a plurality of traffic monitoring units each provided as a component of each of the plurality of DAUs.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page141

8. The system of claim 5 wherein the one or more traffic monitoring units is external to the plurality of DRUs and coupled to each of the plurality of DRUs.

9. The system of claim 5 wherein the one or more traffic monitoring units comprise a plurality of traffic monitoring units each provided as a component of each of the plurality of DRUs.

10. The system of claim 5 wherein the one or more traffic monitoring units is external to the plurality of BTSs and coupled to each of the plurality of BTSs.

11. The system of claim 5 further comprising a network optimization processor coupled to the traffic monitoring unit.

12. The system of claim 11 wherein the network optimization processor comprises an optimization algorithm, which optionally includes an optimization goal.

13. The system of claim 5 wherein the plurality of DAUs are coupled via at least one of Ethernet cable, Optical Fiber, Microwave Line of Sight Link, Wireless Link, or Satellite Link

14. The system of claim 5 wherein the plurality of DAUs are coupled to the plurality of DRUs via at least one of Ethernet cable, Optical Fiber, Microwave Line of Sight Link, Wireless Link, or Satellite Link.

15. The system of claim 5 wherein the DRUs are connected in a daisy chain configuration.

16. The system of claim 5 wherein the DRUs are connected to the DAUs in a star configuration.

17. The system of claim 5 wherein the DAUs are connected to the BTSs via at least one of a Ethernet cable, Optical Fiber, Microwave Line of Sight Link, Wireless Link, or Satellite Link.

18. The system of claim 5 wherein the DRUs are connected in a loop to a plurality of DAUs.

19. The system of claim 5 wherein a single DAU port is connected to a plurality of Base Transceiver Stations.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page142

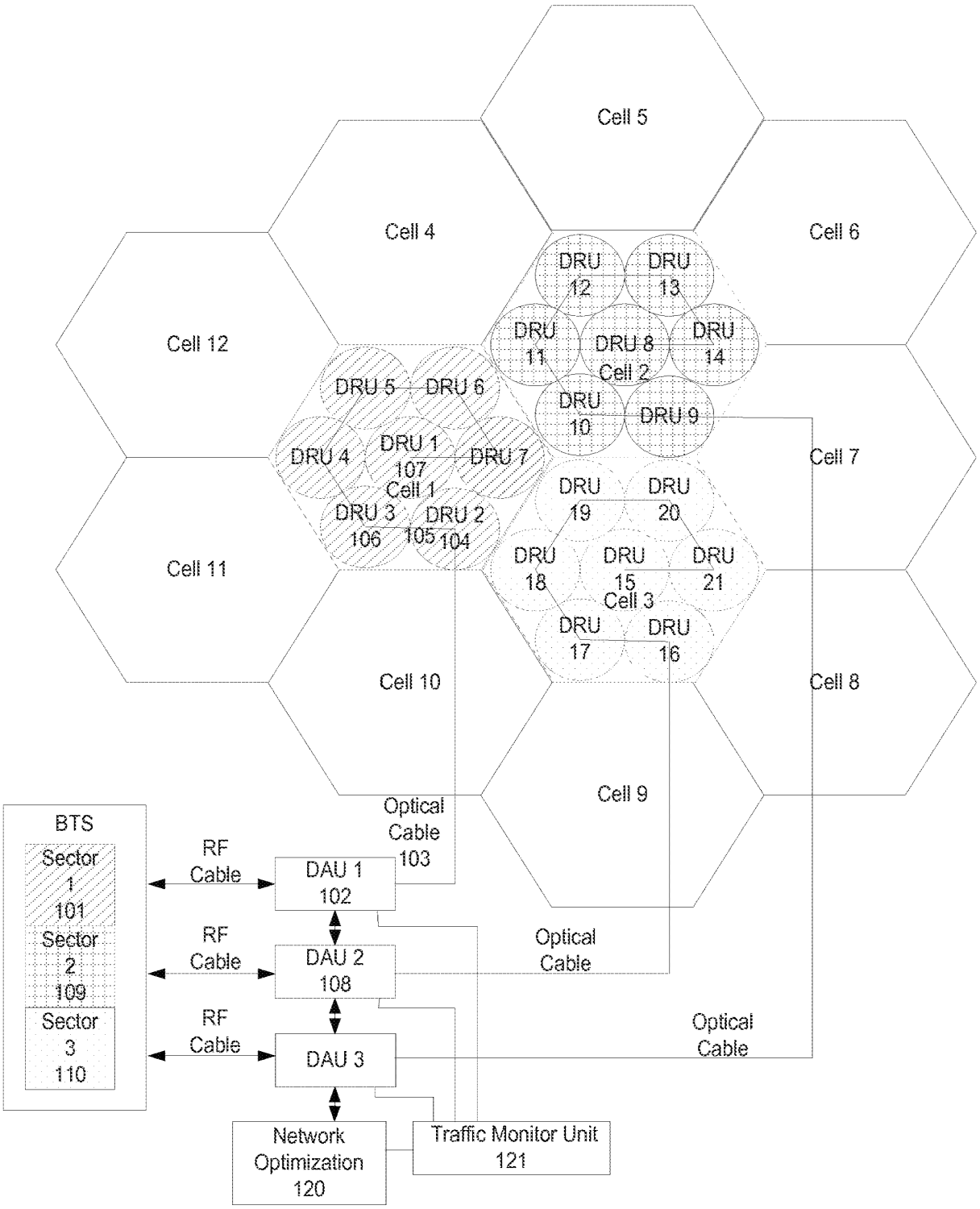

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Cell 4
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DRU 12
DRU 13
DRU 11
DRU 8
Cell 2
DRU 14
DRU 5
DRU 6
DRU 10
DRU 9
DRU 4
DRU 1
107
Cell 1
DRU 7
DRU 3
106
DRU 2
105
104
DRU 19
DRU 20
DRU 18
DRU 15
Cell 3
DRU 21
DRU 17
DRU 16
BTS
Sector 1 101
Sector 2 109
Sector 3 110
RF Cable
RF Cable
RF Cable
Optical Cable 103
DAU 1 102
DAU 2 108
DAU 3
Optical Cable
Optical Cable
Network Optimization 120
Traffic Monitor Unit 121

FIG. 1

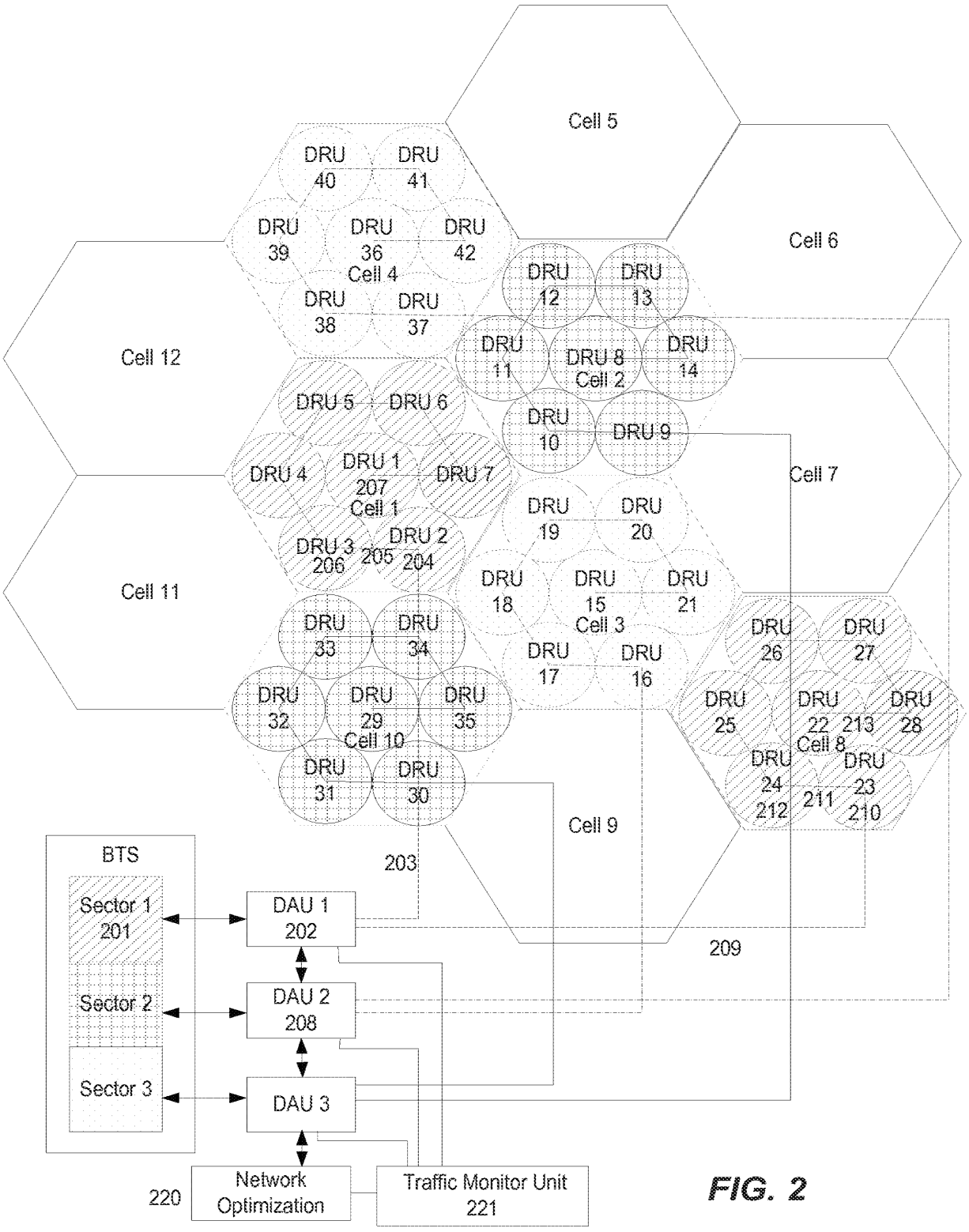

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DRU 40
DRU 41
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DRU 36
DRU 42
DRU 38
DRU 37
DRU 12
DRU 13
DRU 11
DRU 8
DRU 14
DRU 5
DRU 6
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DRU 32
DRU 29
DRU 35
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DRU 28
DRU 31
DRU 30
DRU 24
212
211
DRU 23
210
203
209
BTS
Sector 1
201
Sector 2
Sector 3
DAU 1
202
DAU 2
208
DAU 3
220
Network
Optimization
Traffic Monitor Unit
221

FIG. 2

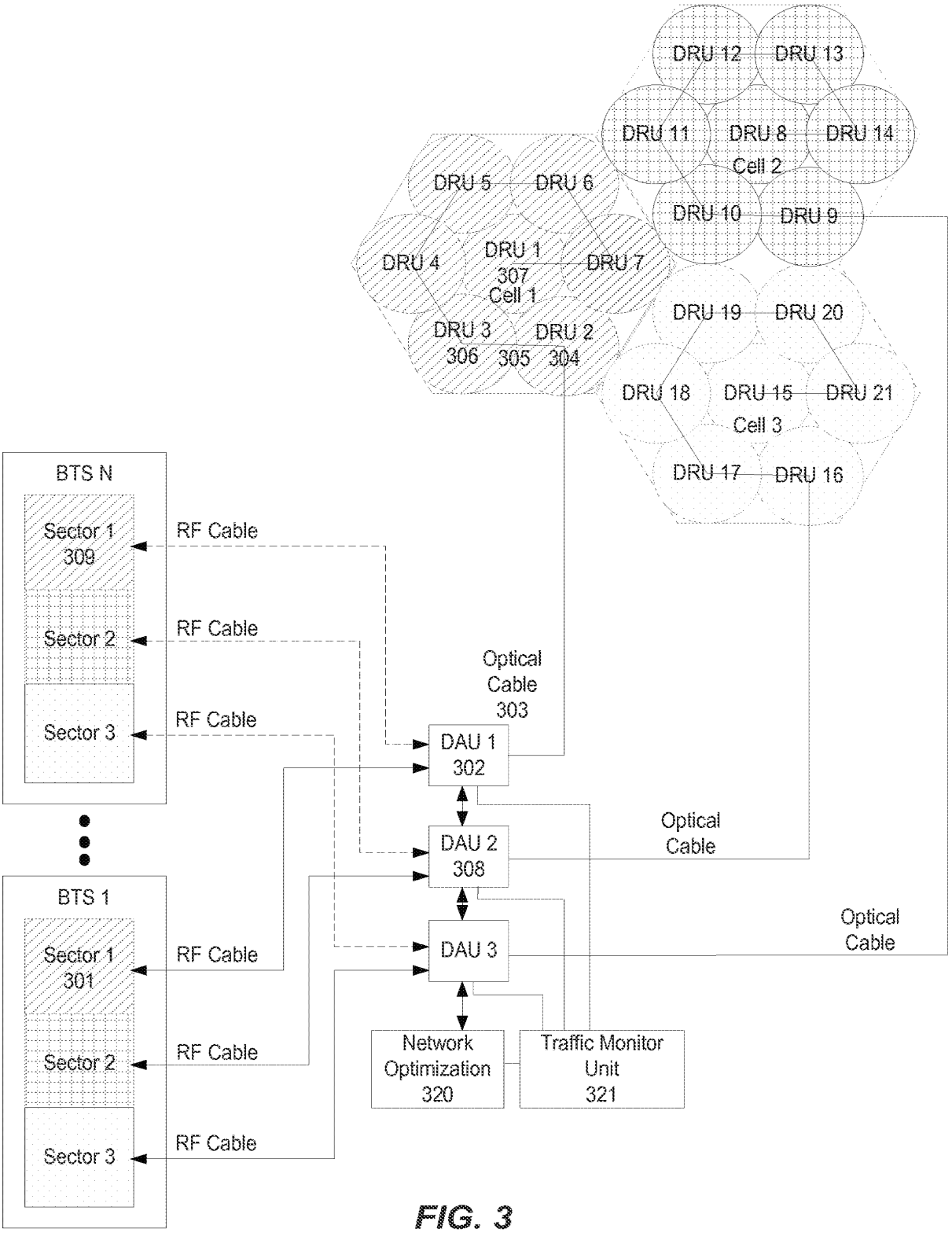

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DRU 8
DRU 14
Cell 2
DRU 5
DRU 6
DRU 10
DRU 9
DRU 4
DRU 1
307
DRU 7
Cell 1
DRU 19
DRU 20
DRU 3
306
DRU 2
305
304
DRU 18
DRU 15
DRU 21
Cell 3
DRU 17
DRU 16
BTS N
Sector 1
309
RF Cable
Sector 2
RF Cable
Sector 3
RF Cable
Optical
Cable
303
DAU 1
302
Optical
Cable
DAU 2
308
Optical
Cable
BTS 1
Sector 1
301
RF Cable
DAU 3
Sector 2
RF Cable
Network
Optimization
320
Traffic Monitor
Unit
321
Sector 3
RF Cable

FIG. 3

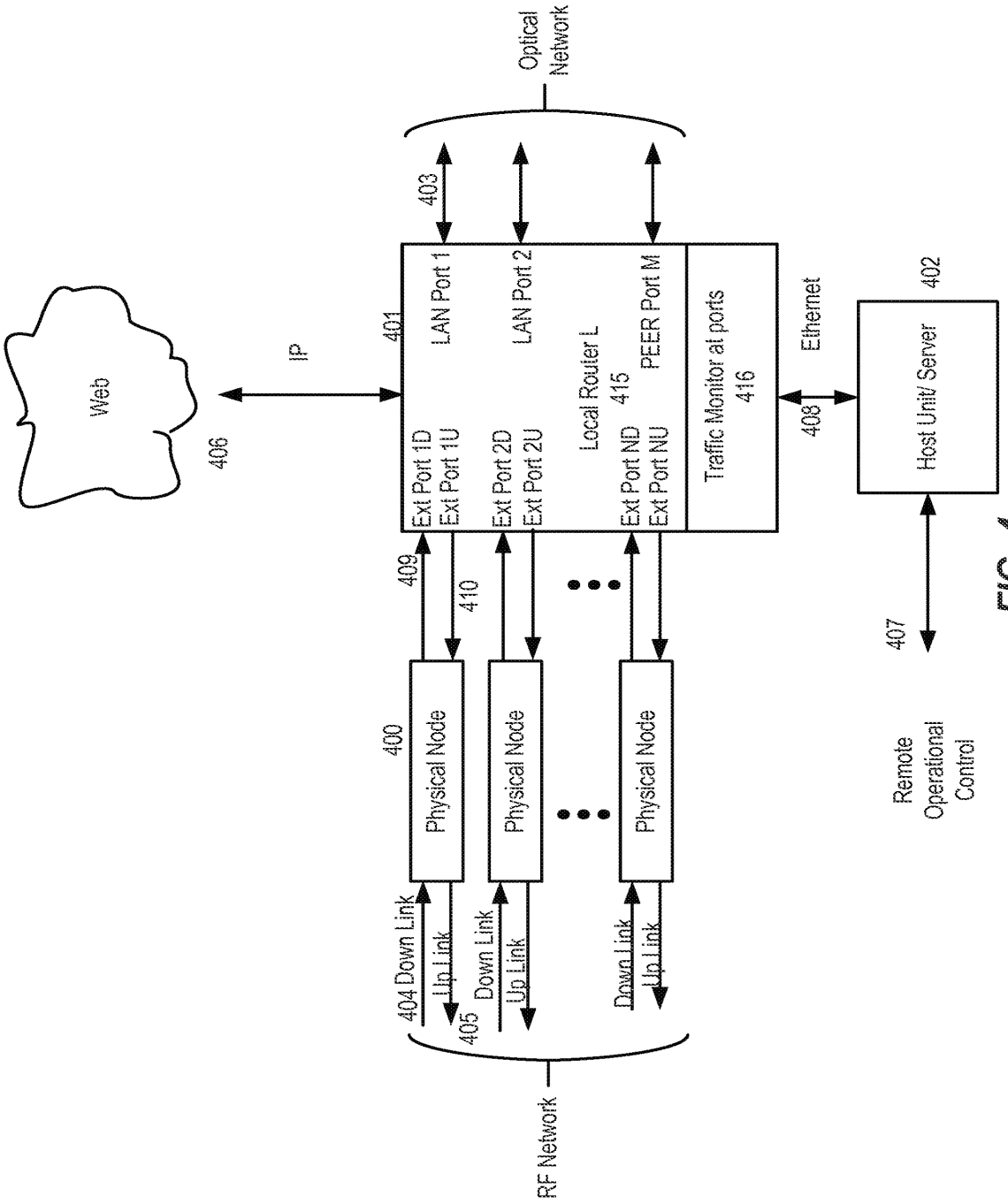


FIG. 4

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page146

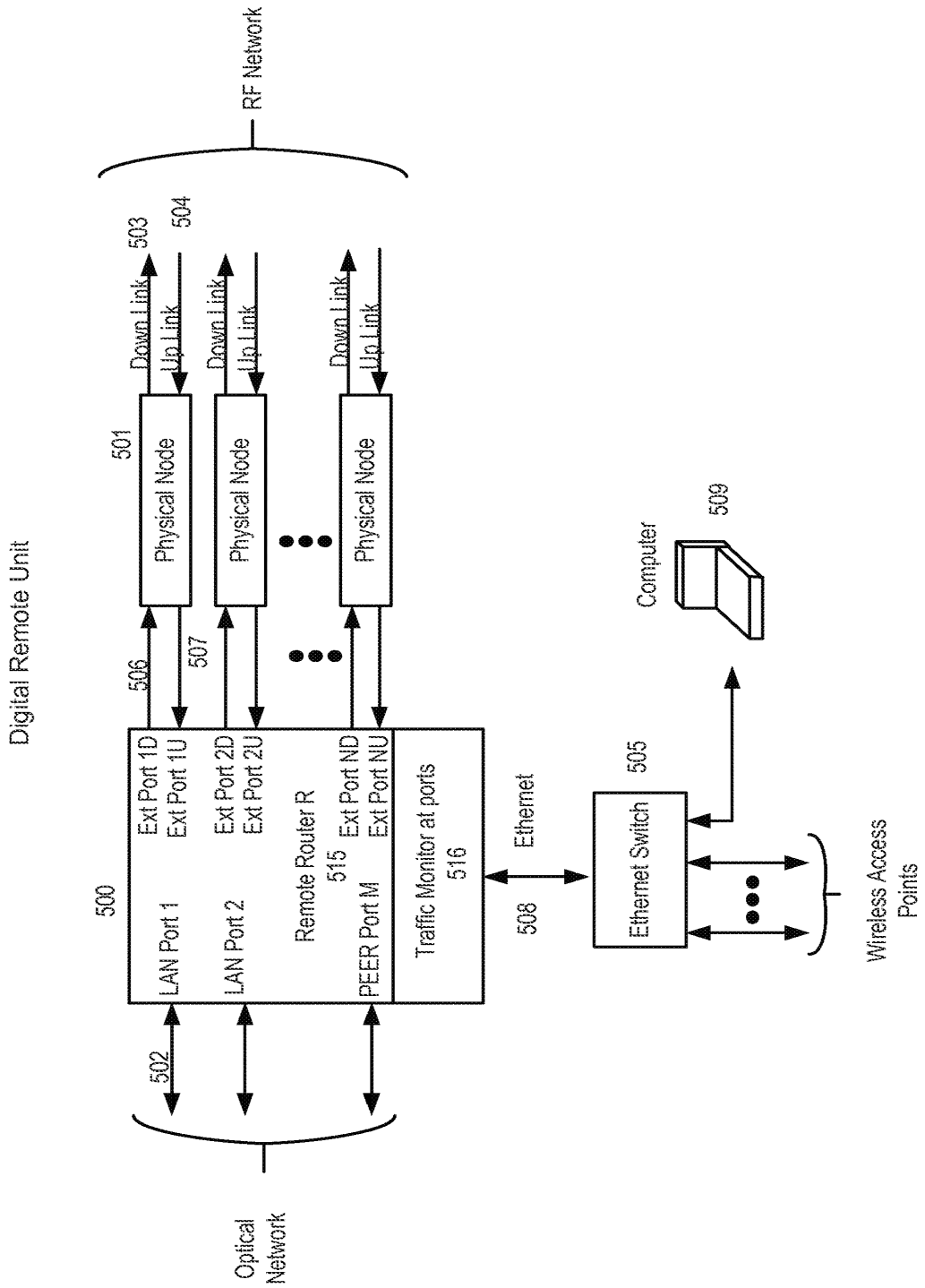


FIG. 5

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page147

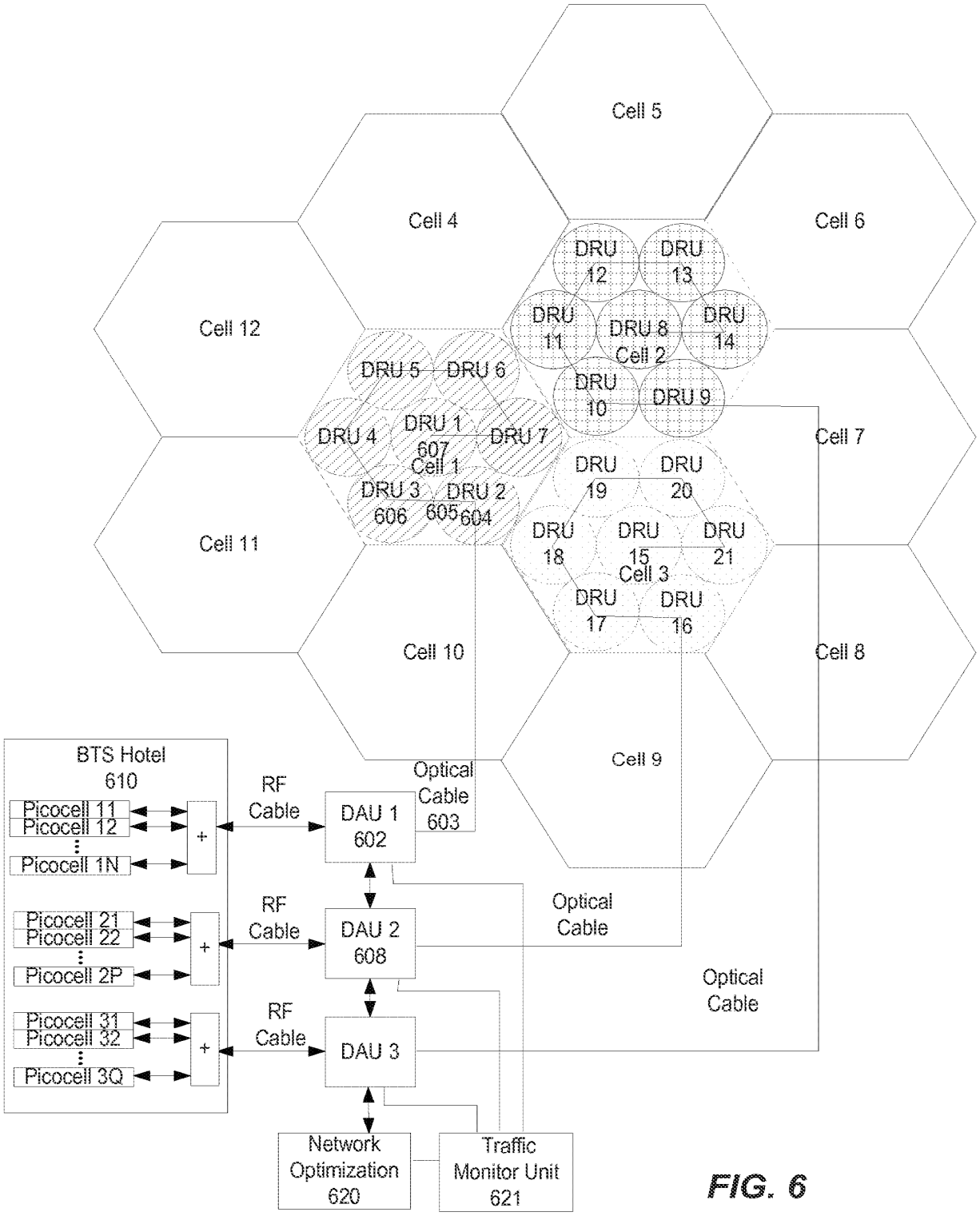

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DRU 2 604
DRU 3 606
DRU 4
DRU 5
DRU 6
DRU 7
DRU 8
DRU 9
DRU 10
DRU 11
DRU 12
DRU 13
DRU 14
DRU 15
DRU 16
DRU 17
DRU 18
DRU 19
DRU 20
DRU 21
BTS Hotel 610
Picocell 11
Picocell 12
Picocell 1N
Picocell 21
Picocell 22
Picocell 2P
Picocell 31
Picocell 32
Picocell 3Q
RF Cable
RF Cable
RF Cable
DAU 1 602
DAU 2 608
DAU 3
Optical Cable 603
Optical Cable
Optical Cable
Network Optimization 620
Traffic Monitor Unit 621

FIG. 6

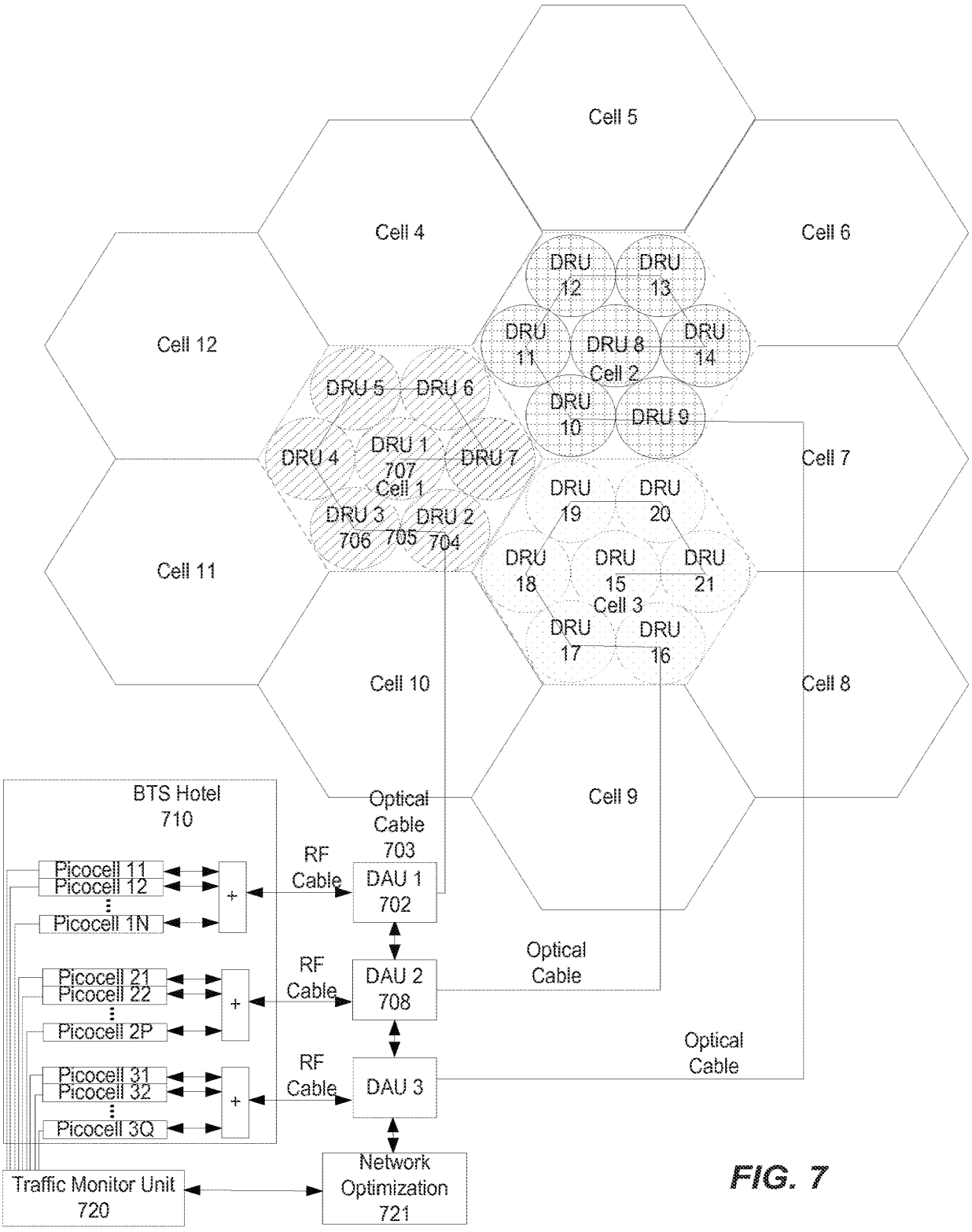

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DRU 10
DRU 9
DRU 4
DRU 1
707
Cell 1
DRU 7
DRU 19
DRU 20
DRU 3
706
DRU 2
705
704
DRU 18
DRU 15
DRU 21
Cell 3
DRU 17
DRU 16
BTS Hotel
710
Optical
Cable
703
RF
Cable
DAU 1
702
Picocell 11
Picocell 12
Picocell 1N
+
Optical
Cable
RF
Cable
DAU 2
708
Picocell 21
Picocell 22
Picocell 2P
+
Optical
Cable
RF
Cable
DAU 3
Picocell 31
Picocell 32
Picocell 3Q
+
Network
Optimization
721
Traffic Monitor Unit
720

FIG. 7

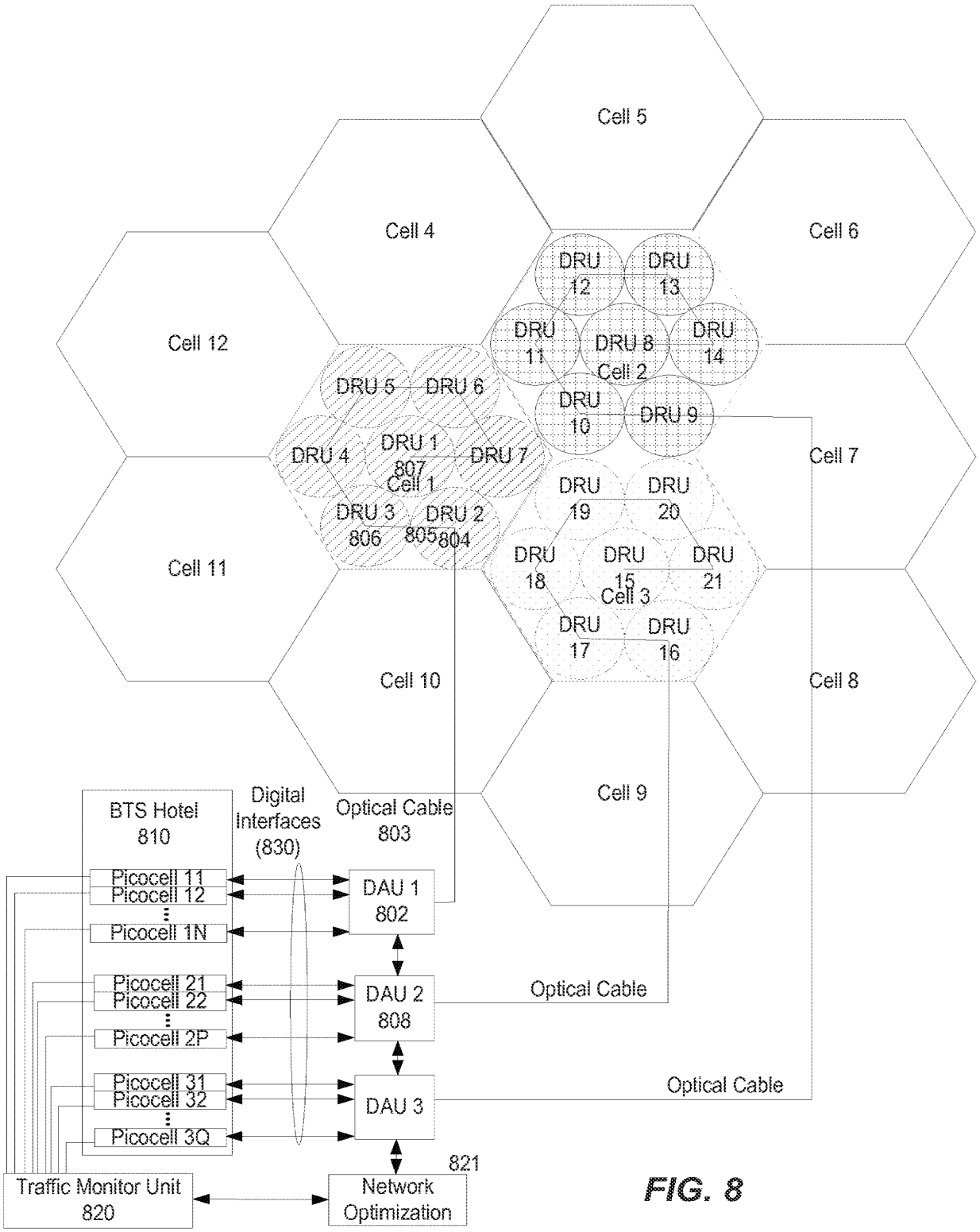

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DRU 10
DRU 9
DRU 5
DRU 6
DRU 4
DRU 1
807
DRU 7
Cell 1
DRU 3
806
DRU 2
805
804
DRU 19
DRU 20
DRU 18
DRU 15
DRU 21
Cell 3
DRU 17
DRU 16
BTS Hotel
810
Digital
Interfaces
(830)
Optical Cable
803
Picocell 11
Picocell 12
Picocell 1N
Picocell 21
Picocell 22
Picocell 2P
Picocell 31
Picocell 32
Picocell 3Q
DAU 1
802
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808
DAU 3
Optical Cable
Optical Cable
821
Traffic Monitor Unit
820
Network
Optimization

FIG. 8

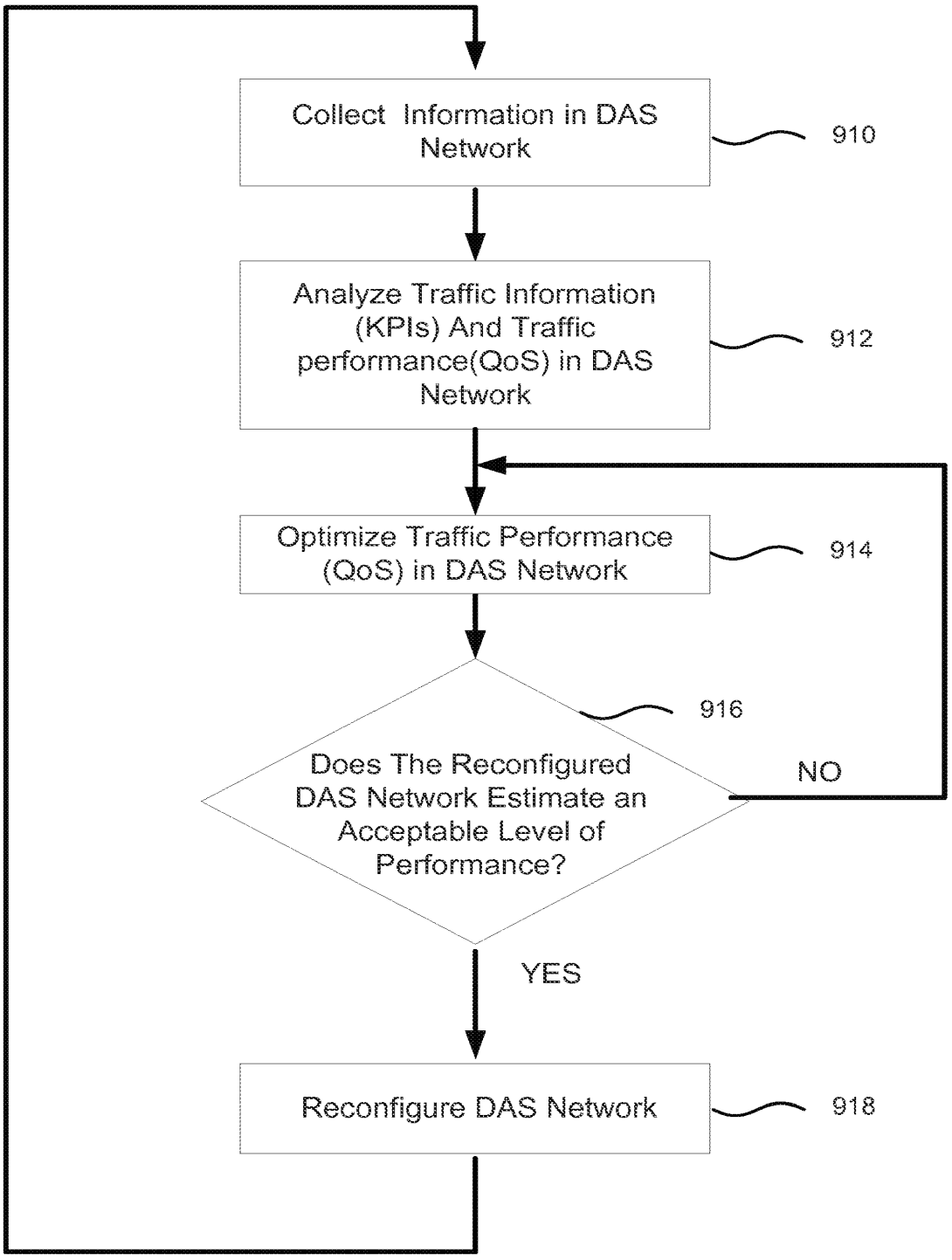

Collect Information in DAS Network
910
Analyze Traffic Information (KPIs) And Traffic performance(QoS) in DAS Network
912
Optimize Traffic Performance (QoS) in DAS Network
914
916
Does The Reconfigured DAS Network Estimate an Acceptable Level of Performance?
NO
YES
Reconfigure DAS Network
918

FIG. 9

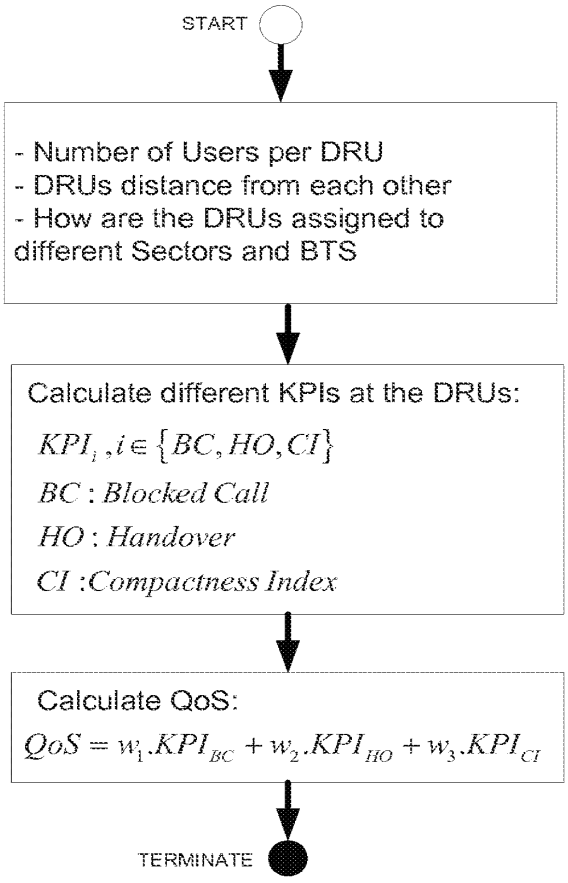
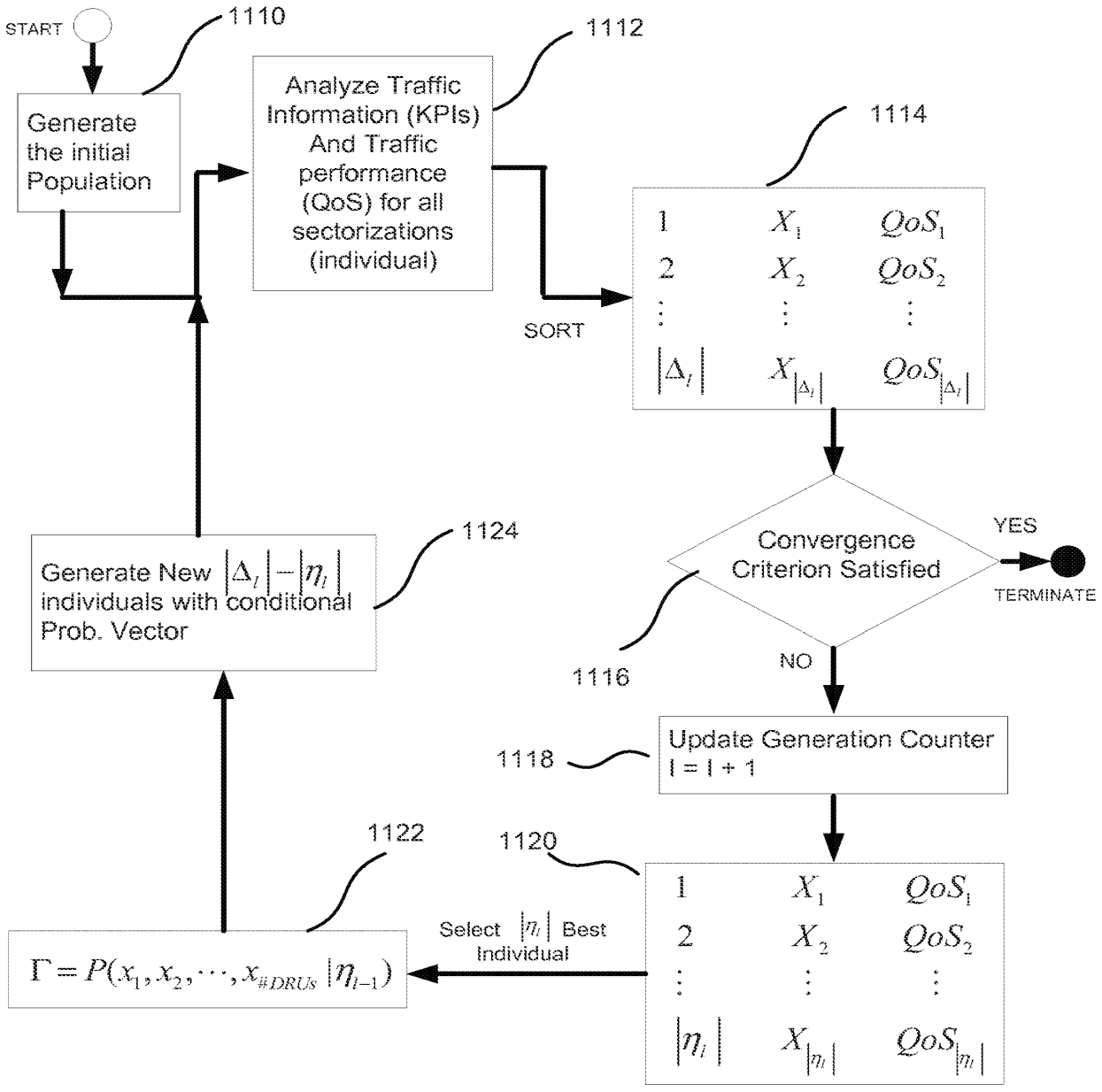

START
- Number of Users per DRU
- DRUs distance from each other
- How are the DRUs assigned to different Sectors and BTS
Calculate different KPIs at the DRUs:
$KPI_i, i \in \{BC, HO, CI\}$
BC : $Blocked\ Call$
HO : $Handover$
CI :$Compactness\ Index$
Calculate QoS:
$QoS = w_1.KPI_{BC} + w_2.KPI_{HO} + w_3.KPI_{CI}$
TERMINATE

FIG. 10



- Δ_l is Set of Individuals(population)
- Individual $X_j = (x_1, x_2, ..., x_{\#DRUs}), x_i \in \{S_{nm} | \text{sector "n" from BTS "m"}\}$

FIG. 11

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 91172-881579	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US2013/052206	International filing date *(day/month/year)* 26 July 2013	(Earliest) Priority Date *(day/month/year)* 31 July 2012
Applicant DALI SYSTEMS CO. LTD.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 7 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

a. the figure of the drawings to be published with the abstract is Figure No. 1

☒ as suggested by the applicant.

☐ as selected by this Authority, because the applicant failed to suggest a figure.

☐ as selected by this Authority, because this figure better characterizes the invention.

b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/052206

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H04W 40/00 (2013.01)
USPC - 370/338
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - H04W 40/00, 64/00 (2013.01)
USPC - 370/338, 396

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - H04W 40/00, 64/00 (2013.01)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Orbit, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 2012/0039320 A1 (LEMSON et al) 16 February 2012 (16.02.2012) entire document	1,5-15,17,18 ---- 2-4,16,19
Y	US 2002/0119772 A1 (YOSHIDA) 29 August 2002 (29.08.2002) entire document	2-4
Y	WO 2012/024349 A1 (STAPLETON et al) 23 February 2012 (23.02.2012) entire document	16,19
A	US 2005/0153743 A1 (BERRA et al) 14 July 2005 (14.07.2005) entire document	1-19

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 October 2013	31 OCT 2013
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: CRAIG C. LARGENT
KILPATRICK TOWNSEND & STOCKTON LLP
1080 MARSH ROAD
MENLO PARK, CA 94025

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	31 OCT 2013
Applicant's or agent's file reference 91172-881579	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/052206	26 July 2013	31 July 2012

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - H04W 40/00 (2013.01)
USPC - 370/338

Applicant DALI SYSTEMS CO. LTD.

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability: citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	24 October 2013	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/052206

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

      ☐ on paper

      ☐ in electronic form

   b. (time)

      ☐ in the international application as filed

      ☐ together with the international application in electronic form

      ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/052206

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	2-4, 6, 8, 12, 14, 19	YES
	Claims	1, 5, 7, 9-11,13-15,17,18	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-19	NO
Industrial applicability (IA)	Claims	1-19	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1, 5, 7, 9-11, 13-15, 17, 18 lack novelty under PCT Article 33(2) as being anticipated by Lemson et al., hereinafter referred to as Lemson.

Regarding claim 1, Lemson discloses a system for dynamically routing signals in a Distributed Antenna System (Distributed Antenna system, abstract; Flexible Simulcast supports dynamic and/or manual rearrangement [rerouting signals] of which specific RRU are involved in signal combining process, para 0039), the system comprising: a plurality of Digital Access units (DAUs), wherein the plurality of DAUs are coupled and operable to route signals between the plurality of DAUs (DAU1 [101] and DAU2 [102] [plurality of DAUs] are coupled and operable to route signals between them using bidirectional optical cable 113, para 0030, see fig. 1); a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs (RRU1 [here RRU is the DRU of the inventor specification] and RRU2 are coupled to DAU1, RRU3, RRU4 are coupled to DAU2, see fig. 1, para 0030) and operable to transport signals between DRUs and DAUs (one signal from DAU1 is fed to RRU1, RRU2 is fed by second optical port via bidirectional optical cable 114 to RRU2, para 0030, see fig. 1; RRU3 is coupled to RRU4 via optical cable 115, para 0031, see fig. 1 [where RRU3 is fed by DAU2]); a plurality of Base Transceiver Stations (BTS) (Composite downlink input signal 107 from a base station enters DAU1 at the DAU1 RF input port, a second composite downlink input signal from a second base station [multiple BTSs] enters DAU2 at the DAU2 RF input port, para 0030, see fig. 1; base transceiver station, para 0049); a plurality of traffic monitoring modules (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7); and a network optimization goal and optimization algorithm (an algorithm operating within the DAU monitoring module detects which carriers and corresponding time slots for each carrier are active for each RRU and control modification of system based on usage [network optimization algorithm with a goal of modification based on the load], para 0052, para 0016 [optimization]).

Regarding claim 5, Lemson discloses a system for dynamically routing signals in a Distributed Antenna System (Distributed Antenna system, abstract; Flexible Simulcast supports dynamic and/or manual rearrangement [rerouting signals] of which specific RRU are involved in signal combining process, para 0039), the system comprising: a plurality of Digital Access units (DAUs), wherein the plurality of DAUs are coupled and operable to route signals between the plurality of DAUs (DAU1 [101] and DAU2 [102] [plurality of DAUs] are coupled and operable to route signals between them using bidirectional optical cable 113, para 0030, see fig. 1); a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs (RRU1 [here RRU is the DRU of the inventor specification] and RRU2 are coupled to DAU1, RRU3, RRU4 are coupled to DAU2, see fig. 1, para 0030) and operable to transport signals between DRUs and DAUs (one signal from DAU1 is fed to RRU1, RRU2 is fed by second optical port via bidirectional optical cable 114 to RRU2, para 0030, see fig. 1; RRU3 is coupled to RRU4 via optical cable 115, para 0031, see fig. 1 [where RRU3 is fed by DAU2]); one or more Base Transceiver Stations (BTSs) (Composite downlink input signal 107 from a base station enters DAU1 at the DAU1 RF input port, a second composite downlink input signal from a second base station [multiple BTSs] enters DAU2 at the DAU2 RF input port, para 0030, see fig. 1; base transceiver station, para 0049); and one or more traffic monitoring units (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7).

Regarding claim 7, Lemson teaches wherein the one or more traffic monitoring units comprise a plurality of traffic monitoring units each provided as a component of each of the plurality of DAUs (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7 [the module is internal to the DAU so component of the DAU]).

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/052206

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Regarding claim 9, Lemson teaches wherein the one or more traffic monitoring units comprise a plurality of traffic monitoring units each provided as a component of each of the plurality of DRUs (RRU management control module [internal or component of the DRU] sets the individual parameters of the RRU digital up converters to enable or disable specific radio resources [traffic control], para 0051, 0052).

Regarding claim 10, Lemson teaches wherein the one or more traffic monitoring units is external to the plurality of BTSs and coupled to each of the plurality of BTSs (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7; wherein the DAU are connected to the BTS, see fig. 1 [external to the BTSs]).

Regarding claim 11, Lemson teaches a network optimization processor coupled to the traffic monitoring unit (a network operations center (NOC) coupled to the DAU [which has the internal monitoring unit] which requests and identifies the BTS where the user has placed the call and asks DAU to determine the radio signature, para 0049).

Regarding claim 13, Lemson teaches wherein the plurality of DAUs are coupled via at least one of Ethernet cable, Optical Fiber (DAU1 and DAU2 are coupled using a bidirectional optical cable 113, para 0030, see fig. 1), Microwave Line of Sight Link, Wireless Link, or Satellite Link.

Regarding claim 14, Lemson teaches wherein the plurality of DAUs are coupled to the plurality of DRUs via at least one of Ethernet cable, Optical Fiber (DAU1 uses an optical port [optical fiber] to feed RRU1 and RRU1 is connected to RRU2 by bidirectional optical cable, para 0030, see fig. 1), Microwave Line of Sight Link, Wireless Link, or Satellite Link.

Regarding claim 15, Lemson teaches wherein the DRUs are connected in a daisy chain configuration (Optical cable 114 performs the function of daisy chaining RRU2 with RRU1, para 0030, see fig. 1).

Regarding claim 17, Lemson teaches wherein the DAUs are connected to the BTSs via at least one of a Ethernet cable, Optical Fiber, Microwave Line of Sight Link (BTS signal is fed to the DAU via a RF input port where the RF signals are received from BTS, para 0030), Wireless Link, or Satellite Link.

Regarding claim 18, Lemson teaches wherein the DRUs are connected in a loop to a plurality of DAUs (DAU is coupled to a daisy chain of RRUs and in a loop, para 0030, see fig. 1).

Claims 6, 8, 12 lack an inventive step under PCT Article 33(3) as being obvious over Lemson.

Regarding claims 6 and 8, Lemson lacks the teaching wherein the one or more traffic monitoring units is external to the plurality of DAUs and coupled to each of the plurality of DAUs. However, Lemson teaches wherein the one or more traffic monitoring units is internal to the plurality of DAUs and coupled to each of the plurality of DAUs (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7). Further, Lemson teaches a network Operation center which controls operation and assignment of users to the corresponding BTS external to the DAU and coupled to the DAU (Network Operation Center (NOC) via external modem to DAU, para 0049, see fig. 5). Furthermore, defining a structural component with same functions to be internal or external would have been a matter of design choice. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate the traffic monitoring unit in the invention of Lemson for the purpose of dynamically reconfiguring the system (modification) to balance the load (Lemson, para 0051, abstract).

Regarding claim 12, Lemson lacks the teaching wherein the network optimization processor comprises an optimization algorithm, which optionally includes an optimization goal. However, Lemson teaches a network optimization goal and optimization algorithm (an algorithm operating within the DAU monitoring module detects which carriers and corresponding time slots for each carrier are active for each RRU and control modification of system based on usage [network optimization algorithm with a goal of modification based on the load], para 0052, para 0016 [optimization]). Furthermore, defining a specific position or component for the algorithm would have been a matter of design choice. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate the network optimization algorithm in the invention of Lemson for the purpose of dynamically reconfiguring the system (modification) to balance the load (Lemson, para 0051, abstract).

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/052206

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Claims 2-4 lack an inventive step under PCT Article 33(3) as being obvious over Lemson and in view of Yoshida.

Regarding claims 2 and 3, Lemson lacks the teaching wherein the Base Transceiver Station comprises a plurality of small cells. However, Lemson teaches a base transceiver station comprising a cell (a user can be located in a BTS cell, para 0049). Yoshida is in the field of base testing for use in testing an active base transceiver station (abstract) and teaches wherein the Base Transceiver station comprises a plurality of small cells (BTS has a cell divided into three or six sectors [cover different areas], para 0003, BTS2 is divided into six sectors, para 0039, see fig. 1 [each base station has 3 independent radio resources known as sectors, para 0027]). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use the teachings of Yoshida to incorporate the sectors in the invention of Lemson for the purpose of repeatedly utilizing the same radio wave resources in a plurality of the BTS and accommodate a great number of subscribers in each BTS (Yoshida, para 0003).

Regarding claim 4, Lemson teaches wherein the wherein the network optimization goal comprises a percentage of users associated with each of a plurality of DRUs (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7; wherein the module controls the downlink load of carrier based on percentage [of users as the usage of the RRUs] of carrier and in the RRU's corresponding coverage area, para 0052). Lemson lacks the teaching of plurality of sectors. Yoshida teaches wherein the Base Transceiver station comprises a plurality of small cells (BTS has a cell divided into three or six sectors [cover different areas], para 0003, BTS2 is divided into six sectors, para 0039, see fig. 1 [each base station has 3 independent radio resources known as sectors, para 0027]). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use the teachings of Yoshida to incorporate the sectors in the invention of Lemson for the purpose of repeatedly utilizing the same radio wave resources in a plurality of the BTS and accommodate a great number of subscribers in each BTS (Yoshida, para 0003).

Claims 16, 19 lack an inventive step under PCT Article 33(3) as being obvious over Lemson and in view of Stapleton et al., hereinafter referred to as Stapleton.

Regarding claim 16, Lemson lacks the teaching wherein the DRUs are connected to the DAUs in a star configuration. Stapleton is in the field of daisy-chained ring of remote units for a distributed antenna system (title, abstract) and teaches wherein the DRUs are connected to the DAUs in a star configuration (DAU coupled to DRUs 125A-125C arranged in a ring configuration, para 0029, see fig. 1). Furthermore, defining a specific configuration for communication was well known in the art and the specifics would have been a matter of design choice. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use the teachings of Stapleton to incorporate the configuration of the DRUs in the invention of Lemson for the purpose of connecting in a ring configuration fault tolerance is built into the system resulting in high availability (Stapleton, para 0009).

Regarding claim 19, Lemson lacks the teaching wherein a single DAU port is connected to a plurality of Base Transceiver Stations. Stapleton teaches wherein a single DAU port is connected to a plurality of Base Transceiver Stations (RF input signals 120A through 120N are received at the DAU 105 from one or more Base Station units (BTS) at 110A through 110p, para 00029, see fig. 1). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use the teachings of Stapleton to incorporate the single DAU to multiple BTSs in the invention of Lemson for the purpose of delivering parallel data streams to different DRUs (Stapleton, para 0029).

Claims 1-19 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

PATENT COOPERATION TREATY

ADVANCE E-MAIL

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From the INTERNATIONAL BUREAU

NOTIFICATION CONCERNING TRANSMITTAL OF COPY OF INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY (CHAPTER I OF THE PATENT COOPERATION TREATY)
(PCT Rule 44bis.1(c))

To:

LARGENT, Craig C.
Kilpatrick Townsend & Stockton LLP
Two Embarcadero Center, Eighth Floor
San Francisco, California 94111
ETATS-UNIS D'AMERIQUE

Date of mailing *(day/month/year)*
11 June 2015 (11.06.2015)

Applicant's or agent's file reference
91172-881579

IMPORTANT NOTICE

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/052206	26 July 2013 (26.07.2013)	31 July 2012 (31.07.2012)

Applicant
DALI SYSTEMS CO. LTD.

The International Bureau transmits herewith a copy of the international preliminary report on patentability (Chapter I of the Patent Cooperation Treaty)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer
Simin Baharlou

e-mail: pt09.pct@wipo.int

Form PCT/IB/326 (January 2004)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference 91172-881579	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2013/052206	International filing date *(day/month/year)* 26 July 2013 (26.07.2013)	Priority date *(day/month/year)* 31 July 2012 (31.07.2012)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant DALI SYSTEMS CO. LTD.		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 02 June 2015 (02.06.2015)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Simin Baharlou e-mail: pt09.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: CRAIG C. LARGENT
KILPATRICK TOWNSEND & STOCKTON LLP
1080 MARSH ROAD
MENLO PARK, CA 94025

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	31 OCT 2013
Applicant's or agent's file reference 91172-881579	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/052206	26 July 2013	31 July 2012

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - H04W 40/00 (2013.01)
USPC - 370/338

Applicant DALI SYSTEMS CO. LTD.

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability: citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	24 October 2013	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/052206

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

      ☐ on paper

      ☐ in electronic form

   b. (time)

      ☐ in the international application as filed

      ☐ together with the international application in electronic form

      ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/052206

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	2-4, 6, 8, 12, 14, 19	YES
	Claims	1, 5, 7, 9-11,13-15,17,18	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-19	NO
Industrial applicability (IA)	Claims	1-19	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1, 5, 7, 9-11, 13-15, 17, 18 lack novelty under PCT Article 33(2) as being anticipated by Lemson et al., hereinafter referred to as Lemson.

Regarding claim 1, Lemson discloses a system for dynamically routing signals in a Distributed Antenna System (Distributed Antenna system, abstract; Flexible Simulcast supports dynamic and/or manual rearrangement [rerouting signals] of which specific RRU are involved in signal combining process, para 0039), the system comprising: a plurality of Digital Access units (DAUs), wherein the plurality of DAUs are coupled and operable to route signals between the plurality of DAUs (DAU1 [101] and DAU2 [102] [plurality of DAUs] are coupled and operable to route signals between them using bidirectional optical cable 113, para 0030, see fig. 1); a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs (RRU1 [here RRU is the DRU of the inventor specification] and RRU2 are coupled to DAU1, RRU3, RRU4 are coupled to DAU2, see fig. 1, para 0030) and operable to transport signals between DRUs and DAUs (one signal from DAU1 is fed to RRU1, RRU2 is fed by second optical port via bidirectional optical cable 114 to RRU2, para 0030, see fig. 1; RRU3 is coupled to RRU4 via optical cable 115, para 0031, see fig. 1 [where RRU3 is fed by DAU2]); a plurality of Base Transceiver Stations (BTS) (Composite downlink input signal 107 from a base station enters DAU1 at the DAU1 RF input port, a second composite downlink input signal from a second base station [multiple BTSs] enters DAU2 at the DAU2 RF input port, para 0030, see fig. 1; base transceiver station, para 0049); a plurality of traffic monitoring modules (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7); and a network optimization goal and optimization algorithm (an algorithm operating within the DAU monitoring module detects which carriers and corresponding time slots for each carrier are active for each RRU and control modification of system based on usage [network optimization algorithm with a goal of modification based on the load], para 0052, para 0016 [optimization]).

Regarding claim 5, Lemson discloses a system for dynamically routing signals in a Distributed Antenna System (Distributed Antenna system, abstract; Flexible Simulcast supports dynamic and/or manual rearrangement [rerouting signals] of which specific RRU are involved in signal combining process, para 0039), the system comprising: a plurality of Digital Access units (DAUs), wherein the plurality of DAUs are coupled and operable to route signals between the plurality of DAUs (DAU1 [101] and DAU2 [102] [plurality of DAUs] are coupled and operable to route signals between them using bidirectional optical cable 113, para 0030, see fig. 1); a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs (RRU1 [here RRU is the DRU of the inventor specification] and RRU2 are coupled to DAU1, RRU3, RRU4 are coupled to DAU2, see fig. 1, para 0030) and operable to transport signals between DRUs and DAUs (one signal from DAU1 is fed to RRU1, RRU2 is fed by second optical port via bidirectional optical cable 114 to RRU2, para 0030, see fig. 1; RRU3 is coupled to RRU4 via optical cable 115, para 0031, see fig. 1 [where RRU3 is fed by DAU2]); one or more Base Transceiver Stations (BTSs) (Composite downlink input signal 107 from a base station enters DAU1 at the DAU1 RF input port, a second composite downlink input signal from a second base station [multiple BTSs] enters DAU2 at the DAU2 RF input port, para 0030, see fig. 1; base transceiver station, para 0049); and one or more traffic monitoring units (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7).

Regarding claim 7, Lemson teaches wherein the one or more traffic monitoring units comprise a plurality of traffic monitoring units each provided as a component of each of the plurality of DAUs (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7 [the module is internal to the DAU so component of the DAU]).

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/052206

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Regarding claim 9, Lemson teaches wherein the one or more traffic monitoring units comprise a plurality of traffic monitoring units each provided as a component of each of the plurality of DRUs (RRU management control module [internal or component of the DRU] sets the individual parameters of the RRU digital up converters to enable or disable specific radio resources [traffic control], para 0051, 0052).

Regarding claim 10, Lemson teaches wherein the one or more traffic monitoring units is external to the plurality of BTSs and coupled to each of the plurality of BTSs (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7; wherein the DAU are connected to the BTS, see fig. 1 [external to the BTSs]).

Regarding claim 11, Lemson teaches a network optimization processor coupled to the traffic monitoring unit (a network operations center (NOC) coupled to the DAU [which has the internal monitoring unit] which requests and identifies the BTS where the user has placed the call and asks DAU to determine the radio signature, para 0049).

Regarding claim 13, Lemson teaches wherein the plurality of DAUs are coupled via at least one of Ethernet cable, Optical Fiber (DAU1 and DAU2 are coupled using a bidirectional optical cable 113, para 0030, see fig. 1), Microwave Line of Sight Link, Wireless Link, or Satellite Link.

Regarding claim 14, Lemson teaches wherein the plurality of DAUs are coupled to the plurality of DRUs via at least one of Ethernet cable, Optical Fiber (DAU1 uses an optical port [optical fiber] to feed RRU1 and RRU1 is connected to RRU2 by bidirectional optical cable, para 0030, see fig. 1), Microwave Line of Sight Link, Wireless Link, or Satellite Link.

Regarding claim 15, Lemson teaches wherein the DRUs are connected in a daisy chain configuration (Optical cable 114 performs the function of daisy chaining RRU2 with RRU1, para 0030, see fig. 1).

Regarding claim 17, Lemson teaches wherein the DAUs are connected to the BTSs via at least one of a Ethernet cable, Optical Fiber, Microwave Line of Sight Link (BTS signal is fed to the DAU via a RF input port where the RF signals are received from BTS, para 0030), Wireless Link, or Satellite Link.

Regarding claim 18, Lemson teaches wherein the DRUs are connected in a loop to a plurality of DAUs (DAU is coupled to a daisy chain of RRUs and in a loop, para 0030, see fig. 1).

Claims 6, 8, 12 lack an inventive step under PCT Article 33(3) as being obvious over Lemson.

Regarding claims 6 and 8, Lemson lacks the teaching wherein the one or more traffic monitoring units is external to the plurality of DAUs and coupled to each of the plurality of DAUs. However, Lemson teaches wherein the one or more traffic monitoring units is internal to the plurality of DAUs and coupled to each of the plurality of DAUs (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7). Further, Lemson teaches a network Operation center which controls operation and assignment of users to the corresponding BTS external to the DAU and coupled to the DAU (Network Operation Center (NOC) via external modem to DAU, para 0049, see fig. 5). Furthermore, defining a structural component with same functions to be internal or external would have been a matter of design choice. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate the traffic monitoring unit in the invention of Lemson for the purpose of dynamically reconfiguring the system (modification) to balance the load (Lemson, para 0051, abstract).

Regarding claim 12, Lemson lacks the teaching wherein the network optimization processor comprises an optimization algorithm, which optionally includes an optimization goal. However, Lemson teaches a network optimization goal and optimization algorithm (an algorithm operating within the DAU monitoring module detects which carriers and corresponding time slots for each carrier are active for each RRU and control modification of system based on usage [network optimization algorithm with a goal of modification based on the load], para 0052, para 0016 [optimization]). Furthermore, defining a specific position or component for the algorithm would have been a matter of design choice. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate the network optimization algorithm in the invention of Lemson for the purpose of dynamically reconfiguring the system (modification) to balance the load (Lemson, para 0051, abstract).

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/052206

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Claims 2-4 lack an inventive step under PCT Article 33(3) as being obvious over Lemson and in view of Yoshida.

Regarding claims 2 and 3, Lemson lacks the teaching wherein the Base Transceiver Station comprises a plurality of small cells. However, Lemson teaches a base transceiver station comprising a cell (a user can be located in a BTS cell, para 0049). Yoshida is in the field of base testing for use in testing an active base transceiver station (abstract) and teaches wherein the Base Transceiver station comprises a plurality of small cells (BTS has a cell divided into three or six sectors [cover different areas], para 0003, BTS2 is divided into six sectors, para 0039, see fig. 1 [each base station has 3 independent radio resources known as sectors, para 0027]). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use the teachings of Yoshida to incorporate the sectors in the invention of Lemson for the purpose of repeatedly utilizing the same radio wave resources in a plurality of the BTS and accommodate a great number of subscribers in each BTS (Yoshida, para 0003).

Regarding claim 4, Lemson teaches wherein the wherein the network optimization goal comprises a percentage of users associated with each of a plurality of DRUs (DAU Monitoring module [each DAU has one module so DAU1 and DAU2 have the modules so plurality of monitoring modules] determining and setting the appropriate amount of radio resources, para 0051, see fig. 7; wherein the module controls the downlink load of carrier based on percentage [of users as the usage of the RRUs] of carrier and in the RRU's corresponding coverage area, para 0052). Lemson lacks the teaching of plurality of sectors. Yoshida teaches wherein the Base Transceiver station comprises a plurality of small cells (BTS has a cell divided into three or six sectors [cover different areas], para 0003, BTS2 is divided into six sectors, para 0039, see fig. 1 [each base station has 3 independent radio resources known as sectors, para 0027]). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use the teachings of Yoshida to incorporate the sectors in the invention of Lemson for the purpose of repeatedly utilizing the same radio wave resources in a plurality of the BTS and accommodate a great number of subscribers in each BTS (Yoshida, para 0003).

Claims 16, 19 lack an inventive step under PCT Article 33(3) as being obvious over Lemson and in view of Stapleton et al., hereinafter referred to as Stapleton.

Regarding claim 16, Lemson lacks the teaching wherein the DRUs are connected to the DAUs in a star configuration. Stapleton is in the field of daisy-chained ring of remote units for a distributed antenna system (title, abstract) and teaches wherein the DRUs are connected to the DAUs in a star configuration (DAU coupled to DRUs 125A-125C arranged in a ring configuration, para 0029, see fig. 1). Furthermore, defining a specific configuration for communication was well known in the art and the specifics would have been a matter of design choice. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use the teachings of Stapleton to incorporate the configuration of the DRUs in the invention of Lemson for the purpose of connecting in a ring configuration fault tolerance is built into the system resulting in high availability (Stapleton, para 0009).

Regarding claim 19, Lemson lacks the teaching wherein a single DAU port is connected to a plurality of Base Transceiver Stations. Stapleton teaches wherein a single DAU port is connected to a plurality of Base Transceiver Stations (RF input signals 120A through 120N are received at the DAU 105 from one or more Base Station units (BTS) at 110A through 110p, para 00029, see fig. 1). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use the teachings of Stapleton to incorporate the single DAU to multiple BTSs in the invention of Lemson for the purpose of delivering parallel data streams to different DRUs (Stapleton, para 0029).

Claims 1-19 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

Electronic Patent Application Fee Transmittal

Application Number:	16661368
Filing Date:	23-Oct-2019
Title of Invention:	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
First Named Inventor/Applicant Name:	Shawn Patrick Stapleton
Filer:	Jason Vick/Joanne Vos
Attorney Docket Number:	10333-41-CON

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	500	500

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**500**

Electronic Acknowledgement Receipt

EFS ID:	39922952
Application Number:	16661368
International Application Number:	
Confirmation Number:	6065
Title of Invention:	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
First Named Inventor/Applicant Name:	Shawn Patrick Stapleton
Customer Number:	167137
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	10333-41-CON
Receipt Date:	06-JUL-2020
Filing Date:	23-OCT-2019
Time Stamp:	18:27:51
Application Type:	Utility under 35 USC 111(a)

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Payment Type	DA
Payment was successfully received in RAM	$500
RAM confirmation Number	E202076I28156920
Deposit Account	191970
Authorized User	Joanne Vos
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.21 (Miscellaneous fees and charges) 37 CFR 1.20 (Post Issuance fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.16 (National application filing, search, and examination fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	ISSUE_FEE_PAYMENT_10333-41-CON.pdf	1608748 6ea057282a8a6ebbf808db5f0ccda6d9e1a0b266	no	1
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Information:					
2	Post Allowance Communication - Incoming	Comments_on_Reason_for_Allowance.pdf	81560 b8616374795a4bbbec077759a46cf0217890381c	no	3
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3		AMEND_312.pdf	88636 a8aacedb163235ee02d9b9a9496438b45cd77c70	yes	3

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment after Notice of Allowance (Rule 312)	1	1
	Specification	2	2
	Applicant Arguments/Remarks Made in an Amendment	3	3

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4		IDS_01_Non-Compliant.pdf	235229 69f083c3254be34021a7f10ea7d6cdeccbf45a40	yes	7

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	2

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6	Foreign Reference	JP2012124695A.pdf	989424 4674e2d08e517c2d51df9753dfe898b624630901	no	27
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7	Foreign Reference	WO2011085514A1.pdf	1170677 c47ae335eac6b213dacf9dd30f2f8ac95a0a8705	no	23
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9	Foreign Reference	WO2014022211A2.pdf	2397011 58a6c474a8609627e4403e2dda5c997fbd316282	no	38
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33	Non Patent Literature	10333-41-PKR_NOA_04-10-2020.pdf	1573829 96aae07f9ca3b4fae41194a45c0b58af5252882c	no	4
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43	Non Patent Literature	10333-41_NOA_07-24-2019.pdf	450211 557cd2e4da98e5570066c932b11015faef4be761	no	8
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44	Non Patent Literature	PART_0001_Corning.pdf	8532433 cd53858096bcd44680405a2a22315fe32fe454b2	no	87
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Information:					
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

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

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

167137 7590 04/09/2020
SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

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

Certificate of Mailing or Transmission

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

Joanne Vos	(Typed or printed name)
/Joanne Vos/	(Signature)
July 6, 2020	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/661,368	10/23/2019	Shawn Patrick Stapleton	10333-41-CON	6065

TITLE OF INVENTION: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	07/09/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
SAMS, MATTHEW C	2646	455-445000

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

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

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Jason H. Vick
2 Sheridan Ross, PC
3

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

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: DALI WIRELESS, INC.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): MENLO PARK, CA

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

4a. Fees submitted: ☑ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

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

☑ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 19-1970

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

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Jason H. Vick/ Date July 6, 2020

Typed or printed name Jason H. Vick Registration No. 45,285

PTOL-85 Part B (08-18) Approved for use through 01/31/2020 OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page179

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Shawn Patrick Stapleton	)	Group Art Unit: 2646
Application No.: 16/661,368	)	Examiner: SAMS, MATTHEW C
Filed: October 23, 2019	)	Confirmation No.: 6065
Atty. File No.: 10333-41-CON	)	

For: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

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

Dear Commissioner:

Applicant submits this Comments on Statement of Reasons for Allowance to address the Notice of Allowability ("Notice") having a mailing date of April 9, 2020.

In the Notice, the Examiner's stated reasons for allowance were that:

> Applicant's independent claim 1 recites, inter alia, a system comprising one or more Digital Access Units (DAUs) operable to receive at least one signal from at least one of a first signal source and a second signal source from one or more of a plurality of signal sources, each DAU of the one or more DAUs including an input port configured as an uplink/downlink port and an output port configured as an uplink/downlink port;
>
> one or more Digital Remote Units (DRUs) connectable to the one or more DAUs and operable to transport signals between one or more of the one or more DRUs and the one or more DAUs;
>
> a plurality of radio resources formed from the one or more DURs comprising a first radio resource and a second radio resource different from the first radio resource, each radio resource comprising a subset of the plurality of DRUs; and
>
> a traffic monitoring unit coupled to at least one of the DAUs, wherein the traffic monitoring unit is configured to determine one or more of: one or more key performance indicators (KPIs) and/or a quality of service (QOS) of a network

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page180

traffic for the one or more DAUs, wherein the QoS is a function of the one or more KPIs and reconfigure the plurality of radio resources based on one or more of the one or more KPIs and/or the QoS by allocating at least one DRU from the first radio resource to the second radio resource.

The closest prior arts of record are:

Lee et al. (US-2013/0128810) which differs from the claimed invention by not explicitly reciting the traffic monitoring unit is configured to determine one or more of: one or more key performance indicators (KPIs) and/or a quality of service (QOS) of a network traffic for the one or more DAUs, wherein the QoS is a function of the one or more KPIs and reconfigure the plurality of radio resources based on one or more of the one or more KPIs and/or the QoS by allocating at least one DRU from the first radio resource to the second radio resource.

Trigui et al. (US-8,498,207) discloses the ability to provide dynamic load balancing in a cellular network, but differs from the claimed invention by not explicitly reciting each DAU of the one or more DAUs including an input port configured as an uplink/downlink port and an output port configured as an uplink/downlink port.

Kummetz et al. (US-2010/0278530) provides for a distributed antenna system for wireless network systems (Abstract) that includes DAUs [0031] "Master Units" and DRUs [0031] "Remote Units", but differs from the claimed invention by not explicitly reciting each DAU of the one or more DAUs including an input port configured as an uplink/downlink port and an output port configured as an uplink/downlink port and that the traffic monitoring unit is configured to determine one or more of: one or more key performance indicators (KPIs) and/or a quality of service (QOS) of a network traffic for the one or more DAUs, wherein the QoS is a function of the one or more KPIs and reconfigure the plurality of radio resources based on one or more of the one or more KPIs and/or the QoS by allocating at least one DRU from the first radio resource to the second radio resource.

Applicant's claims recite a particular combination that is neither taught nor suggested by the prior art and are allowed for these reasons and the reasons stated by the Applicant in the response dated 3/30/2020.

Applicant acknowledges Examiner's statements of Reasons for Allowance and agrees that the claimed subject matter is patentable. However, Applicant takes no position regarding the Reasons for Allowance presented by the Examiner other than the positions Applicant may have previously taken during prosecution. Therefore, the Reasons for Allowance should not be attributed to Applicant for any reason or as an indication of the bases for Applicant's belief that the claims are patentable. Furthermore, Applicant respectfully asserts that there may be additional or alternative reasons for patentability of the claimed subject matter not explicitly stated in this record and Applicant does not waive its rights to such arguments by not further addressing such reasons herein.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page181

While the stated Reasons for Allowance may be a stated reason for allowing some independent claims, Applicant submits that some independent claims may have a different reason for allowance and that some independent claims may have other reasons for allowance.

Specifically, the prior art fails to teach the specific combination of features as recited in the independent claims 1 and 10.

Although the Applicant believes that no fees are due for filing this Comments on Statement of Reasons for Allowance, please charge any fees deemed necessary to Deposit Account No. 19-1970.

Respectfully submitted,

SHERIDAN ROSS P.C.

Date: July 6, 2020

By: /Jason H. Vick/

Jason H. Vick,
Reg. No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202
Telephone: 303-863-9700
jvick@sheridanross.com

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page182

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Shawn Patrick Stapleton	)	Group Art Unit: 2646
Application No.: 16/661,368	)	Examiner: SAMS, MATTHEW C
Filed: October 23, 2019	)	Confirmation No.: 6065
Atty. File No.: 10333-41-CON	)	

For: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

AMENDMENT AFTER ALLOWANCE UNDER 37 C.F.R. 1.312

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

Dear Commissioner:

Applicants submit this Amendment After Allowance pursuant to 37 C.F.R. 1.312 in response to the Notice of Allowance having a mailing date of April 9, 2020. While Applicants believe that no fees are due with the filing of this response, the undersigned hereby authorizes the charge of any fees deemed necessary to Deposit Account No. 19-1970.

An amendment may be entered after the mailing of a Notice of Allowance but prior to payment of the issue fee upon recommendation of the primary Examiner. Therefore, it is respectfully requested that the above-referenced application be amended as follows:

Amendments to the Specification begin on page 2 of this paper.

Remarks begin on page 3 of this paper.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page183

AMENDMENTS TO THE SPECIFICATION

Please amend the first paragraph of the application beneath the heading "CROSS-REFERENCE TO RELATED APPLICATIONS":

[0001] This application is a continuation of pending U.S. Patent Application No. 13/950,160 filed July 24, 2013, now U.S. Patent No. 10,506,454, entitled "OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM", which application claims priority to U.S. Provisional Patent Application No. 61/678,016, filed on July 31, 2012, entitled "OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM". The aforementioned applications are incorporated herein by reference, in their entirety, for any purpose.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page184

REMARKS

By this amendment, the Cross-Reference to Related Applications has been updated. No new matter is believed to be introduced by this amendment.

The Commissioner is hereby authorized to charge to deposit account number 19-1970 any fees under 37 CFR § 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been separately requested, such extension is hereby petitioned.

Respectfully submitted,

SHERIDAN ROSS P.C.

Date: July 6, 2020

By: /Jason H. Vick/

Jason H. Vick
Reg. No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202
Telephone: 303-863-9700
jvick@sheridanross.com

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page185

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	Group Art Unit: 2646
Shawn Patrick Stapleton	Confirmation No.: 6065
Serial No.: 16/661,368	Examiner: Sams, Matthew C
Filed: October 23, 2019	
Atty File No.: 10333-41-CON	INFORMATION DISCLOSURE STATEMENT
Entitled: "OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM"	Electronically Submitted

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

Dear Commissioner:

The references cited on attached Form PTO-1449 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/unpublished patent applications/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. _____filed _____, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☒ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English translation/abstracts and/or in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following related applications:

- Serial No. 13/950,160 filed July 24, 2013 US Patent No. 10,506,454 (Attorney Ref. No. 10333-41)

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page186

☒ Other: DALI WIRELESS, INC. v. CORNING OPTICAL COMMUNICATIONS LLC; U.S. District Court, for the Western District of North Carolina; Civil Action No. 3:19-cv-00714

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

Respectfully submitted,

SHERIDAN ROSS P.C.

Date: July 6, 2020

By: /Jason H. Vick/

Jason H. Vick
Reg. No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202
Telephone: 303-863-9700
jvick@sheridanross.com

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page187

PTO/AIA/80 (07-17)
Approved for use through 03/31/2021. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no person is required to respond to a collection of information unless it displays a valid OMB control number

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

[X] Practitioners associated with Customer Number: 167137

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(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

[X] The address associated with Customer Number: 167137

OR

[ ]

Firm or individual name		
Address		
City	State	Zip
Country		
Telephone	Email	

Assignee name and address: Dali Wireless, Inc.
535 Middlefield Road
Menlo Park, CA 94025

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of the practitioners appointed in this form, 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 December 13, 2019
Name Albert Lee, Ph.D.	Telephone
Title Founder, Chairman and Chief Executive Officer	

This collection of information is required by 37 CFR 1.31, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public, which is to update (and by the USPTO to process) the file of a patent or reexamination proceeding. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 18 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.

Electronic Acknowledgement Receipt

EFS ID:	39904140
Application Number:	16661368
International Application Number:	
Confirmation Number:	6065
Title of Invention:	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
First Named Inventor/Applicant Name:	Shawn Patrick Stapleton
Customer Number:	167137
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	10333-41-CON
Receipt Date:	02-JUL-2020
Filing Date:	23-OCT-2019
Time Stamp:	16:41:33
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	Submission_of_CorrectedADS.pdf	73496 04f69cbbd917fc624f0f455fde1df74170bcc480	no	1

Warnings:

Information:					
2	Application Data Sheet	CorrectedADS.pdf	135074 f5156866849511ef103c06ecad2294e848b64276	no	8
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
3		Statement_Under_373c_w_POA_DaliWireless.pdf	1630278 493c41728438985aa241317ae97a959fab34784e	yes	3

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Assignee showing of ownership per 37 CFR 3.73	1	2
	Power of Attorney	3	3

Warnings:	
Information:	
Total Files Size (in bytes):	1838848

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

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Shawn Patrick Stapleton	)	Group Art Unit: 2646
Application No.: 16/661,368	)	Examiner: SAMS, MATTHEW C
Filed: October 23, 2019	)	Confirmation No.: 6065
Atty. File No.: 10333-41-CON	)	

For: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

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

SUBMISSION OF CORRECTED APPLICATION DATA SHEET

Dear Commissioner:

Attached herewith is a Corrected Application Data Sheet updating the Assignee/Applicant in the referenced application.

The Commissioner is hereby authorized to charge to Deposit Account No. 19-1970 for any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been separately requested, such extension is hereby Petitioned.

Respectfully submitted,
SHERIDAN ROSS P.C.

By: /Jason H. Vick/
Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: July 2, 2020

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page191

CORRECTED ADS

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. 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	~~P282739.US.03 (DW-1039-1)~~ 10333-41-CON
	Application Number	16/661,368
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA 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.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Shawn	Patrick	Stapleton	

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

City	Burnaby	Country of Residence [i]	CA

Mailing Address of Inventor:

Address 1	MAPLES CORPORATE SERVICES LIMITED
Address 2	P.O. Box 309, Ugland House, South Church Street

City	George Town, Grand Cayman	State/Province	
Postal Code	KY1-1104	**Country** [i]	KY

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Seyed	Amin	Hejazi	

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

City	Burnaby	Country of Residence [i]	CA

Mailing Address of Inventor:

Address 1	MAPLES CORPORATE SERVICES LIMITED
Address 2	P.O. Box 309, Ugland House, South Church Street

City	George Town, Grand Cayman	State/Province	
Postal Code	KY1-1104	**Country** [i]	KY

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

Correspondence Information:

CORRECTED ADS

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. 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	~~P282739.US.03 (DW-1039-1)~~ 10333-41-CON
	Application Number	16/661,368
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

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	~~27076~~ 167137		
Email Address	jvick@sheridanross.com	Add Email	Remove Email

Application Information:

Title of the Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM		
Attorney Docket Number	~~P282739.US.03 (DW-1039-1)~~	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional 10333-41-CON		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	11	**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

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).
Either enter 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	~~27076~~ 167137		

CORRECTED ADS

PTO/AIA/14 (02-18)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~P282739.US.03 (DW-1038-1)~~ 10333-41-CON
	Application Number	16/661,368
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim 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.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	13950160	2013-07-24
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
13950160	Claims benefit of provisional	61678016	2012-07-31

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

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. 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. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

			Remove
Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

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

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~P282739.US.03 (DW-1038-1)~~ 10333-41-CON
	Application Number	16/661,368
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

CORRECTED ADS

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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	P282739.US.03 (DW-1039-1) 1033-41-CON
	Application Number	16/661,368
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

Applicant Information:

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

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	~~Dali Systems Co. Ltd.~~ DALI WIRELESS, INC.		
Mailing Address Information For Applicant:			
Address 1	~~Maples Corporate Services Limited~~ 535 MIDDLEFIELD ROAD		
Address 2	~~P.O. Box 309, Ugland House, South Church Street~~ SUITE 280		
City	MENLO PARK ~~George Town, Grand Cayman~~	**State/Province**	CA
Country	~~KY~~ US	Postal Code	~~KY1-1104~~ 94025
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

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

CORRECTED ADS

PTO/AIA/14 (02-18)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P282739.US.03 (DW-1039-1) 10333-41-CON
	Application Number	16/661,368
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

Organization Name	~~Dali Systems Co. Ltd.~~ DALI WIRELESS, INC.

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	~~Maples Corporate Services Limited~~ 535 MIDDLEFIELD ROAD		
Address 2	~~P.O. Box 309, Ugland House, South Church Street~~ SUITE 280		
City MENLO PARK	~~George Town, Grand Cayman~~	**State/Province**	CA
Country ~~KY~~ US		Postal Code	~~KY1-1104~~ 94025
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Jason H. Vick/			Date (YYYY-MM-DD)	2020-07-02
First Name	Jason H.	Last Name	Vick	Registration Number	45285

Additional Signature may be generated within this form by selecting the Add button.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page197

CORRECTED ADS

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P282739.US.03 (DW-1039-1) 10333-41-CON
	Application Number	16/661,368
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

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 CooperationTreaty.

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.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page199

PTO/AIA/96 (08-12)
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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: DALI WIRELESS, INC.

Application No./Patent No.: 16/661,368 Filed/Issue Date: October 23, 2019

Titled: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

DALI WIRELESS, INC., a Corporation

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

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

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 thereof is attached.

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

1. From: Shawn Patrick Stapleton and Seyed Amin Hejazi To: DALI SYSTEMS CO. LTD.

   The document was recorded in the United States Patent and Trademark Office at
   Reel 031392, Frame 0084, or for which a copy thereof is attached.

2. From: DALI SYSTEMS CO. LTD. To: DALI WIRELESS, INC.

   The document was recorded in the United States Patent and Trademark Office at
   Reel 052512, Frame 0010, or for which a copy thereof is attached.

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.**

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

PTO/AIA/96 (08-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

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

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

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

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

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

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

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

Reel _____, Frame _____, or for which a copy thereof is attached.

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

☑ As required by 37 CFR 3.73(c)(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.

/Jason H. Vick/	July 2, 2020
Signature	Date
Jason H. Vick	45,285
Printed or Typed Name	Title or Registration Number

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
16/661,368	10/23/2019	Shawn Patrick Stapleton	10333-41-CON

CONFIRMATION NO. 6065

167137
SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

PUBLICATION NOTICE

OC000000117092828

Title:OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

Publication No.US-2020-0154288-A1
Publication Date:05/14/2020

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 Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, 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 https://portal.uspto.gov/pair/PublicPair. 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

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page202

UNITED STATES PATENT AND TRADEMARK OFFICE

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

167137 7590 04/09/2020

SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

EXAMINER	
SAMS, MATTHEW C	
ART UNIT	PAPER NUMBER
2646	

DATE MAILED: 04/09/2020

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/661,368	10/23/2019	Shawn Patrick Stapleton	10333-41-CON	6065

TITLE OF INVENTION: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	07/09/2020

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

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

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

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

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

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PTOL-85 (Rev. 02/11)

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page203

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

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

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

167137 7590 04/09/2020
SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

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

Certificate of Mailing or Transmission

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

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/661,368	10/23/2019	Shawn Patrick Stapleton	10333-41-CON	6065

TITLE OF INVENTION: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	07/09/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
SAMS, MATTHEW C	2646	455-445000

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

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

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

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

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

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

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

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

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

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

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

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page204

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/661,368	10/23/2019	Shawn Patrick Stapleton	10333-41-CON	6065

167137 7590 04/09/2020

SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

EXAMINER	
SAMS, MATTHEW C	
ART UNIT	PAPER NUMBER
2646	

DATE MAILED: 04/09/2020

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

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

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

PTOL-85 (Rev. 02/11)

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page205

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

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

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

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

Notice of Allowability	Application No. 16/661,368	Applicant(s) Stapleton et al.	
	Examiner MATTHEW C SAMS	Art Unit 2646	AIA (FITF) Status No

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

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

1. ☑ This communication is responsive to 3/30/2020.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

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

3. ☑ The allowed claim(s) is/are 1-19 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

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

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

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

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☑ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/Matthew C Sams/
Primary Examiner, Art Unit 2646

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page207

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

Response to Amendment

2. This office action is in response to the amendment filed on 3/30/2020.

3. Claim 1 has been amended and claims 2-19 have been newly added.

4. The Terminal Disclaimer filed on 4/2/2020 is approved and accordingly, the Double Patenting rejection with US-10,506,454 is withdrawn.

Allowable Subject Matter

5. Claims 1-19 are allowed.

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

Applicant's independent claim 1 recites, *inter alia*, a system comprising one or more Digital Access Units (DAUs) operable to receive at least one signal from at least one of a first signal source and a second signal source from one or more of a plurality of signal sources, each DAU of the one or more DAUs including an input port configured as an uplink/downlink port and an output port configured as an uplink/downlink port;

one or more Digital Remote Units (DRUs) connectable to the one or more DAUs and operable to transport signals between one or more of the one or more DRUs and the one or more DAUs;

a plurality of radio resources formed from the one or more DURs comprising a first radio resource and a second radio resource different from the first radio resource, each radio resource comprising a subset of the plurality of DRUs; and

a traffic monitoring unit coupled to at least one of the DAUs, wherein the traffic monitoring unit is configured to determine one or more of: one or more key performance indicators (KPIs) and/or a quality of service (QOS) of a network traffic for the one or more DAUs, wherein the QoS is a function of the one or more KPIs and reconfigure the plurality of radio resources based on one or more of the one or more KPIs and/or the QoS by allocating at least one DRU from the first radio resource to the second radio resource.

The closest prior arts of record are:

Lee et al. (US-2013/0128810) which differs from the claimed invention by not explicitly reciting the traffic monitoring unit is configured to determine one or more of: one or more key performance indicators (KPIs) and/or a quality of service (QOS) of a network traffic for the one or more DAUs, wherein the QoS is a function of the one or more KPIs and reconfigure the plurality of radio resources based on one or more of the one or more KPIs and/or the QoS by allocating at least one DRU from the first radio resource to the second radio resource.

Trigui et al. (US-8,498,207) discloses the ability to provide dynamic load balancing in a cellular network, but differs from the claimed invention by not explicitly reciting each DAU of the one or more DAUs including an input port configured as an uplink/downlink port and an output port configured as an uplink/downlink port.

Kummetz et al. (US-2010/0278530) provides for a distributed antenna system for wireless network systems (Abstract) that includes DAUs [0031] “Master Units” and DRUs

[0031] "Remote Units", but differs from the claimed invention by not explicitly reciting each DAU of the one or more DAUs including an input port configured as an uplink/downlink port and an output port configured as an uplink/downlink port and that the traffic monitoring unit is configured to determine one or more of: one or more key performance indicators (KPIs) and/or a quality of service (QOS) of a network traffic for the one or more DAUs, wherein the QoS is a function of the one or more KPIs and reconfigure the plurality of radio resources based on one or more of the one or more KPIs and/or the QoS by allocating at least one DRU from the first radio resource to the second radio resource.

Applicant's claims recite a particular combination that is neither taught nor suggested by the prior art and are allowed for these reasons and the reasons stated by the Applicant in the response dated 3/30/2020.

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

Conclusion

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to MATTHEW C SAMS whose telephone number is (571)272-8099. The examiner can normally be reached on M-F 8:30-5 EST.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an

interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Lester Kincaid can be reached on (571)272-7922. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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

/Matthew C Sams/
Primary Examiner, Art Unit 2646

Examiner-Initiated Interview Summary	**Application No.** 16/661,368	**Applicant(s)** Stapleton et al.		
	Examiner MATTHEW C SAMS	**Art Unit** 2646	**AIA (First Inventor to File) Status** No	**Page** **1 of** 1

All participants (applicant, applicants representative, PTO personnel):

1. MATTHEW C SAMS (Primary Examiner); Telephonic

2. Jason H. Vick (Attorney); Telephonic

Date of Interview: 02 April 2020

Brief Description of the main topic(s) of discussion: The Examiner requested the Applicant file an electronic Terminal Disclaimer, which the Applicant agreed to file.

Issues Discussed:

Double Patenting:
Examiner requested the Applicant file a eTD.

/Matthew C Sams/ Primary Examiner, Art Unit 2646	

Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04
Please further see:
MPEP 713.04
Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b)
37 CFR § 1.2 Business to be transacted in writing

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

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

Notice of References Cited	Application/Control No. 16/661,368	Applicant(s)/Patent Under Reexamination Stapleton et al.	
	Examiner MATTHEW C SAMS	Art Unit 2646	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20130128810-A1	05-2013	Lee; Albert S.	H04W84/042	370/328
*	B	US-10264626-B2	04-2019	Lee; Albert S.	H04W4/70	1/1
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

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

NON-PATENT DOCUMENTS

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

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

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page213

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/661,368	Stapleton et al.
	Examiner	**Art Unit**
	MATTHEW C SAMS	2646

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

CLAIMS

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

CLAIM		DATE								
Final	Original	02/10/2020	04/03/2020							
	1	✓	=							
	2		=							
	3		=							
	4		=							
	5		=							
	6		=							
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	8		=							
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	14		=							
	15		=							
	16		=							
	17		=							
	18		=							
	19		=							

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page214

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/661,368	Stapleton et al.
	Examiner	**Art Unit**
	MATTHEW C SAMS	2646

CPC							
Symbol						**Type**	**Version**
H04W	/	24	/	02		F	2013-01-01
H04W	/	16	/	04		I	2013-01-01
H04W	/	88	/	085		A	2013-01-01

CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	19	
/Matthew C Sams/ Primary Examiner, Art Unit 2646	03 April 2020	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	9

U.S. Patent and Trademark Office — Part of Paper No.: 20200403

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page215

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/661,368	Stapleton et al.
	Examiner	**Art Unit**
	MATTHEW C SAMS	2646

INTERNATIONAL CLASSIFICATION					
CLAIMED					
H04W24/02	/	24	/	02	
H04W16/04	/	16	/	04	
H04W88/08	/	88	/	08	

NON-CLAIMED					
	/		/		

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 19	
/Matthew C Sams/ Primary Examiner, Art Unit 2646 (Primary Examiner)	03 April 2020 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 9

U.S. Patent and Trademark Office — Part of Paper No.: 20200403

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page216

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/661,368	Stapleton et al.
	Examiner	**Art Unit**
	MATTHEW C SAMS	2646

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

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		10		19										
	2		11												
	3		12												
	4		13												
	5		14												
	6		15												
	7		16												
	8		17												
	9		18												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	19	
/Matthew C Sams/ Primary Examiner, Art Unit 2646	03 April 2020	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	9

U.S. Patent and Trademark Office — Part of Paper No.: 20200403

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page217

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/661,368	Stapleton et al.
	Examiner	Art Unit
	MATTHEW C SAMS	2646

CPC - Searched*		
Symbol	Date	Examiner
H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025	02/10/2020	MCS

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
PE2E Search	02/10/2020	MCS
PE2E Search	04/03/2020	MCS

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
Same as above		04/03/2020	MCS

/Matthew C Sams/ Primary Examiner, Art Unit 2646	

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page218

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L92	5	"20130128810"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/02 04:15 PM
L93	4	digital with access with unit and sams-matthew$.xp.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L94	0	dali and sams-matthew.xp.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L95	1	dali and sams-matthew$.xp.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L96	98	((("DALI") near3 ("SYSTEMS") near3 ("CO") near3 ("LTD"))).AS,AANM.	USPAT	OR	ON	ON	2020/04/03 12:05 PM
L97	240	((("STAPLETON") near3 ("Shawn")) OR (("HEJAZI") near3 ("Seyed"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	ON	2020/04/03 12:05 PM
L98	3065	optimiz$6 with traffic with load	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L99	97	(L4 or L5) and L6	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L100	1	15/819279	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L101	10	"20100278530" "8498207".pn. "20130071112"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L102	17	(digital with remote with unit DRU) with (chang$3 reconfigur$6) with sector	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2020/04/03 12:05 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page219

			IBM_TDB				
L103	39	(digital with remote with unit DRU) with (switch$3 chang$3 reconfigur$6) with sector	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L104	5	"20070077929"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L105	171	(digital with remote with unit DRU) with (switch$3 chang$3 reconfigur$6) with (array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L106	420	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L107	0	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector) with feedback same (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L108	1	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector) same feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L109	2	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (array sector) same feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L110	154	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (array sector) and feedback and (QOS qualit$3 with service kpi key with performance with	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page220

		indicat$3)					
L111	214	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L112	2	13/950160	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L113	214	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L114	93	traffic with monitor$3 with unit with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L115	1590	(packet communicat$4 traffic) with monitor$3 with unit with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L116	4323	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L117	2	L23 and L24	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L118	173	shift$3 with (dru beam antenna) with between with sectors	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L119	23	shift$3 with (dru beam antenna) with between with sectors and "455".clas.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L120	3	(US-20100278530-$ or US-20130071112-$).did.	US-PGPUB; USPAT	OR	ON	ON	2020/04/03 12:05 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page221

		or (US-8498207-$).did.					
L121	26	L14 AND ((H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025).CPC.)	US-PGPUB; USPAT	OR	ON	ON	2020/04/03 12:05 PM
L122	2	"6785558".pn. "20080139205"	US-PGPUB; USPAT	OR	ON	ON	2020/04/03 12:05 PM
L123	37	("2014/0162664").URPN.	USPAT	OR	ON	ON	2020/04/03 12:05 PM
L124	8	"20120039320"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L125	2	"20020119772"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L126	28	2013/0128810	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L127	5	"20130128810"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L128	420	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L129	26	L39 AND ((H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025).CPC.)	US-PGPUB; USPAT	OR	ON	ON	2020/04/03 12:05 PM
L130	39	(digital with remote with unit DRU) with (switch$3 chang$3 reconfigur$6) with sector	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L131	214	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L132	1590	(packet communicat$4	US-PGPUB; USPAT;	OR	ON	ON	2020/04/03

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page222

		traffic) with monitor$3 with unit with feedback	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB				12:05 PM
L133	4323	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L134	2	L43 and L44	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L135	240	((("STAPLETON") near3 ("Shawn")) OR (("HEJAZI") near3 ("Seyed"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	ON	2020/04/03 12:05 PM
L136	98	((("DALI") near3 ("SYSTEMS") near3 ("CO") near3 ("LTD"))).AS,AANM.	USPAT	OR	ON	ON	2020/04/03 12:05 PM
L137	4	digital with access with unit and sams-matthew$.xp.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L138	0	dali and sams-matthew.xp.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L139	1	dali and sams-matthew$.xp.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L140	98	((("DALI") near3 ("SYSTEMS") near3 ("CO") near3 ("LTD"))).AS,AANM.	USPAT	OR	ON	ON	2020/04/03 12:05 PM
L141	240	((("STAPLETON") near3 ("Shawn")) OR (("HEJAZI") near3 ("Seyed"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	ON	2020/04/03 12:05 PM
L142	3065	optimiz$6 with traffic with load	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L143	97	(L4 or L5) and L6	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page223

L144	1	15/819279	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L145	10	"20100278530" "8498207".pn. "20130071112"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L146	17	(digital with remote with unit DRU) with (chang$3 reconfigur$6) with sector	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L147	39	(digital with remote with unit DRU) with (switch$3 chang$3 reconfigur$6) with sector	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L148	5	"20070077929"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L149	171	(digital with remote with unit DRU) with (switch$3 chang$3 reconfigur$6) with (array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L150	420	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L151	0	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector) with feedback same (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L152	1	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector) same feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L153	2	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (array	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page224

		sector) same feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)					
L154	154	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L155	214	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L156	2	13/950160	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L157	214	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L158	93	traffic with monitor$3 with unit with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L159	1590	(packet communicat$4 traffic) with monitor$3 with unit with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L160	4323	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L161	2	L23 and L24	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page225

L162	173	shift$3 with (dru beam antenna) with between with sectors	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L163	23	shift$3 with (dru beam antenna) with between with sectors and "455".clas.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L164	3	(US-20100278530-$ or US-20130071112-$).did. or (US-8498207-$).did.	US-PGPUB; USPAT	OR	ON	ON	2020/04/03 12:05 PM
L165	26	L14 AND ((H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025).CPC.)	US-PGPUB; USPAT	OR	ON	ON	2020/04/03 12:05 PM
L166	2	"6785558".pn. "20080139205"	US-PGPUB; USPAT	OR	ON	ON	2020/04/03 12:05 PM
L167	37	("2014/0162664").URPN.	USPAT	OR	ON	ON	2020/04/03 12:05 PM
L168	8	"20120039320"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L169	2	"20020119772"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L170	28	2013/0128810	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L171	5	"20130128810"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L172	420	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L173	26	L39 AND ((H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025).CPC.)	US-PGPUB; USPAT	OR	ON	ON	2020/04/03 12:05 PM
L174	39	(digital with remote with unit DRU) with (switch$3 chang$3 reconfigur$6) with sector	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page226

L175	214	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L176	1590	(packet communicat$4 traffic) with monitor$3 with unit with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L177	4323	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L178	2	L43 and L44	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM
L179	240	((("STAPLETON") near3 ("Shawn")) OR (("HEJAZI") near3 ("Seyed"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	ON	2020/04/03 12:05 PM
L180	98	((("DALI") near3 ("SYSTEMS") near3 ("CO") near3 ("LTD"))).AS,AANM.	USPAT	OR	ON	ON	2020/04/03 12:05 PM
L181	5	"20130128810"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/04/03 12:05 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N50	77	shift$3 with (dru beam antenna) with between with sector	USPAT	OR	ON	ON	2020/04/03 12:04 PM
N51	16	shift$3 with (dru beam antenna) with between with sector and "455".clas.	USPAT	OR	ON	ON	2020/04/03 12:04 PM
N52	0	N32 AND ((H04W88/085 OR H04B10/2575 OR	USPAT	OR	ON	ON	2020/04/03 12:04 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page227

		H04B10/25753 OR H04L41/5025).CPC.)					
N53	77	shift$3 with (dru beam antenna) with between with sector	USPAT	OR	ON	ON	2020/04/03 12:04 PM
N54	0	N48 AND ((H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025).CPC.)	USPAT	OR	ON	ON	2020/04/03 12:04 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page228

Bibliographic Data

Application No: 16/661,368

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /Matthew C Sams/ (Examiner's Signature) | (Initials)

Title: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/23/2019	455	2646	10333-41-CON
RULE			

APPLICANTS

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Seyed Amin Hejazi Burnaby, CANADA

CONTINUING DATA

This application is a CON of 13950160 07/24/2013 PAT 10506454

13950160 has PRO of 61678016 07/31/2012

FOREIGN APPLICATIONS

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Doc Code: DIST.E.FILE **Document Description: Electronic Terminal Disclaimer - Filed**	PTO/SB/26 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT**
Application Number	16661368
Filing Date	23-Oct-2019
First Named Inventor	Shawn Stapleton
Attorney Docket Number	10333-41-CON
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

☒ Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action

☒ This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent Interest
Dali Systems Co. Ltd.	100%

The owner(s) with percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s)

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- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
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- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

◉ Terminal disclaimer fee under 37 CFR 1.20(d) is included with Electronic Terminal Disclaimer request.

○	I certify, in accordance with 37 CFR 1.4(d)(4), that the terminal disclaimer fee under 37 CFR 1.20(d) required for this terminal disclaimer has already been paid in the above-identified application.

Applicant claims the following fee status:

◉ Small Entity

○ Micro Entity

○ Regular Undiscounted

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES

I certify, in accordance with 37 CFR 1.4(d)(4) that I am:

◉ An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application

Registration Number 45285

○ A sole inventor

○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application

○ A joint inventor; all of whom are signing this request

Signature	/Jason H. Vick/
Name	Jason H. Vick

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Electronic Patent Application Fee Transmittal

Application Number:	16661368
Filing Date:	23-Oct-2019
Title of Invention:	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
First Named Inventor/Applicant Name:	Shawn Patrick Stapleton
Filer:	Jason Vick/Joanne Vos
Attorney Docket Number:	10333-41-CON

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
STATUTORY OR TERMINAL DISCLAIMER	2814	1	160	160
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**160**

Doc Code: DISQ.E.FILE
Document Description: Electronic Terminal Disclaimer – Approved

Application No.: 16661368

Filing Date: 23-Oct-2019

Applicant/Patent under Reexamination: Stapleton

Electronic Terminal Disclaimer filed on April 2, 2020

☒ APPROVED

This patent is subject to a terminal disclaimer

☐ DISAPPROVED

Approved/Disapproved by: Electronic Terminal Disclaimer automatically approved by EFS-Web

U.S. Patent and Trademark Office

Electronic Acknowledgement Receipt	
EFS ID:	39049122
Application Number:	16661368
International Application Number:	
Confirmation Number:	6065
Title of Invention:	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
First Named Inventor/Applicant Name:	Shawn Patrick Stapleton
Customer Number:	167137
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	10333-41-CON
Receipt Date:	02-APR-2020
Filing Date:	23-OCT-2019
Time Stamp:	17:16:14
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$160
RAM confirmation Number	E202042H16107969
Deposit Account	191970
Authorized User	Joanne Vos
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Terminal Disclaimer-Filed (Electronic)	eTerminal-Disclaimer.pdf	33477 79d75e81002a863e99633f4fcb838a2d18490eea	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30450 7fc2074b0a54ffa212951a47f46f3e21a9ddf4b6	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	63927		

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

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Shawn Patrick Stapleton	)	Group Art Unit: 2646
Application No.: 16/661,368	)	Examiner: SAMS, MATTHEW C
Filed: October 23, 2019	)	Confirmation No.: 6065
Atty. File No.: 10333-41-CON	)	

For: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

AMENDMENT AND RESPONSE

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

Dear Commissioner:

Applicant submits this Amendment and Response to address the Office Action having a mailing date of February 13, 2020. Please credit any overpayment or charge any underpayment to Deposit Account No. 19-1970.

Please amend the above-identified patent application as follows:

Amendments to the Claims are shown in the listing of claims which begins on page 2 of this paper.

Remarks begin on page 6 of this paper.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page237

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently Amended) A system ~~for dynamically routing signals in a Distributed Antenna System, the system comprising:~~

~~a plurality of Digital Access Units (DAUs), wherein the plurality of DAUs are coupled and operable to route signals between the plurality of DAUs;~~

~~a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs;~~

~~a plurality of Base Transceiver Stations (BTS);~~

~~a plurality of traffic monitoring modules; and~~

~~a network optimization goal and optimization algorithm.~~

comprising:

one or more Digital Access Units (DAUs) operable to receive at least one signal from at least one of a first signal source and a second signal source from one or more of a plurality of signal sources, each DAU of the one or more DAUs including an input port configured as an uplink/downlink port and an output port configured as an uplink/downlink port;

one or more Digital Remote Units (DRUs) connectable to the one or more DAUs and operable to transport signals between one or more of the one or more DRUs and the one or more DAUs;

a plurality of radio resources formed from the one or more DRUs comprising a first radio resource and a second radio resource different from the first radio resource, each radio resource comprising a subset of the plurality of DRUs; and

a traffic monitoring unit coupled to at least one of the DAUs, wherein the traffic monitoring unit is configured to:

determine one or more of: one or more key performance indicators (KPIs) and/or a quality of service (QoS) of a network traffic for the one or more DAUs, wherein the QoS is a function of the one or more KPIs; and

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page238

reconfigure the plurality of radio resources based on one or more of the one or more KPIs and/or the QoS by allocating at least one DRU from the first radio resource to the second radio resource.

2. (New) The system of claim 1, further comprising a one or more Base Transceiver Stations (BTSs) coupled to the one or more DAUs, wherein each BTS comprises the plurality of radio resources.

3. (New) The system of claim 2, further comprising a network optimization goal comprising a percentage of users associated with each of the plurality of radio resources.

4. (New) The system of claim 1, wherein the traffic monitoring unit is external to the one or more DAUs.

5. (New) The system of claim 1, wherein the traffic monitoring unit is provided as a component of each of the one or more DAUs.

6. (New) The system of claim 1, wherein the traffic monitoring unit is external to the one or more DRUs.

7. (New) The system of claim 1, wherein the traffic monitoring unit is provided as a component of each of the one or more DRUs.

8. (New) The system of claim 1, wherein the traffic monitoring unit is configured to analyze Key Performance Indicators (KPIs) of the DAS.

9. (New) The system of claim 1, wherein the traffic monitoring unit is configured to analyze Quality of Service (QoS) values of the DAS.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page239

10. (New) A system comprising:

one or more Digital Access Units (DAUs) operable to receive at least one signal from at least one of a first signal source and a second signal source from one or more of a plurality of signal sources, each DAU of the one or more DAUs including an input port configured as an uplink/downlink port and an output port configured as an uplink/downlink port;

one or more Digital Remote Units (DRUs) couplable to the one or more DAUs and operable to transport signals between the one or more DRUs and the one or more DAUs;

a plurality of radio resources formed from the one or more DRUs comprising a first radio resource and a second radio resource different from the first radio resource, each radio resource comprising a subset of the one or more DRUs; and

a traffic monitoring unit external to and couplable to at least one of the DAUs, wherein the traffic monitoring unit is configured to:

determine one or more of one or more key performance indicators (KPIs) and/or a quality of service (QoS) of a network traffic for the one or more DAUs, wherein the QoS is a function of the one or more KPIs; and

reconfigure the plurality of radio resources based on one or more of the one or more KPIs and/or the QoS by allocating at least one DRU from the first radio resource to the second radio resource.

11. (New) The system of claim 10, wherein the traffic monitoring unit is external to one or more Base Transceiver Stations (BTSs) and coupled to each of the one or more BTSs.

12. (New) The system of claim 10, further comprising a network optimization processor coupled to the traffic monitoring unit.

13. (New) The system of claim 10, wherein the one or more DAUs are coupled via at least one of an ethernet cable, optical fiber, microwave line of sight link, wireless link, and/or satellite link.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page240

14. (New) The system of claim 10, wherein the one or more DAUs are coupled to the one or more DRUs via at least one of an ethernet cable, optical fiber, microwave line of sight link, wireless link, and/or satellite link.

15. (New) The system of claim 10, wherein the one or more DRUs are connected in a daisy chain configuration.

16. (New) The system of claim 10, wherein the one or more DRUs are connected to the one or more DAUs in a star configuration.

17. (New) The system of claim 10, wherein the one or more DAUs are connected to one or more BTSs via at least one of an ethernet cable, optical fiber, microwave line of sight link, wireless link, and/or satellite link.

18. (New) The system of claim 10, wherein the one or more DRUs are connected in a loop to one or more of the one or more DAUs.

19. (New) The system of claim 10, wherein a single DAU port is connected to one or more BTSs.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page241

REMARKS

Applicant respectfully requests reconsideration of this application, as amended.

Applicant requests the holding in abeyance of the double patenting rejection until an indication of allowable subject matter has been provided.

While claim 1 is rejected in view of Lee, Applicant respectfully submits that based on the above now-claimed combination of features, the claims are distinguishable from the reference.

Withdrawal of the rejection is respectfully requested.

With all rejections having been overcome, Applicant respectfully submits the application is in condition for allowance.

A prompt Notice of Allowance is respectfully solicited.

Should the Examiner believe anything further is desirable in order to place the application in even better condition for allowance, the Examiner is encouraged to contact Applicants undersigned representative at the telephone number listed below.

The Commissioner is hereby authorized to charge to deposit account number 19-1970 any fees under 37 CFR § 1.16 and 1.17 that may be required by this paper and to credit any overpayment to that Account. If any extension of time is required in connection with the filing of this paper and has not been separately requested, such extension is hereby Petitioned.

Respectfully submitted,

SHERIDAN ROSS P.C.

Date: March 30, 2020

By: /Jason H. Vick/

Jason H. Vick
Reg. No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202
Telephone: 303-863-9700
jvick@sheridanross.com

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page242

Electronic Acknowledgement Receipt

EFS ID:	39004269
Application Number:	16661368
International Application Number:	
Confirmation Number:	6065
Title of Invention:	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
First Named Inventor/Applicant Name:	Shawn Patrick Stapleton
Customer Number:	167137
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	10333-41-CON
Receipt Date:	30-MAR-2020
Filing Date:	23-OCT-2019
Time Stamp:	12:45:54
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		AMEND_01_10333-41-CON.pdf	91573 e4e60bb942ea9b0b6123c6dfbf889b36b0ec74e3	yes	6

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	5
	Applicant Arguments/Remarks Made in an Amendment	6	6
Warnings:			
Information:			
	Total Files Size (in bytes):	91573	

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

New Applications Under 35 U.S.C. 111

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

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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 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 16/661,368	Filing Date 10/23/2019	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $230 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 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	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	03/30/2020	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $230 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/CHANTAE S DESSAU/
*** 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.	

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

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

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/661,368	10/23/2019	Shawn Patrick Stapleton	10333-41-CON	6065

167137 7590 02/13/2020

SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

EXAMINER	
SAMS, MATTHEW C	

ART UNIT	PAPER NUMBER
2646	

NOTIFICATION DATE	DELIVERY MODE
02/13/2020	ELECTRONIC

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

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

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jvick@sheridanross.com

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page246

Office Action Summary	**Application No.** 16/661,368	**Applicant(s)** Stapleton et al.	
	Examiner MATTHEW C SAMS	**Art Unit** 2646	**AIA (FITF) Status** No

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

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

Status

1)☑ Responsive to communication(s) filed on 10/23/2019.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

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

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

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

Disposition of Claims*

5) ☑ Claim(s) 1 is/are pending in the application.

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

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1 is/are rejected.

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

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

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

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

11)☑ The drawing(s) filed on 10/23/2019 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

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

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

Priority under 35 U.S.C. § 119

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

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

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

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

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

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

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

Drawings

2. The drawings filed on 10/23/2019 are accepted.

Double Patenting

3. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double

patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

4. Claim 1 is rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1 and 2 of U.S. Patent No. 10,506,454. Although the claims at issue are not identical, they are not patentably distinct from each other because the instant claim is broader in every instance over the patented claims 1 and 2.

Claim Rejections - 35 USC § 102

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

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

6. Claim 1 is rejected under 35 U.S.C. 102(e) as being anticipated by Lee; Albert S. et al. (US 2013/0128810 A1: hereinafter "Lee").

Regard claim 1, Lee teaches a system for dynamically routing signals in a Distributed Antenna System, the system comprising:

a plurality of Digital Access Units (DAUs) (Fig. 15 items 1505A-1505n, therefore plurality of DAUs), wherein the plurality of DAUs are coupled and operable to route signals between the plurality of DAUs (Fig. 15, 1505A-1505B, are connected, therefore coupled and operable to route signals);

a plurality of Digital Remote Units (DRUs) (Fig. 15 items 1510A-1510m, therefore plurality of DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs (Fig. 15, items 1510A-1510C) are connected, therefore operable to transport signals);

a plurality of Base Transceiver Stations (BTS) (Fig. 15 items 1500A – 1500n, therefore plurality of BTS);

a plurality of traffic monitoring modules (Fig. 14, item 1415 further explained in [0065], …, the NOC 1415 monitors, therefore traffic monitor attached to DAUs, therefore plurality of traffic monitors); and

a network optimization goal and optimization algorithm. (in [0069] an algorithm operating within the DAU Monitoring module, …, therefore algorithm for the purpose of optimization)

Conclusion

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to MATTHEW C SAMS whose telephone number is (571)272-8099. The examiner can normally be reached on M-F 8:30-5 EST.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Lester Kincaid can be reached on (571)272-7922. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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

Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Matthew C Sams/
Primary Examiner, Art Unit 2646

Notice of References Cited	Application/Control No. 16/661,368	Applicant(s)/Patent Under Reexamination Stapleton et al.	
	Examiner MATTHEW C SAMS	Art Unit 2646	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20020119772-A1	08-2002	Yoshida, Katsuya	H04W24/00	455/423
*	B	US-6785558-B1	08-2004	Stratford; Scott B.	H04W88/085	455/561
*	C	US-20080139205-A1	06-2008	Sayeedi; Shahab M.	H04W36/0038	455/436
*	D	US-20100278530-A1	11-2010	Kummetz; Thomas	H04B10/2575	398/41
*	E	US-20120039320-A1	02-2012	Lemson; Paul	H03F1/3247	370/338
*	F	US-20130071112-A1	03-2013	Melester; Matthew Thomas	H04B17/0085	398/38
*	G	US-20130114963-A1	05-2013	Stapleton; Shawn Patrick	H04W24/02	398/115
*	H	US-20130128810-A1	05-2013	Lee; Albert S.	H04W84/042	370/328
*	I	US-10264626-B2	04-2019	Lee; Albert S.	H04W4/70	1/1
*	J	US-8498207-B2	07-2013	Trigui; Hafedh	H04L41/5025	370/235
*	K	US-10506454-B2	12-2019	Stapleton; Shawn Patrick	H04W16/04	1/1
	L					
	M					

FOREIGN PATENT DOCUMENTS

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

NON-PATENT DOCUMENTS

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

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

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/661,368	Stapleton et al.
	Examiner	Art Unit
	MATTHEW C SAMS	2646

CPC - Searched*		
Symbol	Date	Examiner
H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025	02/10/2020	MCS

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
PE2E Search	02/10/2020	MCS

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/Matthew C Sams/ Primary Examiner, Art Unit 2646	

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page254

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/661,368	Stapleton et al.
	Examiner	**Art Unit**
	MATTHEW C SAMS	2646

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

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant				☐ CPA		☐ T.D.		☐ R.1.47		
CLAIM		**DATE**								
Final	Original									

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page255

Bibliographic Data

Application No: 16/661,368

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /Matthew C Sams/ (Examiner's Signature) | (Initials)

Title: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/23/2019	455	2646	10333-41-CON
RULE			

APPLICANTS

Dali Systems Co. Ltd., George Town, CAYMAN ISLANDS

INVENTORS

Shawn Patrick Stapleton Burnaby, CANADA

Seyed Amin Hejazi Burnaby, CANADA

CONTINUING DATA

This application is a CON of 13950160 07/24/2013 PAT 10506454

13950160 has PRO of 61678016 07/31/2012

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

11/07/2019

**** SMALL ENTITY ****

STATE OR COUNTRY

CANADA

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SHERIDAN ROSS PC
1560 Broadway
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Denver, CO 80202
UNITED STATES

FILING FEE RECEIVED

$965

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L37	28	2013/0128810	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 02:57 PM
L38	5	"20130128810"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 02:57 PM
L40	26	L39 AND ((H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025).CPC.)	US-PGPUB; USPAT	OR	ON	ON	2020/02/10 03:05 PM
L39	401	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:05 PM
L41	35	(digital with remote with unit DRU) with (switch$3 chang$3 reconfigur$6) with sector	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:05 PM
L42	202	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:05 PM
L45	1	L43 and L44	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:05 PM
L43	1123	(packet communicat$4 traffic) with monitor$3 with unit with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:05 PM
L44	4065	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:05 PM
L46	236	((("STAPLETON") near3	US-PGPUB; USPAT;	OR	ON	ON	2020/02/10

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page257

		("Shawn")) OR (("HEJAZI") near3 ("Seyed"))).INV.	USOCR; EPO; JPO; DERWENT				03:06 PM
L47	99	((("DALI") near3 ("SYSTEMS") near3 ("CO") near3 ("LTD"))).AS,AANM.	USPAT	OR	ON	ON	2020/02/10 03:06 PM
L48	4	digital with access with unit and sams-matthew$.xp.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L49	0	dali and sams-matthew.xp.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L50	1	dali and sams-matthew$.xp.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L51	98	((("DALI") near3 ("SYSTEMS") near3 ("CO") near3 ("LTD"))).AS,AANM.	USPAT	OR	ON	ON	2020/02/10 03:11 PM
L52	236	((("STAPLETON") near3 ("Shawn")) OR (("HEJAZI") near3 ("Seyed"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	ON	2020/02/10 03:11 PM
L53	3030	optimiz$6 with traffic with load	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L54	94	(L4 or L5) and L6	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L55	1	15/819279	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L56	10	"20100278530" "8498207".pn. "20130071112"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L57	9	(digital with remote with unit DRU) with (chang$3 reconfigur$6) with sector	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L58	31	(digital with remote with	US-PGPUB; USPAT;	OR	ON	ON	2020/02/10

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page258

		unit DRU) with (switch$3 chang$3 reconfigur$6) with sector	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB				03:11 PM
L59	5	"20070077929"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L60	153	(digital with remote with unit DRU) with (switch$3 chang$3 reconfigur$6) with (array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L61	410	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L62	0	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector) with feedback same (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L63	1	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector) same feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L64	2	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (array sector) same feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L65	148	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L66	202	(digital with remote with	US-PGPUB; USPAT;	OR	ON	ON	2020/02/10

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page259

		unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB				03:11 PM
L67	2	13/950160	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L68	202	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L69	93	traffic with monitor$3 with unit with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L70	1560	(packet communicat$4 traffic) with monitor$3 with unit with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L71	4221	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L72	2	L23 and L24	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L73	171	shift$3 with (dru beam antenna) with between with sectors	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L74	23	shift$3 with (dru beam antenna) with between with sectors and "455".clas.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L75	3	(US-20100278530-$ or US-20130071112-$).did. or (US-8498207-$).did.	US-PGPUB; USPAT	OR	ON	ON	2020/02/10 03:11 PM
L76	26	L14 AND ((H04W88/085	US-PGPUB; USPAT	OR	ON	ON	2020/02/10

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page260

		OR H04B10/2575 OR H04B10/25753 OR H04L41/5025).CPC.)					03:11 PM
L77	2	"6785558".pn. "20080139205"	US-PGPUB; USPAT	OR	ON	ON	2020/02/10 03:11 PM
L78	35	("2014/0162664").URPN.	USPAT	OR	ON	ON	2020/02/10 03:11 PM
L79	8	"20120039320"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L80	2	"20020119772"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L81	28	2013/0128810	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L82	5	"20130128810"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L83	410	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6) with (sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L84	26	L39 AND ((H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025).CPC.)	US-PGPUB; USPAT	OR	ON	ON	2020/02/10 03:11 PM
L85	31	(digital with remote with unit DRU) with (switch$3 chang$3 reconfigur$6) with sector	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L86	202	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector) and feedback and (QOS qualit$3 with service kpi key with performance with indicat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L87	1560	(packet communicat$4 traffic) with monitor$3 with unit with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page261

L88	4221	(digital with remote with unit DRU transceiv$3) with (switch$3 chang$3 reconfigur$6 remap$4) with (beam array sector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L89	2	L43 and L44	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/02/10 03:11 PM
L90	236	((("STAPLETON") near3 ("Shawn")) OR (("HEJAZI") near3 ("Seyed"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	ON	2020/02/10 03:11 PM
L91	98	((("DALI") near3 ("SYSTEMS") near3 ("CO") near3 ("LTD"))).AS,AANM.	USPAT	OR	ON	ON	2020/02/10 03:11 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N49	0	N48 AND ((H04W88/085 OR H04B10/2575 OR H04B10/25753 OR H04L41/5025).CPC.)	USPAT	OR	ON	ON	2020/02/10 03:06 PM
N48	72	shift$3 with (dru beam antenna) with between with sector	USPAT	OR	ON	ON	2020/02/10 03:06 PM

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page262

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
16/661,368	10/23/2019	2646	865	P282739.US.03 (DW-1039-1)	1	1

CONFIRMATION NO. 6065

CORRECTED FILING RECEIPT

167137
SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

OC000000114515071

Date Mailed: 02/07/2020

Receipt is acknowledged of this non-provisional utility 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 FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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Inventor(s)

Shawn Patrick Stapleton, Burnaby, CANADA;
Seyed Amin Hejazi, Burnaby, CANADA;

Applicant(s)

Dali Systems Co. Ltd., George Town, CAYMAN ISLANDS;

Assignment For Published Patent Application

Dali Systems Co. Ltd., George Town, CAYMAN ISLANDS

Power of Attorney: The patent practitioners associated with Customer Number 167137

Domestic Priority data as claimed by applicant

This application is a CON of 13/950,160 07/24/2013 PAT 10506454
which claims benefit of 61/678,016 07/31/2012

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 11/07/2019

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/661,368**

Projected Publication Date: 05/14/2020

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

Preliminary Class

455

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page264

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 (1-866-999-4258).

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).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page265

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page266

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/661,368

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	75		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	330		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	380		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	1 minus 20 =	*	x 50 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	1 minus 3 =	*	x 230 =	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 $310 ($155 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	785		TOTAL	

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	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
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.

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United States Patent and Trademark Office
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
16/661,368	10/23/2019		865	P282739.US.03 (DW-1039-1)	1	1

CONFIRMATION NO. 6065

UPDATED FILING RECEIPT

167137
SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

OC000000114514991

Date Mailed: 02/07/2020

Receipt is acknowledged of this non-provisional utility 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 FIRST INVENTOR, 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 corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction 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 provided that the request is grantable.

Inventor(s)

Shawn Patrick Stapleton, Burnaby, CANADA;
Seyed Amin Hejazi, Burnaby, CANADA;

Applicant(s)

Dali Systems Co. Ltd., George Town, CAYMAN ISLANDS;

Assignment For Published Patent Application

Dali Systems Co. Ltd., George Town, CAYMAN ISLANDS

Power of Attorney: The patent practitioners associated with Customer Number 167137

Domestic Priority data as claimed by applicant

This application is a CON of 13/950,160 07/24/2013 PAT 10506454
which claims benefit of 61/678,016 07/31/2012

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 11/07/2019

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/661,368**

Projected Publication Date: 05/14/2020

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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.

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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

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page269

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 (1-866-999-4258).

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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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).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page270

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page271

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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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
16/661,368	10/23/2019	Shawn Patrick Stapleton	P282739.US.03 (DW-1039-1)

CONFIRMATION NO. 6065

167137
SHERIDAN ROSS PC
1560 Broadway
Suite 1200
Denver, CO 80202

POA ACCEPTANCE LETTER

OC000000114515058

Date Mailed: 02/07/2020

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/04/2020.

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.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/yteferra/

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page272

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/661,368	10/23/2019	Shawn Patrick Stapleton	P282739.US.03 (DW-1039-1)

CONFIRMATION NO. 6065

27076
DORSEY & WHITNEY LLP - SEATTLE
INTELLECTUAL PROPERTY DEPARTMENT
COLUMBIA CENTER
701 FIFTH AVENUE, SUITE 6100
SEATTLE, WA 98104-7043

POWER OF ATTORNEY NOTICE

OC000000114515033

Date Mailed: 02/07/2020

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/04/2020.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/yteferra/

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of: Shawn Patrick Stapleton	)	Group Art Unit:
Application No.: 16/661,368	)	Examiner:
Filed: October 23, 2019	)	Confirmation No.: 6065
Atty. File No.: 10333-41-CON	)	

For: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

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

RESPONSE TO NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

Dear Commissioner:

The Notice to File Missing Parts of Nonprovisional Application dated November 13, 2019, required Applicant to satisfy the following fees which are submitted herewith:

Filing Fee	$75.00
Search fee	$330.00
Examination fee	$380.00
Surcharge Set forth in 37 C.F.R. 1.16(f)	$80.00
Total Fees	**$865.00**

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page274

Applicants believe no further fees or petitions are required. However, if any such petitions or fees are necessary, please consider this a request therefore and authorization to charge Deposit Account No. 19-1970 accordingly. Any deficiency or overpayment may also be applied to Deposit Account No. 19-1970.

Respectfully submitted,

SHERIDAN ROSS P.C.

By: /Jason H. Vick/

Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700
jvick@sheridanross.com

Date: February 4, 2020

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page275

PTO/AIA/22 (03-13)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): 10333-41-CON

Application Number: 16/661,368

Filed: October 23, 2019

For: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

Art Unit:

Examiner:

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

		Fee	Small Entity Fee	Micro Entity Fee	
☑	One month (37 CFR 1.17(a)(1))	$200	$100	$50	$ 100
☐	Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$
☐	Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$
☐	Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐	Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☑ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

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

☑ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 19-1970.

☑ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 45,285.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Jason H. Vick/ — Signature

February 4, 2020 — Date

Jason H. Vick — Typed or printed name

303-863-9700 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.136(a). 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 6 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: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

PTO/AIA/96 (08-12)
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U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: DALI SYSTEMS CO. LTD.

Application No./Patent No.: 16/661,368 Filed/Issue Date: October 23, 2019

Titled: OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

DALI SYSTEMS CO. LTD., a Corporation

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

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

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 031392, Frame 0084, or for which a copy thereof is attached.

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

   1. From: _____ To: _____

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

      Reel _____, Frame _____, or for which a copy thereof is attached.

   2. From: _____ To: _____

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

      Reel _____, Frame _____, or for which a copy thereof is attached.

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.**

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

PTO/AIA/96 (08-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

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

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

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

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

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

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

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

Reel _____, Frame _____, or for which a copy thereof is attached.

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

☑ As required by 37 CFR 3.73(c)(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.

/Jason H. Vick/	February 4, 2020
Signature	Date
Jason H. Vick	45,285
Printed or Typed Name	Title or Registration Number

PTO/AIA/80 (07-17)
Approved for use through 03/31/2021. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no person is required to respond to a collection of information unless it displays a valid OMB control number

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

[X] Practitioners associated with Customer Number: 167137

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(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

[X] The address associated with Customer Number: 167137

OR

[ ]

Firm or Individual name		
Address		
City	State	Zip
Country		
Telephone	Email	

Assignee name and address: Dali Systems Co. Ltd.
No. 309 Ugland House, South Church Street, George Town
Grand Cayman KY1-1104, Cayman Islands

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of the practitioners appointed in this form, 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 December 13, 2019
Name Albert Lee, Ph.D.	Telephone
Title Founder, Chairman and Chief Executive Officer	

This collection of information is required by 37 CFR 1.31, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public, which is to update (and by the USPTO to process) the file of a patent or reexamination proceeding. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 18 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.

Electronic Patent Application Fee Transmittal

Application Number:	16661368
Filing Date:	23-Oct-2019
Title of Invention:	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
First Named Inventor/Applicant Name:	Shawn Patrick Stapleton
Filer:	Jason Vick/Joanne Vos
Attorney Docket Number:	P282739.US.03 (DW-1039-1)

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	75	75
UTILITY SEARCH FEE	2111	1	330	330
UTILITY EXAMINATION FEE	2311	1	380	380
Pages:				
Claims:				
Miscellaneous-Filing:				
LATE FILING FEE FOR OATH OR DECLARATION	2051	1	80	80
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 1 month with $0 paid	2251	1	100	100
Miscellaneous:				
		Total in USD ($)		**965**

Electronic Acknowledgement Receipt

EFS ID:	38490435
Application Number:	16661368
International Application Number:	
Confirmation Number:	6065
Title of Invention:	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
First Named Inventor/Applicant Name:	Shawn Patrick Stapleton
Customer Number:	27076
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	P282739.US.03 (DW-1039-1)
Receipt Date:	04-FEB-2020
Filing Date:	23-OCT-2019
Time Stamp:	15:57:29
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$965
RAM confirmation Number	E202024F57540359
Deposit Account	191970
Authorized User	Joanne Vos
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Response_to_Missing_Parts.pdf	184538 aca329c3045424d5d0a3afd1b4e8545f5319e476	yes	3
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Applicant Response to Pre-Exam Formalities Notice		1	2	
	Extension of Time		3	3	
Warnings:					
Information:					
2		Statement_Under_373c_w_POA_10333-41-CON.pdf	234896 e4db383e1b8ce1bb5022c698308207b82b57fd44	yes	3
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Assignee showing of ownership per 37 CFR 3.73		1	2	
	Power of Attorney		3	3	
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	39327 26d10d16035a15f39106fc8800bef18ef5d02eef	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	458761		

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: 16/661,368

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	75		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	330		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	380		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	1 minus 20 =	*	x 50 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	1 minus 3 =	*	x 230 =	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 $310 ($155 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	785		TOTAL	

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	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
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
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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
16/661,368	10/23/2019		0.00	P282739.US.03 (DW-1039-1)	1	1

CONFIRMATION NO. 6065

FILING RECEIPT

27076
DORSEY & WHITNEY LLP - SEATTLE
INTELLECTUAL PROPERTY DEPARTMENT
COLUMBIA CENTER
701 FIFTH AVENUE, SUITE 6100
SEATTLE, WA 98104-7043



Date Mailed: 11/13/2019

Receipt is acknowledged of this non-provisional utility 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 FIRST INVENTOR, 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 corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction 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 provided that the request is grantable.

Inventor(s)

Shawn Patrick Stapleton, Burnaby, CANADA;
Seyed Amin Hejazi, Burnaby, CANADA;

Applicant(s)

Dali Systems Co. Ltd., George Town, CAYMAN ISLANDS;

Assignment For Published Patent Application

Dali Systems Co. Ltd., George Town, CAYMAN ISLANDS

Power of Attorney: The patent practitioners associated with Customer Number 27076

Domestic Priority data as claimed by applicant

This application is a CON of 13/950,160 07/24/2013
which claims benefit of 61/678,016 07/31/2012

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 11/07/2019

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/661,368**

Projected Publication Date: To Be Determined - pending completion of Missing Parts

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page287

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 (1-866-999-4258).

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).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page289

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
16/661,368	10/23/2019	Shawn Patrick Stapleton	P282739.US.03 (DW-1039-1)

CONFIRMATION NO. 6065

27076
DORSEY & WHITNEY LLP - SEATTLE
INTELLECTUAL PROPERTY DEPARTMENT
COLUMBIA CENTER
701 FIFTH AVENUE, SUITE 6100
SEATTLE, WA 98104-7043

FORMALITIES LETTER

OC000000112503372

Date Mailed: 11/13/2019

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. 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 statutory basic filing fee is missing.
- The application search fee must be submitted.
- The application examination fee must be submitted.
- Surcharge as set forth in 37 CFR 1.16(f) must be submitted.
  The surcharge is due for any one of:
  - late submission of the basic filing fee, search fee, or examination fee,
  - late submission of inventor's oath or declaration,
  - filing an application that does not contain at least one claim on filing, or
  - submission of an application filed by reference to a previously filed application.

SUMMARY OF FEES DUE:

The fee(s) required within **TWO MONTHS** from the date of this Notice to avoid abandonment is/are itemized below. Small entity discount is in effect. If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $ **75** basic filing fee.
- $ **80** surcharge.
- $ **330** search fee.
- $ **380** examination fee.
- $(**0**) previous unapplied payment amount.
- $ **865** TOTAL FEE BALANCE DUE.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

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, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". 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.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/tgebre/

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page291

Doc Code: ECOMM.AUTH/ECOMM.WTDW
Doc Description: Internet Communications Authorized/Internet Communications Authorization Withdrawn

PTO/SB/439 (11-15)

AUTHORIZATION FOR INTERNET COMMUNICATIONS IN A PATENT APPLICATION OR REQUEST TO WITHDRAW AUTHORIZATION FOR INTERNET COMMUNICATIONS

Application No.	filed concurrently herewith
Filing Date	filed concurrently herewith
First Named Inventor	Shawn Patrick Stapleton
Art Unit	not yet assigned
Examiner Name	not yet assigned
Practitioner Docket No.	P282739.US.03 (DW-1039-1)

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

I. To authorize permission for Internet Communications.

☑ Recognizing that Internet communications are not secure, I hereby authorize the USPTO to communicate with the undersigned and practitioners in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via video conferencing, instant messaging, or electronic mail. I understand that a copy of these communications will be made of record in the application file. (MPEP 502.03)

II. To withdraw authorization for Internet Communications.

☐ The authorization given on _____, to the USPTO to communicate with the undersigned and any practitioner in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via Internet communications such as video conferencing, instant messaging, or electronic mail is hereby withdrawn. I understand that the withdrawal is effective when approved rather than when received.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 51,916.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Jennifer Spaith/ — Signature

October 23, 2019 — Date

Jennifer Spaith — Typed or printed name

206.903.8836 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Juristic entities must be represented by a patent practitioner (see 37 CFR 1.31, which is applicable to any paper filed on or after September 16, 2012, that is presented on behalf of a juristic entity, regardless of application filing date). Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 (ONE) forms are submitted.

PTO/AIA/15 (10-17)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995 no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UTILITY PATENT APPLICATION TRANSMITTAL

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

Attorney Docket No.	P282739.US.03 (DW-1039-1)
First Named Inventor	Shawn Patrick Stapleton
Title	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
Priority Mail Express® Label No.	N/A

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. [ ] **Fee Transmittal Form** (PTO/SB/17 or equivalent)
2. [✓] **Applicant asserts small entity status.** See 37 CFR 1.27
3. [ ] **Applicant certifies micro entity status.** See 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
4. [✓] **Specification** [*Total Pages* 26] Both the claims and abstract must start on a new page. *(See MPEP § 608.01(a) for information on the preferred arrangement)*
5. [✓] **Drawing(s)** (35 U.S.C. 113) [*Total Sheets* 11]
6. **Inventor's Oath or Declaration** [*Total Pages* 2] *(including substitute statements under 37 CFR 1.64 and assignments serving as an oath or declaration under 37 CFR 1.63(e))*
   a. [ ] Newly executed (original or copy)
   b. [✓] A copy from a prior application (37 CFR 1.63(d))
7. [✓] **Application Data Sheet** ** See note below.* See 37 CFR 1.76 (PTO/AIA/14 or equivalent)
8. **CD-ROM or CD-R** in duplicate, large table, or Computer Program (*Appendix*)
   [ ] Landscape Table on CD
9. **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

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Alexandria, VA 22313-1450

ACCOMPANYING APPLICATION PAPERS

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

***Note:** (1) Benefit claims under 37 CFR 1.78 and foreign priority claims under 1.55 **must** be included in an Application Data Sheet (ADS).
(2) For applications filed under 35 U.S.C. 111, the application must contain an ADS specifying the applicant if the applicant is an assignee, person to whom the inventor is under an obligation to assign, or person who otherwise shows sufficient proprietary interest in the matter. See 37 CFR 1.46(b).

19. CORRESPONDENCE ADDRESS

[✓] The address associated with Customer Number: 27,076 **OR** [ ] Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone		Email	

Signature	/Jennifer Spaith/	Date	October 23, 2019
Name (Print/Type)	Jennifer Spaith	Registration No. (Attorney/Agent)	51,916

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.

Electronic Acknowledgement Receipt

EFS ID:	37539622
Application Number:	16661368
International Application Number:	
Confirmation Number:	6065
Title of Invention:	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
First Named Inventor/Applicant Name:	Shawn Patrick Stapleton
Customer Number:	27076
Filer:	Jennifer Lane Spaith/Alexandra Yaeger
Filer Authorized By:	Jennifer Lane Spaith
Attorney Docket Number:	P282739.US.03 (DW-1039-1)
Receipt Date:	23-OCT-2019
Filing Date:	
Time Stamp:	15:00:48
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	Application Data Sheet	20191023_ADS_P282739US03_DW-1039-1.pdf	1256285 f47e61fc348982f6cbc0c2ccc671da9864657652	no	8

Warnings:

Information:					
2		20191023_ContinuationApplicationAsFiled_P282739US03_DW-1039-1.pdf	13424737 a0b706fcbde2e58085c9de390c3dd989a6f2c2ad	yes	43

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Power of Attorney	42	43
	Oath or Declaration filed	40	41
	Drawings-only black and white line drawings	29	39
	Abstract	28	28
	Claims	27	27
	Specification	3	26
	Internet Communications Authorized	2	2
	Transmittal of New Application	1	1

Warnings:	
Information:	
Total Files Size (in bytes):	14681022

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

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P282739.US.03 (DW-1039-1)
	Application Number	
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA 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.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Shawn	Patrick	Stapleton	

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

City	Burnaby	Country of Residence [i]	CA

Mailing Address of Inventor:

Address 1	MAPLES CORPORATE SERVICES LIMITED
Address 2	P.O. Box 309, Ugland House, South Church Street
City	George Town, Grand Cayman
State/Province	
Postal Code	KY1-1104
Country [i]	KY

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Seyed	Amin	Hejazi	

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

City	Burnaby	Country of Residence [i]	CA

Mailing Address of Inventor:

Address 1	MAPLES CORPORATE SERVICES LIMITED
Address 2	P.O. Box 309, Ugland House, South Church Street
City	George Town, Grand Cayman
State/Province	
Postal Code	KY1-1104
Country [i]	KY

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

Correspondence Information:

PTO/AIA/14 (02-18)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P282739.US.03 (DW-1039-1)
	Application Number	
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

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	27076		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM		
Attorney Docket Number	P282739.US.03 (DW-1039-1)	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	11	**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

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).
Either enter 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	27076		

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P282739.US.03 (DW-1039-1)
	Application Number	
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim 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.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	13950160	2013-07-24
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
13950160	Claims benefit of provisional	61678016	2012-07-31

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 priority to a foreign application. 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. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

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

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P282739.US.03 (DW-1039-1)
	Application Number	
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P282739.US.03 (DW-1039-1)
	Application Number	
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

Applicant Information:

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

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Dali Systems Co. Ltd.		
Mailing Address Information For Applicant:			
Address 1	Maples Corporate Services Limited		
Address 2	P.O. Box 309, Ugland House, South Church Street		
City	George Town, Grand Cayman	**State/Province**	
Country	KY	Postal Code	KY1-1104
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

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

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P282739.US.03 (DW-1039-1)
	Application Number	
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

Organization Name	Dali Systems Co. Ltd.

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	Maples Corporate Services Limited		
Address 2	P.O. Box 309, Ugland House, South Church Street		
City	George Town, Grand Cayman	**State/Province**	
Country i	KY	Postal Code	KY1-1104
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Jennifer Spaith/			Date (YYYY-MM-DD)	2019-10-23
First Name	Jennifer	Last Name	Spaith	Registration Number	51916

Additional Signature may be generated within this form by selecting the Add button. Add

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P282739.US.03 (DW-1039-1)
	Application Number	
Title of Invention	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM	

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 CooperationTreaty.

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.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page303

Doc Code: PA..
Document Description: Power of Attorney

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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	filed concurrently herewith
Filing Date	filed concurrently herewith
First Named Inventor	Shawn Patrick Stapleton
Title	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM
Art Unit	not yet assigned
Examiner Name	not yet assigned
Attorney Docket Number	

SIGNATURE of Applicant or Patent Practitioner

Signature	/Jennifer Spaith/	Date (Optional)	
Name	Jennifer Spaith	Registration Number	51,916
Title (if Applicant is a juristic entity)	Patent Practitioner		
Applicant Name (if Applicant is a juristic entity)	DALI SYSTEMS CO. LTD		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. 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 3 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.

Doc Code: PA..
Document Description: Power of Attorney

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DALI SYSTEMS CO. LTD

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Name	Albert Lee		
Title	CEO		

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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	OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number 13/950,160 filed on July 24, 2013

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: Shawn Patrick Stapleton Date (Optional): 7/25/2013

Signature: _____

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LEGAL NAME OF INVENTOR

Inventor: Seyed Amin Hejazi Date (Optional): 26 July 2013

Signature: _____

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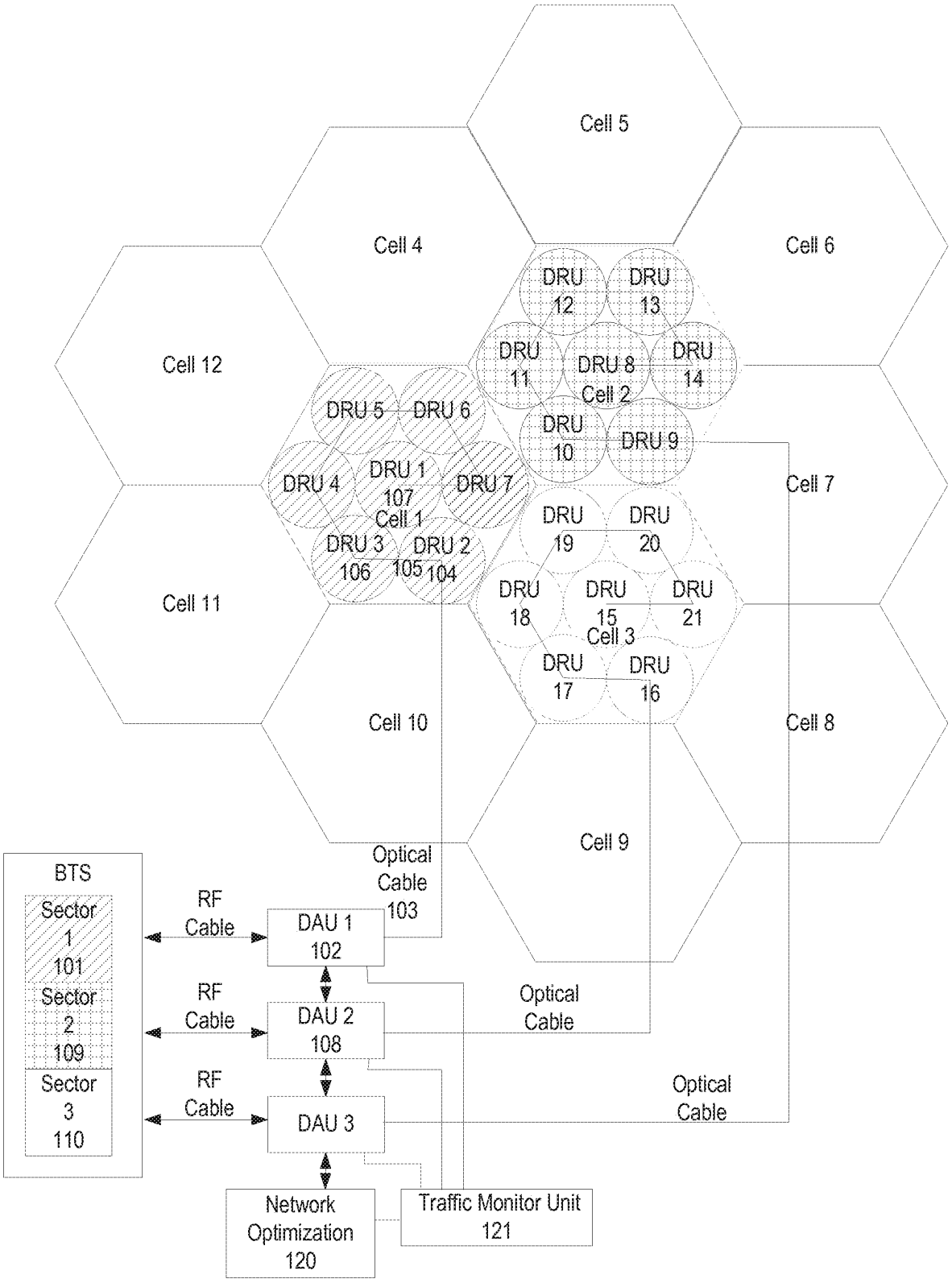

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Cell 4
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Cell 12
Cell 7
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DRU 12
DRU 13
DRU 11
DRU 8
Cell 2
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DRU 5
DRU 6
DRU 10
DRU 9
DRU 4
DRU 1
107
DRU 7
Cell 1
DRU 3
106
DRU 2
105
104
DRU 19
DRU 20
DRU 18
DRU 15
DRU 21
Cell 3
DRU 17
DRU 16
BTS
Sector 1
101
Sector 2
109
Sector 3
110
RF Cable
RF Cable
RF Cable
DAU 1
102
DAU 2
108
DAU 3
Optical Cable
103
Optical Cable
Optical Cable
Network Optimization
120
Traffic Monitor Unit
121

FIG. 1

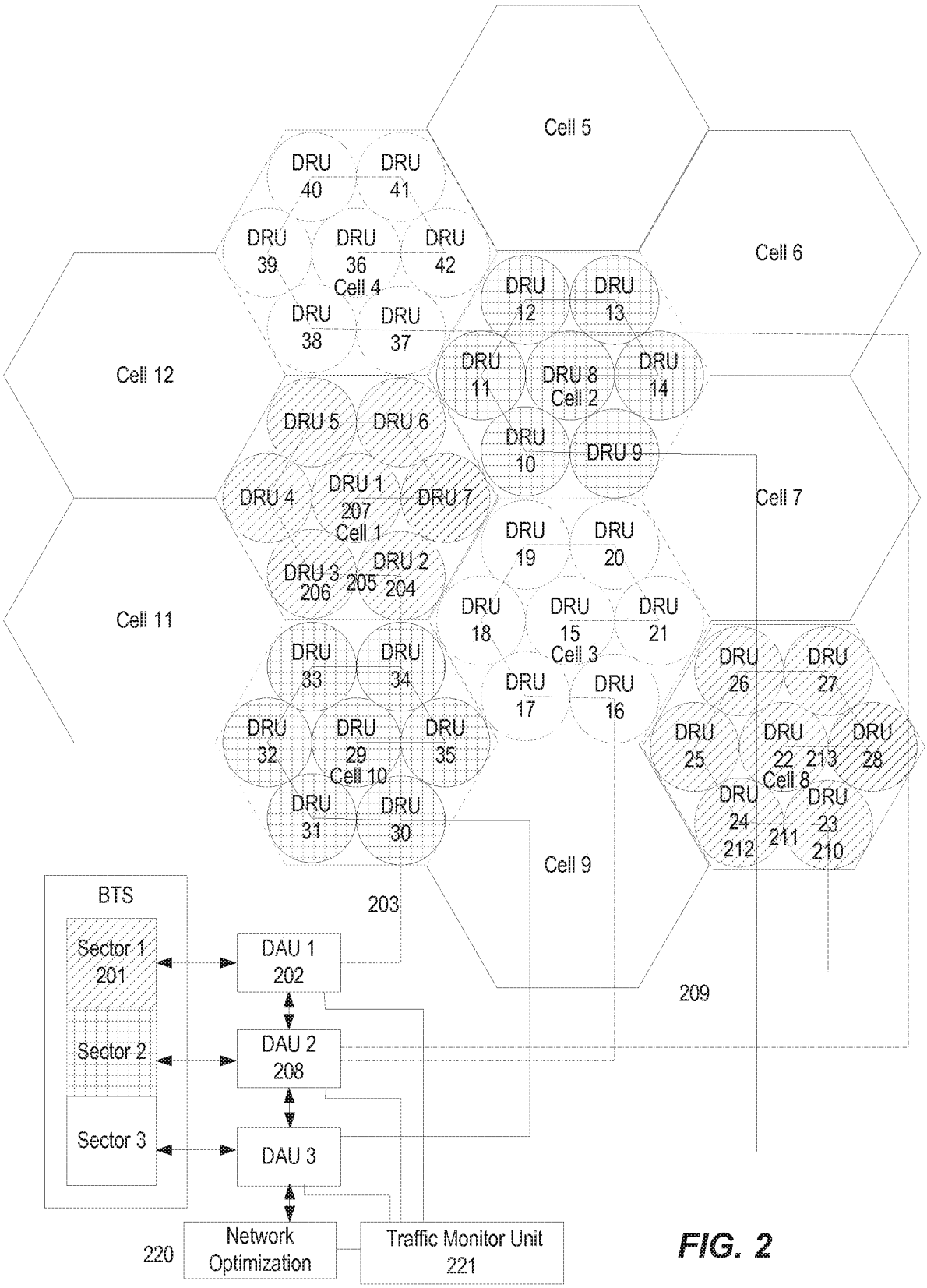

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Cell 2
Cell 1
Cell 3
DRU 40
DRU 41
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DRU 36
DRU 42
DRU 38
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DRU 12
DRU 13
DRU 11
DRU 8
DRU 14
DRU 5
DRU 6
DRU 10
DRU 9
DRU 4
DRU 1
207
DRU 7
DRU 19
DRU 20
DRU 3
206
205
DRU 2
204
DRU 18
DRU 15
DRU 21
DRU 33
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DRU 32
DRU 29
DRU 35
DRU 25
DRU 22
213
DRU 28
DRU 31
DRU 30
DRU 24
212
211
DRU 23
210
203
209
BTS
Sector 1
201
Sector 2
Sector 3
DAU 1
202
DAU 2
208
DAU 3
220
Network
Optimization
Traffic Monitor Unit
221

FIG. 2

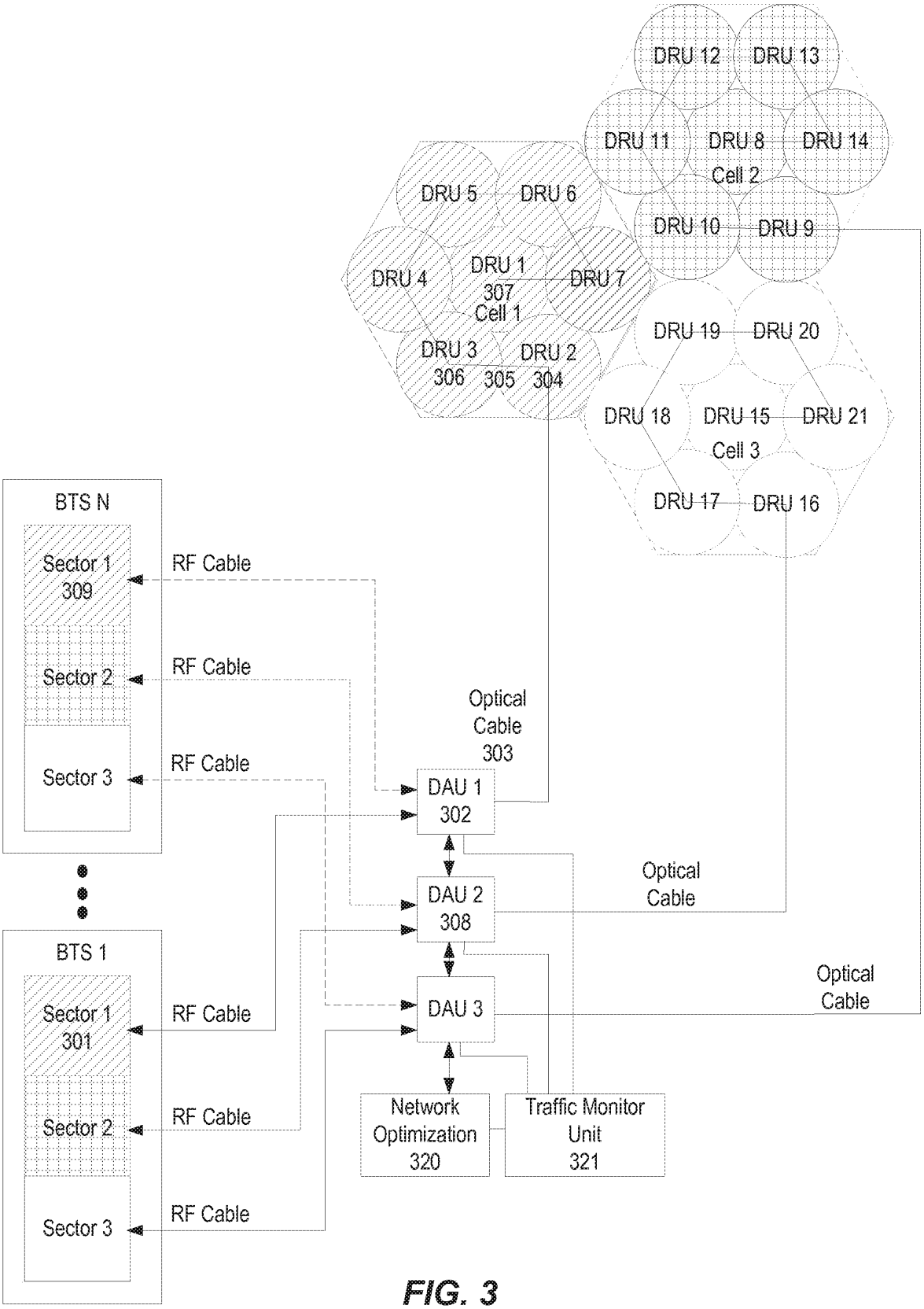

DRU 12
DRU 13
DRU 11
DRU 8
DRU 14
Cell 2
DRU 5
DRU 6
DRU 10
DRU 9
DRU 4
DRU 1
307
Cell 1
DRU 7
DRU 19
DRU 20
DRU 3
306
305
DRU 2
304
DRU 18
DRU 15
DRU 21
Cell 3
DRU 17
DRU 16
BTS N
Sector 1
309
RF Cable
Sector 2
RF Cable
Sector 3
RF Cable
Optical
Cable
303
DAU 1
302
Optical
Cable
DAU 2
308
BTS 1
Optical
Cable
Sector 1
301
RF Cable
DAU 3
Sector 2
RF Cable
Network
Optimization
320
Traffic Monitor
Unit
321
Sector 3
RF Cable

FIG. 3

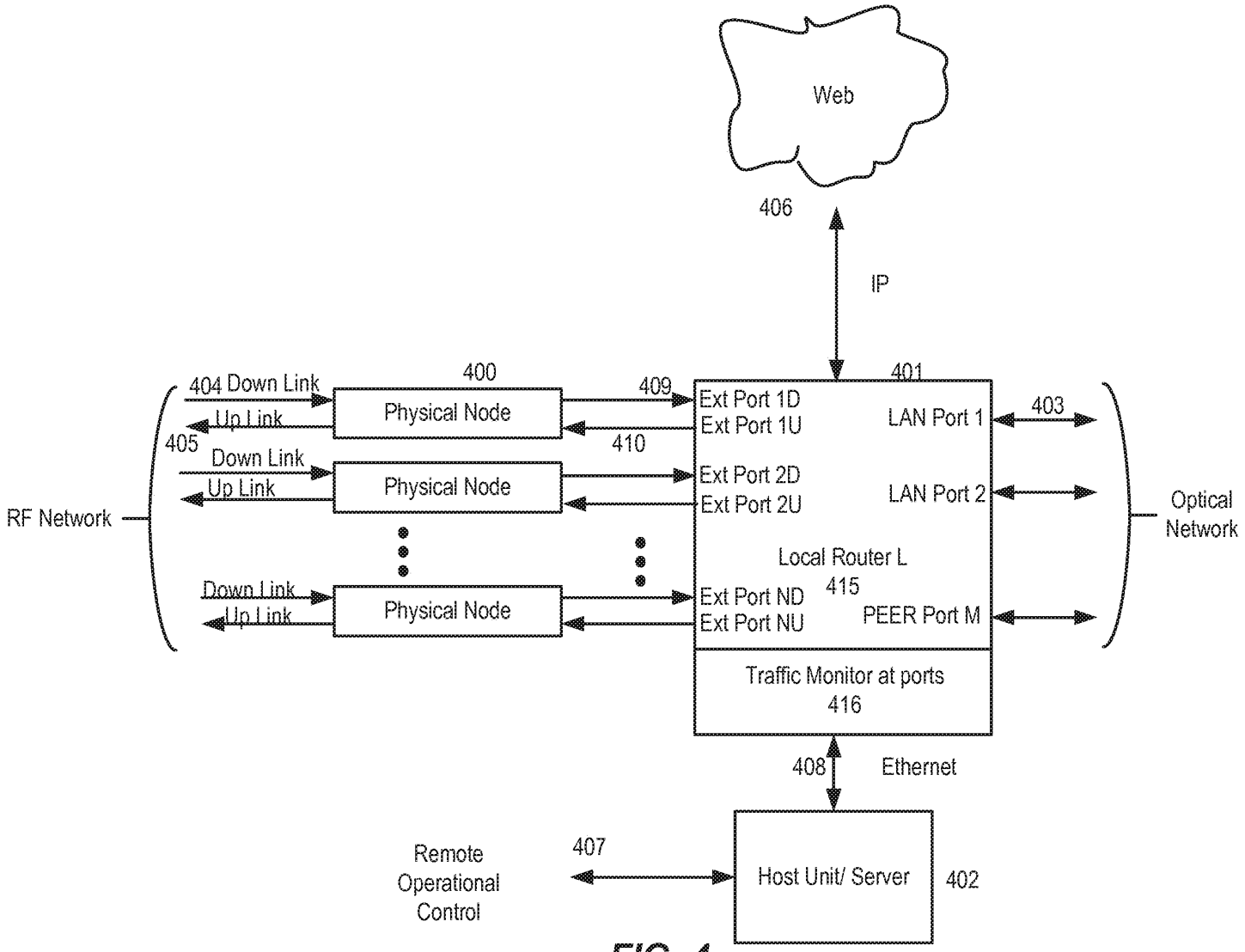

Web
406
IP
400
401
404 Down Link
Up Link
405
Physical Node
409
410
Ext Port 1D
Ext Port 1U
LAN Port 1
403
Down Link
Up Link
Physical Node
Ext Port 2D
Ext Port 2U
LAN Port 2
RF Network
Optical Network
Local Router L
415
Down Link
Up Link
Physical Node
Ext Port ND
Ext Port NU
PEER Port M
Traffic Monitor at ports
416
408
Ethernet
Remote Operational Control
407
Host Unit/ Server
402

FIG. 4

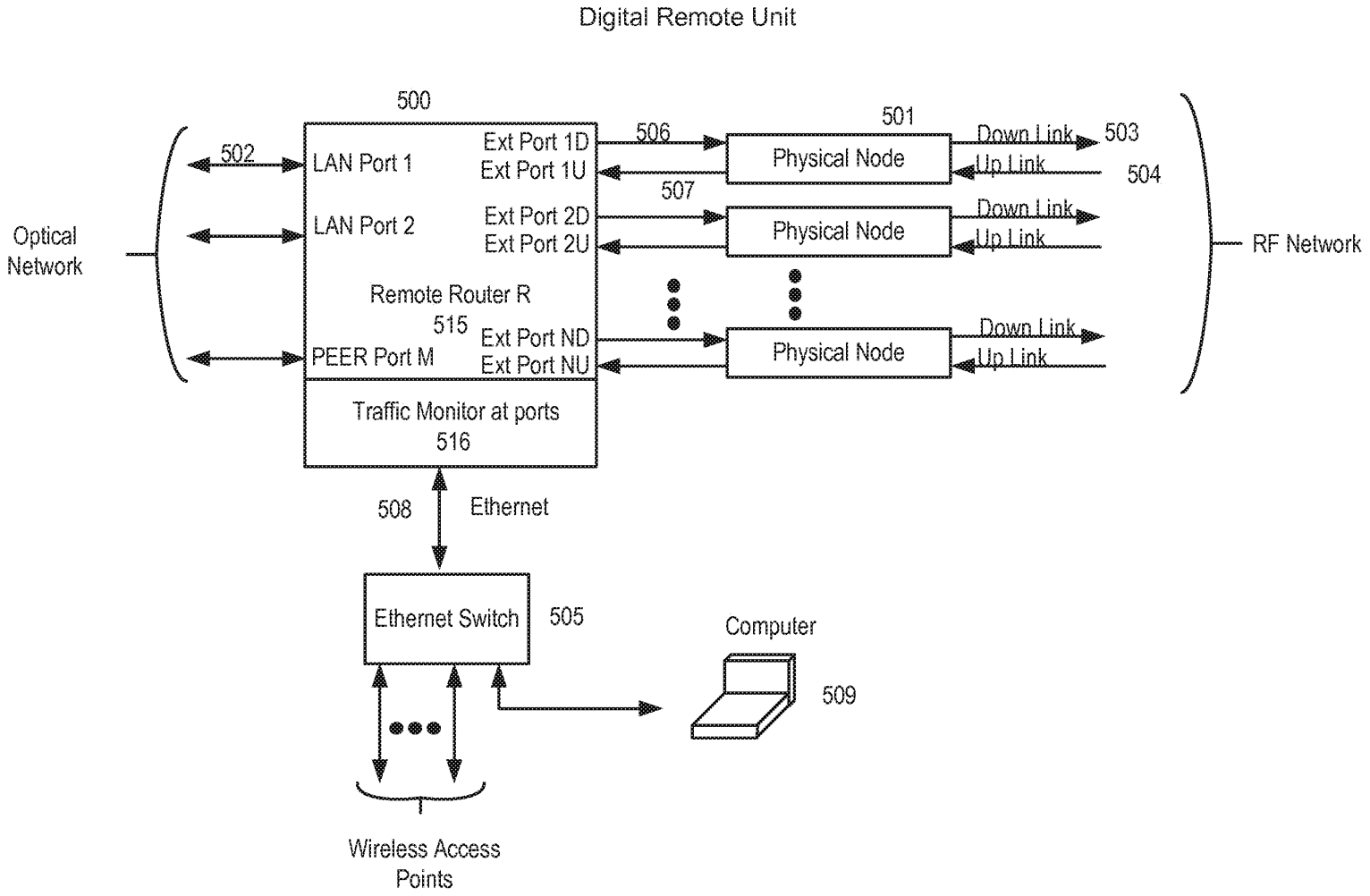


FIG. 5

91172-882666(103900US)
Page 5 of 11

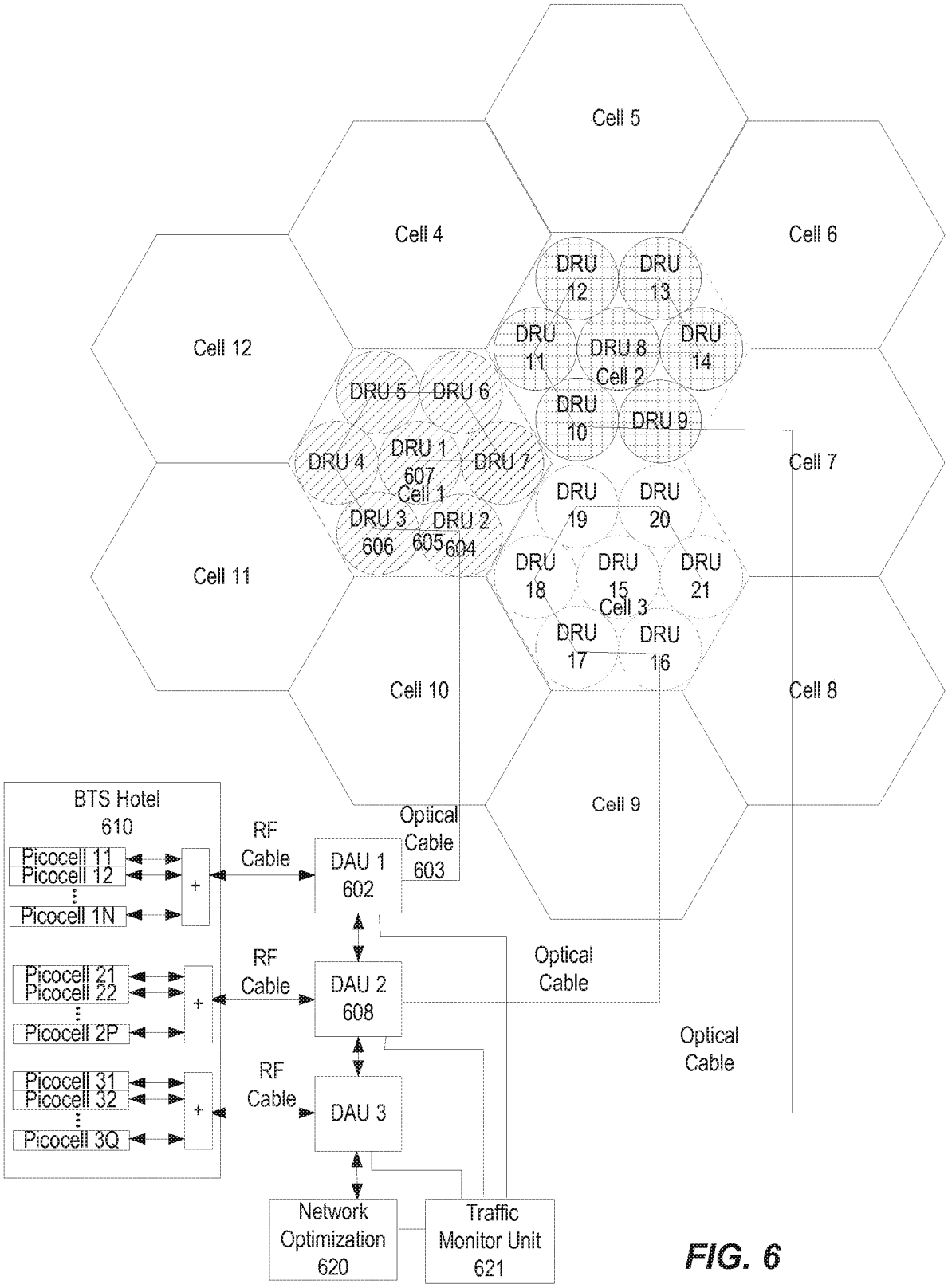

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Cell 4
Cell 6
Cell 12
Cell 7
Cell 11
Cell 10
Cell 8
Cell 9
DRU 12
DRU 13
DRU 11
DRU 8
Cell 2
DRU 14
DRU 5
DRU 6
DRU 10
DRU 9
DRU 4
DRU 1
607
DRU 7
Cell 1
DRU 3
606
DRU 2
605
604
DRU 19
DRU 20
DRU 18
DRU 15
DRU 21
Cell 3
DRU 17
DRU 16
BTS Hotel
610
Picocell 11
Picocell 12
Picocell 1N
Picocell 21
Picocell 22
Picocell 2P
Picocell 31
Picocell 32
Picocell 3Q
+
RF Cable
DAU 1
602
Optical Cable
603
DAU 2
608
DAU 3
Network Optimization
620
Traffic Monitor Unit
621

FIG. 6

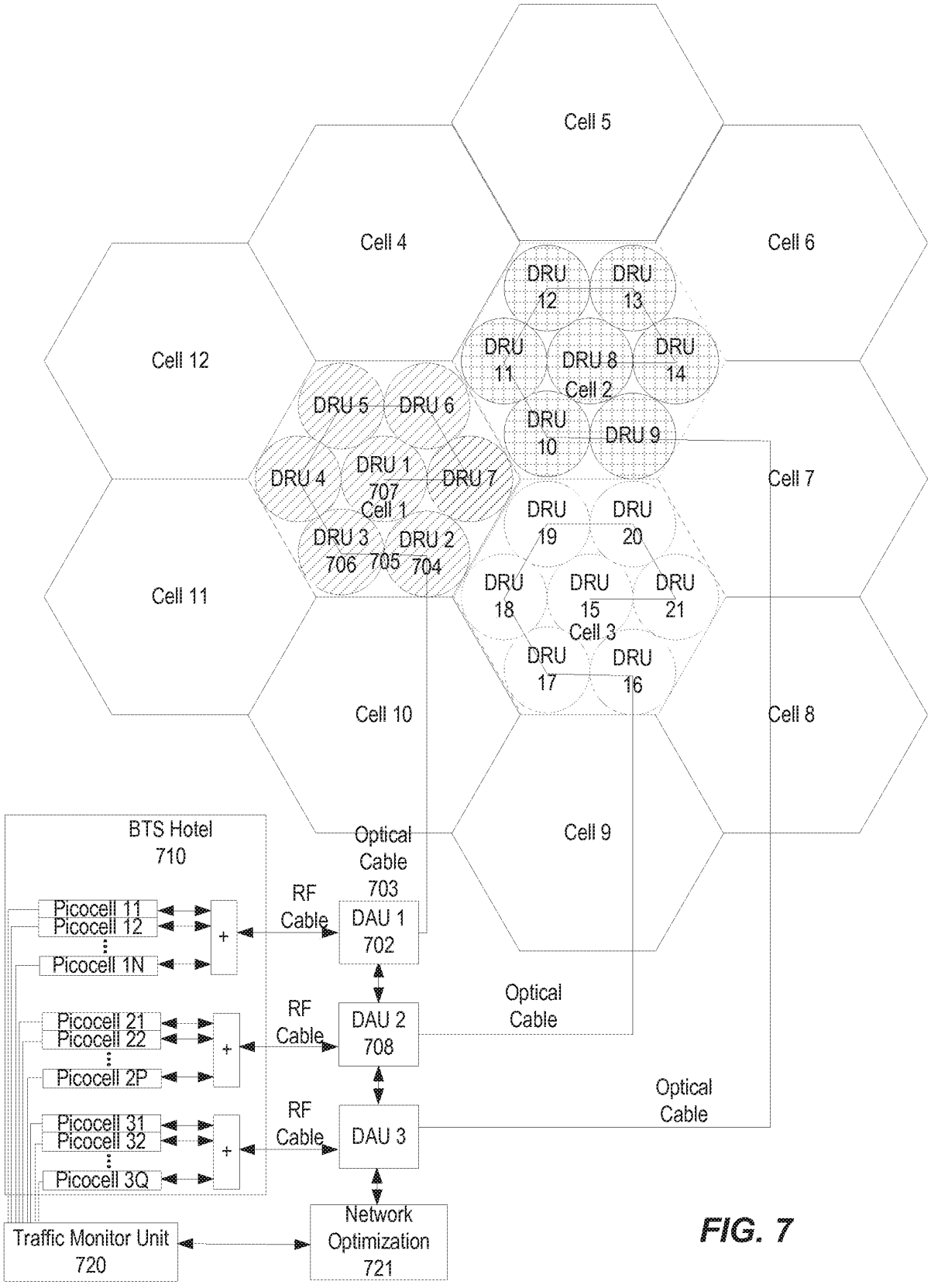

Cell 5
Cell 4
Cell 6
Cell 12
Cell 7
Cell 11
Cell 10
Cell 8
Cell 9
DRU 12
DRU 13
DRU 11
DRU 8
DRU 14
Cell 2
DRU 5
DRU 6
DRU 10
DRU 9
DRU 4
DRU 1
707
DRU 7
Cell 1
DRU 3
706
DRU 2
705
704
DRU 19
DRU 20
DRU 18
DRU 15
DRU 21
Cell 3
DRU 17
DRU 16
BTS Hotel
710
Optical
Cable
703
RF
Cable
DAU 1
702
Picocell 11
Picocell 12
Picocell 1N
+
Optical
Cable
RF
Cable
DAU 2
708
Picocell 21
Picocell 22
Picocell 2P
+
Optical
Cable
RF
Cable
DAU 3
Picocell 31
Picocell 32
Picocell 3Q
+
Network
Optimization
721
Traffic Monitor Unit
720

FIG. 7

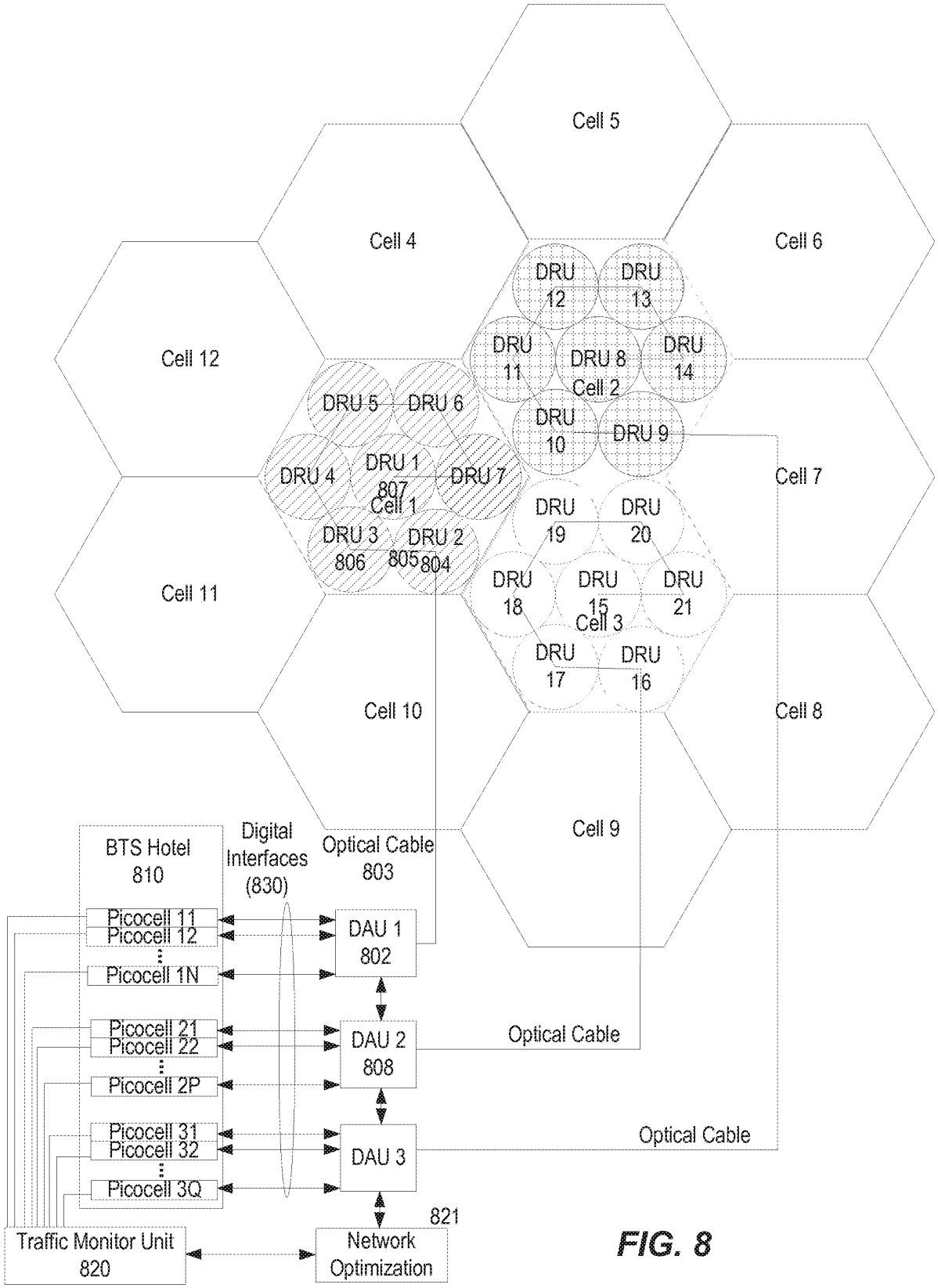

Cell 5
Cell 4
Cell 6
Cell 12
Cell 7
Cell 11
Cell 10
Cell 8
Cell 9
Cell 1
Cell 2
Cell 3
DRU 12
DRU 13
DRU 11
DRU 8
DRU 14
DRU 5
DRU 6
DRU 10
DRU 9
DRU 4
DRU 1
807
DRU 7
DRU 19
DRU 20
DRU 3
806
DRU 2
805
804
DRU 18
DRU 15
DRU 21
DRU 17
DRU 16
BTS Hotel
810
Digital
Interfaces
(830)
Optical Cable
803
Picocell 11
Picocell 12
Picocell 1N
Picocell 21
Picocell 22
Picocell 2P
Picocell 31
Picocell 32
Picocell 3Q
DAU 1
802
DAU 2
808
DAU 3
Optical Cable
Optical Cable
821
Traffic Monitor Unit
820
Network
Optimization

FIG. 8

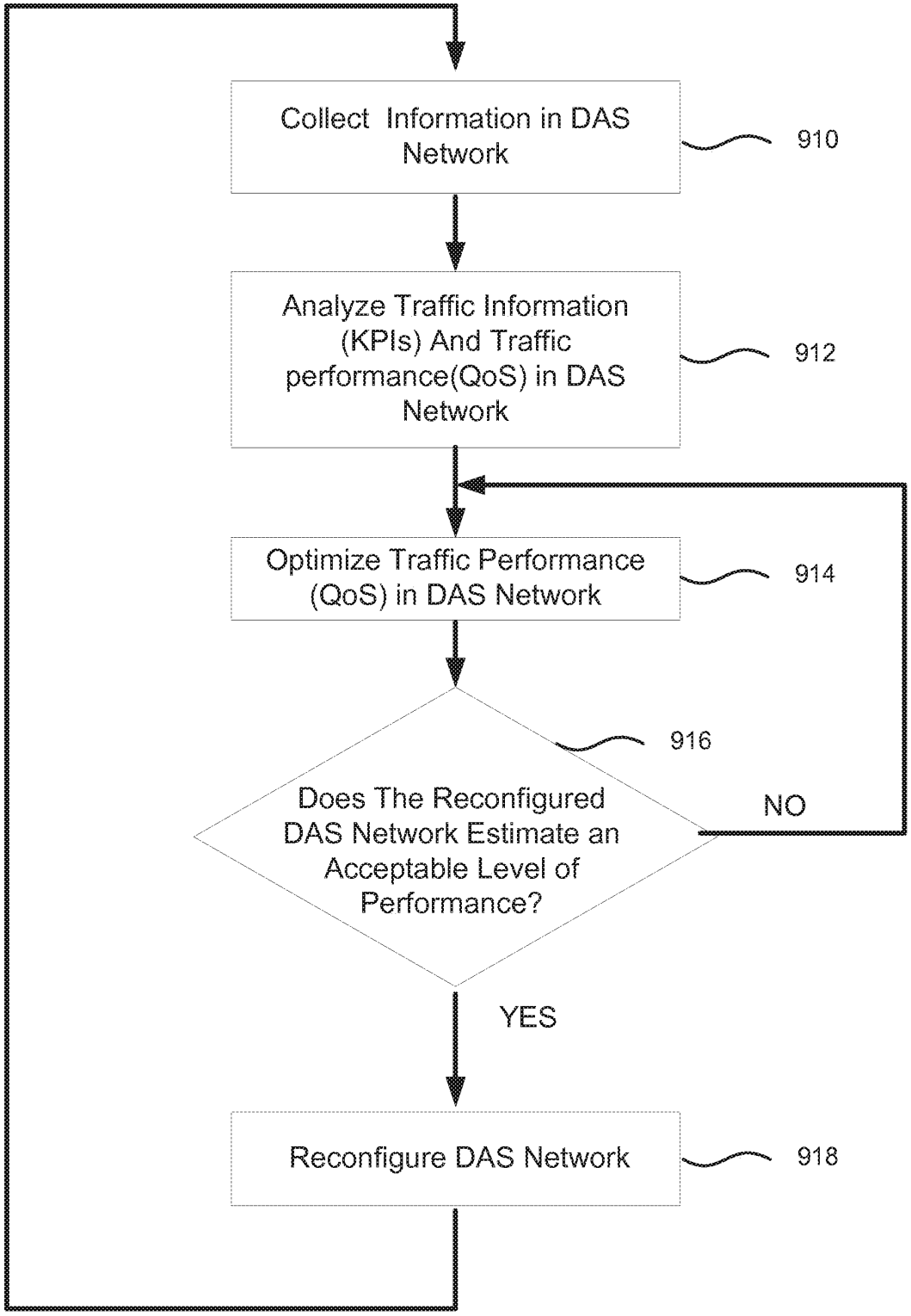

Collect Information in DAS Network
910
Analyze Traffic Information (KPIs) And Traffic performance(QoS) in DAS Network
912
Optimize Traffic Performance (QoS) in DAS Network
914
916
Does The Reconfigured DAS Network Estimate an Acceptable Level of Performance?
NO
YES
Reconfigure DAS Network
918

FIG. 9

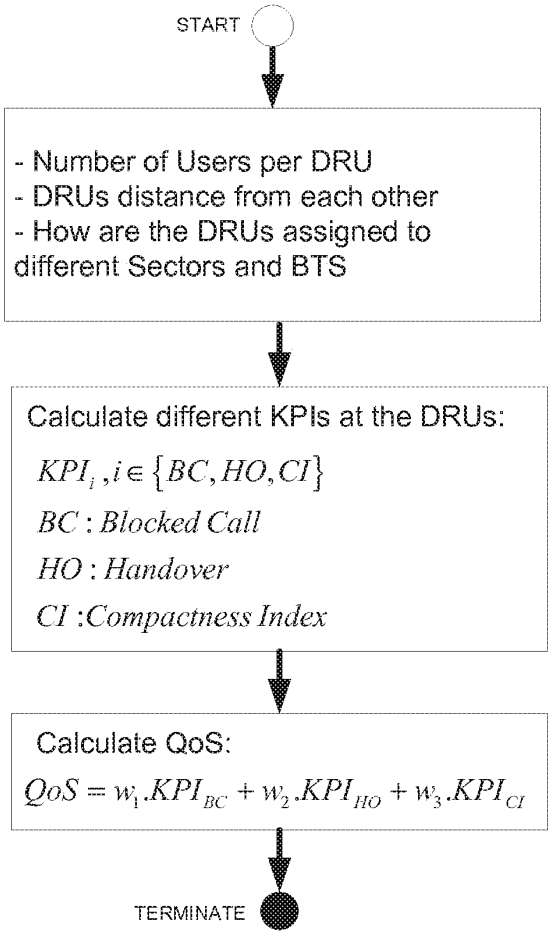
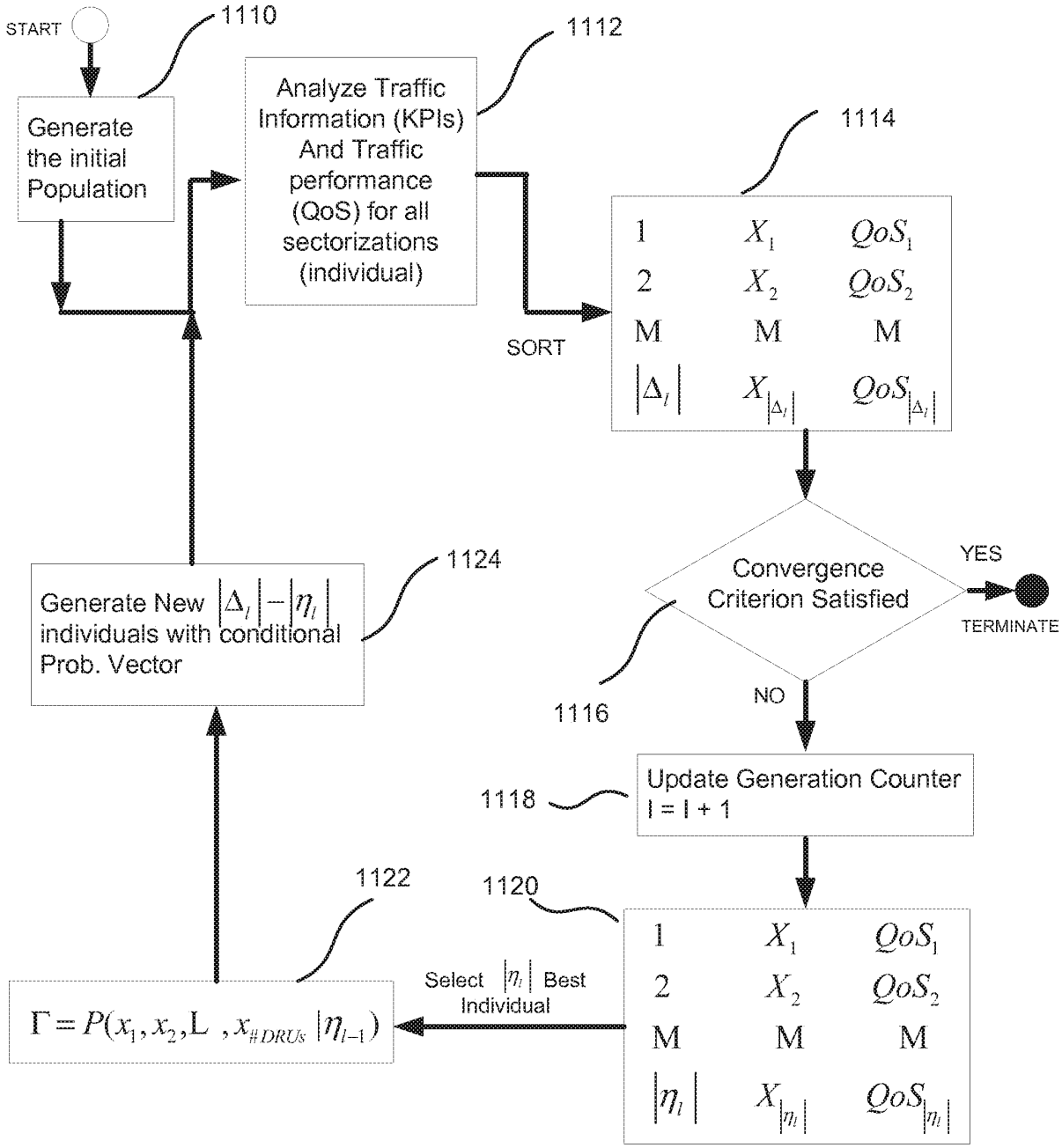

START
- Number of Users per DRU
- DRUs distance from each other
- How are the DRUs assigned to different Sectors and BTS
Calculate different KPIs at the DRUs:
$KPI_i, i \in \{BC, HO, CI\}$
BC : $Blocked\ Call$
HO : $Handover$
CI :$Compactness\ Index$
Calculate QoS:
$QoS = w_1.KPI_{BC} + w_2.KPI_{HO} + w_3.KPI_{CI}$
TERMINATE

FIG. 10



- Δ_l is Set of Individuals(population)
- Individual $X_j = (x_1, x_2, ..., x_{\#DRUs}), x_i \in \{S_{nm} | \text{sector "n" from BTS "m"}\}$

FIG. 11

ABSTRACT

A system for dynamically routing signals in a Distributed Antenna System includes a plurality of Digital Access Units (DAUs). The plurality of DAUs are coupled and operable to route signals between the plurality of DAUs. The system also includes a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs and a plurality of Base Transceiver Stations (BTS). The system further includes a plurality of traffic monitoring modules and a network optimization goal and optimization algorithm.

WHAT IS CLAIMED IS:

1. A system for dynamically routing signals in a Distributed Antenna System, the system comprising:

a plurality of Digital Access Units (DAUs), wherein the plurality of DAUs are coupled and operable to route signals between the plurality of DAUs;

a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs;

a plurality of Base Transceiver Stations (BTS);

a plurality of traffic monitoring modules; and

a network optimization goal and optimization algorithm.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page320

OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application is a continuation of pending U.S. Patent Application No. 13/950,160 filed July 24, 2013 entitled "OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM", which application claims priority to U.S. Provisional Patent Application No. 61/678,016, filed on July 31, 2012, entitled "OPTIMIZATION OF TRAFFIC LOAD IN A DISTRIBUTED ANTENNA SYSTEM". The aforementioned applications are incorporated herein by reference, in their entirety, for any purpose.

SUMMARY OF THE INVENTION

[0002] The present invention generally relates to wireless communication systems employing Distributed Antenna Systems (DAS) as part of a distributed wireless network. More specifically, the present invention relates to a DAS utilizing traffic monitoring and optimization. Wireless network operators faces the continuing challenge of building networks that effectively manage high data-traffic growth rates. Mobility and an increased level of multimedia content for end users typically employs end-to-end network adaptations that support new services and the increased demand for broadband and flat-rate Internet access. One of the most difficult challenges faced by network operators is caused by the physical movement of subscribers from one location to another, and particularly when wireless subscribers congregate in large numbers at one location. A notable example is a business enterprise facility during lunchtime, when a large number of wireless subscribers visit a lunch room or cafeteria location in the building. At that time, a large number of subscribers have moved away from their offices and usual work areas. It's likely that during lunchtime, there are many locations throughout the facility where there are very few subscribers. If the indoor wireless network resources were properly sized during the design process for subscriber loading as it is during normal working hours when subscribers are in their normal work areas, it is very likely that the lunchtime scenario will present some unexpected challenges with regard to available wireless capacity and data throughput.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page321

[0003] According to an embodiment of the present invention, a system for dynamically routing signals in a Distributed Antenna System is provided. The system includes a plurality of Digital Access Units (DAUs). The plurality of DAUs are coupled and operable to route signals between the plurality of DAUs. The system also includes a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs. The system further includes one or more Base Transceiver Stations (BTSs) and one or more traffic monitoring units.

[0004] According to another embodiment of the present invention, a system for dynamically routing signals in a Distributed Antenna System is provided. The system includes a plurality of Digital Access Units (DAUs). The plurality of DAUs are coupled and operable to route signals between the plurality of DAUs. The system also includes a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs and a plurality of Base Transceiver Stations (BTS). The system further includes a plurality of traffic monitoring modules and a network optimization goal and optimization algorithm.

[0005] In an embodiment, a system for dynamically routing signals in a Distributed Antenna System is provided and includes a plurality of Digital Access Units (DAUs). The plurality of DAUs are coupled and operable to route signals between the plurality of DAUs. The system also includes a plurality of Digital Remote Units (DRUs) coupled to the plurality of DAUs and operable to transport signals between DRUs and DAUs and one or more Base Transceiver Stations (BTSs). The system further includes a traffic monitoring unit.

[0006] Numerous benefits are achieved by way of the present invention over conventional techniques. For example, embodiments of the present invention provide for traffic monitoring in a DAS network, improving network performance and user experience. These and other embodiments of the invention along with many of its advantages and features are described in more detail in conjunction with the text below and attached figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a block diagram according to one embodiment of the invention showing the basic structure and an example of the transport routing, traffic monitoring and network

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page322

optimization based on having a single 3 sector BTS with 3 DAUs and 7 DRUs daisy chained together for each cell.

[0008] FIG. 2 is a block diagram according to one embodiment of the invention showing the basic structure for a frequency reuse pattern of N=1 and an example of the transport routing, traffic monitoring and network optimization based on having a single 3 sector BTS with 3 DAUs and 7 DRUs daisy chained together for each cell.

[0009] FIG. 3 is a block diagram according to one embodiment of the invention showing the basic structure and an example of the transport routing, traffic monitoring and network optimization based on having multiple 3 sector BTSs with 3 DAUs and 7 DRUs daisy chained together for each cell. In this embodiment, multiple three sector base stations are connected to a daisy chained DAS network.

[0010] FIG. 4 is a block diagram of a Digital Access Unit (DAU), which contains Physical Nodes, a Local Router, and Port Traffic Monitoring capability according to an embodiment of the present invention.

[0011] FIG. 5 is a block diagram of a Digital Remote Unit (DRU), which contains Physical Nodes, a Remote Router, and Port Traffic Monitoring capability according to an embodiment of the present invention.

[0012] FIG. 6 depicts a typical topology where multiple Local Routers are interconnected with multiple Remote Routers along with Traffic monitoring and Network Optimization functionality according to an embodiment of the present invention.

[0013] FIG. 7 depicts a typical topology where multiple Local Routers are interconnected with multiple Remote Routers along with Traffic monitoring at each Picocell and Network Optimization functionality according to an embodiment of the present invention.

[0014] FIG. 8 depicts a typical topology where multiple Local Routers are interconnected with multiple Remote Routers along with Traffic monitoring at each Picocell and Network Optimization functionality according to an embodiment of the present invention.

[0015] FIG. 9 is a simplified flowchart illustrating a method of optimizing the DAS network according to an embodiment of the present invention.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page323

[0016] FIG. 10 is a simplified flowchart illustrating a method of calculating KPIs and QoS for a DAS network according to an embodiment of the present invention.

[0017] FIG. 11 is a simplified flowchart illustrating an optimization algorithm according to an embodiment of the present invention .

DETAILED DESCRIPTION OF THE INVENTION

[0018] To accommodate variations in wireless subscriber loading at wireless network antenna locations at various times of day and for different days of the week, there are several candidate conventional approaches.

[0019] One approach is to deploy many low-power high-capacity base stations throughout the facility. The quantity of base stations is determined based on the coverage of each base station and the total space to be covered. Each of these base stations is provisioned with enough radio resources, i.e., capacity and broadband data throughput to accommodate the maximum subscriber loading which occurs during the course of the workday and work week. Although this approach typically yields a high quality of service for wireless subscribers, the notable disadvantage of this approach is that many of the base stations' capacity is being wasted for a large part of the time. Since a typical indoor wireless network deployment involves capital and operational costs which are assessed on a per-subscriber basis for each base station, the typically high total life cycle cost for a given enterprise facility is far from optimal.

[0020] A second candidate approach involves deployment of a DAS along with a centralized group of base stations dedicated to the DAS. A conventional DAS deployment falls into one of two categories. The first type of DAS is "fixed", where the system configuration doesn't change based on time of day or other information about usage. The remote units associated with the DAS are set up during the design process so that a particular block of base station radio resources is thought to be enough to serve each small group of DAS remote units. A notable disadvantage of this approach is that most enterprises seem to undergo frequent re-arrangements and re-organizations of various staff groups within the enterprise. Therefore, it's highly likely that the initial DAS setup will need to be changed from time to time, requiring deployment of additional direct staff and contract resources with appropriate levels of expertise regarding wireless networks.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page324

[0021] The second type of DAS is equipped with a type of network switch which allows the location and quantity of DAS remote units associated with any particular centralized base station to be changed manually. Although this approach would appear to support dynamic DAS reconfiguration based on the needs of the enterprise or based on time of day, it frequently implies that additional staff resources would need to be assigned to provide real-time management of the network. Another issue is that it's not always correct or best to make the same DAS remote unit configuration changes back and forth on each day of the week at the same times of day. Frequently it is difficult or impractical for an enterprise IT manager to monitor the subscriber loading on each base station. And it is almost certain that the enterprise IT manager has no practical way to determine the loading at a given time of day for each DAS remote unit; they can only guess the percentage loading.

[0022] Another major limitation of conventional DAS deployments is related to their installation, commissioning and optimization process. Some challenging issues which must be overcome include selecting remote unit antenna locations to ensure proper coverage while minimizing downlink interference from outdoor macro cell sites, minimizing uplink interference to outdoor macro cell sites, and ensuring proper intra-system handovers while indoors and while moving from outdoors to indoors (and vice-versa). The process of performing such deployment optimization is frequently characterized as trial-and-error. Therefore, the results may not be consistent with a high quality of service.

[0023] Based on the conventional approaches described herein, it is apparent that a highly efficient, easily deployed and dynamically reconfigurable wireless network is not achievable with conventional systems and capabilities. Embodiments of the present invention substantially overcome the limitations of the conventional approach discussed above. The advanced system architecture provided by embodiments of the present invention provides a high degree of flexibility to manage, control, enhance and facilitate radio resource efficiency, usage and overall performance of the distributed wireless network. This advanced system architecture enables specialized applications and enhancements including, but not limited to, flexible simulcast, automatic traffic load-balancing, network and radio resource optimization, network calibration, autonomous/assisted commissioning, carrier pooling, automatic frequency selection, radio frequency carrier placement, traffic monitoring, and/or traffic tagging. Embodiments of the present invention can also serve multiple operators, multi-mode radios (modulation-independent)

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page325

and multiple frequency bands per operator to increase the efficiency and traffic capacity of the operators' wireless networks.

[0024] Accordingly, embodiments of this architecture provide a capability for Flexible Simulcast. With Flexible Simulcast, the amount of radio resources (such as RF carriers, LTE Resource Blocks, CDMA codes or TDMA time slots) assigned to a particular DRU or group of DRUs can be set via software control to meet desired capacity and throughput objectives or wireless subscriber needs. Applications of the present invention are suitable to be employed with distributed base stations, distributed antenna systems, distributed repeaters, mobile equipment and wireless terminals, portable wireless devices, and other wireless communication systems such as microwave and satellite communications.

[0025] According to an embodiment of the present invention, a traffic monitoring unit is provided as a component of one or more elements of the system, enabling measurement of the network traffic in the network. A network optimization goal and optimization algorithm is also provided so that based on traffic measurements, which is typically a function of the number of users on the system, performance of the network is optimized using the goal and associated algorithm.

[0026] As an example of traffic monitoring, the system could track the power of the down link or the power of the uplink. Another example, would include some signal processing, including examining certain control signals, for example, pilot signals sent by mobile devices. By locking onto these control signals, the traffic monitor can obtain information on the number of users using various components of the system.

[0027] A distributed antenna system (DAS) provides an efficient means of utilization of base station resources. The base station or base stations associated with a DAS can be located in a central location and/or facility commonly known as a base station hotel. The DAS network comprises one or more digital access units (DAUs) that function as the interface between the base stations and the digital remote units (DRUs). The DAUs can be collocated with the base stations. The DRUs can be daisy chained together and/or placed in a star configuration and provide coverage for a given geographical area. The DRUs are typically connected with the DAUs by employing a high-speed optical fiber link. This approach facilitates transport of the RF signals from the base stations to a remote location or area served by the DRUs. A typical base station comprises 3 independent radio resources, commonly known as sectors. These 3 sectors

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page326

are typically used to cover 3 separate geographical areas without creating co-channel interference between users in the 3 distinct sectors.

[0028] Traffic monitoring in a DAS network is provided by embodiments of the present invention, which has not been performed in conventional systems. As described herein, the traffic monitoring unit can be implemented as a stand-alone unit in conjunction with one or more system components, including DAUs, DRUs, a BTS, a BTS hotel, or the like.

[0029] Once traffic resources are aggregated into eNodeB hotels, the discrete resources of a single eNodeB are still allocated to a specific set of antennas associated with that eNodeB and providing coverage to a specific geographic area. The traffic resources are fixed, i.e., only the resources associated with a specific eNodeB can be allocated to the antennas associated with that eNodeB. However, because the eNodeBs are collocated in an eNodeB hotel, the system can use the aggregated traffic resources of the discrete eNodeBs as a single, pooled traffic resource that can be allocated according to various algorithms. Assumptions are typically predicated on worst-case traffic assets in all areas, network design is wasteful 99 percent of the time, inevitably resulting in over- or under-provisioning of fixed resources. Traffic resources either go unused (idle channels), or are under-provisioned and are insufficient to handle the offered traffic. Both circumstances give rise to the same outcome: lost revenue and lost opportunity. When a site's traffic resources are idle and unused, the traffic asset fails to provide an optimal return on investment. But a site that lacks sufficient capacity to support the offered traffic at any point during the day garners dropped calls, lost revenue opportunity, and dissatisfied customers. The traffic information derived from an extensive sensor network will be used to dynamically allocate the traffic resources to the required geographical areas only for the time period the service is needed. Once the service is supplied and the traffic sensor network determines that the traffic resources are no longer required, they are returned to the resource pool for reallocation. The entire network automatically reconfigures itself based on the perceived (sensed) need or in the event of disruption due to natural or manmade events. Geographic load balancing using DAS is recognized as a new approach for traffic load balancing which provides dynamic load redistribution in real time according to the current geographic traffic conditions. It can be used to improve the performance for any distributed systems containing non-uniformly distributed traffic, especially for resolving traffic hot spots.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page327

[0030] The network's performance (expressed by the number of KPIs (Key Performance Indicators) from different parts of the network) determines the QoS values. Different operators may have different defined business goals and different services of interest. Based on these considerations, efficient and cost effective network performance management varies from operator to operator. Therefore, QoS metrics could be defined and mapped to a set of KPIs.

[0031] An embodiment shown in FIG. 1 illustrates a basic DAS network architecture according to an embodiment of the present invention and provides an example of a data transport network, traffic monitoring and network optimization scenario between a 3 sector Base Station and multiple DRUs. In this embodiment, the DRUs are daisy chained together to achieve coverage in a specific geographical area. Each individual sector covers an independent geographical area, which is identified as a Cell. Although embodiments are discussed in terms of optimization of DAS networks, the term optimization is properly understood to include performance improvements in comparison to conventional systems, even if complete optimization is not achieved. Thus, optimization does not require the maximum values for traffic management metrics, but also includes distribution of traffic that improves system performance while remaining short of maximum performance.

[0032] FIG. 1 depicts a DAS system employing multiple Digital Remote Units (DRUs) and multiple Digital Access Units (DAUs). In accordance with the present invention, each DRU provides unique information associated with each DRU which uniquely identifies uplink data received by that particular Digital Remote Unit.

[0033] One feature of embodiments of the present invention is the ability to route Base Station radio resources among the DRUs or group(s) of DRUs. In order to route radio resources available from one or more Base Stations, it is desirable to configure the individual router tables of the DAUs and DRUs in the DAS network. This functionality is provided by embodiments of the present invention.

[0034] The DAUs are networked together to facilitate the routing of DRU signals among multiple DAUs. The DAUs support the transport of the RF downlink and RF uplink signals between the Base Station and the DRUs. This architecture enables the various Base Station signals to be transported to and from multiple DRUs. PEER ports are used for interconnecting DAUs and interconnecting DRUs.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page328

[0035] The DAUs have the capability to control the gain (in small increments over a wide range) of the downlink and uplink signals that are transported between the DAU and the base station (or base stations) connected to that DAU. This capability provides flexibility to simultaneously control the uplink and downlink connectivity of the path between a particular DRU (or a group of DRUs via the associated DAU or DAUs) and a particular base station sector.

[0036] Embodiments of the present invention use router tables to configure the networked DAUs. The local router tables establish the mapping of the inputs to the various outputs. Internal Merge blocks are utilized for the Downlink Tables when the inputs from an External Port and a PEER Port need to merge into the same data stream. Similarly, Merge blocks are used in the Uplink Tables when the inputs from the LAN Ports and PEER Ports need to merge into the same data stream.

[0037] The remote router tables establish the mapping of the inputs to the various outputs. Internal Merge blocks are utilized for the Downlink Tables when the inputs from a LAN Port and a PEER Port need to merge into the same data stream. Similarly, Merge blocks are used in the Uplink Tables when the inputs from the External Ports and PEER Ports need to merge into the same data stream.

[0038] As shown in FIG. 1, the individual base station sector's radio resources are transported to a daisy-chained network of DRUs. Each individual sector's radio resources provide coverage to an independent geographical area via the networked DRUs. FIG. 1 demonstrates how three cells, each cell comprising an independent network of 7 DRUs, provide coverage to a given geographical area. A server is utilized to control the switching function provided in the DAS network. Referring to FIG. 1 and by way of example, DAU 1 (102) receives downlink signals from BTS Sector 1 (101). DAU 1 translates the RF signals to optical signals and the optical fiber cable 103 transports the desired signals to DRU 2 (104). Optical cable 105 transports all the optical signals to DRU 3 (106). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 1 (107). DAU 1 (102) is networked with DAU 2 (108) to allow the downlink signals from Sector 2 (109) and Sector 3 (110) to be transported to all the DRUs in Cell 1. The system's switching and routing functions enable the selection of which sectors' signals are transmitted and received by each DRU.

[0039] An embodiment illustrating a Traffic monitoring unit (121) at the DAUs is included to track the traffic load at each DAU in the network. The traffic load associated with each DAU is

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page329

collected and stored in the Network Optimization Unit (120). The optimization unit (120) calculates the overall DAS network performance and determines the optimum reconfigured network to improve or maximize performance. Utilizing the traffic monitoring unit 121 in conjunction with the DAUs provides for optimization of the DAS network through a traffic monitoring unit external to the DAUs. Thus, embodiments of the present invention provide for traffic monitoring in a DAS network. Optimization of the DAS network can then be performed using information related to the traffic monitoring.

[0040] Referring to FIG. 1, the traffic monitor unit 121 can be a server determining the number of users on each DAU, with each DAU having multiple ports in some embodiments. Data from the traffic monitor unit 121 is then provided to the network optimization unit 120, which can be the same server including the traffic monitor unit or a different server. The network optimization unit 120 (which can be software running on a server) can model the rebalancing of the traffic load and, after determining that the performance will be acceptable, implements the load rebalancing by communicating with the DAUs and shifting traffic between sectors. Although the network optimization unit 120 is illustrated as coupled to the DAUs in FIG. 1, this is not required by embodiments of the present invention and the network optimization could be performed at one of the DRUs, with data regarding network optimization being transmitted back to the DAUs using, for example, using an Ethernet backhaul connecting the DRUs to the DAUs. Thus, the network optimization server could be located at one of the DRUs, controlling the entire network from that location. One of ordinary skill in the art would recognize many variations, modifications, and alternatives.

[0041] The network optimization unit can implement a network optimization goal, which may relate to the number of users per sector, for example, that each sector carry a percentage of traffic less than 50% of the total traffic, less than 40% of the total traffic, or less than 35% of the total traffic, that each sector have less than 50% of the users, less than 40% of the users, less than 35% of the users, or that each sector have 33% of the users, or the like. Thus, the optimization goals can include metrics of the system performance. Although the system may not reach the goals, progress toward the goals can be provided, improving the user experience.

[0042] FIG. 2 shows an embodiment illustrating how a single base station can be used to provide coverage for a larger geographical area when a frequency reuse pattern of N=1 is used.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page330

Referring to FIG. 2, cell 1 and cell 8 would share the radio resources of sector 1 of the base station. Similarly, cell 2 and cell 10 would share the radio resources of sector 2.

[0043] The DAUs control the routing of data between the base station and the DRUs. Each individual data packet is provided with a header that uniquely identifies which DRU it is associated with. The DAUs are interconnected to allow transport of data among multiple DAUs. This feature provides the unique flexibility in the DAS network to route signals between the sectors and the individual DRUs. A server is utilized to control the switching function provided in the DAS network. Referring to FIG. 2, and by way of example, DAU 1 (202) receives downlink signals from BTS 1 Sector 1 (201). DAU 1 translates the RF signals to optical signals and the optical fiber cable 203 transports the desired signals to DRU 2 (204). Optical cable 205 transports all the optical signals to DRU 3 (206). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 1 (207). DAU 1 (202) is networked with DAU 2 (208) to allow the downlink signals from Sector 2 and Sector 3 to be transported to all the DRUs in Cell 1. Optical fiber cable 209 transports the desired signals to DRU 23 (210). Optical cable 211 transports all the optical signals to DRU 24 (212). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 22 (213). An embodiment illustrating a Traffic monitoring unit (221) at the DAUs is included to track the traffic load at each DAU in the network. The traffic load associated with each DAU is collected and stored in the Network Optimization Unit (220). The optimization unit (220) calculates the overall DAS network performance and determines the optimum reconfigured network to maximize performance.

[0044] FIG. 3 shows an embodiment illustrating an application employing a base station hotel where N BTSs are interconnected to serve a given geographical area. The base stations may represent independent wireless network operators and/or multiple standards (WCDMA, LTE, etc.) or they may represent provision of additional RF carriers. The base station signals may be combined before they are connected to a DAU, as may be the case for a Neutral Host application. Referring to FIG. 3 and by way of example, DAU 1 (302) receives downlink signals from BTS Sector 1 (301). DAU 1 translates the RF signals to optical signals and the optical fiber cable 303 transports the desired signals to DRU 2 (304). Optical cable 305 transports all the optical signals to DRU 3 (306). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 1 (307). DAU 1 (302) is networked with DAU 2 (308) to allow the downlink signals from BTS 1 Sector 2 to be transported to all the DRUs in Cell 1. DAU 1

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page331

(302) receives downlink signals from BTS Sector N (309). DAU 1 translates the RF signals to optical signals and the optical fiber cable 303 transports the desired signals to DRU 2 (304). Optical cable 305 transports all the optical signals to DRU 3 (306). The other DRUs in the daisy chain are involved in passing the optical signals onward to DRU 1 (307). The additional base stations provide the capability to add capacity for Cell 1.

[0045] In order to efficiently utilize the limited base station resources, the network of DRUs should have the capability of re-directing their individual uplink and downlink signals to and from any of the BTS sectors. Because the DRUs data traffic has unique streams, the DAU Router has the mechanism to route the signal to different sectors. An embodiment illustrating a Traffic monitoring unit (321) at the DAUs is included to track the traffic load at each DAU in the network. The traffic load associated with each DAU is collected and stored in the Network Optimization Unit (320). The optimization unit (320) calculates the overall DAS network performance and determines the optimum reconfigured network to maximize performance.

[0046] FIG. 4 shows the two primary elements in a DAU, the Physical Nodes (400) and the Local Router (401). The Physical Nodes translate the RF signals to baseband for the Downlink and from baseband to RF for the Uplink. The Local Router directs the traffic between the various LAN Ports, PEER Ports and the External Ports. The physical nodes connect to the BTS at radio frequencies (RF). The physical nodes can be used for different operators, different frequency bands, different channels, or the like. The physical nodes can combine the downlink and uplink signals via a duplexer or they can keep them separate, as would be the case for a simplex configuration. In one embodiment, Traffic monitoring (416) capability is provided in each DAU for determining the traffic load at each of the DAU ports. In this embodiment, the traffic monitoring function is performed in each DAU in comparison with other implementations in which the traffic monitoring is performed externally.

[0047] FIG. 4 shows an embodiment whereby the physical nodes have separate outputs for the uplinks (405) and separate inputs for the downlink paths (404). The physical node translates the signals from RF to baseband for the downlink path and from baseband to RF for the uplink path. The physical nodes are connected to a Local Router via external ports (409,410)). The router directs the uplink data stream from the LAN and PEER ports to the selected External U ports. Similarly, the router directs the downlink data stream from the External D ports to the selected LAN and PEER ports.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page332

[0048] In one embodiment, the LAN and PEER ports are connected via an optical fiber to a network of DAUs and DRUs. The network connection can also use copper interconnections such as CAT 5 or 6 cabling, or other suitable interconnection equipment. The DAU is also connected to the internet network using IP (406). An Ethernet connection (408) is also used to communicate between the Host Unit and the DAU. The DRU can also connect directly to the Remote Operational Control center (407) via the Ethernet port.

[0049] FIG. 5 shows the two primary elements in a DRU, the Physical Nodes (501) and the Remote Router (500). The DRU includes both a Remote Router and Physical Nodes. The Remote Router directs the traffic between the LAN ports, External Ports and PEER Ports. The physical nodes connect to the BTS at radio frequencies (RF). The physical nodes can be used for different operators, different frequency bands, different channels, etc. FIG. 5 shows an embodiment whereby the physical nodes have separate inputs for the uplinks (504) and separate outputs for the downlink paths (503). The physical node translates the signals from RF to baseband for the uplink path and from baseband to RF for the downlink path. The physical nodes are connected to a Remote Router via external ports (506,507). The router directs the downlink data stream from the LAN and PEER ports to the selected External D ports. Similarly, the router directs the uplink data stream from the External U ports to the selected LAN and PEER ports. The DRU also contains a Ethernet Switch (505) so that a remote computer or wireless access points can connect to the internet.

[0050] In one embodiment, the traffic monitoring (516) capability is provided in each DRU for determining the traffic load at each of the DRU ports. In this embodiment, the traffic monitoring function is performed in each DRU in comparison with other implementations in which the traffic monitoring is performed externally.

[0051] As shown in FIG. 6, the base station hotel (610) is comprised of multiple Picocells. The Picocells are typically wireless operator dependent and frequency band dependent. Picocells that operate in the same frequency band are combined at RF and input to the respective DAUs. The DAU radio resources from the combined Picocells are transported to a daisy-chained network of DRUs. Each individual DAUs radio resources provide coverage to an independent geographical area via the networked DRUs. FIG. 6 demonstrates how multiple DAUs, each cell comprising an independent network of 7 DRUs, provide coverage to a given geographical area.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page333

In one embodiment, the traffic monitoring functionality is located in an external Traffic Monitoring Unit (621), which is connected to the network of DAUs.

[0052] As shown in FIG. 7, the base station hotel (710) is comprised of multiple Picocells. The Picocells are typically wireless operator dependent and frequency band dependent. Picocells that operate in the same frequency band are combined at RF and input to the respective DAUs. The DAU radio resources from the combined Picocells are transported to a daisy-chained network of DRUs. Each individual DAUs radio resources provide coverage to an independent geographical area via the networked DRUs. FIG. 7 demonstrates how multiple DAUs, each cell comprising an independent network of 7 DRUs, provide coverage to a given geographical area. In one embodiment, the traffic monitoring functionality is located in an external Traffic Monitoring Unit (721), which is connected to the Picocells. The BTS Hotel 710 includes a plurality of Picocells that are coupled to traffic monitoring unit 720. The traffic information flows from the Picocells to the traffic monitoring unit, which uses this traffic information to optimize the DAS network. The traffic monitoring unit 820 works in conjunction with network optimization unit 721, which can include traffic management algorithms used to distribute traffic efficiently throughout the DAS network.

[0053] FIG. 8 shows an embodiment of a base station hotel (810), which is comprised of multiple picocells that are interconnected to a network of DAUs via a digital interface (830).

[0054] FIG. 9 illustrates one embodiment of the DAS network optimization flow diagram. The Key Performance Indicators (KPIs) of the network traffic are collected at the various network nodes (910). KPI may comprise information such as: number of blocked calls, number of active calls, average power of uplink channels, average power of downlink channels, traffic on each sector, failed calls, number of satisfied users, number of unsatisfied users, number of users operating through a given DRU, and the like.

[0055] The DAS network performance is then analyzed in the context of the available DAS network radio resources (912). An optimization algorithm is applied to the existing DAS network with the objective to determine the optimum routing of network traffic (914). Once an optimum DAS network has been determined then an estimate of the reconfigured DAS network performance is determined (916). The reconfigured DAS network is evaluated prior to an implementation to insure that the performance will be acceptable. If the reconfigured DAS network has been determined to be acceptable then the reconfigured DAS network is

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page334

implemented (918) and the entire process is repeated. In an embodiment, the load on the sectors prior to reconfiguration and after the proposed reconfiguration can be compared to determine if the shifting of the DRUs to the other sectors improves the system performance.

[0056] Thus, using the KPIs of the network traffic, the DAS network can be modified to improve system performance. As an example, if a particular DRU has a higher load than other adjacent DRUs, traffic can be routed to the adjacent DRUs in order to reduce the load on the particular DRU. Additional description related to load balancing is provided in U.S. Patent Application No. 61/600,530, filed on February 17, 2012, entitled "Evolutionary Algorithms for Geographic Load Balancing Using a Distributed Antenna System," the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

[0057] As an example of optimizing network performance, a base station typically has three sectors. The DRU can be allocated to different sectors in order to improve performance by shifting traffic from a first sector (e.g., a high traffic sector) to a second sector (e.g., a low traffic sector) by shifting a DRU allocated to the first sector to the second sector. Although some embodiments of the present invention will not optimize performance of the system, the system performance can be improved using the techniques described herein, for example, by measuring the traffic load on the DRUs, performing load balancing of the traffic on the DRUs, to reduce the load on a first DRU characterized by a first traffic load by shifting the load to a second DRU characterized by a second traffic load less than the first traffic load. In the optimization process, system performance can be measured against a predetermined threshold, with the optimization process terminating once the predetermined threshold has been reached. One of ordinary skill in the art would recognize many variations, modifications, and alternatives.

[0058] As another example, power settings for the DRUs can be modified to improve system performance as discussed in additional detail in U.S. Patent Application No. 61/669,572, filed on July 9, 2012 and entitled, "A Self-Optimizing Distributed Antenna System Using Soft Frequency Reuse," the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

[0059] FIG. 10 illustrates one embodiment of the DAS network calculation of the KPIs and QoS. The important parameters for determining the DAS network QoS include the number of users allocated to a given DRU, the spatial distance between the various DRUs, as well as identifying which DRUs are assigned to which BTS sector.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page335

[0060] FIG. 11 illustrates one embodiment of the flow chart for the optimization algorithm. In this embodiment an Estimation Distribution Algorithm (EDA) is used. Various DRU allocation scenarios are investigated to determine the optimum DRU scenario that achieves the highest QoS. In an embodiment, the initial population is generated (1110). The traffic information (KPIs) is analyzed and traffic performance (QoS) for all sectorization is analyzed (1112). A sort procedure is performed (1114) and a determination is made if the convergence criterion are satisfied (1116). If so, the process is terminated. If not, then the generation counter is updated (1118), a sort operation is performed (1120), the parameter Γ is computed (1122) and a new population is generated (1124). Then the method proceeds to the traffic information and performance analysis (1112).

[0061] Network Optimization

[0062] The network's performance (expressed by the number of KPIs from different parts of the network) determines the QoS values. Different operators may have different defined business goals and different services of interest. Based on these considerations, efficient and cost effective network performance management varies from operator to operator. Therefore, QoS metrics could be defined and mapped to a set of KPIs. When a set of KPIs is used, then the mapping needs to be represented by a weighted normalized function.

[0063] In this section we formulate the sectorization problem with mixed integer programming to balance traffic among sectors and to minimize handoffs with connected and compact sectors. Given the sectorization of DRUs at time period *t*, our problem is to obtain new sectorization at time period *t+1* that adaptively balances the change in traffic demands.

[0064] In order to formulate the problem, we consider a service coverage area with N DRUs. Each DRU is assumed to have traffic demand T_i $i = 1,\ldots,N$. Note that, UE$_A$ belongs to DRU_B if the received uplink power from UE$_A$ at DRU_B is greater than the other $DRUs$. Let p_{ij} be the transition probability of mobiles from DRU_i to DRU_j . Then, the handoff calls from DRU_i to DRU_j become $h_{ij} = p_{ij}T_i$. The distance between DRU_i and DRU_j is inversely proportional to p_{ij} . Assume that an eNodeB hotel has M VBSs. Let SOS_m and SOD_k be the set of sectors in VBS_m and the set of DRUs allocated to $Sector_k$, respectively, such that $|SOS_m| = 3$ (if each eNodeB/VBS has three sectors), $m=1,\ldots, M$ and $k=1,\ldots, K$. We consider the following three cost factors (KPIs) in the sectorization problem:

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page336

[0065] *KPI_{BC} (Inverse of the number of Blocked Calls) :* The penalty of the blocked calls caused by hard capacity and soft capacity. Let HC_m and SC_k be the hard capacity of VBS_m and soft capacity of $Sector_k$ respectively such that $HC_m = \sum_{k \in SOS_m} SC_k$. The binary variable $x_{ik} = 1$, when DRU_i belongs to $Sector_k$. $y_{im} = \sum_{k \in SOS_m} x_{ik}$, then $y_{im} = 1$ when DRU_i belongs to VBS_m.

$$
\begin{aligned}
sc_k &= \begin{cases} 0 & if \quad \sum_i T_i x_{ik} < SC_k \\ \sum_i T_i x_{ik} - SC_k & otherwise \end{cases} \\
hc_m &= \sum_i T_i y_{im} - HC_m = \sum_i T_i \sum_{k \in SOS_m} x_{ik} - \sum_{k \in SOS_m} SC_k \\
&= \sum_{k \in SOS_m} \sum_i T_i x_{ik} - SC_k \\
&= \sum_{k \in SOS_m} sc_k
\end{aligned} \tag{1}
$$

Since a penalty occurs only when the calls are blocked, we apply just sc_k to the objective function, because the hc_m is a function of sc_k and there is no need to add it as another term to the objective function. sc_k is a nonnegative real variable. So,

$$
KPI_{BC} = \left[\sum_{k \in SOS_m} sc_k \right]^{-1} \tag{2}
$$

[0066] KPI_{HO} (Inverse of the number of Handoffs): we consider three different types of Handoffs :

[0067] **A. *Inter-eNodeB Handoff:*** When user equipment (UE) with an ongoing call moves from one VBS to another VBS, then the UE needs an inter-eNodeB handoff. Inter-eNodeB handoff is executed using the X2 interface (as long as the UE does not leave the LTE coverage area) or S1 interface (when the UE leaves the serving cell). The X2 handoff includes establishing a signaling connection using the X2 Application Part (X2AP) from the source to the target eNodeB. The target eNodeB updates the MME (Mobility Management Entity) with the new geographic position of the UE. To enable this procedure, the MME needs to communicate with S-GW (Serving Gateway) to negotiate the new endpoint. During the S1 handoff, the MME receives the relocation preparation request of the source eNodeB, it starts the handoff resource allocation procedure to request the necessary radio resource from the target eNodeB. After the

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page337

target eNodeB sends the required radio interface parameters embedded in a handoff command message; the MME forwards this handoff command message transparently to the UE, which executes the handoff. The main procedure is triggered by the MME and executed by S-GW.

[0068] Let the binary variable $z_{ijm} = 1$, when DRU_i and DRU_j belong to VBS_m. Then the inter-eNodeB handoff cost is computed by using the variable $z_{ij} = 1 - \sum_m z_{ijm}$, the cost becomes $\sum_i \sum_j h_{ij} z_{ij}$.

[0069] Note that inter-eNodeB handoff occurs when DRU_i and DRU_j belong to different VBS, i.e., $z_{ijm} = 0$.

[0070] *B. **Intra-eNodeB Handoff:*** When a UE with an ongoing call moves from one sector to another in a VBS, then the mobile needs an intra-eNodeB handoff. This procedure doesn't need to involve MME or S-GW because it can be handled entirely within that VBS. Now by letting the binary variable $w_{ijk} = 1$ when DRU_i and DRU_j belong to sector k, the intra-eNodeB handoff cost is computed by using two variables $w_{ij} - z_{ij}$ where $w_{ij} = 1 - \sum_k w_{ijk}$, the cost becomes $\sum_i \sum_j h_{ij}(w_{ij} - z_{ij})$.

[0071] An intra-eNodeB handoff occurs when DRU_i and DRU_j belong to different sectors of the same VBS.

[0072] *C. **Forced Handoff:*** When a DRU changes its sector, all ongoing calls in the cell have to change their pilot PN offsets for WCDMA. The cost of forced handoff is computed by employing the current sectorization a_{ik}, which is equal to zero when DRU_i is in $Sector_k$. Since the cost occurs when DRU_i currently in another sector moves into $Sector_k$, the cost becomes $\sum_i \sum_k a_{ik} T_i x_{ik}$.

[0073] The weighted combination of these three handoff cost would be:

$$KPI_{HO} = \left[c_1 \sum_i \sum_j h_{ij} z_{ij} + c_2 \sum_i \sum_j h_{ij}(w_{ij} - z_{ij}) + c_3 \sum_i \sum_k a_{ik} T_i x_{ik} \right]^{-1} \quad (3)$$

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page338

[0074] ***KPI_{CI} (Inverse of the Compactness Index):*** we will try to minimize the length of handoff border with the compactness index CI which is introduced in Section II.B . In Equation (4) the numerator term represents the number of handoff DRU sides between two different sectors.

$$KPI_{CI} = \left[CI\right]^{-1} = \left[\frac{\sum_{i}\sum_{i<j} w_{ij}B_{ij}}{\sum_{i}\sum_{i<j} B_{ij}}\right]^{-1} \tag{4}$$

Where $B_{ij} = 1$, if DRU_i and DRU_j are adjacent.

Now we consider the following constraints required in the formulation:

1. each DRU has to belong to a sector, that is,

$$\sum_{k} x_{ik} = 1 \qquad \text{for all } i \tag{5}$$

2. The relationship between any two DRUs in a $Sector_k$ has to satisfy $w_{ijk} = 1$ if and only if $x_{ik} = x_{jk} = 1$. Thus we have:

$$w_{ijk} \le x_{ik}, w_{ijk} \le x_{jk} \text{ and } w_{ijk} \ge x_{ik} + x_{jk} - 1 \qquad \text{for all } i,j \text{ and } k \tag{6}$$

[0075] The relationship between two DRUs in a VBS_m. $z_{ijm} = 1$ if and only if $y_{im} = y_{jm} = 1$ which leads to:

$$z_{ijm} \le y_{im}, z_{ijm} \le y_{jm} \text{ and } z_{ijm} \ge y_{im} + y_{jm} - 1 \qquad \text{for all } i,j \text{ and } k \tag{7}$$

3. Connected sectorization, if a sector has more than one DRU, then the DRUs of the sector have to be connected. For the formulation of connected sectors we employ the cut theorem [26] on SOD_k. If $Sector_k$ is connected, then any cut that separates cells in SOD_k has at least one common side of the hexagonal cells. Let $S1_k$ be a proper subset of SOD_k, that is, $S1_k \subset SOD_k, S1_k \neq \phi$, and $S1_k \neq SOD_k$. Also let $S2_k$ be the opposite set of $S1_k$, that is, $S2_k = SOD_k - S1_k$. Because two subsets are connected, there exists at least one common side of the DRUs separated by the subsets. Thus we have

$$\sum_{i \in S1_k}\sum_{j \in S2_k} B_{ij} \ge 1 \tag{8}$$

[0076] Now, our QoS function is the weighted combination of three KPIs (cost factors) which we have already introduced. Obviously our objective function is to maximize the QoS function. They are penalties of blocked calls by hard and soft capacities and handoff calls. The DRU sectorization can be formulated as the following mixed integer linear programming.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page339

Minimize

$$QoS^{-1} = w_1.KPI_{BC}^{-1} + w_2.KPI_{HO}^{-1} + w_3.KPI_{CI}^{-1} \quad (9)$$

Subject to:

$$\sum_k x_{ik} = 1 \qquad for\ all\ \ i$$

$$w_{ijk} \le x_{ik}, w_{ijk} \le x_{jk}\ and\ w_{ijk} \ge x_{ik} + x_{jk} - 1 \qquad for\ all\ i, j\ and\ k$$

$$w_{ij} = 1 - \sum_k w_{ijk} \qquad for\ all\ i, j$$

$$y_{im} = \sum_{k \in SOS_m} x_{ik} \qquad for\ all\ \ m$$

$$z_{ijm} \le y_{im}, z_{ijm} \le y_{jm}\ and\ z_{ijm} \ge y_{im} + y_{jm} - 1 \qquad for\ all\ i, j\ and\ m$$

$$z_{ij} = 1 - \sum_k z_{ijk} \qquad for\ all\ i, j$$

$$\sum_{i \in S1_k} \sum_{j \in S2_k} B_{ij} \ge 1$$

$$for\ all\ S1_k \subset SOD_k\ \ where\ \ S1_k \ne \phi\ \ \ and\ \ \ S1_k \ne SOD_k\ \ \ and\ \ \ S2_k = SOD_k - S1_k$$

$$h_{ij} = p_{ij}T_i \qquad for\ all\ \ i\ and\ \ j$$

$$hc_m = \sum_i T_i y_{im} - HC_m \qquad for\ all\ \ m$$

$$sc_k = \begin{cases} 0 & if \quad \sum_i T_i x_{ik} < SC_k \\ \sum_i T_i x_{ik} - SC_k & otherwise \end{cases} \qquad for\ all\ \ k$$

$$x_{ik}, w_{ijk}, z_{ijm}, P_k \in \{0,1\} \qquad for\ all\ i, j, k\ and\ \ m$$

[0077] Note that many grouping problems which are special cases of the sectorization problem are well-known NP-hard problems. Since our problem is NP hard, the time it takes to execute the algorithm is exponentially increasing with the size of the problem. Such an algorithm is thus in most cases unusable for real-world size problem. As an encouraging result on NP-hard problems, we investigate evolutionary algorithms to solve the sectorization problem and compare the performance with the solutions obtained by the mixed integer programming.

[0078] Estimation distribution algorithm (EDA)

[0079] Unlike other evolutionary algorithms, in EDA a new population of individuals in each generation is generated without crossover and mutation operators. Instead, in EDA a new population is generated based on a probability distribution, which is estimated from the best selected individuals of previous generation. We introduce each main-vector as an individual for our EDA approach, and also our fitness function is objective function that we mentioned it in section III. In general, conventional EDAs can be characterized by parameters and notations:

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page340

$$(I_s, F, \Delta_l, \eta_l, \beta_l, p_s, \Gamma, I_{Ter}) \tag{11}$$

where

1) I_s is the space of all potential solutions (entire search space of individuals).

2) F denotes a fitness function.

3) Δ_l is the set of individuals (population) at the l_{th} generation.

4) η_l is the set of best candidate solutions selected from set Δ_l at the l_{th} generation.

5) We denote $\beta_l \equiv \Delta_l - \eta_l \equiv \Delta_l \cap \eta_l^C$ .where η_l^C is the complement of η_l.

6) p_s is the selection probability. The EDA algorithm selects $p_s|\Delta_l|$ individuals from set Δ_l to make up set η_l.

7) We denote by Γ the distribution estimated from η_l (the set of selected candidate solutions) at each generation.

8) I_{Ter} are the maximum number of generation

In conventional EDAs, each individual is designated by a string. A typical EDA is described in the following steps:

Step 0: Generate initial population Δ_0. The initial population ($|\Delta_0|$ individuals) is typically obtained by sampling according the uniform (equally likely) distribution:

$$(\theta_1, \theta_2, \mathrm{L}\ , \theta_n) = \prod_{i=1}^{n} p_i(\theta_i),$$

$$i = 1, 2, \ldots, n, \text{ and } p_i(\theta_i = S_{11}) = p_i(\theta_i = S_{21}) = \ldots = p_i(\theta_i = S_{|SOS_M|M}) = \frac{1}{\sum_{n=1}^{M} |SOS_n|} \tag{12}$$

For generation l = 1,2, ..., follow steps 1 through 6

***Step 1*:** Evaluate the individuals in the current population Δ_{l-1} according to the fitness function F. Sort the candidate solutions (individuals in the current population) according to their fitness orders.

***Step 2*:** If the best candidate solution satisfies the convergence criterion or the number of generation exceeds its limit I_{Ter} , then terminate; else go to step 3.

Step 3: Select the best $p_s \Delta_{l-1}$ candidate solutions (individuals) from current population Δ_{l-1}. This selection is accomplished according to the sorted candidate solutions.

Step 4: Estimate the probability distribution $p(\theta_1, \theta_2, \mathrm{L}\ , \theta_n)$ on the basis of $|\eta_{l-1}|$ best candidate solutions. We denote this estimation by

$$= P(\theta_1, \theta_2, \mathrm{L}\ , \theta_n | \eta_{l-1}) \tag{13}$$

Step 5: Generate new $|\Delta_{l-1}| - |\eta_{l-1}|$ individuals on the basis of this new estimated probability distribution Γ . Replace the bad $|\beta_{l-1}|$ individuals with newly generated $|\Delta_{l-1}| - |\eta_{l-1}|$ individuals.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page341

Step 6: Go to step 1 and repeat the steps

We followed the steps of the above pseudo code for our EDA implementation. In our experimentation, for estimation (13), we used a simple scheme of estimating the marginal distributions separately and using product form

$$= p(\theta_1, \theta_2, \mathrm{L}\ , \theta_n \mid \eta_{l-1}) = \prod_{i=1}^{n} p_i(\theta_i \mid \eta_{l-1}) = \prod_{i=1}^{n} \left(\frac{\sum_{j=1}^{|\eta_{l-1}|} \delta\left(x_i^j = \theta_i \mid \eta_{l-1}\right)}{|\eta_{l-1}|} \right) \tag{14}$$

Where δ is an indicator function and it can be expressed as

$$\delta\left(x_i^j = \theta \mid \eta_{l-1}\right) = \begin{cases} 1 & \text{if } x_i^j = \theta \\ 0 & \text{otherwise} \end{cases} \tag{15}$$

[0080] It is also understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and scope of the appended claims.

[0081] Appendix I is a glossary of terms used herein, including acronyms.

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page342

APPENDIX I

Glossary of Terms

ACLR	Adjacent Channel Leakage Ratio
ACPR	Adjacent Channel Power Ratio
ADC	Analog to Digital Converter
AQDM	Analog Quadrature Demodulator
AQM	Analog Quadrature Modulator
AQDMC	Analog Quadrature Demodulator Corrector
AQMC	Analog Quadrature Modulator Corrector
BPF	Bandpass Filter
CDMA	Code Division Multiple Access
CFR	Crest Factor Reduction
DAC	Digital to Analog Converter
DET	Detector
DHMPA	Digital Hybrid Mode Power Amplifier
DDC	Digital Down Converter
DNC	Down Converter
DPA	Doherty Power Amplifier
DQDM	Digital Quadrature Demodulator
DQM	Digital Quadrature Modulator
DSP	Digital Signal Processing
DUC	Digital Up Converter
EER	Envelope Elimination and Restoration
EF	Envelope Following
ET	Envelope Tracking
EVM	Error Vector Magnitude
FFLPA	Feedforward Linear Power Amplifier
FIR	Finite Impulse Response
FPGA	Field-Programmable Gate Array
GSM	Global System for Mobile communications
I-Q	In-phase / Quadrature
IF	Intermediate Frequency
LINC	Linear Amplification using Nonlinear Components
LO	Local Oscillator
LPF	Low Pass Filter
MCPA	Multi-Carrier Power Amplifier
MDS	Multi-Directional Search
OFDM	Orthogonal Frequency Division Multiplexing
PA	Power Amplifier
PAPR	Peak-to-Average Power Ratio
PD	Digital Baseband Predistortion
PLL	Phase Locked Loop
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RRH	Remote Radio Head

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page343

RRU	Remote Radio Head Unit
SAW	Surface Acoustic Wave Filter
UMTS	Universal Mobile Telecommunications System
UPC	Up Converter
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network

Ericsson Inc. v. Dali Wireless, Inc.
EX-1002 2of2 Page344