



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

Response to Rule 312 Communication	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 -- 1. ☒ The amendment filed on <u>07 July 2020</u> 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. <u>Applicant amended the specification to change an application number to a patent number.</u>			
/Matthew C Sams/ Primary Examiner, Art Unit 2646			

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.



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 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

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 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 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.

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

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.

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.

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



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.

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. _____



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	04/09/2020	EXAMINER	
SHERIDAN ROSS PC			SAMS, MATTHEW C	
1560 Broadway			ART UNIT	
Suite 1200			PAPER NUMBER	
Denver, CO 80202			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.

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)	5. ☐ Examiner's Amendment/Comment
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.	6. ☒ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. ☐ Other _____.
4. ☒ Interview Summary (PTO-413), Paper No./Mail Date. _____.	

/Matthew C Sams/ Primary Examiner, Art Unit 2646	
---	--

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

<i>Examiner-Initiated Interview Summary</i>	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); 2. Jason H. Vick (Attorney); Telephonic Telephonic Date of Interview: <u>02 April 2020</u> 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.

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.

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~~

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.

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 BTSSs.

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.

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.

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



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	EXAMINER	
SHERIDAN ROSS PC			SAMS, MATTHEW C	
1560 Broadway			ART UNIT	PAPER NUMBER
Suite 1200			2646	
Denver, CO 80202			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

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(I)(1) - 706.02(I)(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

Application/Control Number: 16/661,368
Art Unit: 2646

Page 6

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

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.

65575458V.1

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.

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.

[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

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.

[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.

[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)

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

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.

[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.

[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

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.

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

(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.

[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.

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

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.

[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 $i=1, \dots, N$. Note that, UEA belongs to DRU_B if the received uplink power from UEA 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), $m=1, \dots, M$ and $k=1, \dots, K$. 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 .

$$\begin{aligned}
 sc_k &= \begin{cases} 0 & \text{if } \sum_i T_i x_{ik} < SC_k \\ \sum_i T_i x_{ik} - SC_k & \text{otherwise} \end{cases} \\
 hc_m &= \sum_i T_i y_{im} - HC_m = \sum_i T_i \sum_{k \in SOS_m} x_{ik} - \sum_{k \in SOS_m} SC_k \\
 &= \sum_{k \in SOS_m} \sum_i T_i x_{ik} - SC_k \\
 &= \sum_{k \in SOS_m} sc_k
 \end{aligned} \tag{1}$$

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

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:

$$KPI_{HO} = \left[c_1 \sum_i \sum_j h_{ij} z_{ij} + c_2 \sum_i \sum_j h_{ij} (w_{ij} - z_{ij}) + c_3 \sum_i \sum_k a_{ik} T_i x_{ik} \right]^{-1} \quad (3)$$

[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.

$$KPI_{CI} = [CI]^{-1} = \left[\frac{\sum_i \sum_{i < j} w_{ij} B_{ij}}{\sum_i \sum_{i < j} B_{ij}} \right]^{-1} \quad (4)$$

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,

$$\sum_k x_{ik} = 1 \quad \text{for all } i \quad (5)$$

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:

$$w_{ijk} \leq x_{ik}, w_{ijk} \leq x_{jk} \text{ and } w_{ijk} \geq x_{ik} + x_{jk} - 1 \quad \text{for all } i, j \text{ and } k \quad (6)$$

- [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:

$$z_{ijm} \leq y_{im}, z_{ijm} \leq y_{jm} \text{ and } z_{ijm} \geq y_{im} + y_{jm} - 1 \quad \text{for all } i, j \text{ and } k \quad (7)$$

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, $S1_k \subset SOD_k$, $S1_k \neq \emptyset$, 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 :

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

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

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

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

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

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

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

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

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

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

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

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

[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:

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

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:

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

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

For generation $l = 1, 2, \dots$, 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 $p(\theta_1, \theta_2, L, \theta_n)$ on the basis of $|\eta_{l-1}|$ best candidate solutions.

We denote this estimation by

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

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

$$\begin{aligned}
 p(\theta_1, \theta_2, \dots, \theta_n | \eta_{l-1}) &= \prod_{i=1}^n p_i(\theta_i | \eta_{l-1}) \\
 &= \prod_{i=1}^n \left(\frac{\sum_{j=1}^{|\eta_{l-1}|} \delta(x_i^j = \theta_i | \eta_{l-1})}{|\eta_{l-1}|} \right)
 \end{aligned} \tag{14}$$

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

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

[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.

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
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network