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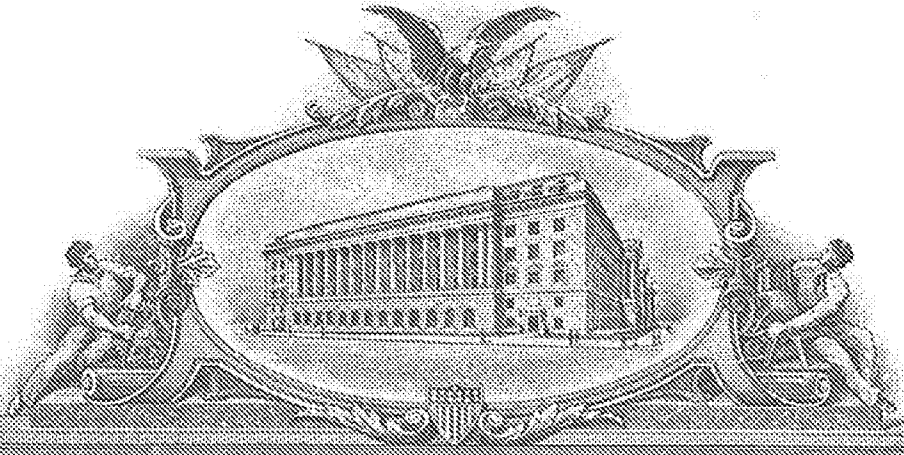
Application number: 62696688

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THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

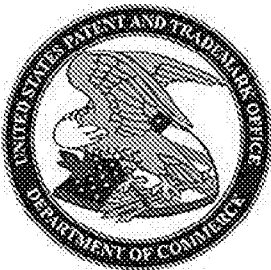
July 26, 2019

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 62/696,688

FILING DATE: *July 11, 2018*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US62/696,688*



Certified by

Anders Iversen

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA/82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	
Filing Date	July 11, 2018
First Named Inventor	Kevin Ross
Title	METHODS FOR BUILDING WIRELESS MESH NETWORK
Art Unit	
Examiner Name	
Attorney Docket Number	Naim-00007

SIGNATURE of Applicant or Patent Practitioner

Signature	/Rory P. Shea/	Date (Optional)	July 11, 2018
Name	Rory P. Shea	Registration Number	60529
Title (if Applicant is a juristic entity)	Attorney of Record		
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ *Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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

POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☒ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above:

130085

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☒ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name

Address

City

State

Zip

Country

Telephone

Email

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

- ☒ Inventor or Joint Inventor (title not required below)
- ☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)
- ☐ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)
- ☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature

Date (Optional)

Name

Kevin Ross

Title

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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

POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☒ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above:

130085

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☒ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

--

- ☒ Inventor or Joint Inventor (title not required below)
- ☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)
- ☐ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)
- ☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	Ahsan Naim	Date (Optional)	12/05/2016
Name	Muhammad Ahsan Naim		
Title			

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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

Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

Inventor(s)

Inventor 1

Remove

Given Name	Middle Name	Family Name	City	State	Country i
Kevin		Ross	Lehi	UT	US

Inventor 2

Remove

Given Name	Middle Name	Family Name	City	State	Country i
Muhammad	Ahsan	Naim	South Jordan	UT	US

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

Add

Title of Invention

METHODS FOR BUILDING WIRELESS MESH NETWORK

Attorney Docket Number (if applicable)

Naim-00007

Correspondence Address

Direct all correspondence to (select one):

☒ The address corresponding to Customer Number

☐ Firm or Individual Name

Customer Number

130085

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

Yes, the invention was made by an agency of the United States Government. The U.S. Government agency name is:

Yes, the invention was under a contract with an agency of the United States Government. The name of the U.S. Government agency and Government contract number are:

Entity Status**Applicant asserts small entity status under 37 CFR 1.27 or applicant certifies micro entity status under 37 CFR 1.29**

- ☒ Applicant asserts small entity status under 37 CFR 1.27
- ☐ Applicant certifies micro entity status under 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
- ☐ No

Warning

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

Signature

Please see 37 CFR 1.4(d) for the form of the signature.

Signature	Rory P. Shea/		Date (YYYY-MM-DD)	2018-07-11
First Name	Rory P.	Last Name	Shea	Registration Number (If appropriate)
				60529

This collection of information is required by 37 CFR 1.51. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **This form can only be used when in conjunction with EFS-Web. If this form is mailed to the USPTO, it may cause delays in handling the provisional application.**

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.

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Naim-00007
		Application Number	
Title of Invention	METHODS FOR BUILDING WIRELESS MESH NETWORK		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

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

Inventor Information:

Inventor	1				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Kevin		Ross			
Residence Information (Select One) • US Residency Non US Residency Active US Military Service						
City	Lehi	State/Province	UT	Country of Residence	US	
Mailing Address of Inventor:						
Address 1	4186 N Red Maple Ct					
Address 2						
City	Lehi	State/Province	UT			
Postal Code	84043	Country i	US			
Inventor	2				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Muhammad	Ahsan	Naim			
Residence Information (Select One) • US Residency Non US Residency Active US Military Service						
City	South Jordan	State/Province	UT	Country of Residence	US	
Mailing Address of Inventor:						
Address 1	2676 West Constance Way					
Address 2						
City	South Jordan	State/Province	UT			
Postal Code	84095	Country i	US			
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.						

Correspondence Information:

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

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Naim-00007
		Application Number	
Title of Invention	METHODS FOR BUILDING WIRELESS MESH NETWORK		

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

Customer Number	130085		
Email Address	ls3_docketing@cardinal-ip.com	Add Email	Remove Email

Application Information:

Title of the Invention	METHODS FOR BUILDING WIRELESS MESH NETWORK		
Attorney Docket Number	Naim-00007	Small Entity Status Claimed ☒	
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	18	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:
☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

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

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.			
Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	130085		

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Naim-00007
		Application Number	
Title of Invention	METHODS FOR BUILDING WIRELESS MESH NETWORK		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status		Remove
Application Number	Continuity Type	Prior Application Number
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.		Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Remove
			Access Code ⁱ (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. ☐ NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.
--

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Naim-00007
		Application Number	
Title of Invention	METHODS FOR BUILDING WIRELESS MESH NETWORK		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	Naim-00007
		Application Number	
Title of Invention	METHODS FOR BUILDING WIRELESS MESH NETWORK		

Applicant Information:

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

Applicant	1 Remove			
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section. Clear				
Assignee	Legal Representative under 35 U.S.C. 117		Joint Inventor	
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest		
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:				
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	Naim-00007
	Application Number	
Title of Invention	METHODS FOR BUILDING WIRELESS MESH NETWORK	

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		Application Number	
Title of Invention	METHODS FOR BUILDING WIRELESS MESH NETWORK		

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Provisional Application for United States Patent

TITLE: METHODS FOR BUILDING WIRELESS MESH NETWORK

INVENTOR(S): Kevin Ross, Lehi, UT 84043

Muhammad A. Naim, South Jordan, UT 84095

[0001] BACKGROUND

[0002] The present disclosure, for example, relates to wireless networks and communications including, but not limited to, broadband internet services to end user, security and/or automation systems, and more particularly to narrow beam mesh networking and related operations and techniques.

[0003] Wired and wireless networking and communications systems are widely deployed to provide various types of communication and functional features, including but not limited to those for security and automation, and/or others. These systems may be capable of supporting communication with a user through a communication connection or a system management action.

[0004] Current wireless mesh networking systems exhibit many shortcomings, including failing to account for extra protection for high reliability wireless path for carrying backhaul data that carries control signaling data along with user data for all the users in the network segment. Current wireless mesh networking systems use same or similar beam transmission techniques for access path that carries data for a single user and backhaul path that may affect network performance as backhaul paths tend to be more sensitive to interference and other signal inhibitors and can degrade the performance of entire network

segment. Thus, there exists multiple needs in the art for improved systems and methods relating to wireless communication network design and operation.

[0005] BRIEF SUMMARY OF THE INVENTION

[0006] The present system and methods relate to narrow beam mesh networks, associated systems, and operations relating to network communication, including, in some embodiments, adjustments and modifications. The present systems and methods may facilitate designing, operating and/or adjusting/modifying wireless networking communications. In some embodiments, the present systems and methods relate to and account for wireless communication nodes with capability of establishing point-to-point extremely narrow beam communication link, point-to-point steerable extremely narrow beam communication link, point-to-point multiple extremely narrow beam communication link, point-to-multipoint narrow beam communication links, ultra-wide-band point-to-point communication link and combination of point-to-point and point-to-multipoint communication links, among other things.

[0007] In some embodiments, a wireless communication node can host a single module that is capable of establishing extremely narrow beam width point-to-point links using metamaterials or other types of parabolic antennas. These links can connect one wireless communication node in a mesh network to another wireless communication node. In some embodiments, these links are non-steerable and in other embodiments these links can be steerable.

[0008] Another aspect of this disclosure is methods and apparatus involving wireless communication node hosting a single module capable of establishing point-to-multipoint

links with multiple wireless communication nodes in a mesh network. Yet in another embodiment, a wireless communication node can also host a single ultra-wide band communication module that can establish a highly reliable extremely high speed (>100 Giga bits) capacity links.

[0009] In another embodiment, wireless communication nodes can host multiple communication modules from a set of modules including point-to-point extremely narrow beam link, steerable point-to-point extremely narrow beam link, point-to-point ultra wide band link, point-to-multipoint steerable beam links. This enables wireless communication nodes in a mesh network to connect with multiple different wireless communication nodes with different link characteristics and dynamically change the modules types that connect one wireless communication node to another thereby changing the characteristics of the link of the wireless mesh network.

[0010] In another embodiment, wireless communication nodes can in addition to hosting single or multiple communication modules described above host a shared or dedicated processor, memory, software, content and applications, etc. to provide edge computing by leveraging the unique networking methods through mesh wireless links already described above.

[0011] The foregoing has outlined rather broadly the features and technical advantages of examples according to this disclosure so that the following detailed description may be better understood. Additional features and advantages will be described below. The conception and specific examples disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same procedures of the present disclosure. Characteristics of the concepts disclosed herein including their

organization and method of operation together with associated advantages will be better understood from the following description when considered in connection with the accompanying figures. Each of the figures is provided for the purpose of illustration and description only, and not as a definition of the limits of the claims.

[00012] BRIEF DESCRIPTION OF THE DRAWINGS

[00013] A further understanding of the nature and advantages the present disclosure may be realized by reference to the following drawings.

[00014] Figure 1. Figure 1 shows a diagram relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00015] Figure 2. Figure 2 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00016] Figure 3. Figure 3 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00017] Figure 4. Figure 4 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00018] Figure 5. Figure 5 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00019] Figure 6. Figure 6 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00020] Figure 7. Figure 7 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00021] Figure 8. Figure 8 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00022] Figure 9. Figure 9 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00023] Figure 10. Figure shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00024] Figure 11. Figure 11 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00025] Figure 12. Figure shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00026] Figure 13. Figure 13 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00027] Figure 14. Figure 14 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00028] Figure 15. Figure 15 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00029] Figure 16. Figure 16 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

[00030] Figure 17. Figure 17 shows designs illustrating exemplary methods relating to wireless networking and communication systems, in accordance with various aspects of this disclosure;

**[00031] DETAILED DESCRIPTION AND BEST MODE OF
IMPLEMENTATION**

[00032] Current wireless mesh networking systems exhibit many shortcoming, including failing to account for extra protection for high reliability wireless path for carrying backhaul data that carries control signaling data along with user data for all the users in the network segment. Current wireless mesh networking systems use same or similar beam transmission techniques for access path that carries data for a single user and backhaul path that may affect network performance as backhaul paths tend to be more

sensitive to interference and other signal inhibitors and can degrade the performance of entire network segment. Thus, there exists multiple needs in the art for improved systems and methods relating to wireless communication network design and operation. Referring to figure 1, a data communication network capable of providing multigigabit internet speeds through wireless point-to-point and point-to-multipoint links is illustrated. Communication network 100 in figure 1 includes Tower/ fiber access points 101 and 102. Tower/fiber access points 101 and 102 can be co-located or can be located at different physical locations. Tower/fiber access points 101 and 102 have access to high bandwidth dark fiber capable of providing up to several hundred gigabits/second of data throughput. Tower/fiber access points provide backhaul connectivity between the core network/data center (not shown in the figure 1 for the sake of simplicity) and seed home of the communication network described below. Tower/Fiber access points 101 and 102 host wireless point-to-point communication nodes 121 and 124. Wireless communication nodes 121 and 124 are capable of reception and transmission of high bandwidth (multiple gigahertz) signals operating at very high frequency (6Ghz ~100Ghz such as 28Ghz, V band, E band, etc.). Wireless communication nodes 121 and 124 consist of baseband/digital unit equipped with components including but not limited to processor, memory etc. Wireless communication nodes 121 and 124 also consist of RF unit and antenna unit. Antenna subsystem of wireless communication nodes 121 and 124 are capable of reception and transmission of directional signals where significant portion of the signal energy is concentrated within few degrees around the antenna boresight, both in vertical and horizontal direction, in contrast to omni directional antennas where signal energy is close to evenly spread across entire 360° degrees. Communication network 100 includes seed

homes 111 and 115. Examples of seed homes include detached single-family homes, multi-dwelling units (MDUs), small/medium business (SMB), etc. where communication equipment nodes can be deployed on roof tops. Seed homes 111 and 115 host wireless point-to-point communication nodes 122 and 123. Wireless communication nodes 122 and 123 are capable of reception and transmission of high bandwidth (multiple gigahertz) signals operating at very high frequency (6Ghz ~100Ghz such as 28Ghz, V band, E band, etc.). Wireless communication nodes 122 and 123 consist of baseband/digital unit equipped with components including but not limited to processor, memory etc. Wireless communication nodes 122 and 123 also consist of RF unit and antenna unit. Antenna subsystem of wireless communication nodes 122 and 123 are capable of reception and transmission of directional signals where significant portion of the signal energy is concentrated within few degrees around the antenna boresight, both in vertical and horizontal direction, in contrast to omni directional antennas where signal energy is close to evenly spread across entire 360° degrees. Wireless communication node 121 residing in Tower/fiber access point location 101 and wireless communication node 122 residing in seed home 111 work in pair to form bi-directional high bandwidth communication point-to-point data link 141 that provides connectivity between Tower/fiber access point 101 and seed home 111 segment of the communication network 100. Similarly, wireless communication node 124 residing in Tower/fiber access point location 102 and wireless communication node 123 residing in seed home 115 work in pair to form bi-directional high bandwidth communication point-to-point data link 142 that provides connectivity between Tower/fiber access point 102 and seed home 115 segment of the communication network 100. Seed home 111, in addition to wireless communication node 122, hosts a

second wireless communication node 131. Second wireless communication module 131 consists of multiple independent transmission/reception modules. Each module of the wireless communication node 131 is capable of reception and transmission of high bandwidth (multiple gigahertz) signals operating at very high frequency (6Ghz ~100Ghz such as 28Ghz, V band, E band, etc.). Each module of wireless communication node 131 contains of an independent baseband/digital unit equipped with components including but not limited to processor, memory etc. Each module in wireless communication node 131 also contains of an independent RF unit and independent antenna unit. Antenna subsystem of each wireless communication node 131's module is capable of reception and transmission of directional signals where significant portion of the signal energy is concentrated within few degrees around the antenna boresight, both in vertical and horizontal direction, in contrast to omni directional antennas where signal energy is close to evenly spread across entire 360° degrees. Communication network 100 also includes multiple anchor homes 112, 113 and 114. Each of these anchor homes hosts a wireless communication node similar to wireless communication node 131 described above. However, unlike seed homes, wireless communication node on anchor home only provide wireless connectivity to one or multiple anchor homes and/or seed homes but does not provide connectivity to the Tower/Fiber access point. For example, anchor home 112 hosts wireless communication node 132. One module of wireless communication node 132 residing in anchor home 112 and another module of wireless communication node 131 residing in seed home 111 work in pair to form bi-directional high bandwidth communication point-to-point data link 151 that provides connectivity between seed home 111 and anchor home 112 segment of the communication network 100. Similarly, another

module of wireless communication node 132 residing in anchor home 112 and a module of wireless communication node 133 residing in anchor home 113 work in pair to form bi-directional high bandwidth communication point-to-point data link 153 that provides connectivity between anchor home 112 and anchor home 113, another module of wireless communication node 132 residing in anchor home 112 and a module of wireless communication node 135 residing in seed home 115 work in pair to form bi-directional high bandwidth communication point-to-point data link 154 that provides connectivity between anchor home 112 and seed home 115, another module of wireless communication node 131 residing in seed home 111 and a module of wireless communication node 134 residing in anchor home 114 work in pair to form bi-directional high bandwidth communication point-to-point data link 152 that provides connectivity between anchor home 114 and seed home 111, another module of wireless communication node 134 residing in anchor home 114 and a module of wireless communication node 135 residing in seed home 115 work in pair to form bi-directional high bandwidth communication point-to-point data link 156 that provides connectivity between anchor home 114 and seed home 115. Bi-directional communication links 141, 142, 151, 152, 153, 154 & 155 shown in figure 1 can use various different multiple access schemes for transmission and reception including but not limited to frequency division multiple access (FDMA), time division multiple access (TDMA), single carrier FDMA (SC-FDMA), single carrier TDMA (SC-TDMA), code division multiple access (CDMA), orthogonal frequency division multiple access (OFDMA), non-orthogonal multiple access (NOMA) as described in various generations of communication technologies including 1G, 2G, 3G, 4G, 5G and 6G etc. Bi-directional communication links 141, 142, 151, 152, 153, 154 & 155 formed by the pairs

of communication nodes from the set including 121, 122, 123, 124, 131, 132, 133, 134 & 135 are capable of data information transfer via a variety of digital transmission schemes including but not limited to amplitude modulation (AM), phase modulation (PM), pulse amplitude modulation/quadrature amplitude modulation (PAM/QAM), ultra-wide band (UWB) pulse modulation (pico-second pulses), etc. In figure 1, two Tower/fiber access points 101 & 102, two seed homes 111 & 115 and three anchor homes 112, 113 & 114 and seven bi-directional point to point data links 141, 142, 151, 152, 153, 154 & 155 are shown to illustrate an example of a communication network. However, in general, communication network 100 can include different numbers of Tower/fiber nodes, seed homes, anchor homes and communication links depending on the specific layout of a particular instantiation of the communication network deployed in the field. Similarly, although, figure 1 shows four communication nodes 121, 122, 123 & 124 that provide connectivity between Tower/fiber access point and seed home, five communication nodes 131, 132, 133, 134 & 135 that provide connectivity between two anchor homes or between anchor and seed home, number of these communication nodes can vary from one communication network to another communication network based on the specific size and layout of a particular instantiation of the communication network. Communication network may also contain other nodes such as network switches/routers etc., that are omitted here for the sake of simplicity.

[00033] Referring to figure 2, one possible embodiment of wireless communication node 131 of figure 1 is shown labelled as 200. Wireless communication node 200 in figure 2 consists of a single module labelled as Module A. Module A consists of base band unit or digital unit 201 which runs the physical layer level protocol including digital

modulation/demodulation (modem) and other higher layer protocols such as MAC layer etc. Base band unit 201 interacts with other nodes of communication network that are external to the wireless communication node 200 via wired medium. Module A also includes RF unit 202 which among other things perform processing of intermediate frequency (IF) signals and defines the frequency range of the radio signals that can be transmitted or received with the Module A, etc. RF unit 202 is capable of operating over a wide range of frequencies for example V band frequencies ranging from 57Ghz to 71 Ghz. Finally, module A also consist of antenna unit 203 which performs the transmission and reception of over the air radio signals. Antenna unit 203 is capable of transmitting and receiving extremely narrow beam of signals. Antenna unit 203 is constructed with metamaterials that have excellent properties of controlling the directionality of radio signals that cannot be exhibited by ordinary antennas. Module A with the help of antenna module 203 is capable of establishing point-to-point links with a different module residing in a different wireless communication node. Referring to figure 3, an example of an antenna pattern of Module A created by antenna unit 203 is shown. It can be seen from antenna pattern in figure 3 that beam width of antenna unit 203 of Module A is extremely narrow (less than a degree) and side lobes power levels start to drop at a rapid rate. Just 5~6 degrees from main lobe, power levels drop by more than 30dB. Antenna pattern of antenna unit 203 shown in figure 3 is just one example showing the extremely narrow beam antenna pattern generation capability of Module A. In other instances, due to change in antenna elements, size, frequency, etc.), different patterns are generated. In some embodiments, module A can be constructed using metamaterials described above. In some other embodiments, module A can be constructed using a parabolic antenna or other types of

antennas. However, the main characteristic of generation of extremely narrow antenna beam pattern generation is common to all the instances of module A.

[00034] Referring to figure 4, a point-to-point wireless communication link 400 established between two wireless communication nodes 401 and wireless communication node 402 is shown. Both wireless communication nodes 401 and 402 each host a single communication Module A as depicted in figure 2 and described above. Due to the antenna unit characteristics of Module A in wireless communication node 401 and 402, the bi-directional point-to-point link 400 has extremely narrow beam. This transmission and reception capability of radio signals over extremely narrow beam via this point-to-point link 400 provides interference immunity in scenarios where there are large number of wireless communication links established by multiple wireless communication nodes concentrated in a small area and operating in same frequency.

[00035] In another embodiment, Module A can additionally provide beam steerability characteristic in addition to the capability of transmission and reception of data over extremely narrow beams as explained above and illustrated in the context of figure 2, figure 3 and figure 4. Referring to figure 5, a wireless communication node 501 consisting of a single Module A, a second wireless communication node 502 consisting of a single Module A and third wireless communication node 503 consisting of a single Module A is shown. During time T1, Module A of wireless communication node 501 and Module A of wireless communication node 502 work in pair to establish extremely narrow beam based bi-directional link 500 for the exchange of information data between wireless communication nodes 501 and 502. Due to some trigger, Module A of wireless communication node 501 invokes the beam steering capability of the module and changes

the direction of the antenna transmission and reception beam towards wireless communication node 503 and works in pair with Module A of wireless communication node 503 to dynamically establish the bi-directional extremely narrow beam-based link 500 between wireless communication node 501 and wireless communication node 503 during time T2. Trigger for this beam steering can be due to changes in the link condition between wireless communication node 501 and wireless communication node 502 due to various factors including but not limited to change from LOS path to non-LOS path due to change in environment, increased interference, change in position of wireless communication node 502 with respect to wireless communication node 501, instructions from higher layers, etc. In one embodiment, wireless communication node 503 can be different than wireless communication node 502. In other embodiment, wireless communication node 503 can be same as wireless communication node 502 but with a different physical location.

[00036] In another embodiment, wireless communication nodes defined above and discussed in the context of figure 2, figure 3, figure 4 and figure 5 can host more than one Module A. This allows a wireless communication node to communicate simultaneously with multiple wireless communication nodes by establishing multiple extremely narrow beam bi-directional links with the help of multiple Module A belonging to different wireless communication nodes working in pair. Referring to figure 6, wireless communication nodes 601 and 602 each host two Module A, 1 and 2 while wireless communication nodes 603 and 604 each host single Module A. 1st Module A of wireless communication node 601 and 1st Module A of wireless communication node 602 work in pair to establish extremely narrow bi-directional beam-based link 600 to provide wireless

connection between wireless communication node 601 and 602. Similarly, 2nd Module A of wireless communication node 601 and 602 and 1st (and only) Module A of wireless communication node 603 and 604 respectively work in pair to establish extremely narrow bi-directional beam-based links 610 and 620 to provide wireless connection between wireless communication node pairs 601-603 and 602-604 respectively. In one embodiment, 1st and 2nd Module As of wireless communication nodes 601 and 602 can be inside same physical enclosure and in other embodiment 1st Module A of wireless communication nodes 601 and 603 be inside one physical enclosure and 2nd Module A of wireless communication nodes 601 and 603 be inside a different physical enclosure. In case of different Module As belonging to same wireless communication node contained in separate physical enclosures, these can be connected via wired link as they are co-located in same seed home or anchor home. In figure 6, a maximum of two Module As are shown to be contained in a wireless communication node that enables the wireless communication node to establish two independent bi-directional links with different wireless communication nodes simultaneously. However, wireless communication node can host more than two module As and the maximum number of Module As (greater than two) that a wireless communication node can host depends on the maximum total power available to the wireless communication node. In one embodiment, all Module As belonging to same wireless communication node operate on same carrier frequencies of a frequency band. In another embodiment, different Module As belonging to same wireless communication node operate on different carrier frequencies of a frequency band.

[00037] Referring to figure 7, another embodiment of wireless communication node 131 of figure 1 is shown labelled as 700. Wireless communication node 700 in figure 7

consists of a single module labelled as Module B. Module B consists of base band unit or digital unit 701 which runs the physical layer level protocol including digital modulation/demodulation (modem) and other higher layer protocols such as MAC layer etc. Base band unit 701 interacts with other nodes of communication network that are external to the wireless communication node 700 via wired medium. Module B also includes RF unit 702 which among other things perform processing of intermediate frequency (IF) signals and defines the frequency range of the radio signals that can be transmitted or received with the Module B, etc. RF unit 702 is capable of operating over a wide range of frequencies for example V band frequencies ranging from 57Ghz to 71 Ghz. Finally, module B also consists of antenna unit 703 which performs the transmission and reception of over the air radio signals. Antenna unit 703 is an active antenna system (AAS) that consists of phased array of transmitters and receivers that are capable of doing beamforming and creating multiple beams simultaneously in different directions. By virtue of simultaneous creation of multiple beams in different direction, AAS system of antenna unit 703 enables the wireless communication node 700 to establish point-to-multipoint wireless communication links with multiple wireless communication nodes. Hence Module B with the help of antenna unit 703 is capable of establishing point-to-multipoint links with a different module residing in a different wireless communication node. Referring to figure 7, Module B residing in wireless communication node 700 is shown to create 1 to N multiple beams with the help of AAS of antenna unit 703. Value N depends on number of transmit and received antennas in AAS of antenna unit 703. Specifically, it can be seen that wireless communication unit 700 is connected to wireless communication unit 710, wireless communication unit 720 and wireless communication unit 7N0 via bi-directional

beam 1, beam 2 and beam N respectively. It can also be seen from antenna pattern in figure 7 that beam width of point-to-multipoint beams of antenna unit 703 of Module B are **not** extremely narrow (e.g. 3dB beam width of 7~10 degree) and side lobes power levels **don't** start to drop at a rapid rate which is in contrast to antenna pattern of antenna unit belonging to Module A described above and discussed in the context of figure 2 to figure 6.

[00038] Referring again to figure 7, Module B of wireless communication node 700 also differs from Module A (discussed above in the context of figures 2-6) with respect to the limitation of all the multiple bi-directional links to be operated in a single frequency range at one time. For example, signal beams 1 to N that connect wireless communication node 700 to wireless communication nodes 710 to 7N0 respectively can only operate within a same frequency range at one instant of time. It is to be noted that a different time instant, all beams 1 to N can switch to operate at a frequency range different from the frequency range used in the previous time instant, however, frequency range of an individual beam remains same as the frequency range of all the other N-1 beams at a given instant. Hence, Module B although due to phased antenna arrays can create multiple beams to create point-to-multi point links to connect one wireless communication node with multiple wireless communication nodes as shown in figure 7, interference profile at the receiver side with such point-to-multipoint network is inferior to interference profile of point-to-multiple point network where a wireless communication node hosts multiple Module A and create multiple point-to-point links as shown in figure 6 where wireless communication node 601 uses two Module A to connect to wireless communication node 602 and wireless communication node 603 simultaneously. The main reasons of high interference with Module B is due to 1) individual phased antenna array-based beams not narrow as

extremely narrow beams generated by metamaterial-based antenna of Module A and 2) all beams of Module B belonging to one wireless communication unit cannot operate at different frequency ranges unlike multiple point-to-point narrow beams of wireless communication node that host multiple Module A.

[00039] Referring to figure 8, another possible embodiment of wireless communication node 131 of figure 1 is shown labelled as 800 and 810. Wireless communication node 800 in figure 8 consists of a single module labelled as Module C. Module C consists of base band unit or digital unit which runs the physical layer level protocol including digital modulation/demodulation (modem) and other higher layer protocols such as MAC layer etc. Module C's baseband unit of wireless communication node 800 interacts with other nodes of communication network that are external to the wireless communication node 800 via wired medium. Module C also includes ultra-wide band antenna embedded with the baseband unit. Module C is capable of generation, transmission and reception of extremely short duration pulse (few pico seconds long) and uses pulse modulation (and its variations such as pulse amplitude modulation, etc.) to transmit data at extremely high rate such as greater than 100Gbps by transmitting signals over a very wide range of frequencies. In one embodiment, pulses used for communication by Module C can use frequencies ranging from few hundred megahertz to few hundred gigahertz. In a different embodiment, range of frequencies used by pulses generated by Module C of wireless communication unit 800 can take a different range. The fundamental characteristic of signals generated by Module C that is different from signals generated by Module A and Module B is that these signals are ultra wide band signals and their power spectral density over the entire range of frequencies is very low. Hence these UWB signals

do not create interference with other signals operating on a narrow band of frequencies as these UWB signals are treated as noise by receivers of normal wireless communication nodes. Figure 8 shows that Module C of wireless communication node 800 and Module C of wireless communication unit 810 establish a link 801 by working in pair. As explained above, such a communication link 801 operates over an ultra-wide range of frequencies. However, even in the presence of other wireless communication nodes (not shown in figure 8) such as wireless communication nodes with Module A or Module B that operate on a narrow band of frequencies compare to Module C of wireless communication node 800, performance of network is not impacted as power spectral density over the frequency range of communication link 801 that overlaps with frequency ranges on which a nearby wireless communication node using narrow band signals using for example Module A and/or Module B operates is very low and is treated as noise by the receivers of Module A and/or Module B.

[00040] In another preferred embodiment, wireless communication nodes 131 in figure 1 can host two types of modules. This allows a wireless communication node to communicate simultaneously with multiple wireless communication nodes and with two different interference profiles. Referring to figure 9, wireless communication node 910 hosts one Module A and one Module B. Module A of wireless communication node 910 and a communication module of wireless communication node 920 work in pair to establish extremely narrow bi-directional beam-based link 901 to provide wireless connection between wireless communication nodes 910 and 920. Simultaneously, Module B of wireless communication node 910 which is based on AAS and generates multiple beams simultaneously creates a point-to-multipoint link that connects wireless communication

node 910 with wireless communication nodes 930, 940, 950 and 960. Specifically Module B of wireless communication node 910 coordinates with, module of wireless communication node 930 to establish bi-directional beam 902, module of wireless communication node 940 to establish bi-directional beam 903, module of wireless communication node 950 to establish bi-directional beam 904 and module of wireless communication node 960 to establish bi-directional beam 905. In one embodiment, extremely narrow beam 901 and group of beams including 902, 903, 904 and 905 all operate on same range of carrier frequencies at same time. In another embodiment, extremely narrow beam 901 operates on a different range of frequencies compared to range of frequencies used by group of beams including 902, 903, 904 and 905 at the same time.

[00041] In one embodiment, Module A and Module B of wireless communication node 910 can be inside same physical enclosure and in other embodiment Module A and Module B of wireless communication node 910 can be inside two separate physical enclosures. In case of Module A and Module B belonging to same wireless communication node contained in separate physical enclosures, these can be connected via wired link as they are co-located in same seed home or anchor home. In figure 9, a maximum of two modules i.e. a single Module A and a single Module B are shown to be contained in a wireless communication node 910 that enables the wireless communication node to establish two independent and different types of bi-directional links with different wireless communication nodes simultaneously. However, wireless communication node 910 can host more than two module such as multiple Module A and single Module B or multiple Module B and single Module A or a different combination of number of Module A and Module B and the maximum number of total modules that a wireless communication node

can host depends on the maximum total power available to the wireless communication node. In one embodiment, all modules belonging to same wireless communication node operate on same carrier frequencies of a frequency band. In another embodiment, different modules belonging to same wireless communication node operate on different carrier frequencies of a frequency band.

[00042] In another preferred embodiment, wireless communication nodes 131 in figure 1 can host more than one type of modules. This allows a wireless communication node to communicate simultaneously with multiple wireless communication nodes and with different interference profiles. Referring to figure 10, wireless communication node 1010 hosts one Module C and one Module B. Module C of wireless communication node 1010 and Module C of wireless communication node 1020 work in pair to establish extremely high data rate ultra-wide frequency low power spectral density beam-based link 1001 to provide wireless connection between wireless communication nodes 1010 and 1020. Simultaneously, Module B of wireless communication node 1010 which is based on AAS and generates multiple beams simultaneously creates a point-to-multipoint link that connects wireless communication node 1010 with wireless communication nodes 1030, 1040, 1050 and 1060. Specifically, Module B of wireless communication node 1010 coordinates with, module of wireless communication node 1030 to establish bi-directional beam 1002, module of wireless communication node 1040 to establish bi-directional beam 1003, module of wireless communication node 1050 to establish bi-directional beam 1004 and module of wireless communication node 1060 to establish bi-directional beam 1005.

[00043] In one embodiment, Module C and Module B of wireless communication node 1010 can be inside same physical enclosure and in other embodiment Module C and

Module B of wireless communication node 1010 can be inside two separate physical enclosures. In case of Module C and Module B belonging to same wireless communication node contained in separate physical enclosures, these can be connected via wired link as they are co-located in same seed home or anchor home. In figure 10, a maximum of two modules i.e. a single Module C and a single Module B are shown to be contained in a wireless communication node 1010 that enables the wireless communication node to establish two independent and different types of bi-directional links with different wireless communication nodes simultaneously. However, wireless communication node 1010 can host more than two types of module such as a single Module C, single Module A and a single Module B or a different combination of number of Module A, Module B and Module C and the maximum number of total modules that a wireless communication node can host depends on the maximum total power available to the wireless communication node. In one embodiment, all modules belonging to same wireless communication node operate on same carrier frequencies of a frequency band. In another embodiment, different modules belonging to same wireless communication node operate on different carrier frequencies of a frequency band.

[00044] In another preferred embodiment, wireless communication nodes 131 in figure 1 can host more than one type of modules and dynamically change type of links between wireless communication nodes they are connected with. This allows a wireless communication node to communicate simultaneously with multiple wireless communication nodes and with different interference profiles and to adapt with changes in network environment. Referring to figure 11, wireless communication node 1110 hosts single Module C or Module A and a single Module B. During time T1, Module A/Module

C of wireless communication node 1110 and communication module of wireless communication node 1010 work in pair to establish either an extremely high data rate ultra-wide frequency low power spectral density beam or extremely narrow beam-based link 1101 to provide wireless connection between wireless communication nodes 1110 and 1120. Simultaneously, at the same time duration T1, Module B of wireless communication node 1110 which is based on AAS and generates multiple beams simultaneously creates a point-to-multipoint link that connects wireless communication node 1110 with wireless communication nodes 1130, 1140, 1150 and 1160. Specifically Module B of wireless communication node 1110 coordinates with, module of wireless communication node 1130 to establish bi-directional beam 1102, module of wireless communication node 1140 to establish bi-directional beam 1103, module of wireless communication node 1150 to establish bi-directional beam 1104 and module of wireless communication node 1160 to establish bi-directional beam 1105. At a different time T2, due to some trigger, Module A/Module C of wireless communication node 1110 dynamically switches its wireless link from wireless communication node 1120 to wireless communication node 1140 by steering the beam towards wireless communication node 1140. At the same time or after receiving instructions from higher layer, Module B of wireless communication node 1110 disconnects its link with wireless communication node 1140 via beam 1103 and generates a new beam 1101 in the direction of wireless communication node 1120 and establishes connection with wireless communication node 1120. Trigger for this beam steering can be due to changes in the link condition between wireless communication node 1110 and wireless communication node 1120 or 1140 due to various factors including but not limited to change from LOS path to non-LOS path due to change in environment, increased

interference, change in position of wireless communication node 1120 or 1140 with respect to wireless communication node 1110, instructions from higher layers, etc. In figure 11, dynamic link switching occurs between wireless communication nodes 1110, 1120 and 1140. However, dynamic switching can also occur between a different communication of nodes. It may also happen that one or multiple wireless communication nodes leave the communication network. In such case, such links between nodes are dropped and communication network dynamically re-aligns its self by adjusting/switching links types between the remaining number of wireless communication nodes in the communication network to best suit the needs to the wireless communication nodes and communication network. In some embodiments, wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can host multiple modules of same or different types. For example, one, some or each one of wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can host one Module A and one Module B. Hence, when wireless communication node 1110 makes a point-to-point link using its Module A or Module C with first communication modules (Module A or C) of wireless communication nodes 1120, 1130, 1140, 1150 and 1160, then the other Module B of wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can simultaneously create point-to-multipoint wireless communication links with other modules of wireless communication nodes in the mesh network that are not shown here. Similarly, when wireless communication node 1110 makes a point-to-multipoint links using its Module B with first communication modules (Module A or C) of wireless communication nodes 1120, 1130, 1140, 1150 and 1160, then the other Module B of wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can simultaneously create point-to-multipoint wireless communication links with other modules of wireless

communication nodes in the mesh network that are not shown here. In another embodiment, one, some or each one of wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can host two Module A or Module C. Hence, when wireless communication node 1110 makes a point-to-point link using its Module A or Module C with first Module A or C of wireless communication nodes 1120, 1130, 1140, 1150 and 1160, then the other Module A or Module C of wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can simultaneously create point-to-point wireless communication links with other modules of wireless communication nodes in the mesh network that are not shown here. Similarly, when wireless communication node 1110 makes a point-to-multipoint links using its Module B with first communication modules (Module A or C) of wireless communication nodes 1120, 1130, 1140, 1150 and 1160, then the other Module A or C of wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can simultaneously create point-to-point wireless communication links with other modules of wireless communication nodes in the mesh network that are not shown here. In another embodiment, wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can host multiple Module A or Module C and Module B. For example, one, some or each of wireless communication node 1120, 1130, 1140, 1150 and 1160 can host two Module A or Module C and one Module B. Hence, when wireless communication node 1110 makes a point-to-point link using its Module A or Module C with first Module A or C of wireless communication nodes 1120, 1130, 1140, 1150 and 1160, then the other Module A or Module C of wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can simultaneously create point-to-point wireless communication links with other modules of wireless communication nodes in the mesh network that are not shown here and third Module B of wireless

communication nodes 1120, 1130, 1140, 1150 and 1160 can simultaneously create point-to-multipoint wireless communication links with other modules of wireless communication nodes in the mesh network that are not shown here. Similarly, when wireless communication node 1110 makes a point-to-multipoint links using its Module B with first communication modules (Module A or C) of wireless communication nodes 1120, 1130, 1140, 1150 and 1160, then the other Module A or C of wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can simultaneously create point-to-point wireless communication links with other modules of wireless communication nodes in the mesh network that are not shown here and third Module B of wireless communication nodes 1120, 1130, 1140, 1150 and 1160 can simultaneously create point-to-multipoint wireless communication links with other modules of wireless communication nodes in the mesh network that are not shown here.

[00045] It is to be noted that wireless communication links established by Module A or Module C have high reliability due to interference immunity either due to extremely narrow beams or due to transmission of data over ultra-high bandwidth. These features make these links more suitable to carry control information and data for multiple or all users of the wireless communication network mesh. Hence links established by Module A or Module C can act as wireless backhaul for the network mesh while links established with Module B can provide access to individual users of the communication network.

[00046] In one embodiment, entire wireless mesh can be composed of point-to-point links where both links providing backhaul and access have interference immunity. Such links although are more expensive due to the requirement of separate modules to establish individual links but suitable when certain high service quality or reliability is required to

be ensured for all customers of the network. For example, figure 12 shows a location 1200 of a communication network that can be a seed or an anchor home. Location 1200 hosts a wireless communication node 1201 that contains a total of 6 communication modules that belong to either Module A or Module C class. Hence this wireless communication node is capable of establishing six point-to-point links. Wireless communication node 1201 uses 1st and 4th Module A/ Module C to establish connections with location 1210 and location 1260 respectively that serve as backhaul links while wireless communication node 1201 uses 2nd, 3rd, 5th and 6th Module A/Module C to establish point-to-point links with location 1220, 1230, 1250 and 1240 respectively to provide access links. In other words, links between locations 1200-1220, locations 1200-1230, locations 1200-1240 and locations 1200-1250 only carry data for individual users where as links between locations 1200-1260 and locations 1200-1210 carry signaling and data for all the locations including 1200, 1210, 1220, 1230, 1240, 1250 and 1260.

[00047] In another embodiment, entire wireless mesh can be composed of combination of point-to-point links and point-to-multipoint links where point-to-point links act as backhaul links and point-to-multipoint links act as access links to individual users. Such wireless mesh network due to presence of point-to-multipoint links although does provide interference immunity to all the users of the communication network but are less expensive due to the non-requirement of separate modules to establish individual links. For example, figure 13 shows a location 1300 of a communication network that can be a seed or an anchor home. Location 1300 hosts a wireless communication node 1301 that contains a total of 4 communication modules that belong to either Module A/ Module C or Module B class. Hence this wireless communication node is capable of establishing two

point-to-point links and two point-to-multipoint links. Wireless communication node 1301 uses 1st and 4th Module A/ Module C to establish connections with location 1310 and location 1360 respectively that serve as backhaul links while wireless communication node 1301 uses 2nd Modules B to establish point-to-multipoint links with locations 1320, 1330, and used 3rd Module B to establish point-to-multipoint links with locations 1350 and 1340 respectively to provide access links. In other words, links between locations 1300-1320, locations 1300-1330, locations 1300-1340 and locations 1300-1350 only carry data for individual users where as links between locations 1300-1360 and locations 1300-1310 carry signaling and data for all the locations including 1300, 1310, 1320, 1330, 1340, 1350 and 1360.

[00048] Referring to figure 14, another possible embodiment of wireless communication node 131 of figure 1 is shown labelled as 1400. Wireless communication node 1400 in figure 14 consists of a single module labelled as Module D. Module D consists of base band unit or digital unit 1401 which runs the physical layer level protocol including digital modulation/demodulation (modem) and other higher layer protocols such as MAC layer etc. Base band unit 1401 interacts with other nodes of communication network that are external to the wireless communication node 1400 via wired medium. Module D also includes RF unit 1402 which among other things perform processing of intermediate frequency (IF) signals and defines the frequency range of the radio signals that can be transmitted or received with the Module D, etc. RF unit 1402 is capable of operating over a wide range of frequencies for example 5Ghz band frequencies ranging from 5 Ghz to 6 Ghz. Finally, module D also consist of antenna unit 1403 which performs the transmission and reception of over the air radio signals. Antenna unit 1403 is capable

of transmitting and receiving extremely narrow beam of signals. Antenna unit 1403 is constructed with either 1 dimensional or 2-dimensional antenna element arrays that have excellent properties of controlling the directionality of radio signals using beam forming and can propagate even in a non-line of sight environment. Module D with the help of antenna module 1403 is capable of establishing point-to-multipoint links with tower capable of performing massive MIMO (multiple input multiple output) beams. In one embodiment, Module D can be designed and manufactured at least in part using ASIC (Application specific integrated circuit) and integrated RF unit called RFIC. Referring to figure 15, an example of multiple Module Ds connected to a tower 1500 is shown. Specifically, wireless communication node 1501 hosting a Module D described above is connected to tower 1500 via massive MIMO beam link 1510 that can be both line-of-sight and non-line-of-sight, wireless communication node 1502 hosting a Module D described above is connected to tower 1500 via massive MIMO beam link 1520 that can be both line-of-sight and non-line-of-sight and a third wireless communication node 1503 hosting a Module D described above is connected to tower 1500 via massive MIMO beam link 1530 that can be both line-of-sight and non-line-of-sight. The tower 1500 is equipped with a Massive MIMO module can create multiple bi-directional narrow beam links simultaneously in all direction covering entire 360 degrees of coverage area. In one embodiment, tower 1500 can operate in 5Ghz band including frequencies ranging from 5000Mhz to 6000Mhz. In other embodiments, tower 1500 and associated wireless communication nodes 1501, 1502 and 1503 can operate on a different frequency band. Figure 15 shows only one tower and just three wireless communication nodes hosting Module D in the network. However, a network can have multiple towers similar to 1500

and these towers can each be connected to a large number of wireless communication nodes providing these nodes host beside other modules a Module D. The route that a particular packet takes from source to destination is dynamically selected based on factors including but not limited to link quality, loading, latency etc. For example, referring to figure 16 that shows and communication system 1600 that is similar to communication system 100 and has all the components described originally in the context of figure 1. Additionally, system 1600 of figure 16 includes a tower 1610 which is similar to tower 1500 described in the context of figure 15. In contrast to communication system 100 in figure 1, wireless communication nodes 131, 132, 133, 134 and 135 host an additional Module D besides Module A/Module B or Module C that enables these wireless communication nodes to optionally establish bi-directional links with features described in the context of figure 14 and 15 with tower 1610 using massive MIMO beamforming capabilities. Such links labelled as 1601, 1602, 1603, 1604 and 1605 can work in both line-of-sight and non-line of sight environment and can provide alternate communication path to wireless communication nodes 131, 132, 133, 134 and 135 in an event where point-to-point or point-to-multipoint links that connect one wireless communication node to a peer wireless communication node to form a mesh network fails or experience performance degradation due to various reasons including but not limited to change on the line-of-sight profile of millimeter wave link between two wireless communication nodes. In figure 16, only 1 tower 1610 capable of massive MIMO point-to-multipoint communication is shown to be connected to five wireless communication nodes 131-135. However, in general, a communication system can also have a different number of towers each connected to multiple different wireless communication nodes provided those wireless communication

nodes host beside other modules at least one Module D. In areas within tower 1500 (and other towers of same type) coverage area, communication network can initially start in a point-to-multipoint manner where tower 1500 (and other towers of same type) providing access to individual customers using sub 6Ghz massive MIMO point-multipoint beams. Later, nodes in the network can opportunistically connect with other nodes using regular modules (e.g. Module A/Module B/Module C) in the presence of line-of-sight. This way, network evolves into mesh network with point-to-point and point-to-multipoint connection between nodes in addition to each communication node having a path directly (non-line-of-sight) to tower 1500 (and other towers of same type) that fall within the coverage area. A route that a packet takes from source to destination in this network is optimized by considering various factors including latency, congestion, reliability etc. Communication network can later also add seed homes such as 111 and 115 in figure 1 along with tower/fiber access points 101 and 102 to provide alternate backhaul as per need basis.

[00049] In another embodiment, instead of providing massive MIMO point-to-multipoint networking capability using a terrestrial tower, point to multipoint massive MIMO capability to networks wireless communication nodes can also be provided by a satellite for example a low earth orbit (LEO) satellite. For example, referring to figure 17 that shows and communication system 1700 that is similar to communication system 100 and has all the components described originally in the context of figure 1. Additionally, system 1700 of figure 17 includes a satellite 1710 which is capable of doing massive MIMO transmission and reception on frequencies including but not limited to 5-6Ghz similar to tower 1500 described in the context of figure 15. In contrast to communication system 100 in figure 1, wireless communication nodes 131, 132, 133, 134 and 135 host an

additional Module D besides Module A/Module B or Module C that enables these wireless communication nodes to optionally establish bi-directional links with features described in the context of figure 14 and 15 with satellite 1710 using massive MIMO beamforming capabilities. Such links labelled as 1701, 1702, 1703, 1704 and 1705 can provide alternate communication path to wireless communication nodes 131, 132, 133, 134 and 135 in an event where point-to-point or point-to-multipoint links that connect one wireless communication node to a peer wireless communication node to form a mesh network fails or experience performance degradation due to various reasons including but not limited to change on the line-of-sight profile of millimeter wave link between two wireless communication nodes. In figure 17, only one satellite 1710 capable of massive MIMO point-to-multipoint communication is shown to be connected to five wireless communication nodes 131-135. However, in general, a communication system can also have a different number of satellites each connected to multiple different wireless communication nodes provided those wireless communication nodes host beside other modules at least one Module D.

[00050] In another embodiment, some of the wireless communication nodes that provide backhaul functionality can be equipped with multiple communication modules that enables these wireless communication nodes to provide transport backhaul data between end user and the network using multiple different types of communication links. For example, referring to figure 18 that shows and communication system 1800 that is similar to communication system 100 and has all the components described originally in the context of figure 1. Additionally, system 1800 of figure 18 includes a satellite 1810 which is capable of doing massive MIMO transmission and reception on frequencies including

but not limited to 5-6Ghz similar to tower 1500 described in the context of figure 15 along with a massive MIMO cable tower 1820 which is also similar to tower 1500 described in the context of figure 15. In contrast to communication system 100 in figure 1, wireless communication nodes 131, 132, 133, 134 and 135 host an additional Module D besides Module A/Module B or Module C that enables these wireless communication nodes to optionally establish bi-directional links with features described in the context of figure 14 and 15 with satellite 1810 and tower 1820 using massive MIMO beamforming capabilities. Such links labelled as 1801, 1802, 1803 and 1804 can provide alternate communication path to wireless communication nodes 131, 132, 133, 134 and 135 in an event where point-to-point or point-to-multipoint links that connect one wireless communication node to a peer wireless communication node to form a mesh network fails or experience performance degradation due to various reasons including but not limited to change on the line-of-sight profile of millimeter wave link between two wireless communication nodes. Specifically, satellite 1810 in figure 18 is connected to seed home 115 using wireless communication node 135 via link 1804 and to anchor home 112 using wireless communication node 132 via link 1803. Seed home 115 thus has multiple options to route backhaul traffic to the network. In one embodiment, seed home 115 using wireless communication node 135 at one time can pick a satellite link 1804 to transport backhaul data and based on some trigger at a different time instruct wireless communication module 135 to switch links for backhaul data transmission from 1804 to a point-to-point or point-to-multipoint millimeter wave (e.g. E-band) based links to tower/fiber access point 102. Such trigger includes but not limited to latency, bandwidth, packet loss requirements, etc. of a particular application. Figure 18 also shows a end user home 113 where wireless communication node 133 transports the

data using anchor home 112's wireless communication node 132. Wireless communication node 132 is shown to have multiple options to transport end user data of home 113 including direct satellite link connection using 1803, in-direct satellite link connection using 1804 via anchor node 135 or through point to point/ point-multi-point connections using millimeter wave through towers 101 or 102 via seed homes 111 and 115 respectively besides other options. In one embodiment, wireless communication node 132 can dynamically switch connection link it uses to route packets/data to and from end user home 113. For example, due to some trigger similar to triggers described above, wireless communication node 132 can dynamically switch from satellite link 1803 to satellite link 1804 via wireless communication node 135 to transport data to and from end user home 113. Links 1803 and 1804 can be part of same massive MIMO beam or links 1803 and 1804 can be part of different massive MIMO beams. Satellite links 1802 and 1804 can use same frequency range of communications or these can be operating on different frequency ranges. In figure 18, only one satellite 1810 capable of massive MIMO point-to-multipoint communication is shown to be connected to two wireless communication nodes 132 and 135. However, in general, a communication system can also have a different number of satellites each connected to multiple different wireless communication nodes provided those wireless communication nodes host beside other modules at least one Module D.

[00051] Additionally, tower 1820 in figure 18 is connected to seed home 111 using wireless communication node 135 via link 1804 and to anchor home 112 using wireless communication node 131 via link 1801 and to anchor home 114 using wireless communication node 134 via link 1802. This provides anchor home 114 to route packets to the network in multiple ways including a) through point-to-point or point-to-multipoint

millimeter wave-based links 152 or 155 and b) via direct massive MIMO based link to tower 1820 via link 1802. Similarly, seed home 111 has multiple options to route backhaul traffic to the network. In one embodiment, seed home 111 using wireless communication node 131 at one time can pick a satellite link 1801 to transport backhaul data and based on some trigger at a different time instruct wireless communication module 131 to switch links for backhaul data transmission from 1801 to a point-to-point or point-to-multipoint millimeter wave (e.g. E-band) based links to tower/fiber access point 101. Such trigger includes but not limited to latency, bandwidth, packet loss requirements, etc. of a particular application. In figure 18, only one tower 1820 capable of massive MIMO point-to-multipoint communication is shown to be connected to two wireless communication nodes 131 and 134. However, in general, a communication system can also have a different number of massive MIMO towers each connected to multiple different wireless communication nodes provided those wireless communication nodes host beside other modules at least one Module D.

[00052] In another embodiment, some or every single wireless communication node described above and discussed with the aid of the figures 1-18 in this disclosure can additionally be an edge computing node by hosting a processor (separate or shared), memory, digital contents, software, etc. and other components for computing, storage and other required operations for edge computing in addition to the high speed low latency networking capability that has already been described above. This enables communication system to provide cloud services in a distributed manner closer to the end user as wireless communication nodes are distributed across the network and provide interface between the network and the end-user. This memory unit can store a copy of local digital contents and

can additionally store a copy of portion of digital content that that are not local. The non-local digital contents amongst other things can include digital contents belonging to other nodes. This provides content redundancy in the communication system. Hence, when an end user of a communication system requests for a digital content or data, then this edge computing mechanism allows request to be fulfilled in a variety of different ways including request processed by a local node and/or remote node based various criteria including but not limited to latency, network congestion, etc. of the application making the request.

[00053] The invention has been disclosed in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the claims (to be added later), the invention may be practiced otherwise than as specifically described. The invention is defined by the claim(s).

ABSTRACT:

[00054] Methods, apparatuses, and systems relating to narrow beam communications and wireless networking are disclosed. Exemplary methods for wireless networking and communications may include wireless communication nodes hosting a subset of communication modules that can establish extremely narrow beam point-to-point links, extremely narrow steerable point-multipoint links, ultra-wideband point-to-point links and steerable point-to-multipoint links, using these different type of modules to connect with different wireless communication nodes to create a mesh network and based on some trigger dynamically changing the selection of modules that connect one wireless communication node in a mesh network to another wireless communication node thereby dynamically changing the characteristics of wireless communication link that connects the two nodes.

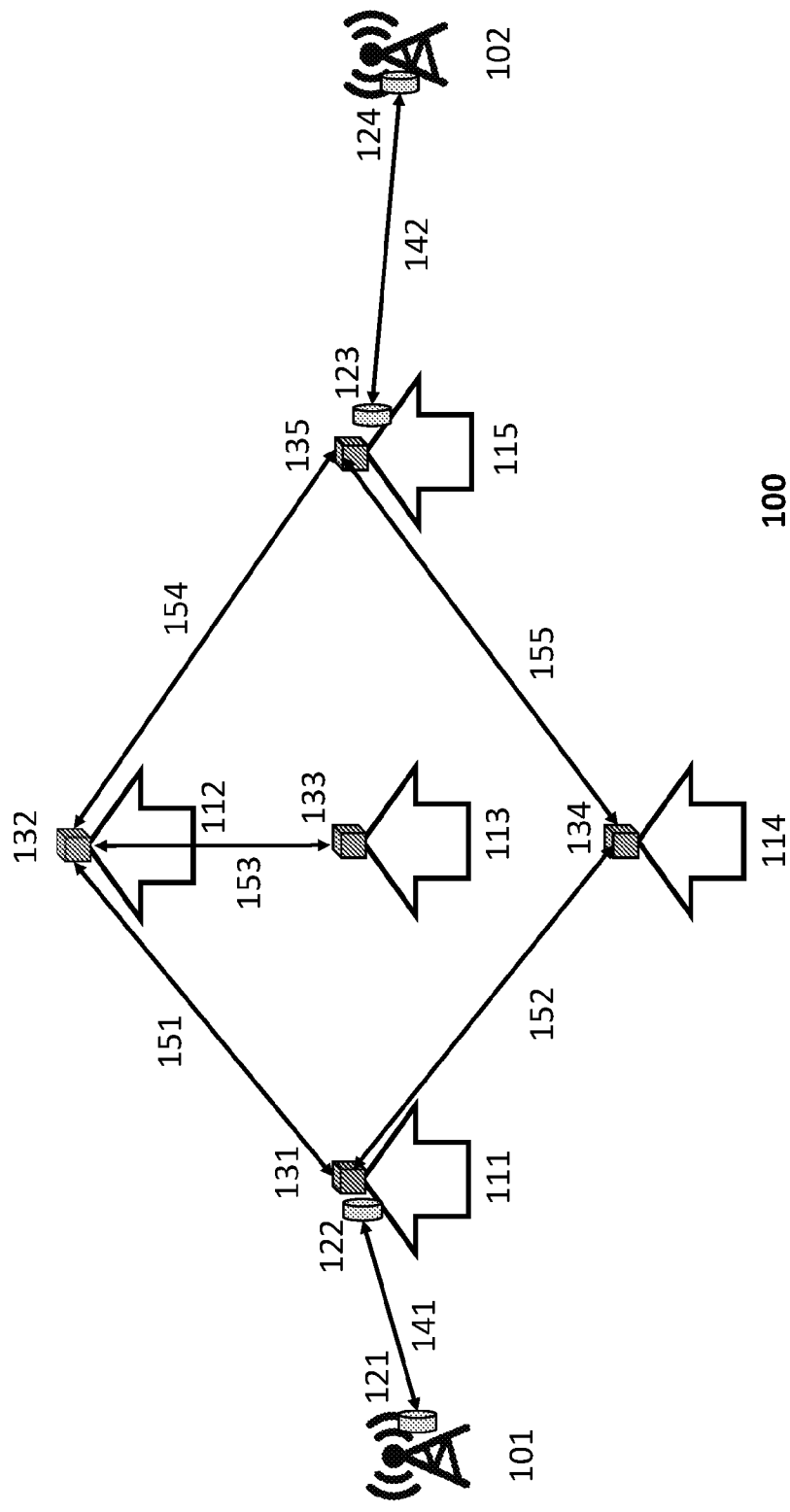


Fig 1

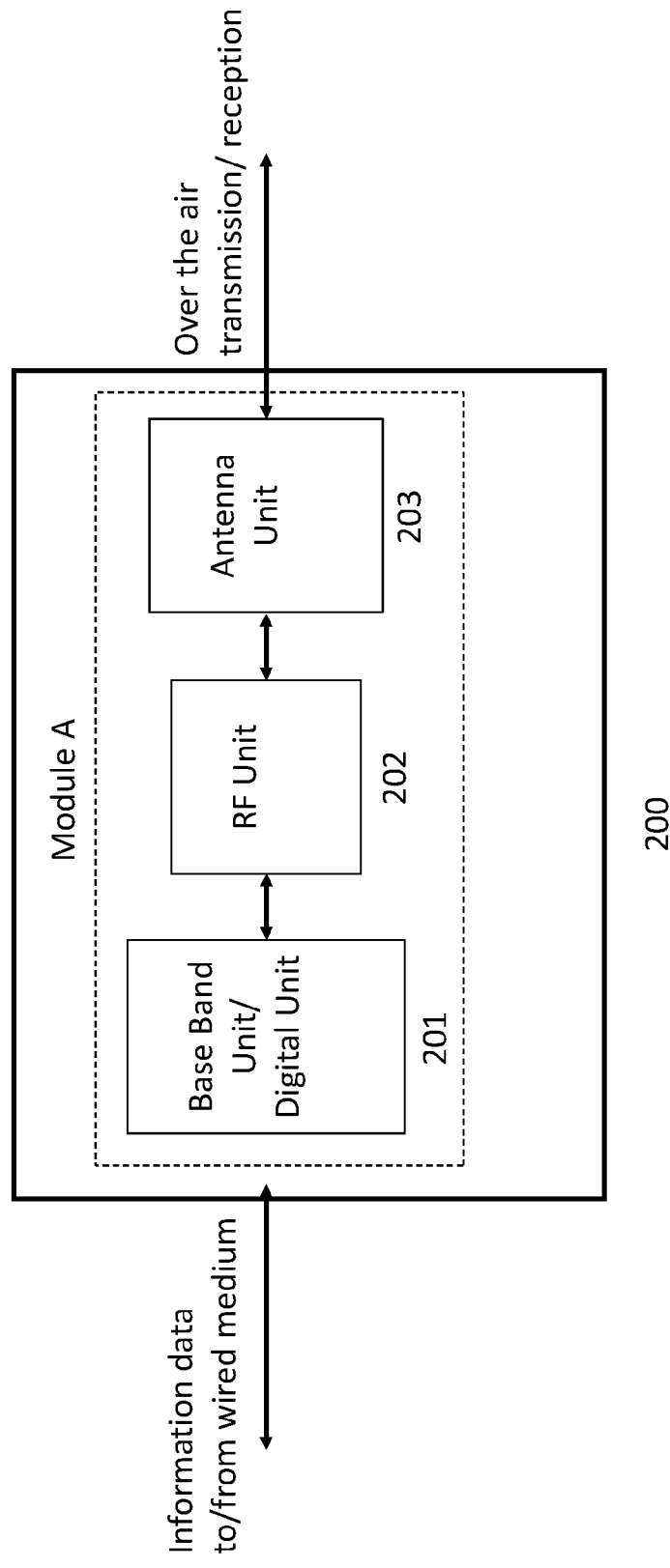


Fig 2

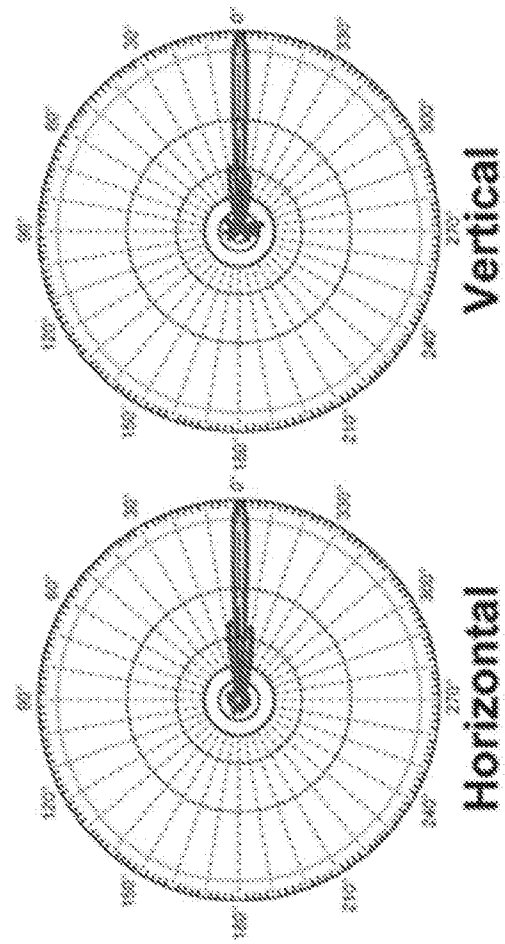


Fig 3

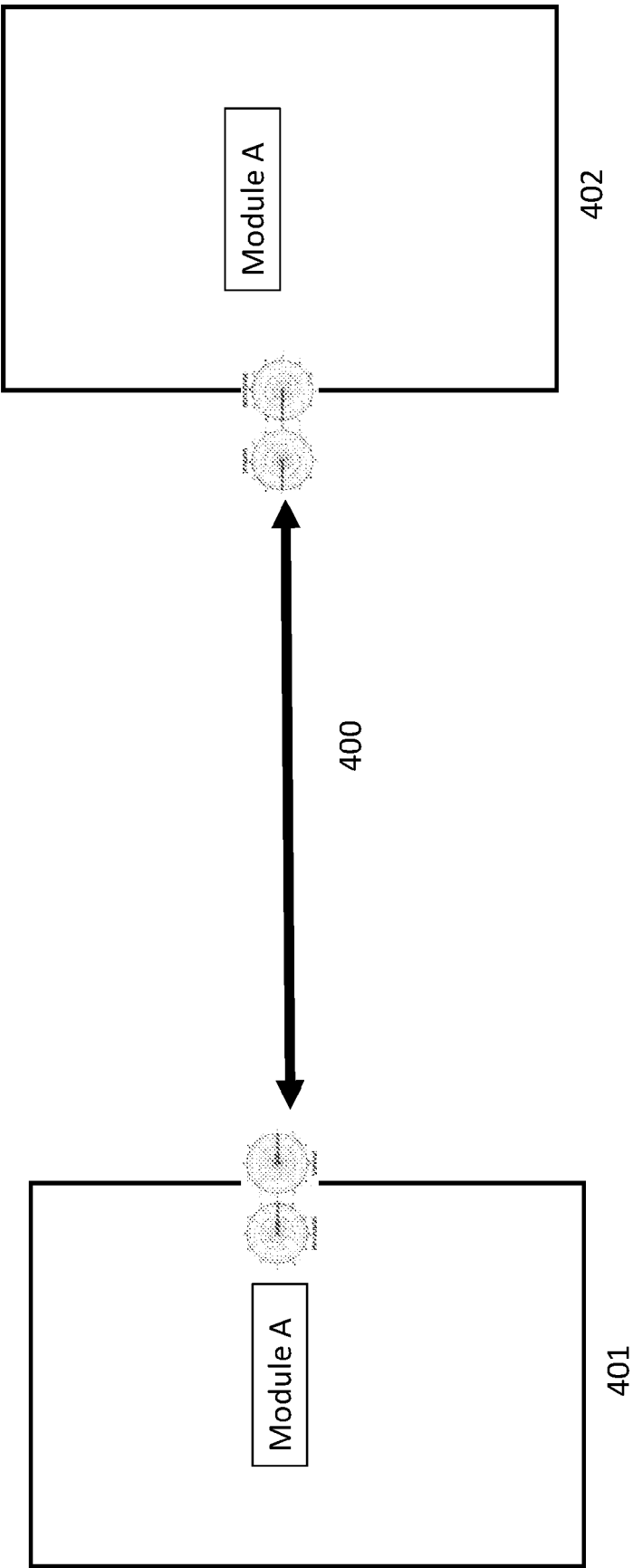


Fig 4

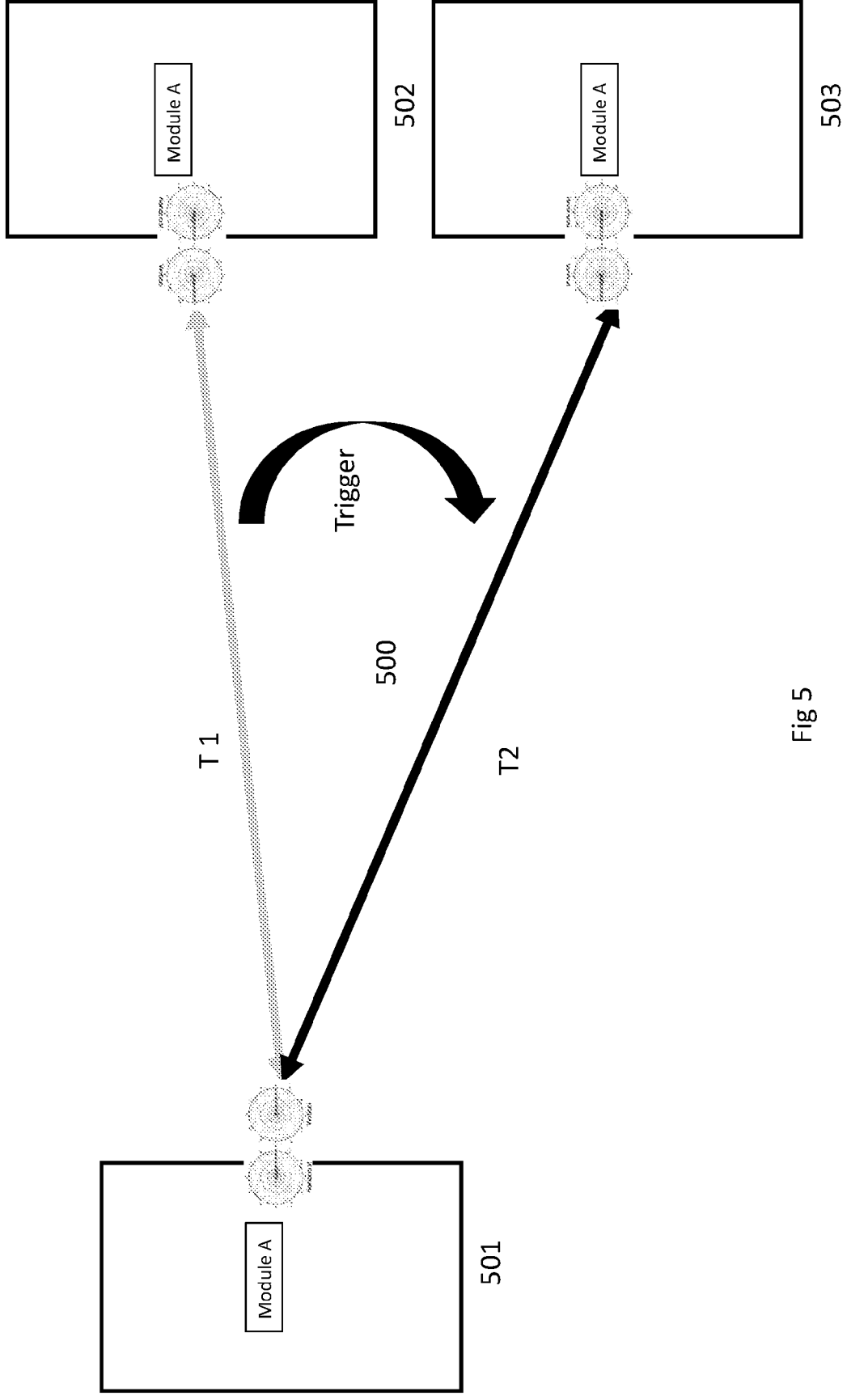


Fig 5

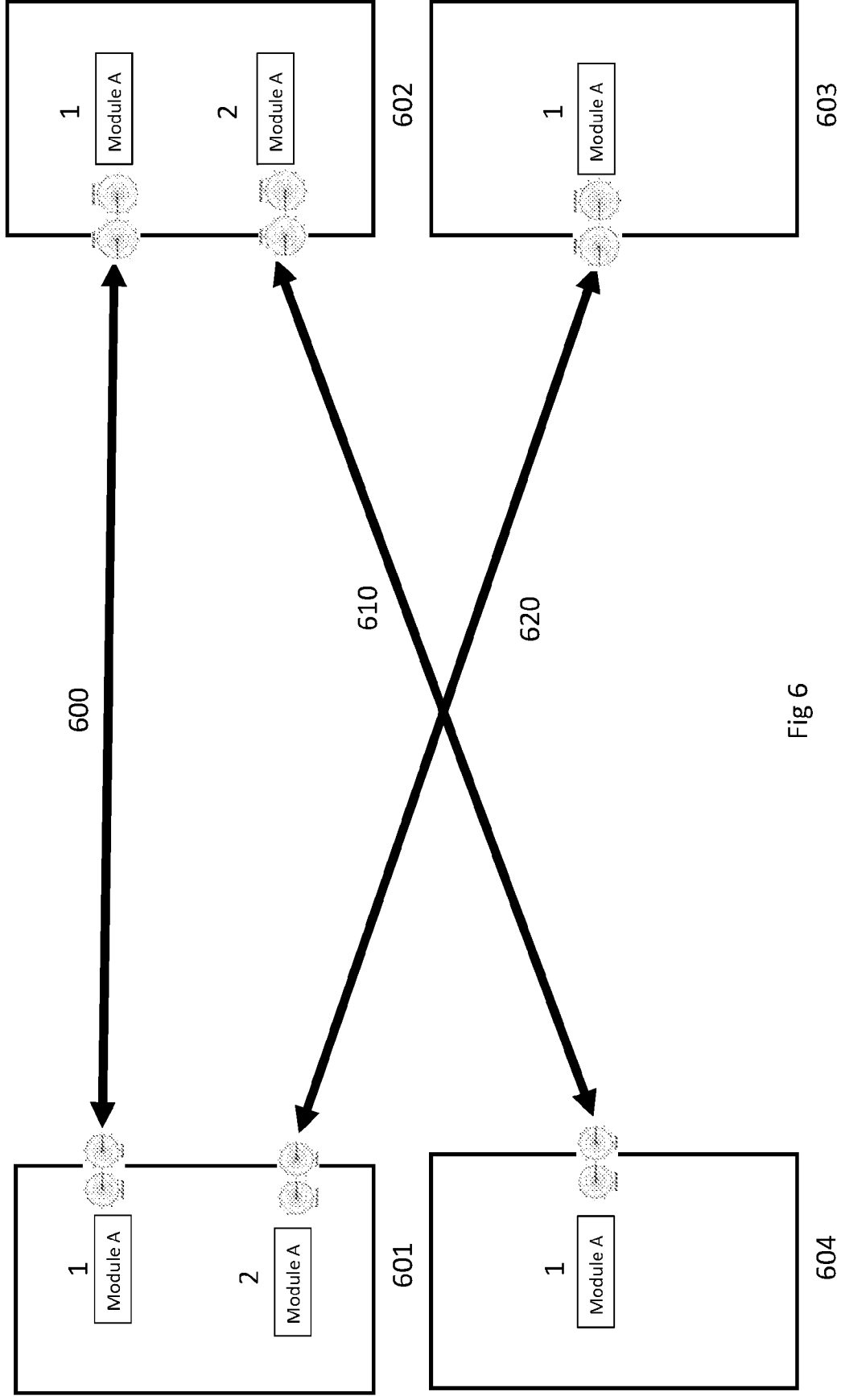


Fig 6

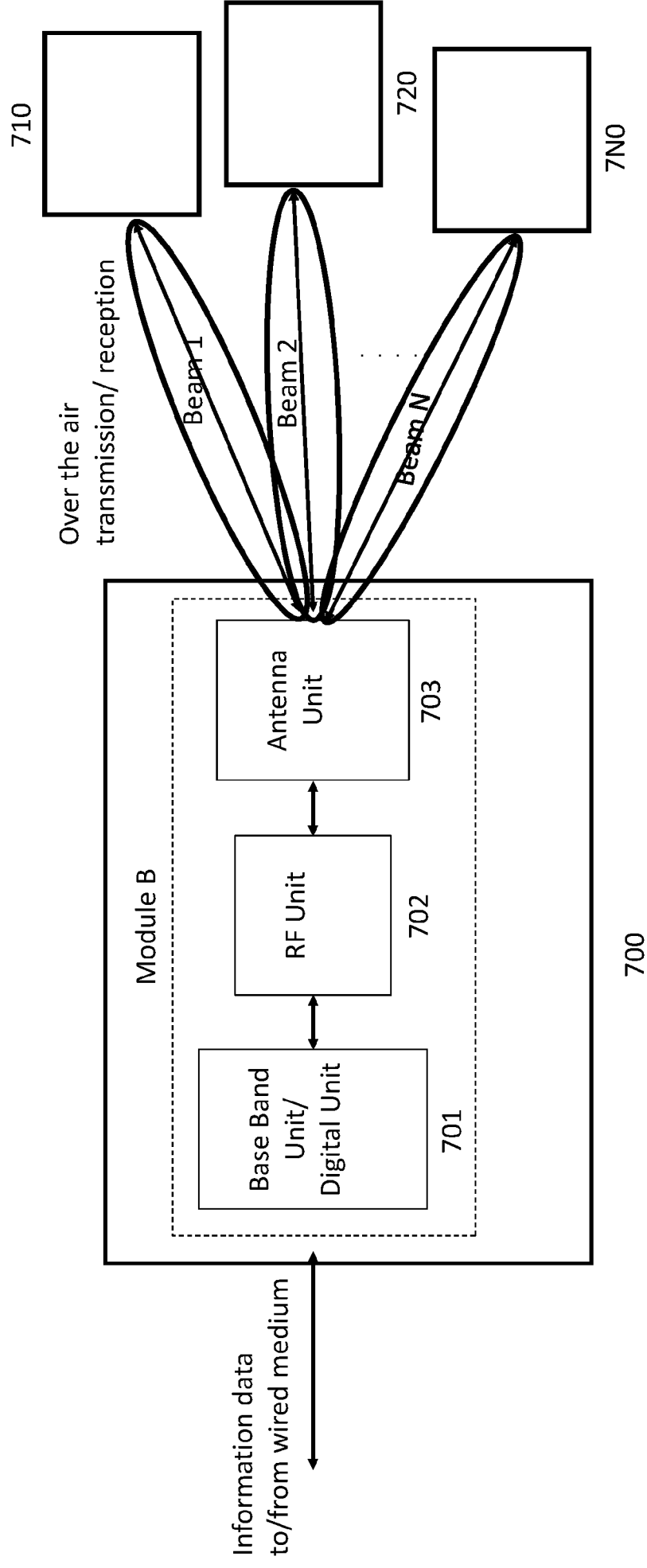


Fig 7

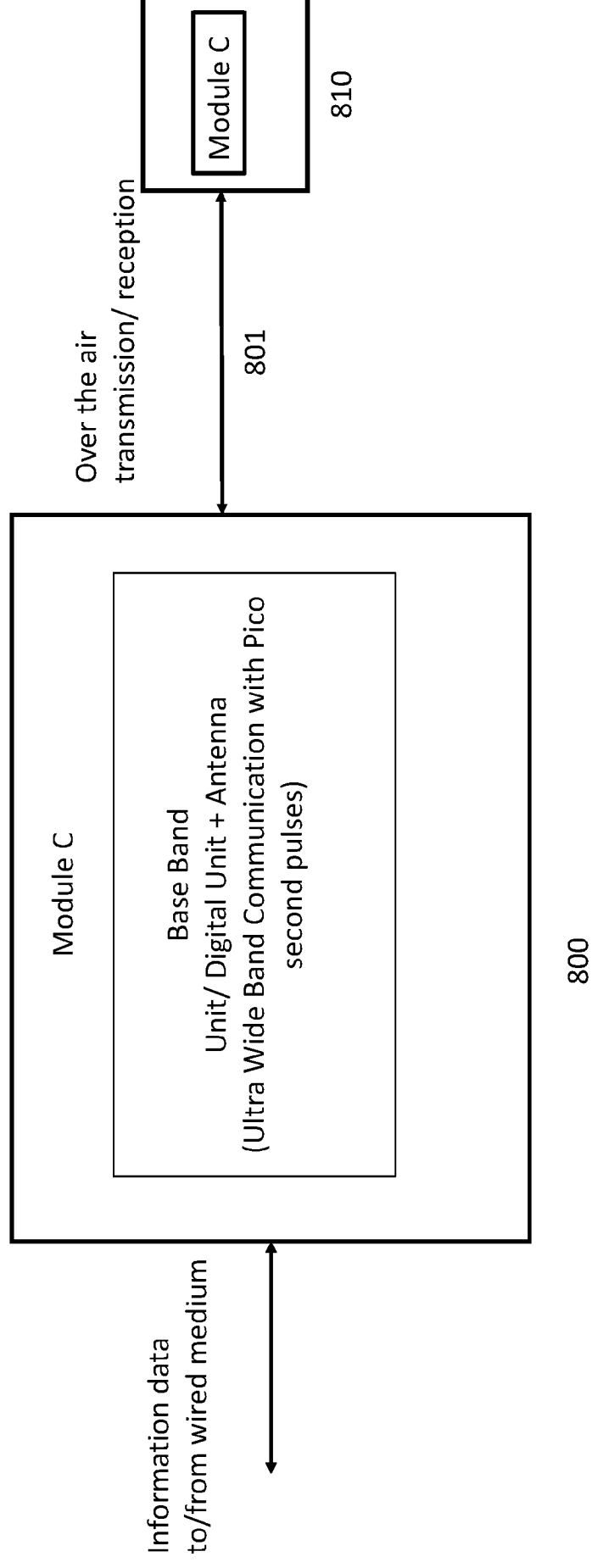


Fig 8

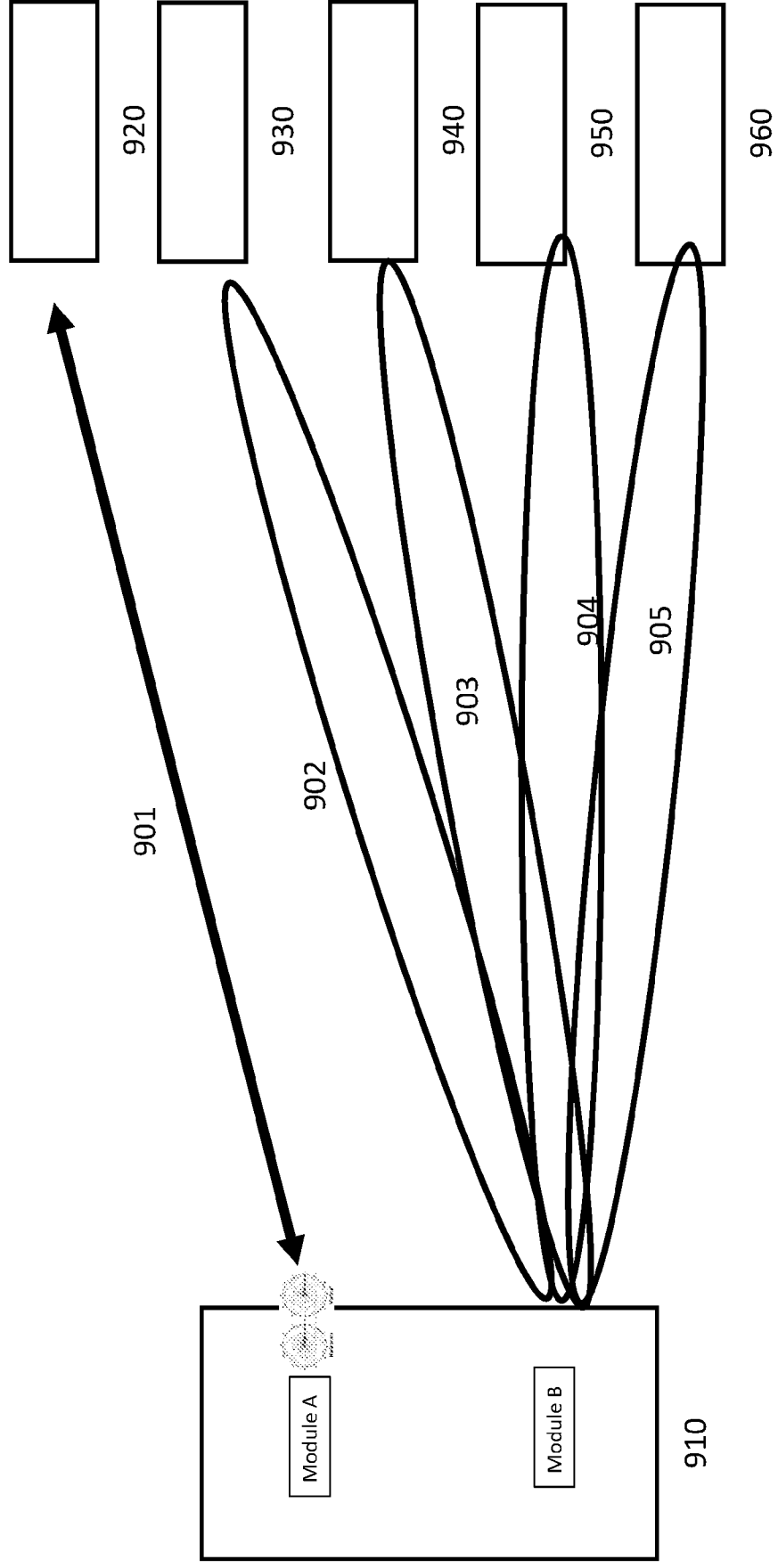


Fig 9

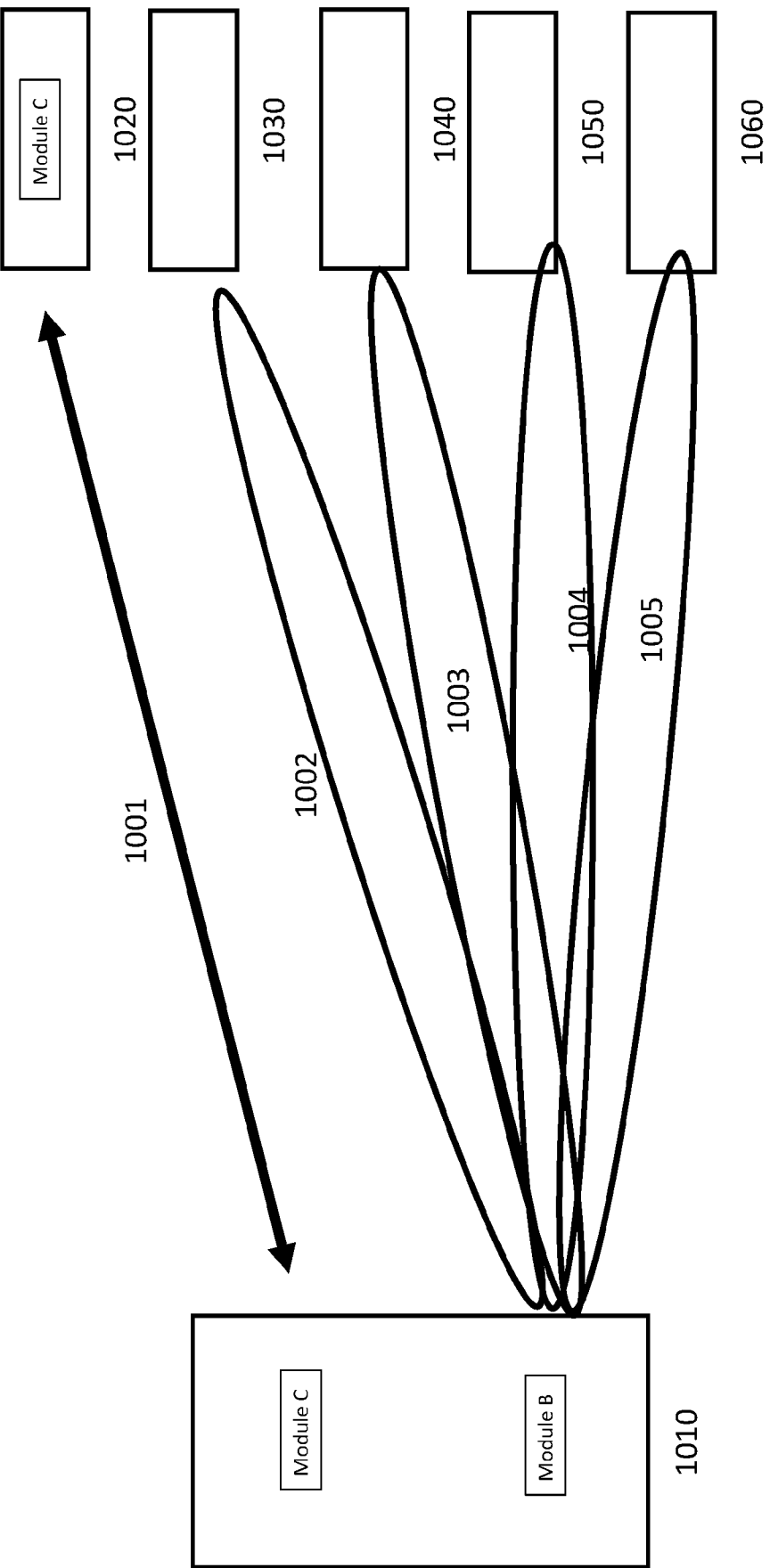


Fig 10

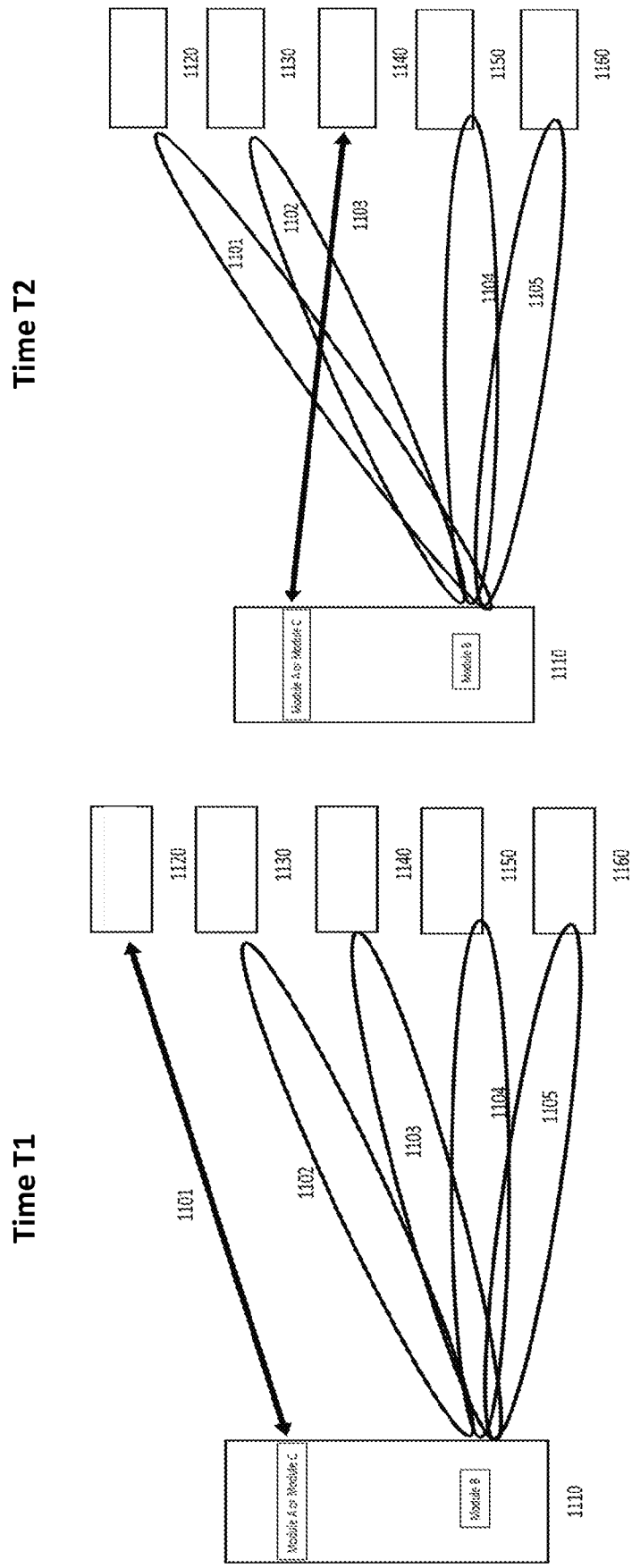


Fig 11

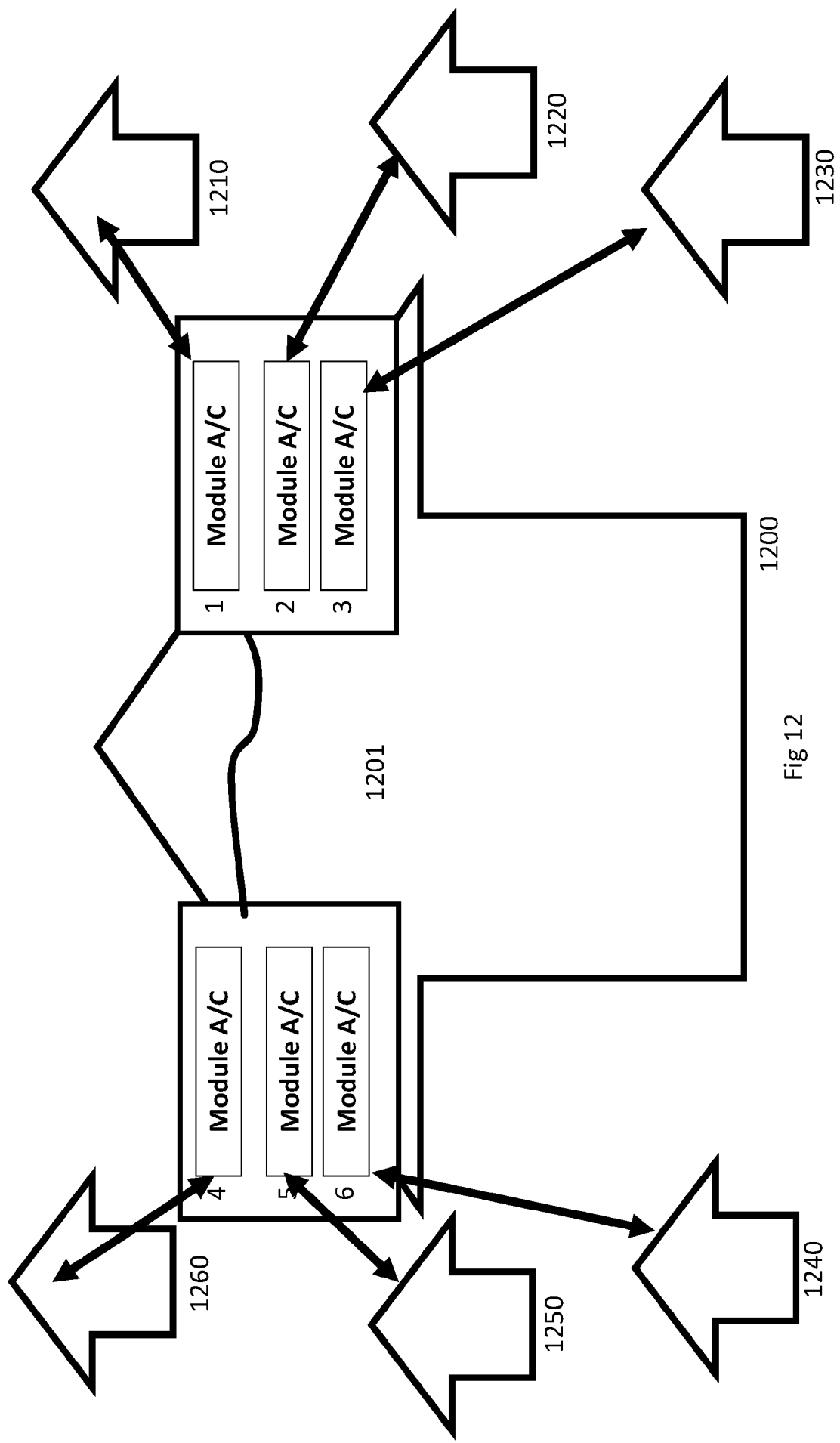


Fig 12

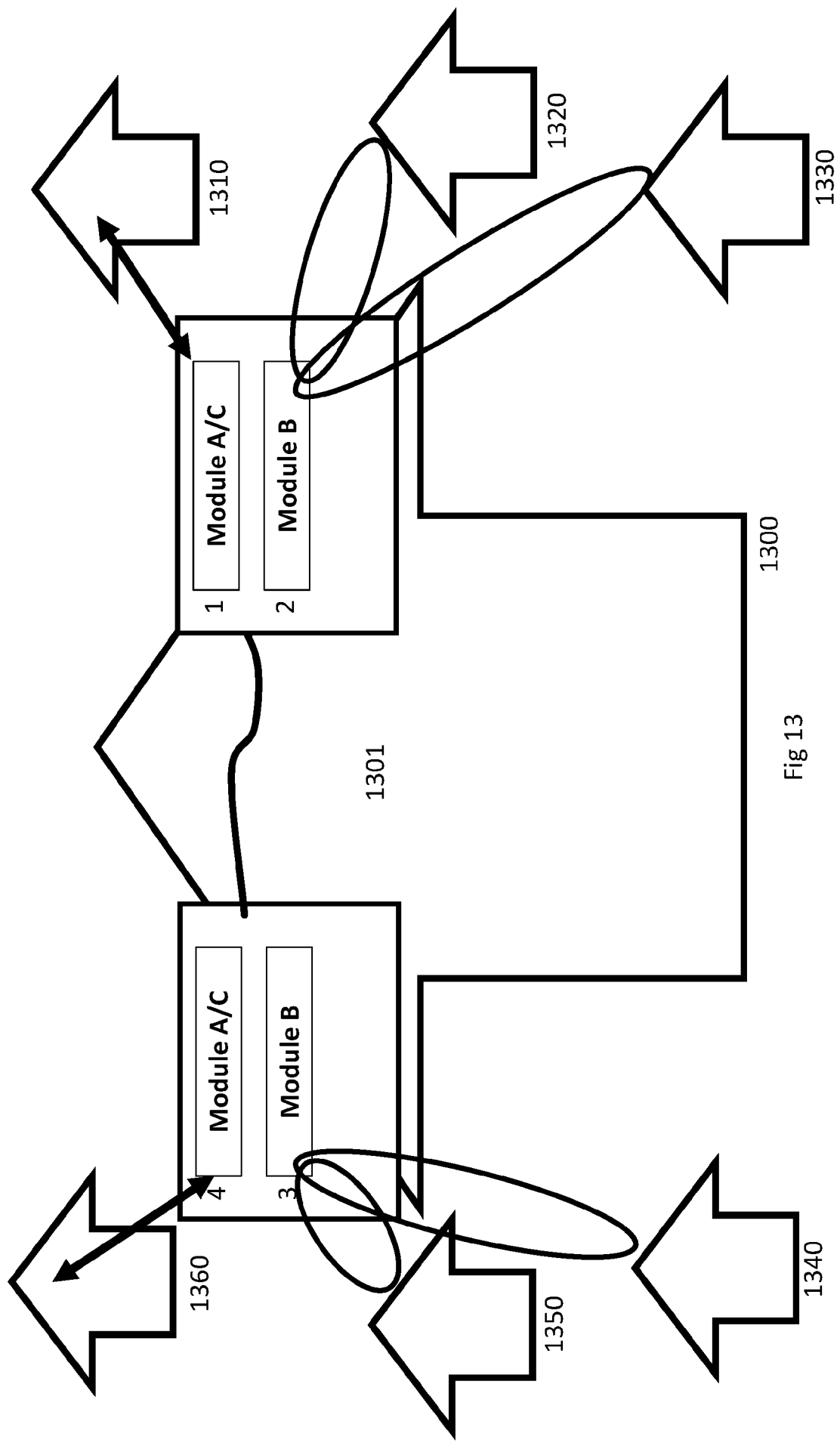


Fig 13

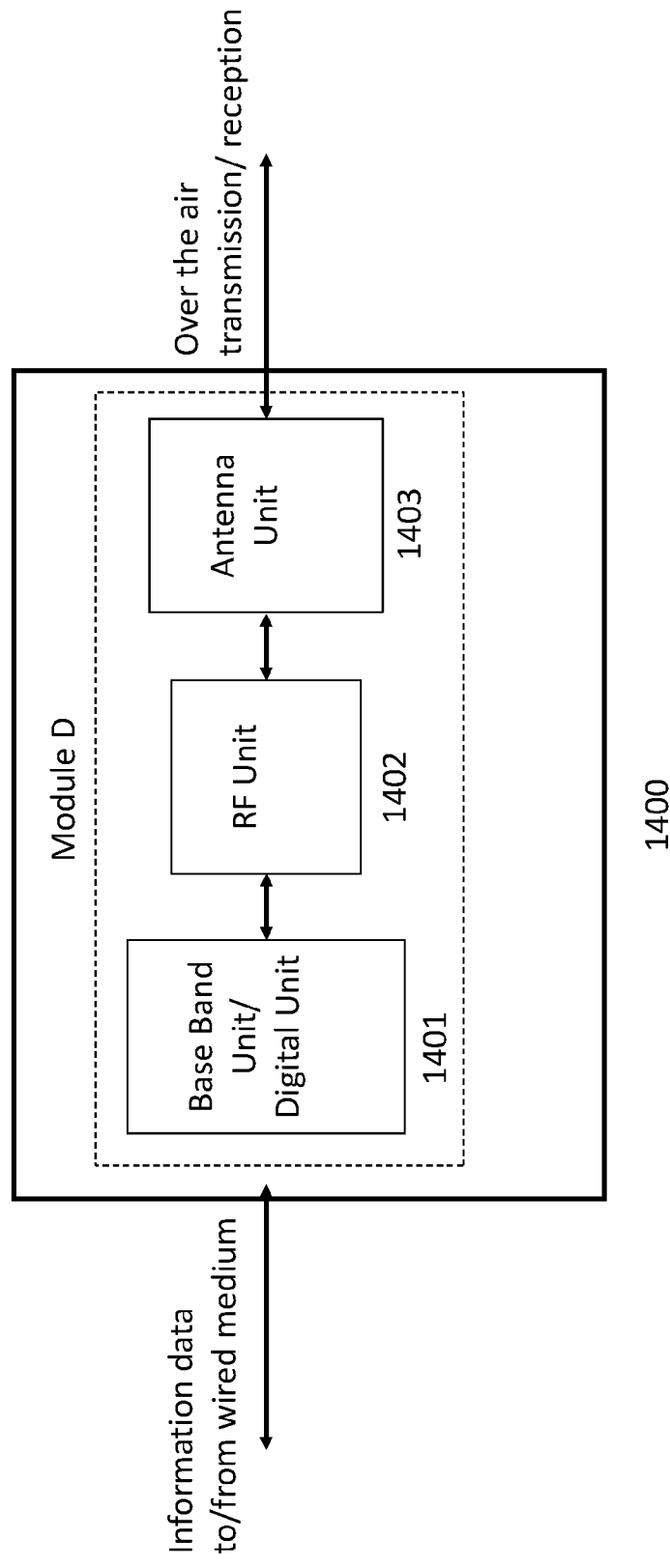


Fig 14

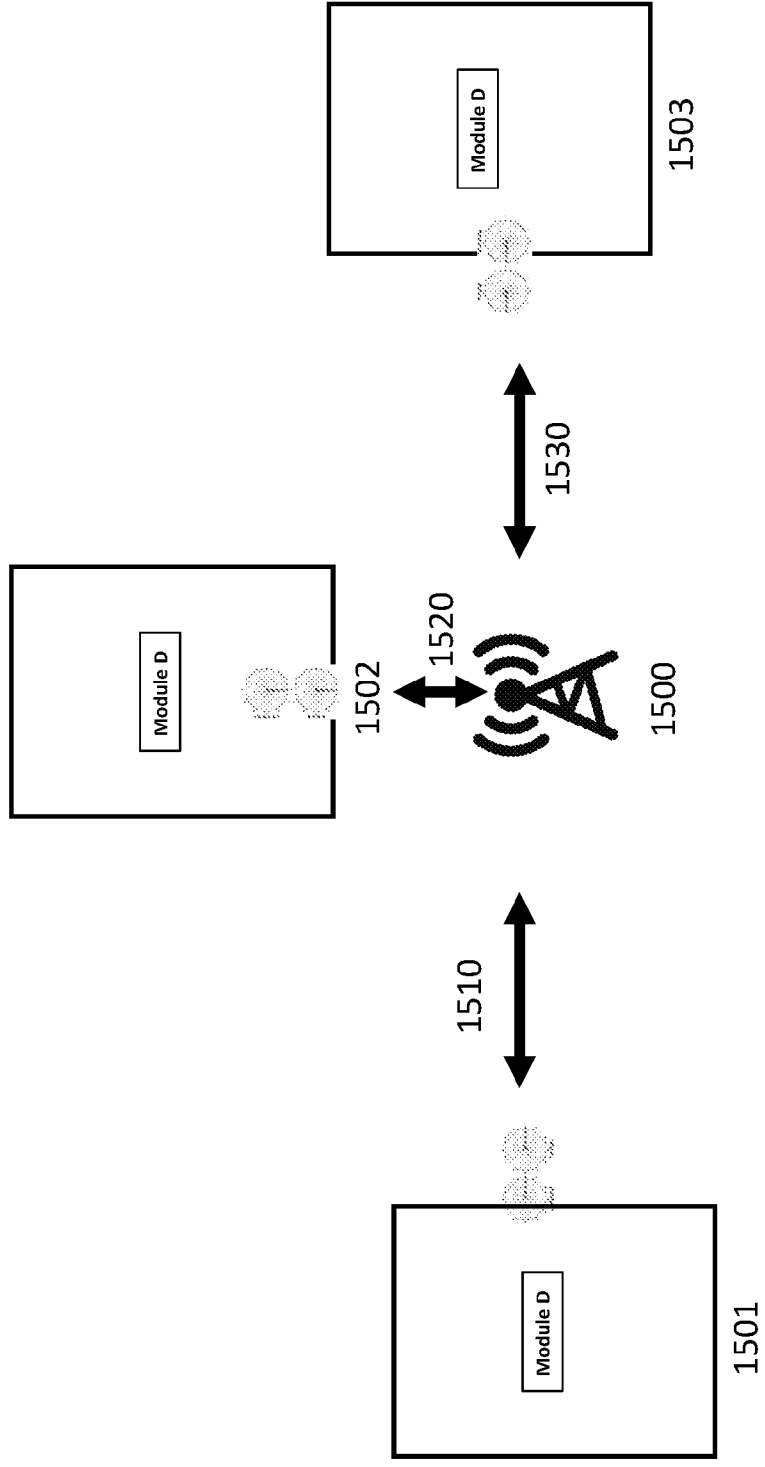


Fig 15

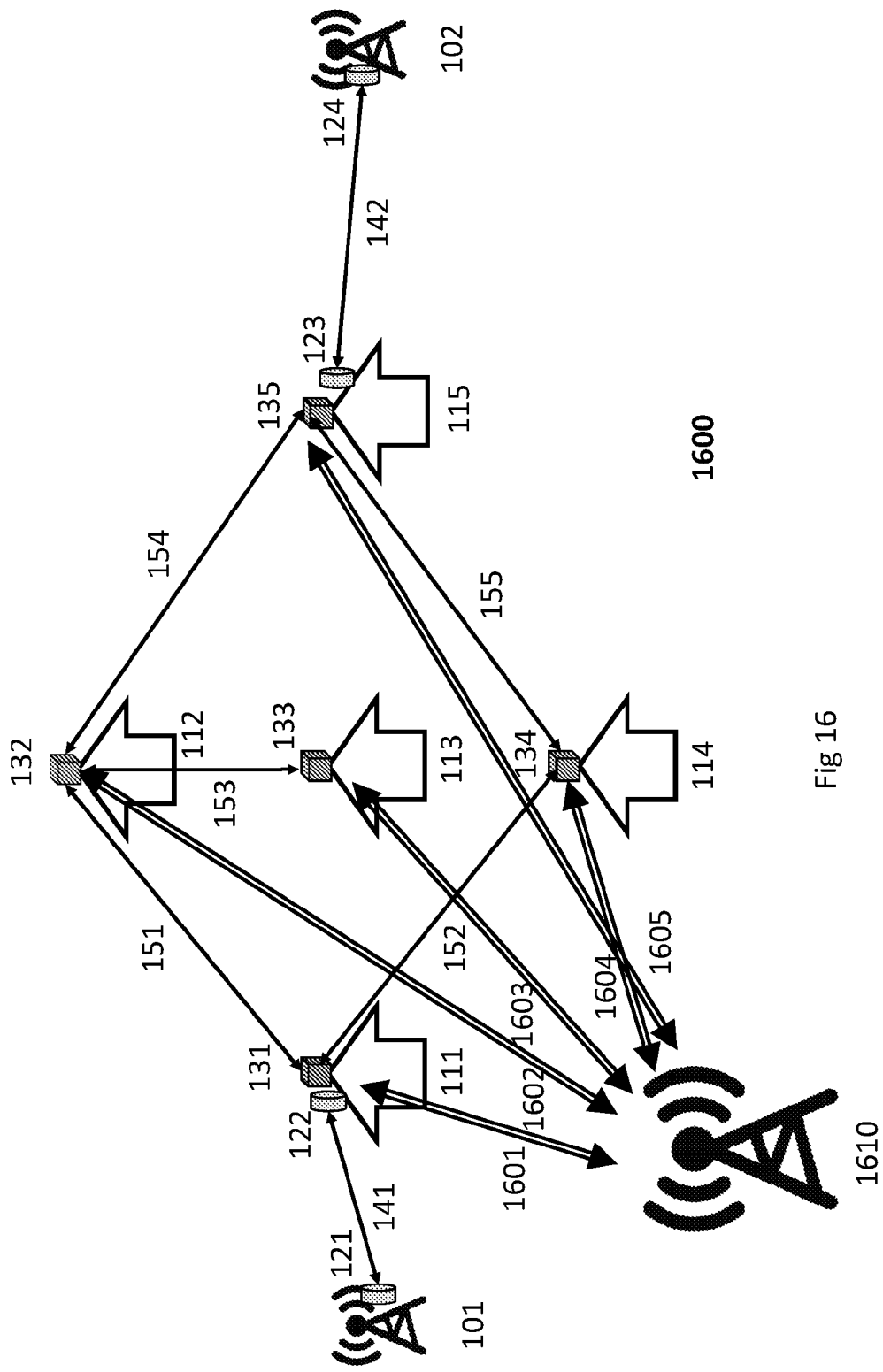


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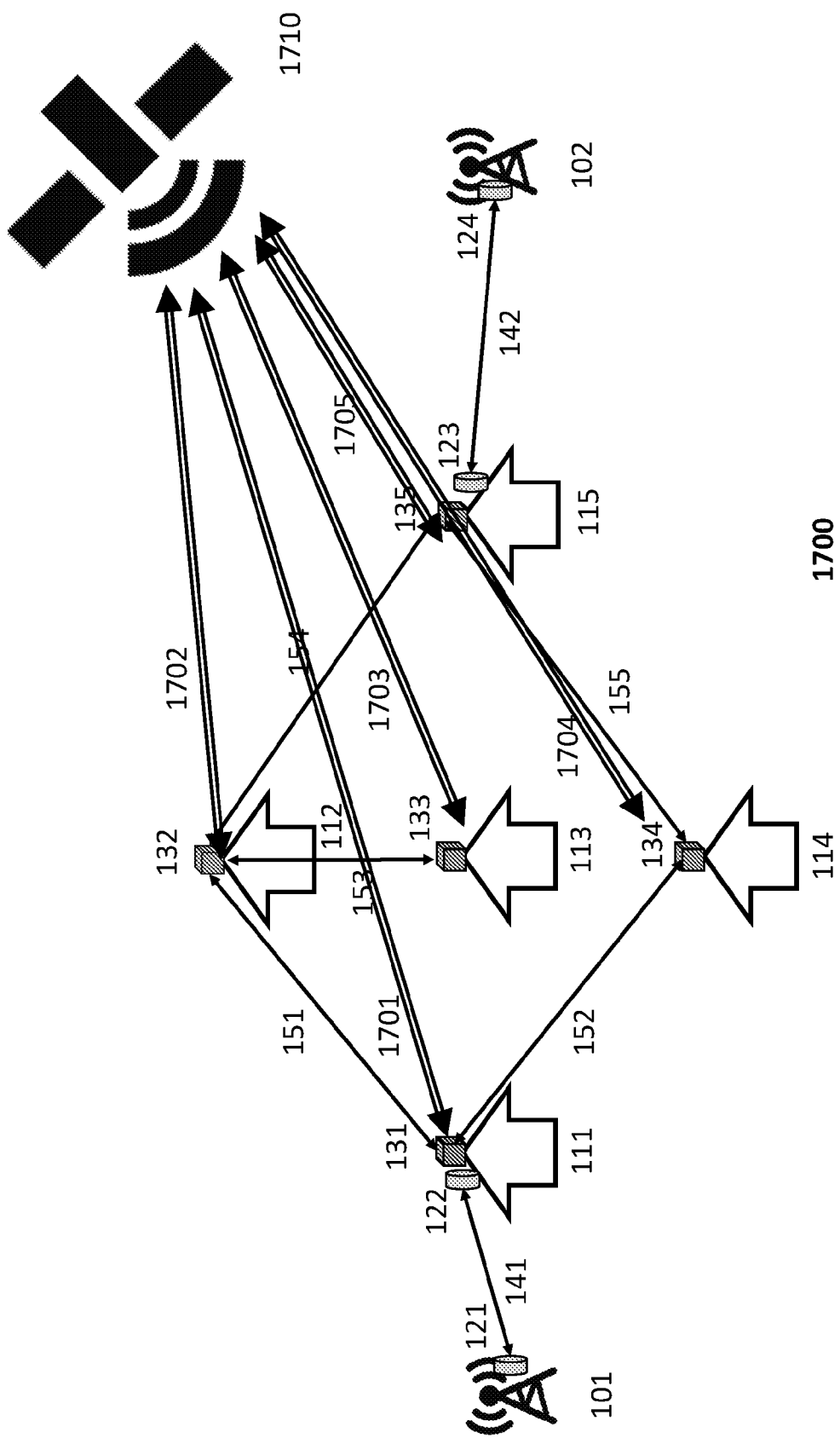
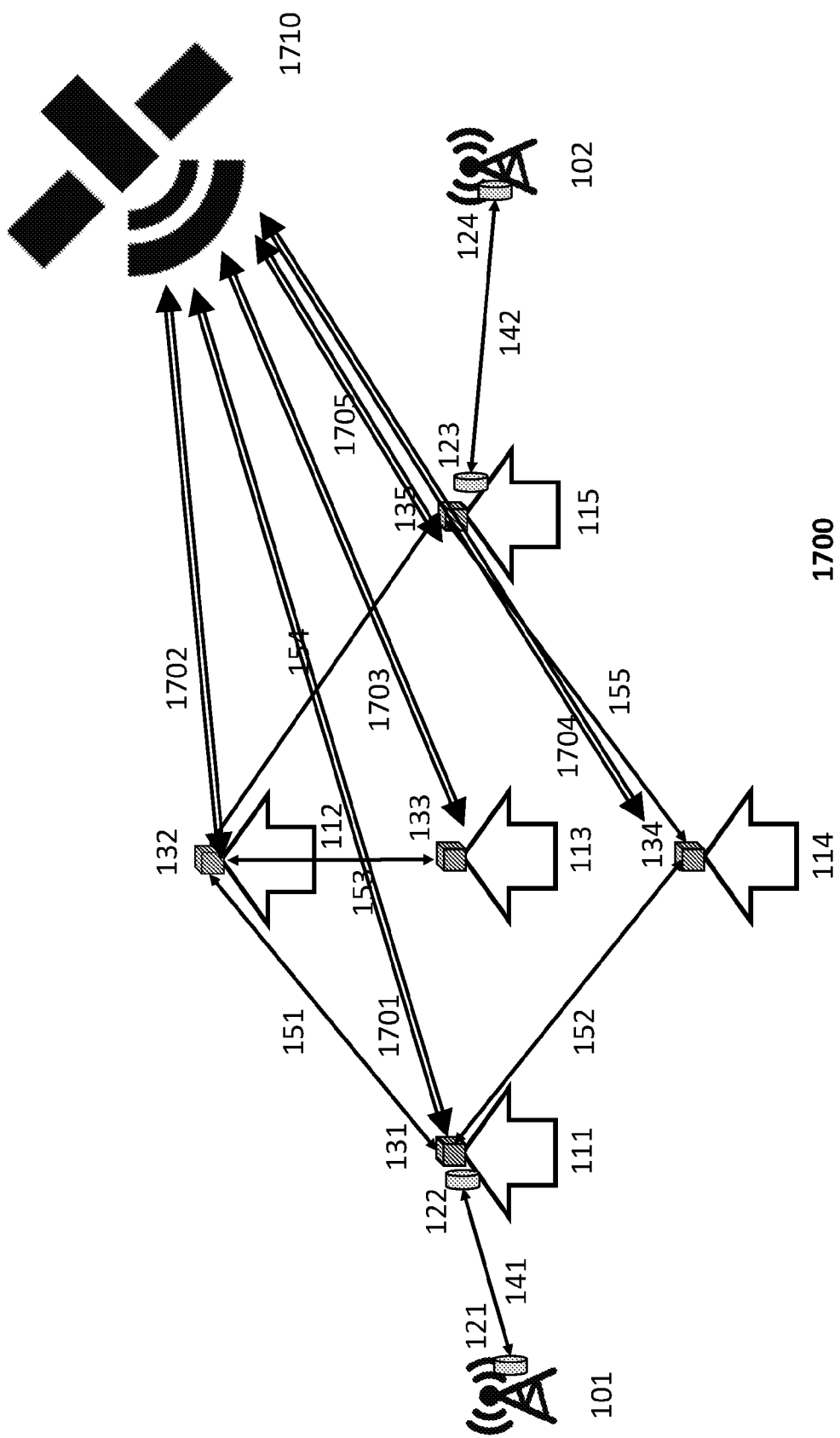


Fig 17

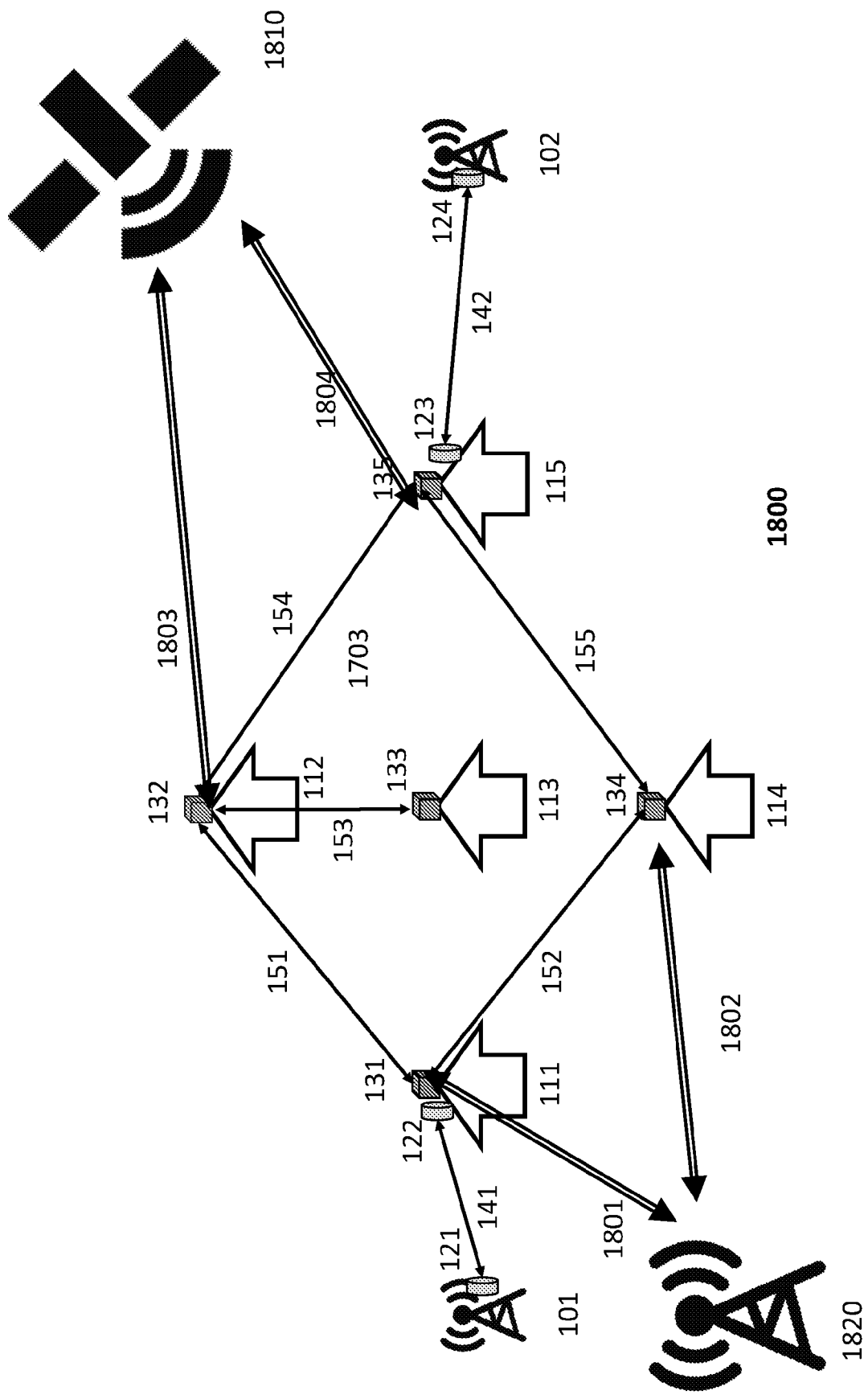


Fig 18

Electronic Acknowledgement Receipt

EFS ID:	33144578
Application Number:	62696688
International Application Number:	
Confirmation Number:	7976
Title of Invention:	METHODS FOR BUILDING WIRELESS MESH NETWORK
First Named Inventor/Applicant Name:	Kevin Ross
Customer Number:	130085
Filer:	Rory Patrick Shea
Filer Authorized By:	
Attorney Docket Number:	Naim-00007
Receipt Date:	11-JUL-2018
Filing Date:	
Time Stamp:	17:56:00
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 140
RAM confirmation Number	071218INTEFSW17581200
Deposit Account	506632
Authorized User	Rory Shea
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	Naim-00007_POA-ForFiling.pdf	842096	no	3
			ba5086ecd323e384d607375b1d4245e6c7c50aec		
Warnings:					
Information:					
2	Provisional Cover Sheet (SB16)	Naim-00007_ProvCoverSheet.pdf	2032308	no	3
			53af13e92f41bfdc0205fa82340abc64897c47a4		
Warnings:					
Information:					
3	Application Data Sheet	Naim-00007_ADS.pdf	1255718	no	8
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4		WeLink_Provisional_Patent_Final.pdf	215138	yes	37
			93e492c88820fce2fefe37998d6ad950fd169651		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	36	
	Abstract		37	37	
Warnings:					
Information:					
5	Drawings-only black and white line drawings	Welink_patent_figures_Final2-ForFiling.pdf	343369	no	18
			3edd4bdbaf0638d626d542a6160622285aa0b2a7		
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Information:					

6	Fee Worksheet (SB06)	fee-info.pdf	29735 1959d2ae5fde2cc719841e5ebfe01e791c899773	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			4718364		
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