Doc Code: TRACK1.REQ
Document Description: TrackOne Request

PTO/AIA/424 (04-14)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

First Named Inventor:	Marcus DA SILVA	Nonprovisional Application Number (if known):	
Title of Invention:	DIRECTED WIRELESS COMMUNICATION		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently $0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.

3. The applicable box is checked below:

I. ☑ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, **or** the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /Nicholas R. Transier/	Date April 12, 2017
Name (Print/Typed) Nicholas R. TRANSIER	Practitioner Registration Number 68743

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☑ *Total of 1 forms are submitted.

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.

Doc code: Oath
Document Description: Oath or declaration filed

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SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	Directed Wireless Communication

This statement is directed to:

[ ] The attached application,

OR

[x] United States application or PCT international application number 13/855,410 filed on 04/02/2013.

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

Marcus Da Silva

Residence (except for a deceased or legally incapacitated inventor):

Spokane	WA	United States of America
City	State	Country

Mailing Address (except for a deceased or legally incapacitated inventor):

5510 East 25th

Spokane	WA	99223	United States of America
City	State	Zip	Country

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Relationship to the inventor to whom this substitute statement applies:

[ ] Legal Representative (for deceased or legally incapacitated inventor only),

[x] Assignee,

[ ] Person to whom the inventor is under an obligation to assign,

[ ] Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or

[ ] Joint Inventor.

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SUBSTITUTE STATEMENT

Circumstances permitting execution of this substitute statement:

- [ ] Inventor is deceased,
- [ ] Inventor is under legal incapacity,
- [x] Inventor cannot be found or reached after diligent effort, or
- [ ] Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- [x] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

- [ ] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

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 the 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.

PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name:	Date (Optional):
Kai Hansen	

Signature: 

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: XR Communications, LLC D/B/A Vivato Technologies

Title of Person Executing This Substitute Statement:

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City	State	Country
San Diego	CA	United States of America

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

6260 Sequence Drive; Suite 100

City	State	Zip	Country
San Diego	CA	92121	United States of America

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

Doc code: Oath
Document Description: Oath or declaration filed

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SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	Directed Wireless Communication

This statement is directed to:

[ ] The attached application,

OR

[X] United States application or PCT international application number 13/855,410 filed on 04/02/2013.

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

William J. Crilly, Jr.

Residence (except for a deceased or legally incapacitated inventor):

Liberty Lake	WA	United States of America
City	State	Country

Mailing Address (except for a deceased or legally incapacitated inventor):

23825 E. 2nd Avenue Ct.

Liberty Lake	WA	99019	United States of America
City	State	Zip	Country

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Relationship to the inventor to whom this substitute statement applies:

[ ] Legal Representative (for deceased or legally incapacitated inventor only),

[X] Assignee,

[ ] Person to whom the inventor is under an obligation to assign,

[ ] Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or

[ ] Joint Inventor.

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SUBSTITUTE STATEMENT

Circumstances permitting execution of this substitute statement:

- [ ] Inventor is deceased,
- [ ] Inventor is under legal incapacity,
- [x] Inventor cannot be found or reached after diligent effort, or
- [ ] Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- [x] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

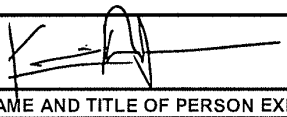
- [ ] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

WARNING:

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PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name:	Date (Optional):
Kai Hansen	

Signature: 

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: XR Communications, LLC D/B/A Vivato Technologies

Title of Person Executing This Substitute Statement:

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City	State	Country
San Diego	CA	United States of America

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

6260 Sequence Drive; Suite 100

City	State	Zip	Country
San Diego	CA	92121	United States of America

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

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

Title of Invention	Directed Wireless Communication

As the below named inventor, I hereby declare that:

This declaration is directed to:
- [ ] The attached application, or
- [x] United States application or PCT international application number 13/855,410 filed on April 2, 2013 .

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

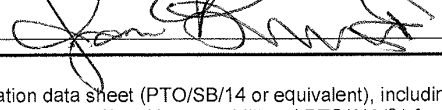
I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: James Brennan Date (Optional): Nov. 5, 2015

Signature: 

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

Doc code: Oath
Document Description: Oath or declaration filed

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SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	Directed Wireless Communication

This statement is directed to:

[ ] The attached application,

OR

[x] United States application or PCT international application number 13/855,410 filed on 04/02/2013.

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

Robert J. Conley

Residence (except for a deceased or legally incapacitated inventor):

Liberty Lake	WA	United States of America
City	State	Country

Mailing Address (except for a deceased or legally incapacitated inventor):

23326 E. 2nd Avenue

Liberty Lake	WA	99019	United States of America
City	State	Zip	Country

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Relationship to the inventor to whom this substitute statement applies:

[ ] Legal Representative (for deceased or legally incapacitated inventor only),

[x] Assignee,

[ ] Person to whom the inventor is under an obligation to assign,

[ ] Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or

[ ] Joint Inventor.

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SUBSTITUTE STATEMENT

Circumstances permitting execution of this substitute statement:

- [ ] Inventor is deceased,
- [ ] Inventor is under legal incapacity,
- [x] Inventor cannot be found or reached after diligent effort, or
- [ ] Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- [x] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

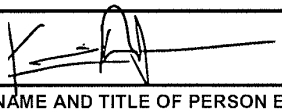
- [ ] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

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PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name:	Date (Optional):
Kai Hansen	

Signature: 

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: XR Communications, LLC D/B/A Vivato Technologies

Title of Person Executing This Substitute Statement:

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City	State	Country
San Diego	CA	United States of America

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

6260 Sequence Drive; Suite 100

City	State	Zip	Country
San Diego	CA	92121	United States of America

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

Doc code: Oath
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SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	Directed Wireless Communication

This statement is directed to:

☐ The attached application,

OR

☒ United States application or PCT international application number 13/855,410 filed on 04/02/2013.

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

Siavash Alamouti

Residence (except for a deceased or legally incapacitated inventor):

Spokane	WA	United States of America
City	State	Country

Mailing Address (except for a deceased or legally incapacitated inventor):

2123 West 1st Ave., Apt 3

Spokane	WA	99204	United States of America
City	State	Zip	Country

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

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☒ Assignee,

☐ Person to whom the inventor is under an obligation to assign,

☐ Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or

☐ Joint Inventor.

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SUBSTITUTE STATEMENT

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- [ ] Inventor is under legal incapacity,
- [x] Inventor cannot be found or reached after diligent effort, or
- [ ] Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- [x] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

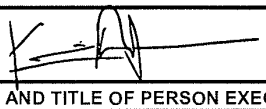
- [ ] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

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PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name:	Date (Optional):
Kai Hansen	

Signature: 

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: XR Communications, LLC D/B/A Vivato Technologies

Title of Person Executing This Substitute Statement:

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City	State	Country
San Diego	CA	United States of America

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

6260 Sequence Drive; Suite 100

City	State	Zip	Country
San Diego	CA	92121	United States of America

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

Doc code: Oath
Document Description: Oath or declaration filed

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SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	Directed Wireless Communication

This statement is directed to:

☐ The attached application,

OR

☒ United States application or PCT international application number 13/855,410 filed on 04/02/2013.

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

Eduardo Casas

Residence (except for a deceased or legally incapacitated inventor):

Vancouver	BC	Canada
City	State	Country

Mailing Address (except for a deceased or legally incapacitated inventor):

7542 Ontario Street

Vancouver		V5X3C2	Canada
City	State	Zip	Country

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Relationship to the inventor to whom this substitute statement applies:

☐ Legal Representative (for deceased or legally incapacitated inventor only),

☒ Assignee,

☐ Person to whom the inventor is under an obligation to assign,

☐ Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or

☐ Joint Inventor.

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SUBSTITUTE STATEMENT

Circumstances permitting execution of this substitute statement:

- [ ] Inventor is deceased,
- [ ] Inventor is under legal incapacity,
- [x] Inventor cannot be found or reached after diligent effort, or
- [ ] Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- [x] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

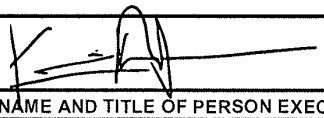
- [ ] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

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 the 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.

PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name:	Date (Optional):
Kai Hansen	

Signature: 

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: XR Communications, LLC D/B/A Vivato Technologies

Title of Person Executing
This Substitute Statement:

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City	State	Country
San Diego	CA	United States of America

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

6260 Sequence Drive; Suite 100

City	State	Zip	Country
San Diego	CA	92121	United States of America

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

Doc code: Oath
Document Description: Oath or declaration filed

PTO/AIA/02 (07-13)
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SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	Directed Wireless Communication

This statement is directed to:

[ ] The attached application,

OR

[X] United States application or PCT international application number 13/855,410 filed on 04/02/2013.

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

Hujun Yin

Residence (except for a deceased or legally incapacitated inventor):

Spokane	WA	United States of America
City	State	Country

Mailing Address (except for a deceased or legally incapacitated inventor):

2415 N. Cherry Street, Apt. 23

Spokane	WA	99216	United States of America
City	State	Zip	Country

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Relationship to the inventor to whom this substitute statement applies:

[ ] Legal Representative (for deceased or legally incapacitated inventor only),

[X] Assignee,

[ ] Person to whom the inventor is under an obligation to assign,

[ ] Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or

[ ] Joint Inventor.

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SUBSTITUTE STATEMENT

Circumstances permitting execution of this substitute statement:

- [ ] Inventor is deceased,
- [ ] Inventor is under legal incapacity,
- [x] Inventor cannot be found or reached after diligent effort, or
- [ ] Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- [x] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

- [ ] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

WARNING:

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PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name:	Date (Optional):
Kai Hansen	

Signature: 

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: XR Communications, LLC D/B/A Vivato Technologies

Title of Person Executing This Substitute Statement:

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City	State	Country
San Diego	CA	United States of America

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6260 Sequence Drive; Suite 100

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

Title of Invention	Directed Wireless Communication

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [ ] The attached application, or
- [x] United States application or PCT international application number 13/855,410 filed on April 2, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: Bobby Jose Date (Optional): 21 NOV 2015

Signature:

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

PTO/AIA/01 (06-12)
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	Directed Wireless Communication

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- [ ] The attached application, or
- [x] United States application or PCT international application number 13/855,410 filed on April 2, 2013.

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LEGAL NAME OF INVENTOR

Inventor: Yang-Seok Choi Date (Optional): _____

Signature: _____

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

PTO/AIA/01 (06-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	Directed Wireless Communication

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [ ] The attached application, or
- [x] United States application or PCT international application number 13/855,410 filed on April 2, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

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LEGAL NAME OF INVENTOR

Inventor: Vahid Tarokh Date (Optional): 11/02/2015

Signature: Vahid Tarokh

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	Directed Wireless Communication

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [ ] The attached application, or
- [x] United States application or PCT international application number 13/855,410 filed on April 2, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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 the 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.

LEGAL NAME OF INVENTOR

Inventor: Praveen Mehrotra Date (Optional): 11/05/2015

Signature: Praveen

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	
Filing Date	Herewith
First Named Inventor	Marcus DA SILVA
Title	Directed Wireless Communication
Art Unit	
Examiner Name	
Attorney Docket Number	

SIGNATURE of Applicant or Patent Practitioner

Signature	/Nicholas R. Transier/	Date (Optional)	
Name	Nicholas R. TRANSIER	Registration Number	68743
Title (if Applicant is a juristic entity)	Attorney of Record		
Applicant Name (if Applicant is a juristic entity)	XR Communications, LLC D/B/A Vivato Technologies		

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

☑ *Total of 1 forms are submitted.

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

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

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 11/30/2014. OMB 0651-0031
U.S. Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE
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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: 114581

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)

XR Communications, LLC D/B/A Vivato Technologies

☐ 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)	1-24-14
Name	Karl Hansen		
Title	Managing Member, XR Communications, LLC D/B/A Vivato Technologies		

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.

PTO/SB/08a (03-15)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Marcus DA SILVA
Art Unit	TBD
Examiner Name	TBD
Attorney Docket Number	E1027.800(T).US1D1C1D1C1

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4231040		1980-10-28	Walker	
	2	5327143		1994-07-05	Goetz et al.	
	3	5771017		1998-06-23	Dean et al.	
	4	5809141		1998-09-15	Dent et al.	
	5	5987037		1999-11-16	Gans	
	6	6049307		2000-04-11	Lim	
	7	6091788		2000-07-18	Keskitalo et al.	
	8	6104935		2000-08-15	Smith et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Marcus DA SILVA
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	E1027.800(T).US1D1C1D1C1

	9	6108323		2000-08-22	Gray	
	10	6141335		2000-10-31	Kuwahara et al.	
	11	6169910		2001-01-02	Tamil et al.	
	12	6311075		2001-10-30	Bevan et al.	
	13	6337659		2002-01-08	Kim	
	14	6438376		2002-08-20	Elliott et al.	
	15	6470195		2002-10-22	Meyer	
	16	6611695		2003-08-26	Periyalwar	
	17	6628235		2003-09-30	Wight	
	18	6631277		2003-10-07	Berg et al.	
	19	6850741		2005-02-01	Lei et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Marcus DA SILVA
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	E1027.800(T).US1D1C1D1C1

	20	6907269		2005-06-14	Yamaguchi et al.	
	21	7346365		2008-03-18	Hovers et al.	
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	First Named Inventor	Marcus DA SILVA
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	E1027.800(T).US1D1C1D1C1

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	1	9921391	WO	A2	1999-04-29	Radio Design Innovation Tj Ab		

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	1	Anastasi, et. al., "MAC Protocols for Widcband Wireless Local Access: Evolution Towards Wireless ATM", IEEE Personal Communications Magazine, pp. 53-64, Oct. 1998.	
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	Filing Date	
	First Named Inventor	Marcus DA SILVA
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	E1027.800(T).US1D1C1D1C1

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Application No.:	To be assigned
Filing Date:	Herewith
Title:	DIRECTED WIRELESS COMMUNICATION
Examiner:	To be assigned
Art Unit:	To be assigned
Confirmation No.:	To be assigned

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Dear Sir:

Pursuant to 37 C.F.R. § 1.56, 1.97 and 1.98, the attention of the United States Patent and Trademark Office is hereby directed to the references listed on the attached PTO/SB/08. It is respectfully requested that the information be expressly considered during the prosecution of the above-identified application, and that the references be made of record therein and appear among the "References Cited" on any patent to issue therefrom.

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Respectfully submitted,

EIP US LLP

Dated: April 12, 2017

By: / Nicholas R. Transier /

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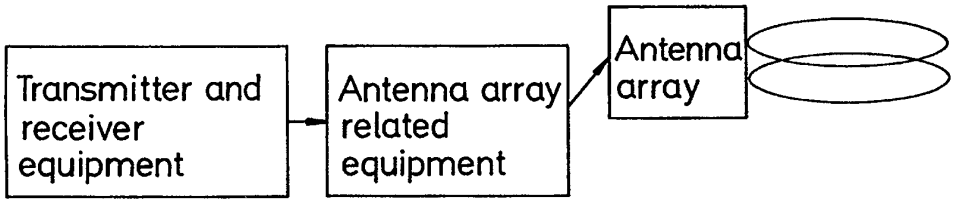
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(54) Title: SEAMLESS LOBE HANDOVER



(57) Abstract

The present invention relates to a method in a telecommunication system for communication between mobile stations and base station sites in the telecommunication system. The mobile stations in said telecommunication system, preferably a cellular mobile radio system, move within a site on the same channel by use of seamless lobe or sector handover.

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APPLICANT: RADIO DESIGN INNOVATION TJ AB
TITLE OF INVENTION: SEAMLESS LOBE HANDOVER

Field of invention

The present invention relates to a method in a telecommunication system for communication between mobile stations and at least one base station site in said telecommunication system.

Prior art

Figure 1 discloses a schematic diagram of a flexible lobe shaping system. The antenna array has preferably eight antenna elements.

Each frequency channel has its own set of weights (e.g. $W_1(1) - W_8(1)$ in Figure 1). The number of these weights is determined by the number of antenna elements used.

The number of weight sets is determined by the number of simultaneously channels. Each frequency channel has one set of weights and if SDMA (Spatial Division Multiple Access) is used there must be several weight settings for each frequency channel.

No. Of weight sets = No. of frequency channels × SDMA factor.

No. of complex weights = No. of frequency channels × SDMA factor × number of antenna elements.

The lobe shaping system of Figure 1 is described in detail in the pending applications 9601613-4 (Method and Arrangement of Converting a Cellular Telecommunication System, Applicant: Radio Design AB), 9601615-9 (Rotating Lobe Access Method, Applicant: Radio Design AB) and 9601614-2 (Antenna System, Applicant: Radio Design AB) , which applications are incorporated herein by reference.

A problem with this flexible lobe shaping system is that it is very expensive to implement since much equipment is used.

A less hardware-consuming and thus less expensive solution is the fixed lobe-shaping system as can be seen in Figure 2.

The object of this invention is to avoid the changing of channel when hand-over is carried out in for example the above mentioned fixed lobe-shaping system.

CONFIRMATION COPY

Another object of the invention is to avoid the changing of receiver/transmitter equipment in the base station site.

Brief description of the invention

The above object is achieved by means of a method in a telecommunication system for communication between mobile stations and at least one base station site in said telecommunication system, wherein said mobile stations move within said base station site on a channel by use of seamless lobe/sector handover.

Handover without changing transmitter/receiver equipment implies increased capacity since it results in better trunking efficiency at the base station site.

Other features of the invention are set out in the dependent claims.

Brief description of the drawings

Figure 1 is a flexible lobe-shaping system;

Figure 2 is a fixed lobe-shaping system according to the invention;

Figure 3 is a block diagram of the system in Figure 2;

Figure 4 discloses adjacent fixed lobes with three excited antenna panels according to the invention;

Figure 5 discloses a base station site with three sectors comprising one lobe each, and with one antenna per sector;

Figure 6 discloses a base station site according to the invention with three sectors comprising five lobes each, and one antenna array per sector;

Figure 7 discloses a base station site according to the invention with three sectors comprising five lobes each, and one antenna array for all sectors;

Figure 8 discloses a base station site according to the invention with one sector comprising fifteen lobes and one antenna array for said sector;

Figures 9-12 disclose different structures of the lobe shaping system according to the invention.

Detailed description of an embodiment of the invention

The invention preferably refers to handover between lobes without changing channel. This implies that the mobile terminal can move within a site on the same channel by use of seamless lobe handover. The handover is seamless in the meaning that it can not be noted by the mobile user.

The invention will now be described with reference to Figures 3-12.

Figure 2 discloses an implementation of the block diagram in Figure 3. TRX in Figure 2 corresponds to transmitter and receiver equipment in Figures 3, 9-12. LF1 – LFn and the antennas in Figure 2 correspond to the Antenna array related equipment and the antenna array in Figures 3, 10, 12, respectively.

The cellular mobile radio system of the invention includes several base

station sites and mobile stations (terminals). Each base station site has one or more sectors divided into a number of fixed lobes (Figures 4-8). The base station site comprises base stations with base station transmitter equipment and a base station receiver equipment. The mobile station comprises a mobile station receiver and a mobile station transmitter. The communication in the cellular mobile radio system between a base station site and a mobile station is achieved by the following steps. As mentioned above each base station site uses a number of fixed lobes (Figures 4-8) in accordance with Figures 2, 3, 9-12. A connection is established between the base station site transmitter/receiver equipment and a mobile station. One of the lobes in one of the sectors of the base station site is used for transmission of signals between base station site transmitter/receiver and mobile station transmitter/receiver. The base station site continuously measures the signals received from the mobile station. For example the base station site determines the best lobe by comparing the signal received in actual lobe with signal received in alternative lobes. This can be carried out by comparing received signal strength or by comparing received signal to interference ratio in each lobe.

This comparison between signal strengths etc. in the lobes may imply a handover between the lobes. When the handover is performed the base station site changes utilized lobe of the base station site to another lobe of the same base station site without changing the serving transmitter and receiver equipment, i.e. the base station site uses the same transmitter/receiver equipment for the new lobe.

In another embodiment of the invention the base station site also changes transmitter/receiver equipment when changing lobe.

Thus, the channel is not changed when changing lobe. It should be realized that with channel we mean frequency, time slot, CDMA-coding etc. It should also be realized that instead of effecting handover between lobes as mentioned above, handover between sectors can also be achieved in the same manner.

A number of different handover situations will now be described with reference particularly to Figures 5-12. First the concept "base station site" will be explained with reference to Figure 6. The concept "base station site" in Figure 6 is defined as the covering area of the three sectors, and the base station site includes the three antenna arrays which normally are controlled by three base stations, i.e. one base station for each antenna array.

As mentioned above handover (HO) can be performed between different lobes and different sectors in a base station site. As disclosed in Figure 5 a base station site can consist of three different physical antennas, each connected to a base station, wherein handover can be performed between these antennas (base stations). This is the case in Figures 5, 11 in which lobe/sector handover is performed changing from sector 1 to sector 2. The transmitter/receiver equipment (TRX) controlling sector 1 is changed during handover to another transmitter/re-

ceiver equipment for sector 2. However, the same channel is used.

Another possibility is described in Figures 5, 9. In this case lobe/sector handover is performed changing from sector 1 to sector 2 but the same transmitter/receiver equipment of the base station site is used. The same channel or another channel can be used.

In Figures 3 and 6, lobe handover within a sector is performed without changing transmitter/receiver equipment. Same or changed channel can be used.

In Figures 6 and 12 sector/lobe handover is performed changing from one sector and corresponding TRX1 to another sector and corresponding TRX2. Same or changed channel can be used.

In Figures 3 and 7 lobe handover between lobes 4 and 5 is either performed within a sector or a lobe/sector handover is performed between sectors 6 and 7, wherein handover is performed from lobe 8 in sector 6 to lobe 9 in sector 7. In this case the same TRX equipment is used and the same or changed channel can be used.

In Figures 6, 10 lobe/sector handover is performed changing from one sector to another sector but the same transmitter/receiver equipment of the base station site is used.

The above is only to be considered as a preferable embodiment, and the scope of the invention is only limited by the following claims.

CLAIMS

1. A method in a telecommunication system for communication between mobile stations and at least one base station site in said telecommunication system, **characterized** in that said mobile stations move within said at least one base station site on a channel by use of seamless lobe handover.

2. A method as claimed in claim 1, **characterized** in that said telecommunication system includes said at least one base station site having one or more sectors each divided into a number of fixed lobes comprising the steps of:

- establishing a connection between a base station site transmitter/receiver equipment in said at least one base station site and a mobile station;

- transmitting signals from said base station site transmitter equipment to said mobile station receiver and transmitting signals from said mobile station transmitter to said base station site receiver equipment by utilizing one of said lobes in one of the sectors of said base station;

- changing said utilized lobe of said at least one base station site to another lobe of said at least one base station site without changing transmitter/receiver equipment of said base station site.

3. A method as claimed in claim 1, **characterized** in that said telecommunication system includes said at least one base station site having one or more sectors each divided into a number of fixed lobes comprising the steps of:

- establishing a connection between a base station site transmitter/receiver equipment in said at least one base station site and a mobile station;

- transmitting signals from said base station site transmitter equipment to said mobile station receiver and transmitting signals from said mobile station transmitter to said base station site receiver equipment by utilizing one of said lobes in one of the sectors of said base station;

- changing said utilized lobe and corresponding transmitter/receiver equipment (TRX1) of said at least one base station site to another lobe and corresponding transmitter/receiver equipment (TRX2) of said base station site.

4. A method as claimed in any of the preceding claims, **characterized** in that an antenna array and its supporting equipment is used to form fixed lobes.

5. A method as claimed in any of the preceding claims, **characterized** in that the channel is not changed when changing lobe.

6. A method as claimed in claim 5, **characterized** in that the change of the lobe is made without any signalling or channel order to and from said base station site to control the change of the lobe.

7. A method as claimed in any of claims 1-4, **characterized** in that said channel is changed when changing lobe.

8. A method as claimed in any of the preceding claims, **characterized** in that equipment in said base station site determines the best lobe by comparing signals

received in actual lobe with signals received in adjacent lobes.

9. A method as claimed in claim 8, **characterized** in that signals are compared by detecting received signal strength.

10. A method as claimed in claim 8, **characterized** in that signals are compared by evaluating received signal to interference ratio.

11. A method in a telecommunication system for communication between mobile stations and at least one base station site in said telecommunication system, **characterized** in that said mobile stations move within said at least one base station site on a channel by use of seamless sector handover.

12. A method as claimed in claim 11, **characterized** in that said telecommunication system includes said at least one base station site having a plurality of sectors comprising the steps of:

- establishing a connection between a base station site transmitter/receiver equipment in said at least one base station site and a mobile station;
- transmitting signals from said base station site transmitter to said mobile station receiver and transmitting signals from said mobile station transmitter to said base station site receiver equipment by utilizing one of the sectors in said base station site;
- changing utilized sector in said base station site to another sector in said base station site without changing transmitter/receiver equipment of said base station site.

13. A method as claimed in claim 11, **characterized** in that said telecommunication system includes said at least one base station site having a plurality of sectors comprising the steps of:

- establishing a connection between a base station site transmitter/receiver equipment and a mobile station;
- transmitting signals from said base station site transmitter to said mobile station receiver and transmitting signals from said mobile station transmitter to said base station site receiver equipment by utilizing one of the sectors in said base station site;
- changing utilized sector and corresponding transmitter/receiver equipment (TRX1) of said at least one base station site to another sector and corresponding transmitter/receiver equipment (TRX2) of said at least one base station site.

14. A method as claimed in any of claims 11-13, **characterized** in that said channel is not changed when changing sector.

15. A method as claimed in any of claims 11-14, **characterized** in that said change of sector is made without any signalling or channel order to and from said base station site to control said change of sector.

16. A method as claimed in any of claims 11-13, **characterized** in that said channel is changed when changing sector.

17. A method as claimed in any of claims 11-16, **characterized** in that equipment in said base station site determines the best sector by comparing signals received in actual sector with signals received in adjacent sectors.

18. A method as claimed in claim 17, **characterized** in that said signals are compared by detecting received signal strength.

19. A method as claimed in claim 17, **characterized** in that said signals are compared by evaluating received signal to interference ratio.

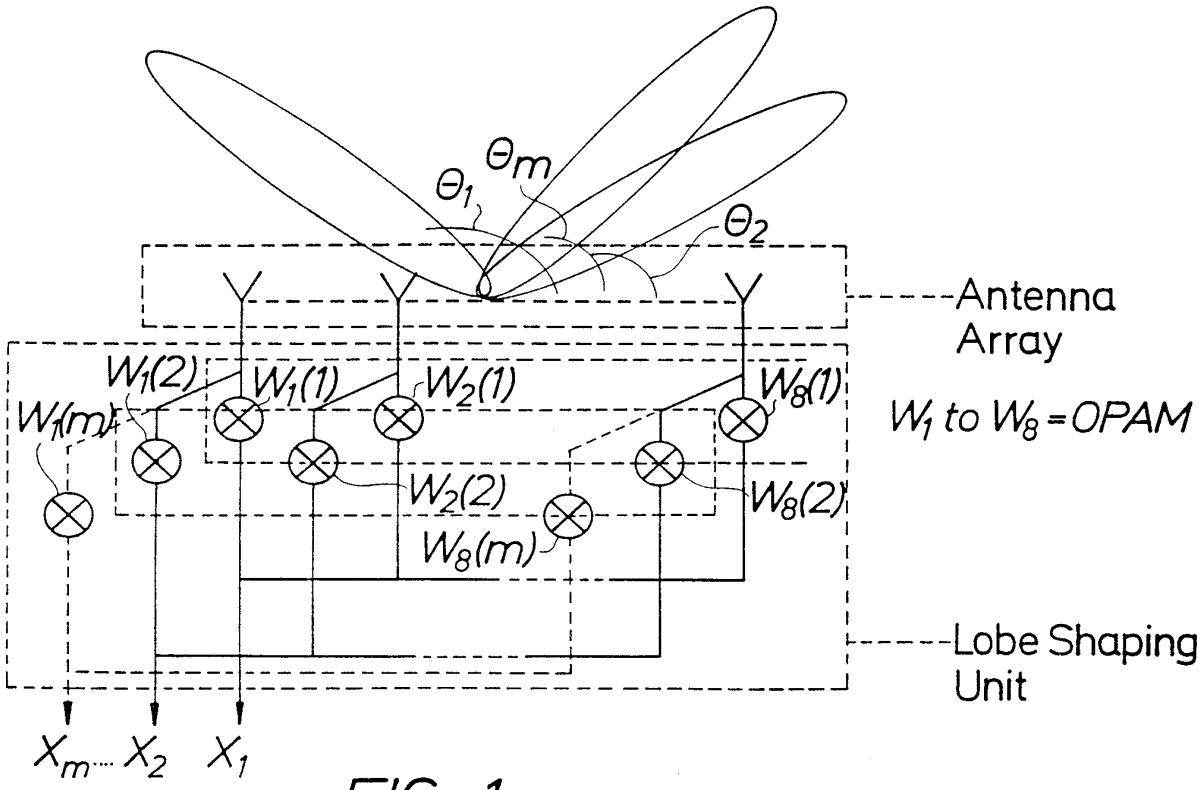

Θm
Θ1
Θ2
Antenna Array
W1(2)
W1(1)
W2(1)
W8(1)
W1(m)
W1 to W8 = OPAM
W2(2)
W8(2)
W8(m)
Lobe Shaping Unit
Xm
X2
X1

FIG. 1

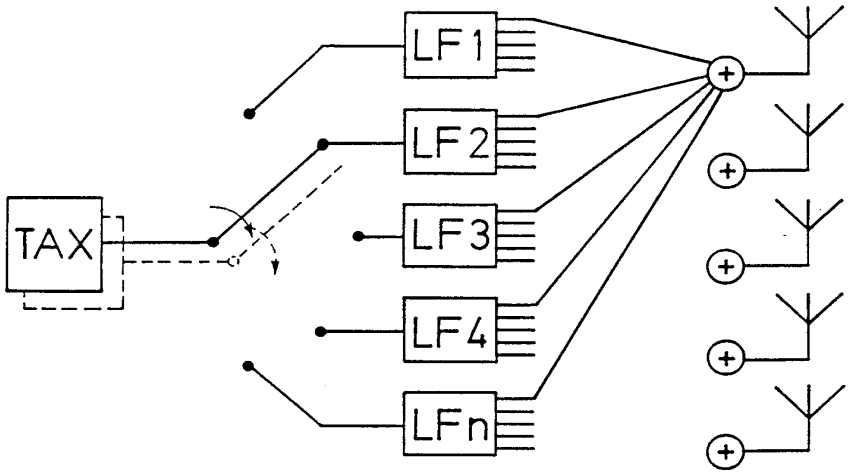

LF1
LF2
LF3
LF4
LFn
TAX

FIG. 2

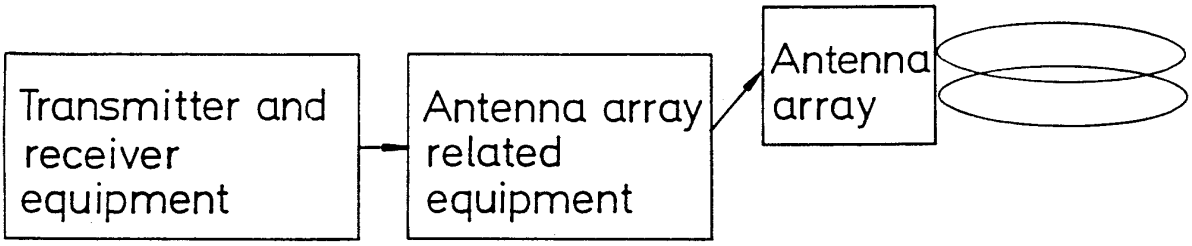

Transmitter and receiver equipment
Antenna array related equipment
Antenna array

FIG. 3

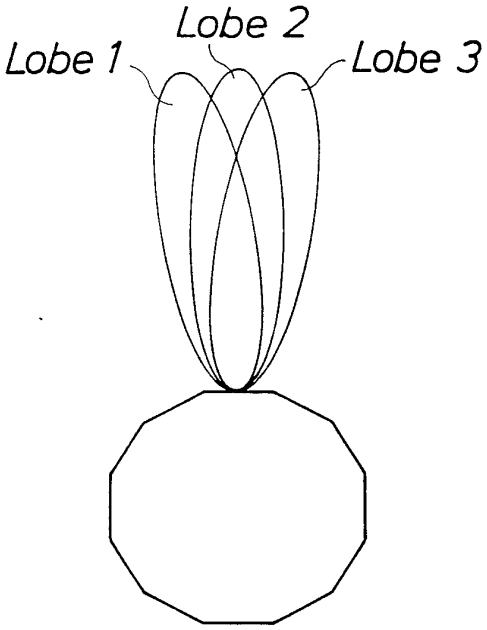

Lobe 1
Lobe 2
Lobe 3

FIG. 4

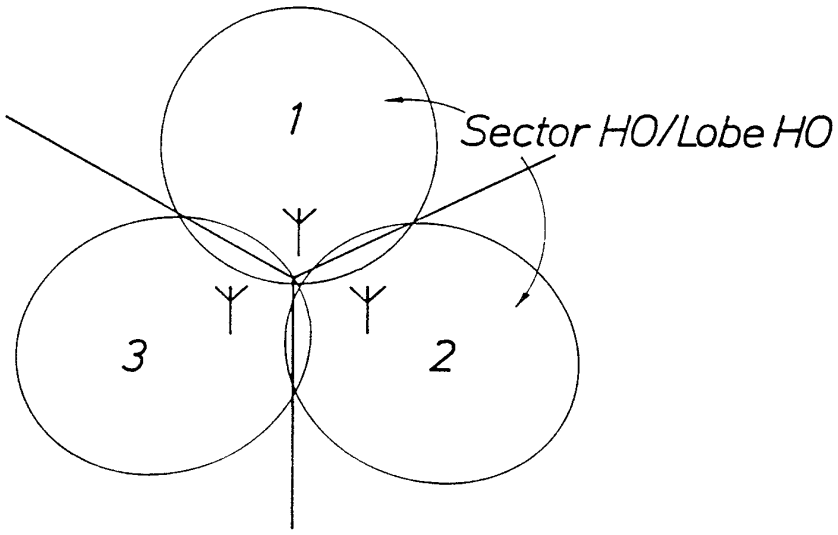


FIG. 5

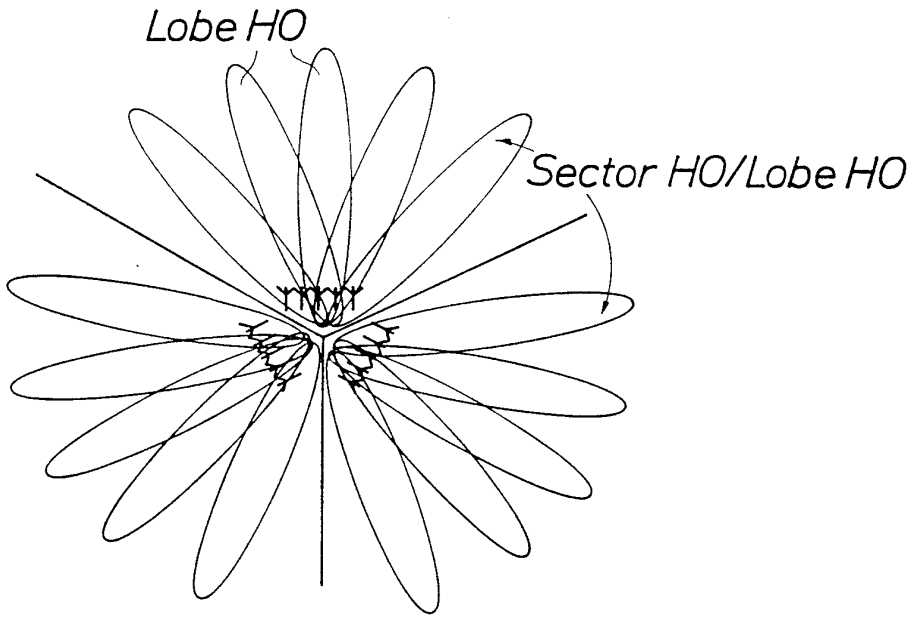


FIG. 6

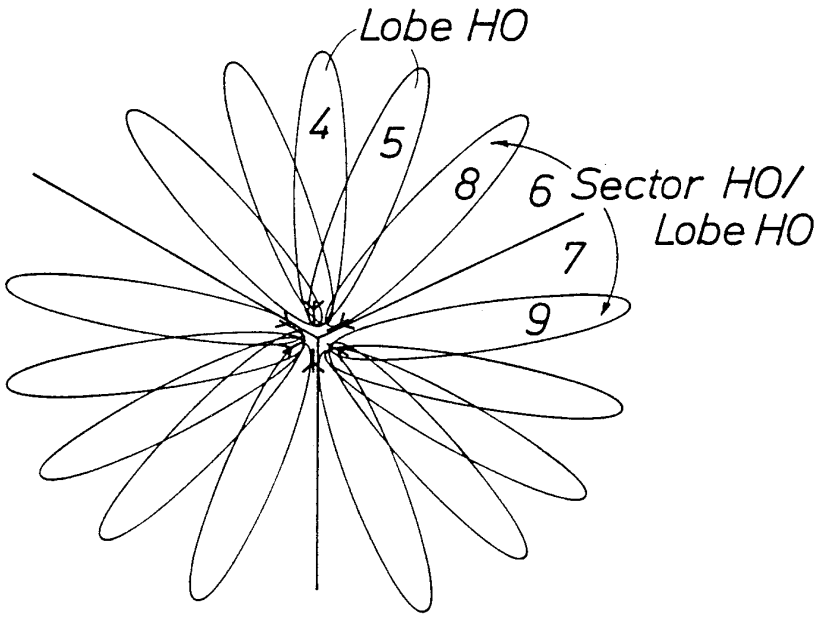


FIG. 7

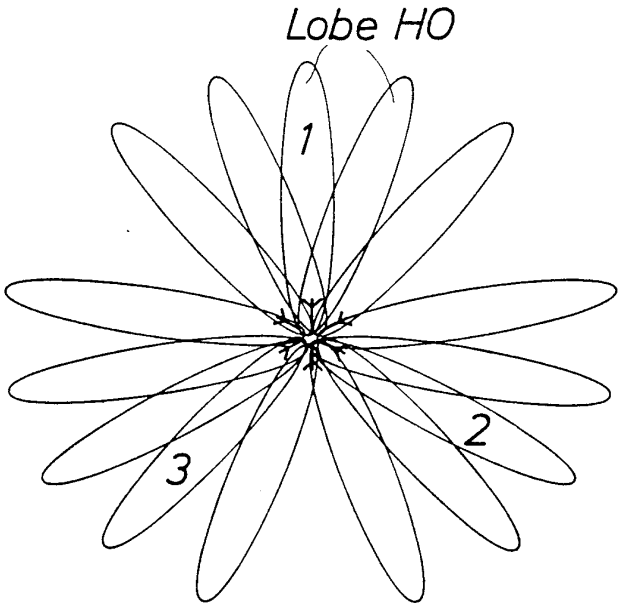


FIG. 8

Exhibit 1002
Page 0043 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

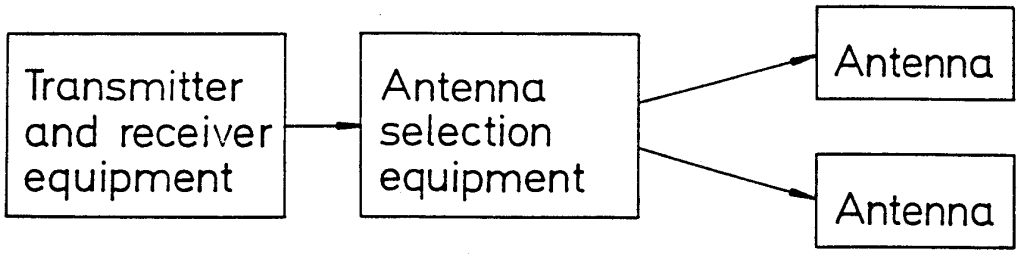


FIG. 9

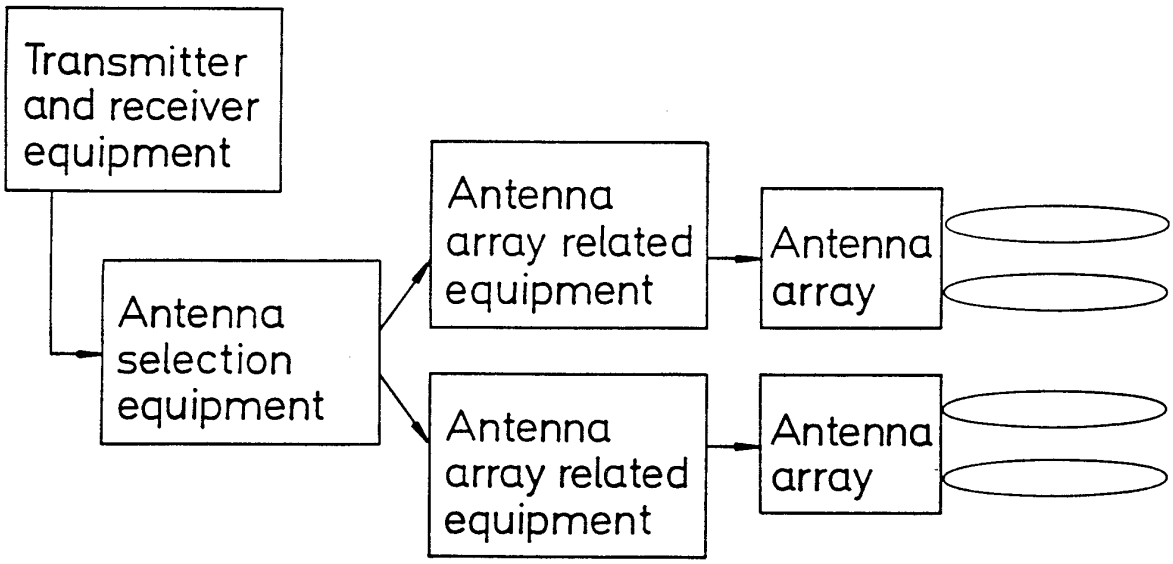


FIG. 10

Exhibit 1002
Page 0044 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

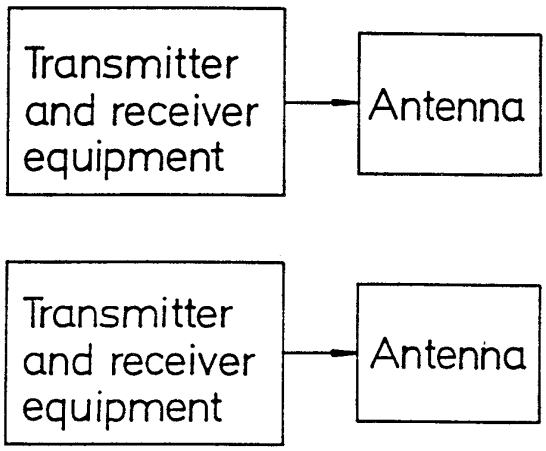

Transmitter and receiver equipment
Antenna
Transmitter and receiver equipment
Antenna

FIG. 11

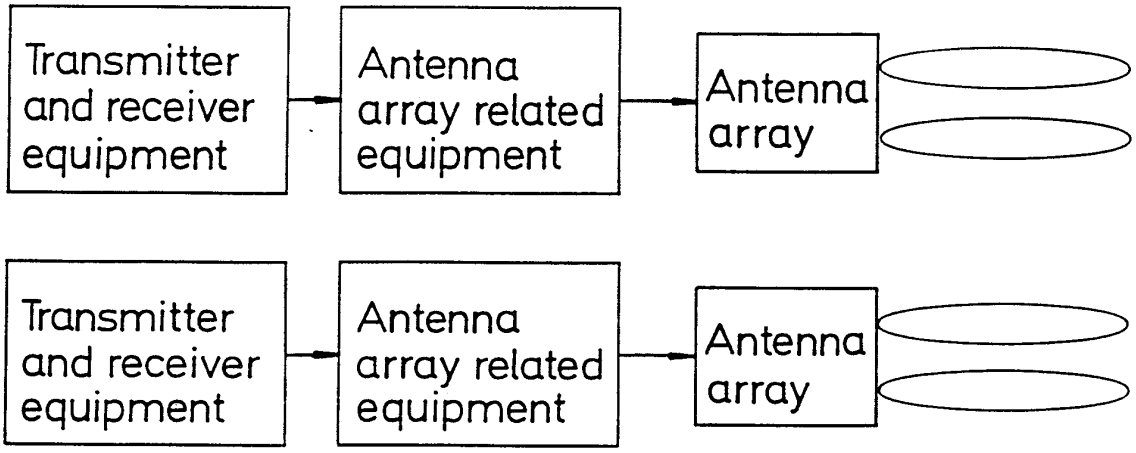

Transmitter and receiver equipment
Antenna array related equipment
Antenna array
Transmitter and receiver equipment
Antenna array related equipment
Antenna array

FIG. 12

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Filer:	Nicholas R. Transier/Jenny Stedman
Attorney Docket Number:	E1027.800(T).US1D1C1D1C1

Filed as Small Entity

Filing Fees for Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	70	70
UTILITY SEARCH FEE	2111	1	300	300
UTILITY EXAMINATION FEE	2311	1	360	360
REQUEST FOR PRIORITIZED EXAMINATION	2817	1	2000	2000
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	2202	10	40	400
INDEPENDENT CLAIMS IN EXCESS OF 3	2201	1	210	210

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous-Filing:				
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	2830	1	70	70
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**3410**

Electronic Acknowledgement Receipt	
EFS ID:	28912078
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	114581
Filer:	Nicholas R. Transier/Jenny Stedman
Filer Authorized By:	Nicholas R. Transier
Attorney Docket Number:	E1027.800(T).US1D1C1D1C1
Receipt Date:	12-APR-2017
Filing Date:	
Time Stamp:	20:51:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$3410
RAM confirmation Number	041317INTEFSW20522600
Deposit Account	
Authorized User	
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	WebADS.pdf	233715 f66708c4639165a0368a4f91e6f63802de3794b6	no	11
Warnings:					
Information:					
2		2017-04-12_Specification.pdf	389508 b38616c92f12be05e1d9564cec9912216aa7888f	yes	51
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	44	
	Claims		45	50	
	Abstract		51	51	
Warnings:					
Information:					
3	Drawings-only black and white line drawings	2017-04-12_Figures.pdf	2451085 f4dd97d68a463dfca9fd3bf1b0f4bf41da2dbe07	no	18
Warnings:					
Information:					
4	TrackOne Request	2017-04-12_Track_One.pdf	126070 00a1d89f39fa8d85d5f1b8e98da01208bcb1c026	no	2
Warnings:					
Information:					
5	Oath or Declaration filed	2017-04-12_Declarations.pdf	1030156 7bcbc2e3b69c895557bcc20566648210d846c23c	no	17

Warnings:					
Information:					
6	Power of Attorney	2017-04-12_POA.pdf	765443 c277d813708788fbe7e2286f0ef3bd35b8b182f0	no	2
Warnings:					
Information:					
7	Information Disclosure Statement (IDS) Form (SB08)	2017-04-12_IDS.pdf	1037297 af8a7f1148d0143f3855045dcb304de41b2e87b6	no	7
Warnings:					
Information:					
8	Transmittal Letter	2017-04-12_IDS_Transmittal.pdf	16874 5089292e9947fe4d822e08fd0a3565005c9c2c2e	no	2
Warnings:					
Information:					
9	Non Patent Literature	Anastasi.pdf	2727329 74ec4368eb7923f56b5b1382e3cf6ea0096992ba	no	12
Warnings:					
Information:					
10	Non Patent Literature	CDNA18957ENC_001.pdf	9980272 05ae8b480f93cf245c50b90e62a4068abc55d41c	no	516
Warnings:					
Information:					
11	Non Patent Literature	gans.pdf	1175070 9d2e9168ff2c9d858f3b02620197e6c2a27ecf5b	no	7
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12	Non Patent Literature	German_et_al.pdf	3338193 9772a2d3bb97735c846000537631b26c3e0d9030	no	4
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13	Non Patent Literature	Gucsalla.pdf	10263985 6f3fdd751d8dec41f5f77fb3a94a24131abe73e2	no	25
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14	Non Patent Literature	hashemi_indoor.pdf	2636715 8e3455cdd8f39be2081cf81fe98aa028bcefe502	no	26
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Information:					
15	Non Patent Literature	leland.pdf	3243962 79a47a567e0957f9189dc1552f7389a00c46ae52	no	15
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Information:					
16	Non Patent Literature	medbo_pathloss.pdf	491294 4f0a9fca125ef0111f9de799075782b4217d6943	no	7
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Information:					
17	Foreign Reference	WO1999021391A2.pdf	358774 ee34181f8fcb75b59ae9e43dc8e6d85a29d0b4e6	no	15
Warnings:					
Information:					
18	Non Patent Literature	kivinen.pdf	10957942 419be9d5f90c570011cfa95049209c61383261fc	no	13
Warnings:					
Information:					
19	Fee Worksheet (SB06)	fee-info.pdf	43087 c50c1db8b947f4453e95ceb8da659f0f69c878e2	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	51266771	

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

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

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Marcus		Da Silva	

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Inventor 2

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	William	J.	Crilly	

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

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Mailing Address of Inventor:

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Address 2			
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Postal Code	99019	Country [i]	US

Inventor 3

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	James		Brennan	

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

Residence Information (Select One)	◉ US Residency	○ Non US Residency	○ Active US Military Service		
City	Sammamish	**State/Province**	WA	**Country of Residence** [i]	US

Mailing Address of Inventor:

Address 1	414 213th PL SE		
Address 2			
City	Sammamish	**State/Province**	WA
Postal Code	98074	**Country** [i]	US

Inventor 4

Legal Name

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	Robert	J.	Conley	

Residence Information (Select One)	◉ US Residency	○ Non US Residency	○ Active US Military Service		
City	Liberty Lake	**State/Province**	WA	**Country of Residence** [i]	US

Mailing Address of Inventor:

Address 1	23326 E. 2nd Avenue		
Address 2			
City	Liberty Lake	**State/Province**	WA
Postal Code	99019	**Country** [i]	US

Inventor 5

Legal Name

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	Siavash		Alamouti	

Residence Information (Select One)	◉ US Residency	○ Non US Residency	○ Active US Military Service		
City	Spokane	**State/Province**	WA	**Country of Residence** [i]	US

Mailing Address of Inventor:

Address 1	2123 West 1st Ave., Apt 3		
Address 2			
City	Spokane	**State/Province**	WA
Postal Code	99204	**Country** [i]	US

Inventor 6

Legal Name

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	Eduardo		Casas	

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

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

City	Vancouver	Country of Residence [i]	CA

Mailing Address of Inventor:

Address 1	7542 Ontario Street		
Address 2			
City	Vancouver	State/Province	
Postal Code	V5X3C2	Country [i]	CA

Inventor 7

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Hujun		Yin	

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

City	Spokane	State/Province	WA	Country of Residence [i]	US

Mailing Address of Inventor:

Address 1	2415 N. Cherry Street, Apt. 23		
Address 2			
City	Spokane	State/Province	WA
Postal Code	99216	Country [i]	US

Inventor 8

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Bobby		Jose	

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

City	Veradale	State/Province	WA	Country of Residence [i]	US

Mailing Address of Inventor:

Address 1	15821 East 4th Ave., Apt F 125		
Address 2			
City	Veradale	State/Province	WA
Postal Code	99037	Country [i]	US

Inventor 9

Legal Name

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	Yang-Seok		Choi	

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

City	Liberty Lake	**State/Province**	WA	**Country of Residence** [i]	US

Mailing Address of Inventor:

Address 1	22809 East Country Vista Drive, Apt 438		
Address 2			
City	Liberty Lake	**State/Province**	WA
Postal Code	99019	**Country** [i]	US

Inventor 10

Legal Name

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	Vahid		Tarokh	

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

City	Cambridge	**State/Province**	MA	**Country of Residence** [i]	US

Mailing Address of Inventor:

Address 1	157 Pleasant Street, Apt 305		
Address 2			
City	Cambridge	**State/Province**	MA
Postal Code	02139	**Country** [i]	US

Inventor 11

Legal Name

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	Praveen		Mehrotra	

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

City	Spokane	**State/Province**	WA	**Country of Residence** [i]	US

Mailing Address of Inventor:

Address 1	13303 East Mission Ave., Apt 75		
Address 2			
City	Spokane	**State/Province**	WA
Postal Code	99216	**Country** [i]	US

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

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

Correspondence Information:

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

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

Customer Number	114581		
Email Address	sandiego@eip.com	Add Email	Remove Email

Application Information:

Title of the Invention	DIRECTED WIRELESS COMMUNICATION		
Attorney Docket Number	E1027.800(T).US1D1C1D1C1	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
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.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	114581		

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix	Remove
Registration Number					
Prefix	**Given Name**	Middle Name	**Family Name**	Suffix	Remove
Registration Number					

Additional Representative Information blocks may be generated within this form by selecting the **Add** button.

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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 this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	15260147	2016-09-08

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
15260147	Continuation of	13855410	2013-04-02	9462589	2016-10-04

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13855410	Division of	10700329	2003-11-03	8412106	2013-04-02

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
10700329	Claims benefit of provisional	60423660	2002-11-04

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

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) 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	Filing Date (YYYY-MM-DD)	Access Code (if applicable)

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

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

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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.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

Applicant Information:

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

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:	
If the Applicant is an Organization check here.	☒
Organization Name	XR Communications, LLC D/B/A Vivato Technologies

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Email Address			

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

Assignee Information including Non-Applicant Assignee Information:

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

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country [i]		Postal Code	
Phone Number		Fax Number	
Email Address			

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	E1027.800(T).US1D1C1D1C1
	Application Number	
Title of Invention	DIRECTED WIRELESS COMMUNICATION	

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e. g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Nicholas R. Transier/			Date (YYYY-MM-DD)	
First Name	Nicholas	Last Name	TRANSIER	Registration Number	68743

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DIRECTED WIRELESS COMMUNICATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Application No. 15/260,147, filed September 8, 2016, which is a continuation application of US. Patent Application No. 13/855,410, filed on April 2, 2013 (now U.S. Patent No. 9,462,589), which is a divisional application of U.S. Patent Application No. 10/700,329, filed on November 3, 2003 (now U.S. Patent No. 8,412,106), which claims the benefit of U.S. Provisional Application No. 60/423,660, filed on November 4, 2002. Each of the above-referenced patent applications is incorporated herein by reference in its entirety.

BACKGROUND

[0002] The following disclosure relates to directed wireless communication.

[0003] Computing devices and other similar devices implemented to send and/or receive data can be interconnected in a wired network or wireless network to allow the data to be communicated between the devices. Wired networks, such as wide area networks (WANs) and local area networks (LANs) for example, tend to have a high bandwidth and can therefore be configured to communicate digital data at high data rates. One obvious drawback to wired networks is that the range of movement of a device is constrained since the device needs to be physically connected to the network for data exchange, For example, a user of a portable computing device will need to remain near to a wired network junction to maintain a connection to the wired network.

[0004] An alternative to wired networks is a wireless network that is configured to support similar data communications but in a more accommodating manner. For example, the user of the portable computing device can move around within a region that is supported by the wireless network without having to be physically connected to the network. A limitation of conventional wireless networks, however, is their relatively low bandwidth which results in a much slower exchange of data than a wired network. Further, conventional wireless networks are implemented with multiple base stations, or access points, that relay communications between wireless-configured devices. These conventional access points have a limited communication range,

typically 20 to 200 feet, and a wireless network requires a large number of these access points to cover and provide a communication link over a large area.

[0005] Many conventional wireless communication systems and networks implement omni-directional antennas to transmit data packets to a client device and receive data packets from or via an access point. With a standard wireless LAN, for example, a transmission is communicated equally in all directions from an omni-directional antenna, or point of emanation. Receiving devices located within range and positioned at any angle with respect to the emanating point can receive the wireless transmission.

[0006] However, standard omni-directional wireless LANs or omni-directional wireless wide area networks (WANs) have drawbacks and limitations. For example, transmission range is limited and electromagnetic interference associated with transmissions is unmanaged and can interfere with or otherwise restrict the use of other communicating devices that operate in the same frequency band within the transmission coverage area. Furthermore, inefficiencies and data corruption can occur if two or more centralized points of emanation are positioned proximate to have overlapping coverage areas.

SUMMARY

[0007] Directed wireless communication is described herein. In an implementation, a multi-beam directed signal system coordinates directed wireless communication with client devices. A transmit beam-forming network routes data communication transmissions to the client devices via directed communication beams that are emanated from an antenna assembly, and a receive beam-forming network receives data communication receptions from the client devices via the directed communication beams.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The same numbers are used throughout the drawings to reference like features and components.

[0009] FIG. 1 illustrates an exemplary wireless communications environment.

[0010] FIG. 2 illustrates an exemplary directed wireless communication system.

[0011] FIG. 3 illustrates an exemplary communication beam array which can be generated with the exemplary directed wireless communication system shown in FIG. 2.

[0012] FIG. 4 illustrates an exemplary antenna array for an antenna assembly as shown in FIG. 3.

[0013] FIG. 5 illustrates an exemplary implementation of the directed wireless communication system shown in FIG. 2.

[0014] FIG. 6 illustrates an exemplary set of communication beams that emanate from an antenna array of an antenna assembly as shown in FIG. 3.

[0015] FIG. 7 illustrates an exemplary multi-beam directed signal system that establishes multiple access points.

[0016] FIGS. 8A and 8B illustrate various components of a multi-beam directed signal system and an antenna assembly of the directed wireless communication system shown in FIG. 2.

[0017] FIG. 9 illustrates an exemplary multi-beam directed signal system that includes various components such as medium access controllers (MACs), baseband units, and MAC coordinator logic.

[0018] FIG. 10 further illustrates various components of the exemplary multi-beam directed signal system shown in FIG. 9.

[0019] FIG. 11 illustrates a state transition diagram for a medium access controller (MAC).

[0020] FIG. 12 illustrates a multi-beam directed signal system receiving and weighting various communication signals.

[0021] FIG. 13 illustrates an exemplary multi-beam directed signal system that includes various component implementations.

[0022] FIG. 14 further illustrates a component implementation of the multi-beam directed signal system for complementary beam-forming.

[0023] FIG. 15 illustrates a graph depicting a signal level output (dB) for the component implementation shown in FIG. 14.

[0024] FIG. 16 illustrates a state transition diagram for a roaming client device in wireless communication with a multi-beam directed signal system as shown in FIG. 2.

[0025] FIG. 17 is a flow diagram of an exemplary method for a directed wireless communication system implemented with a multi-beam directed signal system and antenna assembly.

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

[0026] FIG. 18 is a flow diagram of an exemplary method for a directed wireless communication system implemented with a multi-beam directed signal system and antenna assembly.

[0027] FIG. 19 is a flow diagram of an exemplary method for client device roaming in a directed wireless communication system.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

[0028] Directed wireless communication is described in which a multi-beam directed signal system is implemented to communicate over a wireless communication link via an antenna assembly with client devices implemented for wireless communication within the wireless system. The directed wireless communication system can be implemented to communicate with multiple devices, such as portable computers, computing devices, and any other type of electronic and/or communication device that can be configured for wireless communication. Further, the multiple electronic and/or computing devices can be configured to communicate with one another within the wireless communication system. Additionally, a directed wireless communication system can be implemented as a wireless local area network (WLAN), a wireless wide area network (WAN), a wireless metropolitan area network (MAN), or as any number of other similar wireless network configurations.

[0029] The following description identifies various systems and methods that may be included in such directed wireless communication systems and networks. It should be noted, however, that these are merely exemplary and that not all of the techniques described herein need be implemented in a given wireless system or network. Furthermore, many of the exemplary systems and methods described herein are also applicable and/or adaptable for use in other communication systems and networks.

[0030] Directed wireless communication provides improved performance over conventional wireless network arrangements by utilizing multi-beam receiving and/or transmitting adaptive antennas, when practical. In an implementation, simultaneous transmission and reception may occur at a wireless routing device by applying multi-channel techniques. In a described implementation, a multi-beam directed signal system (e.g., also referred to as an access point or Wi-Fi switch) is a long-range packet switch designed to support 802.11b clients in accordance with an 802.11 standard. An increase in communication range is achieved by beam-forming

directed communication beams which simultaneously transmit directed signals and receive communication signals from different directions via receive and transmit beam-forming networks.

[0031] The multi-beam directed signal system establishes multiple point-to-point links (e.g., directed communication beams) by which data packets can be communicated. The point-to-point links have a communication range that covers a much larger area than conventional access points, eliminating the need for multiple communication access points and significantly reducing the complexity and cost of a wireless LAN (WLAN) network. Further, a client device can use a conventional wireless card to communicate with the multi-beam directed signal system over long distances with no modification of the client device. Accordingly, directed wireless communication as described herein represents a significant improvement over conventional wireless networks that use switched beam and/or omni-directional antennas.

[0032] FIG. 1 illustrates an exemplary wireless communications environ merit 100 that is generally representative of any number of different types of wireless communications environments, including but not limited to those pertaining to wireless local area networks (LANs) or wide area networks (WANs) (e.g., Wi-Fi compatible) technology, cellular technology, trunking technology, and the like. In wireless communications environment 100, an access station 102 communicates with remote client devices 104(1), 104(2), . . . , 104(N) via wireless communication or communication links 106(1), 106(2), . . . , 106(N), respectively. Although not required, access station 102 is typically fixed, and remote client devices 104 may be fixed or mobile. Although only three remote client devices 104 are shown, access station 102 can wirelessly communicate with any number of different client devices 104.

[0033] A directed wireless communication system, Wi-Fi communication system, access station 102, and/or remote client devices 104 may operate in accordance with any IEEE 802.11 or similar standard. With respect to a cellular system, for example, access station 102 and/or remote client devices 104 may operate in accordance with any analog or digital standard, including but not limited to those using time division/demand multiple access (TDMA), code division multiple access (CDMA), spread spectrum, some combination thereof, or any other such technology.

[0034] Access station 102 can be implemented as a nexus point, a trunking radio, a base station, a Wi-Fi switch, an access point, some combination and/or derivative thereof, and so forth. Remote client devices 104 may be, for example, a hand-held device, a desktop or laptop computer, an expansion card or similar that is coupled to a desktop or laptop computer, a personal digital

assistant (FDA), a mobile phone, a vehicle having a wireless communication device, a tablet or hand/palm-sized computer, a portable inventory-related scanning device, any device capable of processing generally, some combination thereof, and the like. Further, a client device 104 may be any device implemented to receive and/or transmit information (e.g., in the form of data packets) via the applicable wireless communication links 106. Remote client devices 104 may also operate in accordance with any standardized and/or specialized technology that is compatible with the operation of access station 102.

[0035] FIG. 2 illustrates an exemplary directed wireless communication system 200 that can be implemented in any form of a wireless communications environment 100 as described with reference to FIG. 1. The directed wireless communication system 200 includes an access station 102 and remote client devices 202 and 204. The access station 102 includes a multi-beam directed signal system 206 coupled to an antenna assembly 208 via a communication link 210. In this example implementation, access station 102 is coupled to an Ethernet backbone 212.

[0036] The antenna assembly 208 can be implemented as two or more antennas, and optionally as a phased array of antenna elements, to emanate multiple directed communication beams 214(1), 214(2), . . . , 214(N). The antenna assembly 208 is an unobtrusive indoor or outdoor Wi-Fi antenna panel that can include various operability components such as RF devices and components, a central processing unit, a power supply, and other logic components. The antenna assembly can be implemented as a lightweight and thin structure that can be mounted on a wall or in a corner of a room to provide wireless communication over a broad coverage area, such as throughout a building and surrounding area, or over an expanded region, such as a college campus or an entire corporate or manufacturing complex. While the antenna assembly may be applicable or adaptable for use in many other communication systems, the antenna assembly is described in the context of an exemplary wireless communications environment 100 (FIG. 1).

[0037] The multi-beam directed signal system 206 can transmit and/or receive (i.e., transceive) information (e.g., in the form of data packets) by way of one or more directed communication beams 214 as a wireless communication via the antenna assembly 208. Additionally, wireless communication(s) are transmitted and/or received from (i.e., transceived with respect to) a remote client device, such as client devices 202 and 204. The wireless communications may be transceived directionally with respect to one or more particular communication beams 214. The multi-beam directed signal system 206 can be implemented for

multi-channel directed wireless communication. For example, client device 202 can communicate via directed communication beam 214(1) with a first channel of the multi-beam directed signal system 206, and client device 204 can communicate via directed communication beam, 214(N) with a second channel of the multi-beam directed signal system 206.

[0038] In the exemplary directed wireless communication system 200, signals may be sent from a transmitter to a receiver using electromagnetic waves that emanate from one or more antenna elements of the antenna assembly 208 which are focused in one or more desired directions. For example, the multi-beam directed signal system generates a directed wireless communication for transmission to wireless client device 202 via directed communication beam 214(1). This is in contrast to conventional omni-directional transmission systems that transmit a communication in all directions from an omni-directional antenna (e.g., example omni-directional transmission area 216 emanating from a central transmission point with reference to antenna assembly 208 and shown only for comparison). Although not to scale, the illustration depicts that the power to transmit over the omni-directional transmission area 216 can be directed as one or more communication beams over a farther distance 218 from a point of transmission (e.g., antenna assembly 208).

[0039] When the electromagnetic waves are focused in a desired direction, the pattern formed by the electromagnetic wave is termed a "beam" or "beam pattern", such as a directed communication beam 214. The production and/or application of such electromagnetic beams 214 is typically referred to as "beam-forming." Beam-forming provides a number of benefits such as greater range and/or coverage per unit of transmitted power, improved resistance to interference, increased immunity to the deleterious effects of multi-path transmission signals, and so forth. For example, a single communication beam 214(1) can be directed for communication with a specific wireless-configured client device 202 and can be transmitted over a much greater distance 218 than would be covered by a conventional omni-directional antenna (e.g., example omni-directional transmission area 216 shown only for comparison).

[0040] FIG. 3 illustrates an exemplary communication beam array 300 of directed communication beams 214(1), 214(2), ... 214(N) that emanate from an antenna array 302 which is part of the antenna assembly 208. Antenna assembly 208 is also referred to herein as an "adaptive antenna" which describes an arrangement that includes the antenna array 302 having a plurality of antenna elements, and operatively supporting mechanisms and/or components (e.g., circuits, logic,

etc.) that are part of a wireless routing device and configured to produce a transmission pattern that selectively places transmission nulls and/or peaks in certain directions within an applicable coverage area.

[0041] A transmission peak of a directed communication beam 214 occurs in the transmission pattern 300 when a generated and particular amount of energy is directed in a particular direction. Transmission peaks are, therefore, associated with the signal path and/or communication beam to a desired receiving node, such as another wireless routing device or a wireless client device. In some cases, sidelobes to a communication beam may also be considered to represent transmission peak(s).

[0042] Conversely, a transmission null (e.g., not a communication beam) occurs in the transmission pattern when no transmission of energy occurs in a particular direction, or a relatively insignificant amount of energy is transmitted in a particular direction. Thus, a transmission null is associated with a signal path or lack of a communication beam towards an undesired, possibly interfering, device and/or object. Transmission nulls may also be associated with the intent to maximize power in another direction (i.e., associated with a transmission peak), to increase data integrity or data security, and/or to save power, for example. A determination to direct a transmission null and/or a transmission peak (e.g., a communication beam 214) in a particular direction can be made based on collected or otherwise provided routing information which may include a variety of data associated with the operation of the multi-beam directed signal system 206, wireless routing device, and other devices at other locations or nodes within the wireless network.

[0043] One or more of the communication beams 214(1), 214(2), . . . , 214(N) are directed out symmetrically from antenna array 302 to communicate information (e.g., in the form of data packets) with one or more wireless client devices. The communication beam array 300 shown in FIG. 3 is merely exemplary and other communication beam arrays, or patterns, may differ in width, shape, number, angular coverage, azimuth, and so forth. Further, although all of the directed communication beams 214 are shown emanating from antenna array 302 at what would appear as a same time, transmission and reception via one or more communication beams 214 is controlled and coordinated with signal control and coordination logic 304 of the multi-beam directed signal system 206.

[0044] The signal control and coordination logic 304 can monitor each of the directed communication beams 214 as an individual access point. Further, the signal control and coordination logic 304 can control a directed wireless transmission to a first client device and a directed wireless transmission from a second client device such that the directed wireless transmission does not interfere with the directed wireless reception. Optionally, a directed wireless transmission and a directed wireless reception can be simultaneous.

[0045] As used herein, the term "logic" (e.g., signal control and coordination logic 304) refers to hardware, firmware, software, or any combination thereof that may be implemented to perform the logical operations associated with a given task. Such, logic can also include any supporting circuitry that may be required to complete a given task including supportive non-logical operations. For example, "logic" may also include analog circuitry, memory, input/output (I/O) circuitry, interface circuitry, power providing/regulating circuitry, etc.

[0046] The directed communication beams 214 of antenna array 302 can be directionally controllable, such as steerable in an analog implementation or stepable in a digital implementation. For example, a directed communication beam 214 can be directionally stepable by the width (e.g., degrees) of the communication beam to "steer" or "aim" addressable data packets when communicating with a client device. Further, a communication beam 214 can be directionally controllable such that only an intended client device will receive a directed wireless communication via the communication beam 214, and such that an unintended recipient will not be able to receive the directed wireless communication.

[0047] Although data signals (e.g., information as data packets) can be directed to and from a particular client device (e.g., client devices 202 and 204) via one or more directed communication beams 214, interference between communications beams 214 can occur. For example, a downlink signal transmission from antenna assembly 208 via communication beam 214(2) can corrupt an uplink signal reception at antenna assembly 208 via communication beam 214(3). The signal control and coordination logic 304 coordinates uplink and downlink signal transmissions across (e.g., between and/or among) the different communication beams 214 so as to avoid, or at least reduce, the frequency at which downlink directed signals are transmitted via a first communication beam (e.g., communication beam 214(2)) while uplink directed signals are being received via a second communication beam (e.g., communication beam 214(3)).

[0048] FIG. 4 illustrates an exemplary antenna array 302 (also referred to herein as an adaptive antenna) that is formed with an array of antenna elements 400. Each antenna element 400 has multiple communication signal transfer slots 402 (e.g., transfer slots 402(1) and 402(2)) that are formed into a front surface 404 of an antenna element 400. The antenna array 302 transmits and receives data as electromagnetic communication signals via the transfer slots 402 in each antenna element 400.

[0049] In an exemplary implementation, the communication signal transfer slots 402 in an antenna element 400 are formed into two parallel slot rows 406(1) and 406(2) in which the transfer slots 402(1) in slot row 406(1) are staggered, or otherwise offset, in relation to the transfer slots 402(2) in slot row 406(2). Each transfer slot 402(1) in slot row 406(1) is offset from each transfer slot 402(2) in slot row 406(2) in a direction 408 and a distance 410. For example, transfer slot 402(1) in slot row 406(1) is offset from transfer slot 402(2) in slot row 408(2) in a direction that is parallel to the slot rows 406 (e.g., the direction 408) over a distance that is approximately the length of one rectangular transfer slot 402 (e.g., the distance 410). The distance 410 between transfer slots 402 in a slot row 406 is approximately the antenna element wavelength $\lambda_g/2$ apart.

[0050] The gain of an adaptive antenna (e.g., antenna array 302) is dependent on the implementation of the multi-beam directed signal system 206. However, for a uniformly illuminated antenna array, the antenna gain is related to its effective aperture by an equation:

$$G_R = \frac{4\pi \cdot A_{eff}}{\lambda^2}$$

Assuming A_{eff} is equal to a cross-sectional area of the antenna array:

$$G_R = \frac{4\pi \cdot w \cdot h}{\lambda^2}$$

where w is the width of the antenna, h is the height of the antenna, and λ is the wavelength. For an example indoor implementation of an antenna array where $w=8\lambda$ and $h=4\lambda$, the antenna gain is determined by the equation:

$$G_R = \frac{4\pi \cdot 8\lambda \cdot 4\lambda}{\lambda^2} = 128\pi = 26 \text{ dBi}$$

For an example outdoor implementation of an antenna array where $w=8\lambda$ and $h=8\lambda$, the antenna gain is determined by the equation:

$$G_R = \frac{4\pi \cdot 8\lambda \cdot 8\lambda}{\lambda^2} = 256\pi = 29.1 \text{ dBi}$$

When dissipation losses are zero, the antenna gain is equivalent to directivity. The effective aperture may include the effect of losses, and therefore the formulas may be used to calculate the gain. When the actual dimensions of the antenna array 302 are used as the "effective area", the losses are assumed to be zero (e.g., for an ideal implementation).

[0051] In this example illustration, the antenna array 302 is shown configured for indoor use with sixteen antenna elements (e.g., sixteen of antenna elements 400 formed or otherwise positioned together) each having two parallel rows of four communication signal transfer slots each (e.g., slot rows 406(1) and 406(2)). The antenna array 302 can be configured for outdoor use with thirty-two antenna elements (e.g., multiple antenna elements 400) each having two parallel rows of eight communication signal transfer slots each, or can be configured as a larger antenna array or antenna panel with more antenna elements having more communication signal transfer slots per slot row. The antenna array 302 can be configured with as many antenna elements 400 having any number of transfer slots 402 per slot row 406 as needed to provide communication signal transfer (e.g., wireless communication) over a region or desired coverage area.

[0052] FIG. 5 illustrates an exemplary implementation 500 of a directed wireless communication system (e.g., directed wireless communication system 200 shown in FIG. 2) that includes antenna assembly 208 and antenna array 302 as shown in FIG. 4. In this example, antenna array 302 is positioned outside of a building 502 and mounted on an adjacent building 504 to provide wireless communication throughout building 502 and throughout a region 506 outside of building 502. The antenna array 302 is coupled to the multi-beam directed signal system 206 (FIG. 2) which can be communicatively coupled via a LAN connection, for example, to a server computing device positioned in building 504. The server computing device can be implemented to administrate and control the associated functions and operations of the directed wireless communication system 200. Alternatively, antenna array 302 can be mounted within building 502 to provide wireless communication throughout building 502 and throughout the region 506 outside of building 502. For example, antenna array 302 can be mounted in a corner between two interior perpendicular walls to provide wireless communication coverage throughout the coverage area (e.g., building 502 and region 506 outside of the building).

[0053] The directed wireless communication system 200 (e.g., shown in implementation 500) provides wireless communication of information (e.g., in the form of data packets) via directed communication beams 508(1), 508(2), . . . , 508(N) to any number of electronic and/or computing client devices that are configured to recognize and receive transmission signals from the antenna array 302. Any one or more of the electronic and computing client devices may also transmit information via the directed communication beams 508. Such electronic and computing devices can include printing devices, desktop and portable computing devices such as a personal digital assistant (PDA), cellular phone, and similar mobile communication devices, and any other type of electronic devices configured for wireless communication connectivity throughout building 502, as well as portable devices outside of building 502, such as computing device 510 within region 506. One or more of the electronic and computing client devices may also be connected together via a wired network and/or communication link.

[0054] FIG. 6 illustrates an exemplary set or array of communication beams 600 that emanate from an antenna array 302 as shown in FIGS. 3 and 4. In a described implementation, antenna array 302 can include sixteen antenna elements 400(0, 1, . . . , 14, and 15) (not explicitly shown in FIGS. 4 and 6). From the sixteen antenna elements 400(0-15), sixteen different communication beams 602(0), 602(1), . . . , 602(15) are formed as the wireless communication signals emanating from antenna elements 400(0-15) which may add and/or subtract from each other during electromagnetic propagation.

[0055] Communication beams 602(1), 602(15) spread out, or are directed out, symmetrically from a central communication beam 602(0). The narrowest beam is the central beam 602(0), and the beams become wider as they spread outward from the central beam. For example, beam 602(15) adjacent beam 602(0) is slightly wider than beam 602(0), and beam 602(5) is wider than beam 602(15). Also, beam 602(10) is wider still than beam 602(5). The communication beam pattern of the set of communication beams 600 illustrated in FIG. 6 are exemplary only and other communication beam pattern sets may differ in width, shape, number, angular coverage, azimuth, and so forth.

[0056] Due to implementation effects of the interactions between and among the wireless signals as they emanate from antenna array 302 (e.g., assuming a linear antenna array in a described implementation), communication beam 602(8) is degenerate such that its beam pattern is formed on both sides of antenna array 302. These implementation effects also account for the

increasing widths of the other beams 602(1-7) and 602(15-9) as they spread outward from the central communication beam 602(0). In addition to the implementation effects of the interactions between and among the wireless signals, an obliquity effect explains that an azimuth beamwidth is related to the projected horizontal dimension of the array, as viewed from an oblique angle. Accordingly, the array appears narrower when viewed from an oblique angle, and therefore has a wider beamwidth as compared to a beamwidth viewed from a perpendicular angle. Beamwidth and directivity are inversely proportional and an obliquity factor (i.e., cos(azimuth angle)) defines a reduction in antenna array directivity at oblique angles and thus an increase in beamwidth. In a further implementation, communication beams 602(7) and 602(9) may be too wide for efficient and productive use. Hence, communication beams 602(7), 602(8), and 602(9) are not used and the implementation utilizes the remaining thirteen communication beams 602 (e.g., communication beams 602(0-6) and beams 602(10-15)).

[0057] FIG. 7 illustrates an exemplary implementation 700 of the multi-beam directed signal system 206 which establishes multiple access points 702(1), 702(2), 702(N). The multi-beam directed signal system 206 establishes any number access points 702 which can each correspond to, for example, an individual access point in accordance with an IEEE 802.11-based standard. Additionally, a wireless coverage area or region for each respective access point 702 may correspond to, for example, a respective directed communication beam 214 as shown in FIGS. 2 and 3, or a respective communication beam 602 as shown in FIG. 6.

[0058] Although communication signals directed into (or obtained from) different access points 702 may be directed at particular or specific coverage areas, interference between access points 702 can occur. For example, a downlink signal transmission for access point 702(2) can destroy an uplink signal reception for access point 702(1). Generally, signal control and coordination logic 304 coordinates uplink signal receptions and downlink signal transmissions across (e.g., between and/or among) different access points 702 so as to avoid, or at least reduce, the frequency at which downlink signals are transmitted at a first access point while uplink signals are being received at a second access point.

[0059] Specifically, signal control and coordination logic 304 is adapted to monitor the multiple access points 702(1), 702(2), . . . , 702(N) to ascertain when a signal, or communication of information, is being received. When an access point 702 is ascertained to be receiving a signal, the signal control and coordination logic 304 limits (e.g., prevents, delays, etc.) the transmission

of signals on the other access points 702 such that signal transmission does not interfere with signal reception. The monitoring, ascertaining, and restraining of signals can be based on and/or responsive to many factors. For example, the signals can be coordinated (e.g., analyzed and controlled) based on a per-channel basis.

[0060] FIGS. 8A and 8B illustrate various components of the multi-beam directed signal system 206 and the antenna assembly 208 both shown in FIGS. 2 and 3. FIG. 8A illustrates antenna array 302 which includes the sixteen antenna elements 400(0, 1, . . . , 15) as described with reference to FIG. 6. The antenna assembly 208 includes RF (radio frequency) components which are shown as a left transmit antenna board 800, a right transmit antenna board 802, a left receive antenna board 804, and a right receive antenna board 806. The multi-beam directed signal system 206 includes a transmit beam-forming network 808 and a receive beam-forming network 810.

[0061] The left transmit antenna board 800 includes transmission logic 812(0, 1, 7) and the right transmit antenna board 802 includes transmission logic 812(8, 9, . . . , 15). Each transmission logic 812 (e.g., circuit, component, etc.) corresponds to an antenna element 400(0-15) of the antenna array 302 and corresponds to a signal connection (e.g., node, port, channel, etc.) of the transmit beam-forming network 808(0-15). Similarly, the left receive antenna board 804 includes reception logic 814(0, 1, . . . , 7) and the right receive antenna board 806 includes reception logic 814(8, 9, 15). Each reception logic 814 (e.g., circuit, component, etc.) corresponds to an antenna element 400(0-15) of the antenna array 302 and corresponds to a signal connection (e.g., node, port, channel, etc.) of the receive beam-forming network 810(0-15).

[0062] Generally, a beam-forming network 808 and 810 may include multiple ports for connecting to antenna array 302 and multiple ports for connecting to the multiple RF components, such as the transmit and receive antenna boards 800-806. One or more active components (e.g., a power amplifier (PA), a low-noise amplifier (LNA), etc.) may also be coupled to the multiple ports on the antenna array side of a beam-forming network. Thus, antenna array 302 may be directly or indirectly coupled to a beam-forming network 808 and 810.

[0063] Specifically, a beam-forming network 808 and 810 may include at least "N" ports for each of the multiple RF transmission and receive logic components 812 and 814, respectively. For example, each directed communication beam 214 (FIG. 2) or 602 (FIG. 6) emanating from antenna array 302 corresponds to an RF logic component 812 and/or 814. Each RF logic component 812 and 814 can be implemented as, for example, a transmit and/or receive signal

processor operating at one or more radio frequencies, with each frequency corresponding to a different channel. It should be noted that channels may be defined alternatively (and/or additionally) using a mechanism other than frequency, such as a code, a time slot, some combination thereof, and so forth.

[0064] FIG. 8B further illustrates various components of the multi-beam directed signal system 206 which includes the signal control and coordination logic 304, a multi-beam controller 816, one or more memory components 818, communication interface(s) 820, a scanning receiver 822, and receiver/transmitters (Rx/Tx) 824(0, 1, . . . , 15). The multi-beam controller 816 (e.g., any of a processor, controller, logic, circuitry, etc.) can be implemented to control channel assignments for communication signals and data communication coordinated by the signal control and coordination logic 304.

[0065] The channel assignments coordinated by the signal control and coordination logic 304 provides the best channel assignment for a signal based on given measurement information. Parameters of a channel assignment algorithm include:

[0066] *ChannelAssignmentCycle* which identifies a duration between changes in the channel assignment;

[0067] *HeavyInterference* which identifies an interference activity threshold. If, for example, interference activity is determined to be above this value, a particular channel may be considered deficient for the duration of time that the interference can be detected;

[0068] *BadChannelThreshold* which identifies a number of measurement periods (e.g., a *MeasurementDuration*) that a channel has interference activity above the *HeavyInterference* threshold; and

[0069] *JamInterference* which identifies an interference activity threshold above the *HeavyInterference* parameter.

[0070] Further, channel assignment internal parameters can include:

[0071] *MeasurementCycle* which identifies a time duration (e.g., twenty-four hours) in which a measurement is completed;

[0072] *MeasurementDuration* which identifies a time duration (e.g., minutes) between two measurement points;

[0073] *PeakLoadLimit* which identifies a maximum load allowed on one channel; and

[0074] *ChannelSixBiasFactor* which is a bias factor to compensate for transmission on channel six to reduce inter-modulation.

[0075] The scanning receiver 822 and the receiver/transmitters (Rx/Tx) 824 measure metrics of channel activity every specified *MeasurementDuration* during a cycle of *MeasurementCycle*. The metrics can include a number of associated client devices, throughput and packet error rates (PER) of each receiver/transmitter 824, interference and channel utilization of each communication beam (e.g., frequency, or channel), and/or any number of other metrics. The channel activity metrics include:

[0076] $N_i(t)$ which is a number of associated clients of the *i*th Rx/Tx 824 and which is averaged over the *MeasurementDuration* period;

[0077] $S_i(t)$ which is the throughput of the *i*th Rx/Tx 824 measured in packets/second or bytes/second, and which is averaged over the *MeasurementDuration* period;

[0078] $P_i(t)$ which is a packet error rate (PER) of the *i*th Rx/Tx 824 and which is averaged over the *MeasurementDuration* period;

[0079] $D_i(t)$ which is a delay of the *i*th Rx/Tx 824 and which is averaged over the *MeasurementDuration* period;

[0080] $\rho_{ij}(t)$ which is channel utilization of the *i*th beam on the *j*th channel and which is measured by both the Rx/Tx 824 and scanning receiver 822 and averaged over the *MeasurementDuration* period. This is also referred to as a Channel Utilization Factor (CUF);

[0081] $Ns_j(t)$ which is a number of downlink data packets transmitted on the *j*th channel and which is averaged over the *MeasurementDuration* period;

[0082] $Nr_{ij}(t)$ which is a number of correctly received uplink data packets transmitted by client devices associated with the *i*th beam on the *j*th channel, and which is averaged over the *MeasurementDuration* period;

[0083] $Nn_{ij}(t)$ which is a number of uplink data packets transmitted by client devices associated with other communication beams, and which are correctly received by the *i*th beam on the *j*th channel. This is measured by the scanning receiver 822 and is averaged over the *MeasurementDuration* period. This is also referred to as the Self Interference Metric (SIM);

[0084] $No_{ij}(t)$ which is a number of uplink data packets transmitted by the client devices from overlapping subnets and which are correctly received by the *i*th beam on the *j*th channel. This

is measured by the scanning receiver 822 and is averaged over the *MeasurementDuration* period. This is also referred to as the Overlapping Subnet Interference (OSI);

[0085] $Ne_{ij}(t)$ which is a number of uplink data packets with PLCP or data CRC errors in the *i*th beam on the *j*th channel and which is measured by the scanning receiver 822 and averaged over the *MeasurementDuration* period. This is also referred to as the Unidentified Interference Metric (UIM); and

[0086] $I_{ij}(t)$ which is the interference of the *i*th beam on the *j*th channel and which is measured by the scanning receiver 822.

[0087] These and other metrics can be maintained with a memory component 818 in a data table (or similar data construct) within the *MeasurementCycle*. When the cycle restarts, the data table can either be cleared or updated with some aging factor to identify past metrics.

[0088] The metric $I_{ij}(t)$ can be derived from other measurements when the receiver/transmitters 824 are on the same channel. In such cases, $I_{ij}(t)$ can be estimated by first estimating a total number of packets from any overlapping subnets by an equation:

$$NI_{ij}(t) = No_{ij}(t) + Ne_{ij}(t) \cdot \frac{No_{ij}(t)}{Nr_{ij}(t) + Nn_{ij}(t) + No_{ij}(t)}$$

Further, $I_{ij}(t)$ may be estimated by:

$$I_{ij}(t) = \frac{NI_{ij}(t)}{NS_i(t) + Nr_{ij}(t) + Nn_{ij}(t) + No_{ij}(t) + Ne_{ij}(t)} \cdot \rho_{ij}(t)$$

[0089] For channel assignment pre-processing, a channel that has interference activity which exceeds *HeavyInterference* for a *BadChannelThreshold* is not used. The interference activity is averaged over intervals of the *MeasurementDuration* period. In an implementation, a *MeasurementCycle* can include forty-eight measurement intervals. A channel can be eliminated if the interference activity *HeavyInterference* exceeds the *BadChannelThreshold* for a specified number of periods.

[0090] The total number of active users (e.g., client devices) associated with any one directed communication beam 214 (FIG. 2) or 602 (FIG. 6) can be estimated by dividing the number of associated users of that communication beam by the percentage of time available to those users. The total number of users on beam *i* and channel *j* may therefore be described by:

$$N_{ij}(t) = \frac{N_i(t)}{1 - I_{ij}(t)}$$

where $\tilde{I}_{ij}(t) = \min\{I_{ij}(t), HeavyInterference\}$ which is the interference activity limited to a maximum allowable interference on a given communication beam. This ensures that the estimate does not provide large peaks due to an unusual period of high interference.

[0091] A block-based channel assignment algorithm assigns adjacent communication beams to the same frequency channel which minimizes the hidden beam problem as described further with reference to FIG. 14. The algorithm allocates the thirteen communication beams into a maximum of three blocks, with each block assigned to one frequency channel (e.g., channels 1, 6, or 11) so that the peak load on each channel is minimized. To determine an optimal solution, the boundaries between the assignment blocks (i.e. the number of communication beams in each block) and the frequency channel of each block is determined.

[0092] There are sixty-six possible combinations that divide thirteen communication beams into three blocks. For each of these possible combinations, the three blocks would be assigned to the three different channels. The number of channel permutations is six and the best channel-beam combination from three hundred, ninety-six (66×6=396) possible combinations can be determined. A factor $L_j(t)$ is denoted as the total load on the jth frequency channel at time (t) such that. $L_j^*=\max\{L_j(t)\}$ where t is of the set $[0,T]$ which is the peak load on the jth channel in the last measurement period, and where T is the measurement cycle (i.e., *MeasurementCycle*). A combination can be determined that minimizes the peak load on all of the channels which can be described as $\min\{\max\{L_j^*\}\}$ where j is of the set $[f_1 f_6 f_{11}]$.

[0093] In an event that the overall network communication load, or traffic, is minimal, fewer than the three frequency channels may be used. A parameter *PeakLoadLimit* identifies a communication load limit below which only two of the frequency channels (e.g., channel 1 and channel 11, for example) are used. If the peak communication load on either of the two channels exceeds the *PeakLoadLimit*, then the three frequency channels can be utilized.

[0094] The block-based channel assignment algorithm can be implemented to utilize two or three frequency channels. Initially, the thirteen communication beams are divided into two blocks of which there are twelve possible combinations. For each combination, the channel selections can be $f_1 f_6$, $f_1 f_{11}$, $f_6 f_1$, $f_6 f_{11}$, $f_{11} f_1$, or $f_{11} f_6$ such that there are a total of seventy-two block and channel combinations. Assuming that the kth block-channel combination has a configuration as follows:

[0095] Block 1: communication beams 0 to b_k (0 to N–2) are assigned to channel C_1; and

[0096] Block 2: communication beams b_k +1 to N–1 (1 to N–1) are assigned to channel C_2

Then the communication traffic load of channels C_1 and C_2 are:

$$L_{C1}^{k}(t) = \sum_{i=0}^{b_k} N_{iC1}(t)$$

$$L_{C2}^{k}(t) = \sum_{i=b_k+1}^{N-1} N_{iC2}(t)$$

[0097] The peak communication load on the first block for combination k is denoted by:

$$PL_1(k) = \max\{L^k_{C1}(t)\} \text{ where } t \text{ is of the set } [0,T]$$

$$PL_2(k) = \max\{L^k_{C2}(t)\} \text{ where } t \text{ is of the set } [0,T],$$

[0098] And the peak communication load for the busiest block (e.g., channel) is:

$$PL_{max}(k) = \max\{PL_1(k), PL_2(k)\}$$

[0099] A combination index R with the least peak communication load is then selected such that $PL_{max}(R)$=min $\{PL_{max}(k)\}$ where $(0 \leq k \leq 71)$ which is the combination of channels and beams that minimize the peak load on any channel. If the peak load on a channel is not less than the *PeakLoadLimit*, then a three channel assignment can be implemented. Initially, the thirteen communication beams are divide into three blocks of which there are sixty-six possible combinations. For each combination, the channel selections can be $f_1f_6f_{11}$, $f_1f_{11}f_6$, $f_6f_1f_{11}$, $f_6f_{11}f_1$, $f_{11}f_1f_6$, or $f_{11}f_6f_1$ such that there are a total of three-hundred, ninety-six block and channel combinations. Assuming that the kth block-channel combination has a configuration as follows:

[0100] Block 1: communication beams 0 to b_k (0 to N–3) are assigned to channel C_1; and

[0101] Block 2: communication beams b_k +1 to p_k (1 to N–2) are assigned to channel C_2; and

[0102] Block 3: communication beams p_k +1 to N–1 (2 to N–1) are assigned to channel C_3;

[0103] Then the communication traffic load of channels C_1, C_2, and C_3 are:

$$L_{C1}^{ki}(t) = \sum_{i=0}^{b_k} N_{iC1}(t)$$

$$L_{C2}^{k}(t) = \sum_{i=b_k+1}^{p_k} N_{iC2}(t)$$

$$L_{C3}^{k} = \sum_{i=p_k+1}^{N-1} N_{iC3}(t)$$

[0104] The peak communication load on the first block for combination k is denoted by:

$$PL_1(k) = \max\{L^k_{C1}(t)\} \text{ where } t \text{ is of the set } [0,T]$$

$$PL_2(k) = \max\{L^k_{C2}(t)\} \text{ where } t \text{ is of the set } [0,T],$$

$$PL_3(k) = \max\{L^k_{C3}(t)\} \text{ where } t \text{ is of the set } [0,T],$$

[0105] and the peak communication load for the busiest block (e.g., channel) is:

$$PL_{max}(k) = \max\{PL_1(k), PL_2(k), PL_3(k)\}$$

[0106] A combination index R with the least peak communication load is then selected such that $PL_{max}(R)=\min\{PL_{max}(k)\}$ where $(0 \le k \le 395)$ which is the combination of channels and beams that minimize the peak load on any channel.

[0107] When taking into account intermodulation such that channel combinations $f_1 f_6$ and $f_6 f_{11}$ are to be avoided, then f_6 is avoided. Initially, the thirteen communication beams are divide into two blocks of which there are twelve possible combinations. For each combination, the channel selections can be $f_1 f_{11}$ and $f_{11} f_1$ such that there are a total of twenty-four block and channel combinations. Assuming that the kth block-channel combination has a configuration as follows:

[0108] Block 1: communication beams 0 to b_k (0 to $N-2$) are assigned to channel C_1; and

[0109] Block 2: communication beams b_k+1 to $N-1$ (1 to $N-1$) are assigned to channel C_2 Then the communication traffic load of channels f_1 and f_{11} is the sum of the loads of the communication beams assigned to those channels as follows:

$$L_{f1}^{k}(t) = \sum_{f_1} N_{if1}(t) \quad \forall\, (i \in f_1)$$

$$L_{f11}^{k}(t) = \sum_{f_{11}} N_{if11}(t) \quad \forall\, (i \in f_{11})$$

[0110] The peak communication load on the first block for combination k is denoted by:

$$PL_1(k) = \max\{L^k_{f1}(t)\} \text{ where } t \text{ is of the set } [0,T]$$

$$PL_2(k) = \max\{L^k_{f11}(t)\} \text{ where } t \text{ is of the set } [0,T],$$

[0111] and the peak communication load for the busiest block (e.g., channel) is:

$$PL_{max}(k) = \max\{PL_1(k), PL_2(k)\}$$

[0112] A combination index R with the least peak communication load is then selected such that $PL_{max}(R)$=min $\{PL_{max}(k)\}$ where (0≤k≤71) which is the combination of channels and beams that minimize the peak load on any channel. If the peak load on a channel is not less than the *PeakLoadLimit*, then a three channel assignment can be implemented.

[0113] Memory component(s) 818 can maintain routing and signal information which can include transmit power level information, transmit data rate information, antenna pointing direction information, weighting information, constraints information, null/zero location information, peak location information, quality of service (QoS) information, priority information, lifetime information, frequency information, timing information, user and node authentication information, keep out area information, etc., that is associated with each sending and receiving communication channel of the wireless communication system and within the multi-beam directed signal system 206. In an implementation, at least some of routing information can be maintained with memory component(s) 818 within one or more routing tables or similar data structure(s).

[0114] The routing table(s) or similar data structure(s) provide an information basis for each routing decision within the wireless communication system (e.g., multi-beam directed signal system 206). By way of example, routing table(s) entries may include all or part of the following information: IP address (e.g., IPv6) of a node in the wireless network—e.g., as an index; 48-bit unique address—e.g., IEEE 802.1 MAC address; Protocol ID—e.g., IEEE 802.11, 802.16.1, etc.; Modulation method; Connection ID (CID) of a node—e.g., as used in an IEEE 802.16.1 MAC; Nominal direction to a node—e.g., one or two dimension; Nominal transmit power level to a node; Nominal received signal strength indicator (RSSI) level from a node; Nominal channel to transmit

Exhibit 1002
Page 0084 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

on, and perhaps a backup channel; Nominal channel to receive on, and perhaps a backup channel; Nominal transmission data rate, e.g., 6 Mbps-54 Mbps, or as available; Nominal receive data rate, e.g., 6 Mbps-54 Mbps, or as available; Known station interference nulls; and Unknown station interference nulls.

[0115] In an exemplary implementation, and within the structure of signal control/coordination logic 304, the routing table(s) are configured to receive or include data and/or primitives (e.g., function calls) from an Internet Protocol (IP) layer and a medium access control (MAC) layer, and to instruct a physical (PHY) layer to provide media access through the MAC layer. Therefore, in some examples, a routing table is more than simply a data table (or other similar structure) since it may also perform or otherwise support controlling and/or scheduling functions.

[0116] The communication interface(s) 820 can be implemented as any one of a serial, parallel, network, or wireless interface that communicatively couples the multi-beam directed signal system 206 with other electronic and/or computing devices. For example, the multi-beam directed signal system 206 can be coupled with a wired connection (e.g., an input/output cable) via a communication interface 820 to a network switch that communicates digital information corresponding to a communication signal to a server computing device. Any of the communication interfaces 820 can also be implemented as an input/output connector to couple digital, universal serial bus (USB), local area network (LAN), wide area network (WAN), metropolitan area network (MAN), and similar types of information and communication connections.

[0117] The scanning receiver 822 scans each directed communication beam (e.g., directed communication beams 214 shown in FIGS. 2 and 3) consecutively and monitors for client devices and associated information such as the transmit power of a client device, roaming status, and the many other communication factors to update data that is maintained about each client device that is in communication via a communication beam. In an implementation, the scanning receiver 822 can be described in two operating states: a scan mode and a roaming mode. While operating in the scan mode, the scanning receiver 822 periodically scans the thirteen communication beams on the three channels and collects activity information to be maintained with the client device data.

[0118] FIG. 9 illustrates an exemplary multi-beam directed signal system 206 that includes various components such as medium access controllers (MACs) 900, baseband units (BB) 902, and MAC coordinator logic 904. The multi-beam directed signal system 206 also includes radio

frequency (RF) components 906 such as the left and right transmit antenna boards 800 and 802 (shown in FIG. 8), respectively, and the left and right receive antenna boards 804 and 806, respectively. This example also illustrates the antenna array 302, the transmit beam-forming network 808 and the receive beam-forming network 810, and an Ethernet switch and/or router 908.

[0119] As described in the implementation with reference to FIG. 8, antenna array 302 (e.g., via antenna assembly 208) is coupled to the beam-forming networks 808 (transmit) and 810 (receive). The beam-forming networks 808 and 810 are coupled to multiple RF components 906(1), 906(2), . . . , 906(N). Respective RF components 906(1), 906(2), . . . , 906(N) are each coupled to a respective baseband unit 902(1), 902(2), . . . , 902(N) which are coupled to MAC coordinator logic 904. The Ethernet switch/router 908 is coupled to the multiple MACs 900(1), 900(2), . . . , 900(N) which are also each coupled to MAC coordinator logic 904.

[0120] In operation generally, each MAC 900 is associated with a respective baseband unit 902. Although not specifically shown in FIG. 9, each respective MAC 900 may also be communicatively coupled to a corresponding baseband unit 902. MAC coordinator logic 904 is configured to coordinate the activities of the multiple MACs 900 with regard to at least one non-associated respective baseband unit 902. For example, MAC coordinator logic 904 may forward an instruction to MAC 900(1) responsive, at least partly, to an indicator provided from baseband unit 902(2). MAC coordinator logic 904 can be implemented as hardware, software, firmware, and/or some combination thereof.

[0121] The Ethernet switch/router 908 is coupled to Ethernet backbone 212 (FIG. 2) and is configured to relay incoming packets from Ethernet backbone 212 to the appropriate MAC 900 to which they correspond. Ethernet switch/router 908 is also configured to relay outgoing packets from the multiple MACs 900 to Ethernet backbone 212. Ethernet switch/router 908 may be implemented using, for example, a general purpose central processing unit (CPU) and memory. The CPU and memory can handle layer-2 Internet protocol (IP) responsibilities, flow control, and so forth. When receiving packets from Ethernet backbone 212, Ethernet switch/router 908 obtains the destination port for the destination MAC 900 address. In this manner, an Ethernet switch and/or router may be realized using software (or hardware, firmware, some combination thereof, etc.).

[0122] The beam-forming networks 808 and 810, in conjunction with antenna array 302, form the multiple directed communication beams 214 (FIGS. 2 and 3), A beam-forming network can be implemented as an active or passive beam-former. Examples of such active and passive

beam-formers include a tuned vector modulator (multiplier), a Butler matrix, a Rotman lens, a canonical beam-former, a lumped-element beam-former with static or variable inductors and capacitors, and so forth. Alternatively, communication beams may be formed using full adaptive beam-forming.

[0123] As described with reference to FIGS. 8A and 8B, a beam-forming network 808 and 810 may include multiple ports for connecting to antenna array 302 and additional ports for connecting to the multiple RF components 906. One or more active components (e.g., a power amplifier (PA), a low-noise amplifier (LNA), etc.) may also be coupled to the multiple ports on the antenna array side of the beam-forming networks 808 and 810. Thus, antenna array 302 may be directly or indirectly coupled to the beam-forming networks 808 and 810.

[0124] The beam-forming networks 808 and 810 may include at least "N" parts for each of the multiple RF components 906(1, 2, . . . , N). In an example implementation, each communication beam 214 emanating from antenna array 302 corresponds to an RF component 906. Each RF component 906 can be implemented as a transmit and/or receive signal processor operating at radio frequencies and each RF component 906 can operate at one or more frequencies, with each frequency corresponding to a different channel. It should be noted that channels may be defined alternatively (and/or additionally) using a mechanism other than frequency, such as a code, a time slot, a signal node, some combination thereof, and so forth.

[0125] As described above, each respective RF component 906(1, 2, . . . , N) is coupled to a respective baseband unit 902(1, 2, N) and each respective MAC 900(1, 2, . . . , N) is associated with a corresponding baseband unit 902(1, 2, . . . , N). Although not illustrated in this example or required, each MAC 900 and associated respective baseband unit 902 may be located on individual respective electronic cards. Additionally, the respective RF component 906 to which each respective baseband unit 902 is coupled may also be located on the individual respective electronic cards.

[0126] Each respective MAC 900 and corresponding baseband unit 902 may be associated with a different respective access point, such as access points 702(1, 2, . . . , N) (FIG. 7). Each respective RF component 906, along with signal nodes (e.g., ports, communication nodes, etc.) of the beam-forming networks 808 and 810, and/or antenna array 302, and respective communication beams 214 may also correspond to the different respective access points 702. The MACs 900 are configured to control access to the media that is provided, at least partially, by baseband units 902.

In this case, the media corresponds to the signals transmitted and/or received via communication beams 214 (FIGS. 2 and 3). These signals can be analog, digital, and so forth. In a described implementation, digital signals comprise one or more data packets.

[0127] In a packet-based environment, a data packet arriving at the multi-beam directed signal system 206 (or at access station 102) via a particular communication beam 214 from a particular remote client device 202 (FIG. 2) is received via the antenna array 302 and the beam-forming networks 808 and/or 810. The data packet is processed through a particular RF component 906 and a corresponding baseband unit 902. The data packet is then forwarded from baseband unit 902 to a corresponding MAC 900 which facilitates data packet communication via the Ethernet backbone 212 (FIG. 2) by Ethernet switch/router 908. Data packets arriving at the multi-beam directed signal system 206 (or at access station 102) via Ethernet switch/router 908 are transmitted to a remote client device 202 and/or 204 via directed communication beam(s) 214 in an opposite communication path. The transmission and reception of data packets via directed communication beams 214, as well as the forwarding of packets within the multi-beam directed signal system 206 is controlled at least partially by the MACs 900.

[0128] In a typical MAC-baseband environment, a MAC controls the associated baseband circuitry using input solely from the associated baseband circuitry. For example, if baseband circuitry indicates to its associated MAC that it is receiving a packet, then the associated MAC does not initiate the baseband circuitry to transmit a packet, which can jeopardize the integrity of the packet being received.

[0129] With co-located access points 702 (e.g., as in FIG. 7) and/or co-located pairs of MACs 900 and associated baseband units 902, a first access point 702(1) and/or a first MAC 900(1)/baseband unit 902(1) pair are unaware of the condition or state (e.g., transmitting, receiving, idle, etc.) of a second access point 702(2) and/or a second MAC 900(2)/baseband unit 902(2) pair, and vice versa. As a result, absent additional control and/or logic, a data packet being received by the first access point 702(1) and/or the first MAC 900(1)/baseband unit 902(1) pair can be corrupted (e.g., altered, destroyed, interfered with, rendered unusable for its intended purpose, etc.) by a transmission from the second access point 702(2) and/or the second MAC 900(2)/baseband unit 902(2) pair. This corruption may occur even though the packet reception and the packet transmission are effectuated using different communication beams 214(3) and 214(2), respectively, when the reception and transmission occur on the same channel. Effectively, an

incoming data packet reception via a first communication beam 214 can be rendered unsuccessful by an outgoing data packet transmission via a second communication beam 214 that occurs on the same channel and is overlapping.

[0130] As described above, MAC coordinator logic 904 is coupled to the multiple baseband units 902(1, 2, . . . , N) and to the multiple MACs 900(1, 2, . . . , N). The MAC coordinator logic 904 is configured to prevent MACs 900(1, 2, . . . , N) from generating or otherwise causing a transmission if at least one and optionally if any of the baseband units 902(1, 2, . . . , N) are receiving. For example, if baseband unit 902(2) indicates that it is receiving a data packet, MAC coordinator logic 904 initiates that MACs 900(1, 2, . . . , N) refrain from generating or otherwise causing a data packet transmission during the data packet reception. Factors that can modify, tune, tweak, extend, etc. this data packet transmission restraint may include one or more of the MACs 900 enabling transmissions on different channel(s) from that of baseband unit 902(2) which is receiving.

[0131] More specifically, each baseband unit 902 forwards a corresponding receive indicator to MAC coordinator logic 904 which monitors the baseband units 902. The MAC coordinator logic 904 analyzes the receive indicators to generate constructive receive indicators that are communicated, or otherwise provided, to each of the MACs 900. In a described implementation, each baseband unit 902 forwards a receive indicator that reflects whether and/or when a baseband unit 902 is currently receiving a signal. Optionally, not physically forwarding an indicator may constitute a receive indicator that reflects no signal is being received. After processing the different receive indicators, MAC coordinator logic 904 forwards the same constructive receive indicator to each MAC 900 based on multiple, and possibly all, receive indicators. The MAC coordinator logic 904 may provide different constructive receive indicators to at least different subsets of the MACs 900.

[0132] The receive indicators forwarded to MAC coordinator logic 904 may be comprised of any one or more different indications from the baseband units 902. For example, the receive indicators may comprise clear channel assessment (CCA) or busy/non-busy indications. Alternatively, the receive indicators may comprise indications of signal reception based on energy signals, cross-correlation signals, data signals, other transmit and/or control signals, seine combination thereof, and so forth. Furthermore, a receive indicator may comprise an analog or

digital indication (of one or more bits), the driving of one or more lines, the presentation of one or more messages, some combination thereof, and so forth.

[0133] The MAC coordinator logic 904 is configured to accept the receive indicators from the baseband units 902 and combine them in some manner to generate or otherwise produce the constructive receive indicator(s). For example, MAC coordinator logic 904 may "OR" the receive indicators together to generate the constructive receive indicator(s). Consequently, if any receive indicator from baseband units 902 indicates that a baseband unit is receiving a signal, then, the constructive receive indicator indicates to each MAC 900 that a reception is occurring on a directed communication beam 214 (and/or access point 702) of the multi-beam directed signal system 206. As a result, the MACs 900 that are provided with an affirmative constructive receive indicator do not cause their respective associated baseband units 902 to transmit.

[0134] The constructive receive indicators provided from MAC coordinator logic 904 may be comprised of any one or more different indications interpretable by the MACs 900. For example, the constructive receive indicators may comprise an indication for one or more predetermined inputs, such as a CCA or busy/non-busy input of the MACs 900. Alternatively, the constructive receive indicators may be input to a different type of do-not-transmit input, a specially-designed input, a message-capable input, some combination thereof, and so forth. Furthermore, a constructive receive indicator may comprise an analog or digital indication (of one or more bits), the driving of one or more lines, the presentation of one or more messages, some combination thereof, and the like.

[0135] FIG. 10 further illustrates various components of the multi-beam directed signal system 206 shown in FIG. 9 which includes the MACs 900, baseband units 902, and MAC coordinator logic 904. In this example, the exemplary multi-beam directed signal system 206 includes thirteen MACs 900(1, 2, . . . , 13) and thirteen baseband units 902(1, 2, . . . , 13) that are associated respectively therewith. Thirteen baseband units 902(1, 2, . . . , 13) and thirteen MACs 900(1, 2, . . . , 13) are utilized in this exemplary multi-beam directed signal system 206 to comport with the efficiently usable communication beams 602(0-6) and 602(10-15) of the exemplary set of communication beams shown in FIG. 6. However, the elements and features described with reference to FIG. 10 are applicable to multi-beam directed signal systems 206 and/or access stations 102 with more than or fewer than thirteen MACs 900 and associated baseband units 902.

[0136] The baseband units 902(1, 2, . . . , 13) are configured to communicate with MACs 900(1, 2, . . . , 13), and vice versa, directly or indirectly without MAC coordinator logic 904 input. Specifically, control data may be transferred there between which may include, for example, data packets for wireless communication on communication beams 214 (FIGS. 2 and 3), carrier sense multiple access/collision avoidance (CSMA/CA) type information, and so forth. The media access technique in 802.11 is based on a Carrier Sense Multiple Access (CSMA) operation in which a each station transmits only when it determines that no other station is currently transmitting. This tends to avoid collisions that occur when two or more stations transmit at the same time where a collision would typically require that a transmitted packet be retransmitted.

[0137] In this example, the baseband units 902(1, 2, . . . , 13) forward receive indicators (1, 2, . . . , 13) to MAC coordinator logic 904. The MAC coordinator logic 904 includes a receive indicators combiner 1000 which may be comprised of one or more of program coding, a field-programmable gate array, discrete logic gates, and so forth, and which may be implemented as hardware, software, firmware, and/or some combination thereof. Receive indicators combiner 1000 combines receive indicators (1, 2, . . . , 13) to generate constructive receive indicators (1, 2, . . . , 13). For example, receive indicators (1, 2, . . . , 13) may be combined using a logical "OR" functionality which ensures that if any one or more receive indicators of receive indicators (1, 2, . . . , 13) is indicating that a signal is being received, then the associated constructive receive indicators of constructive receive indicators (1, 2, . . . , 13) also indicate that a signal is being received.

[0138] The constructive receive indicators (1, 2, . . . 13) are provided or otherwise communicated to MACs 900(1, 2, . . . 13), respectively, so that. MACs 900(1, 2, . . . , 13) do not cause baseband units 902(1, 2, . . . , 13) to transmit a signal while another signal is being received. The baseband units 902(1, 2, . . . , 13) and the MACs 900(1, 2, . . . , 13) may be segmented or grouped by a characteristic and/or state, such as by wireless communication channels. When segmented or grouped, a constructive receive indicator of a given segment or group indicates to a MAC that a signal is being received and that no signal should therefore be transmitted when any receive indicator of that given segment or group indicates that a signal is being received (or when multiple receive indicators of that given segment or group indicate that multiple signals are being received).

[0139] The MAC coordinator logic 904 can be modified, adjusted, expanded, etc. based on any number of different factors that include channel assignment information 1002, receive indicator enable information 1004, timer logic 1006, and scanning logic 1008. Although illustrated as separate components, any one or combination of the channel assignment information 1002, receive indicator enable information 1004, timer logic 1006, and/or scanning logic 1008 can be implemented together and/or as part of MAC coordinator logic 904 or as another component of a multi-beam directed signal system 206.

[0140] Channel assignment information 1002 enables receive indicators (1, 2, . . . , 13) to be combined by the receive indicators combiner 1000 on a per-channel basis. As a result, constructive receive indicators (1, 2, . . . , 13) restrain signal transmissions from MAC 900 and baseband unit 902 pairs when a signal reception is occurring on the same channel, even if by a different MAC 900 and baseband unit 902 pair. A downlinked data packet that is transmitted on one channel while an uplinked data packet is being received on another channel does not usually cause the uplinked data packet to be corrupted. On the other hand, a downlinked data packet that is transmitted on a channel while an uplinked data packet is being received on the same channel does usually cause the uplinked data packet to be corrupted (e.g., indistinguishable, non-communicative, etc.), even if the transmission and reception occur via different communication beams 214 (FIGS. 2 and 3).

[0141] Channel assignment information 1002 may be implemented as, for example, a vector that relates each MAC 900 and associated baseband unit 902 to one of two or more channels. Hence, prior to a combination generated by the receive indicators combiner 1000, each respective receive indicator (1, 2, . . . , 13) can be mapped to a channel segmentation or grouping based on a wireless communication channel used by a corresponding MAC 900 and baseband unit 902 pair.

[0142] Receive indicator enable information 1004 provides information for receive indicators combiner 1000 that stipulates which receive indicators (1, 2, . . . , 13) are to be used in a combination operation to produce the constructive receive indicators (1, 2, . . . , 13). Thus, certain receive indicators may be excluded from the combination operation for one or more operational considerations. The receive indicator enable information 1004 may be implemented as, for example, a masking register 1010 that comprises a register with exclusionary bits for masking one or more of the receive indicators (1, 2, . . . , 13) from a combination operation of the receive indicators combiner 1000. In a described implementation, masking register 1010 includes thirteen

bits that correspond to the thirteen receive indicators (1, 2, . . . , 13), which correspond to the thirteen baseband units 902(1, 2, . . . , 13).

[0143] Timer logic 1006 can be used for one or more factors and, although only shown once, may alternatively be implemented as multiple components in an exemplary multi-beam directed signal system 206 to account for multiple timer functions, or one implementation may be capable of handling multiple timer functions. Timer logic 1006 includes a watchdog timer 1012 and optionally watchdog interrupt enable information 1014.

[0144] For a first factor, timer logic 1006 relates to individual receive indicators (1, 2, …, 13). A duration of watchdog timer 1012 is set equal to a maximum data packet duration (e.g., a maximum-allowed length of a data packet). Watchdog timer 1012 is started when a particular receive indicator begins indicating that a signal is being received and stopped when the particular receive indicator ceases indicating that the signal is being received. If watchdog timer 1012 is not tolled by an indication of signal reception cessation prior to its expiration, then the signal being received is likely to not be intended for multi-beam directed signal system 206. In this case, timer logic 1006 may indicate that the baseband unit 902 corresponding to the particular receive indicator is not to be used in a combination operation. This exclusion indication may be effectuated using receive indicator enable information 1004 (e.g., by setting a bit in masking register 1010).

[0145] For a second factor, timer logic 1006 relates to constructive receive indicators (1, 2, . . . , 13) on a per-channel basis. A duration of watchdog timer 1012 is set with consideration of a temporal threshold beyond which a problem or error should be contemplated to have occurred and hence investigated. Watchdog timer 1012 is started when a particular constructive receive indicator (or indicators) for a given channel begins indicating that a signal is being received on the given channel and stopped when the particular constructive receive indicator ceases indicating that the signal is being received on the given channel. If watchdog timer 1012 is not tolled by an indication of signal reception cessation prior to its expiration, then there is a likelihood that an error has occurred.

[0146] Watchdog interrupt enable information 1014 is used for this second factor, and it stipulates which channel(s) (and thus which constructive receive indicators) are enabled for interruption. If watchdog timer 1012 expires and the given channel is enabled in accordance with watchdog interrupt enable information 1014, an interrupt is generated and provided to MAC coordinator logic 904 or another component of the multi-beam directed signal system 206.

[0147] Scanning logic 1008 may act independently or interactively with any one or more of channel assignment information 1002, receive indicator enable information 1004, and timer logic 1006. For example, scanning logic 1008 can scan across communication beams 214 using different channels on receive to detect which channel or channels have the least or lowest interference levels. This scanning may occur once, periodically, continuously, and the like. A channel assignment vector or similar for channel assignment information 1002 may be configured responsive to such scanning and interference determinations of scanning logic 1008.

[0148] As another example, scanning logic 1008 may scan across communication beams 214 to detect the presence of other access points (e.g., non-co-located access points) that are causing interference on a regular or constant basis. The existence of an access point may be inferred by receiving a basic service set identifier (BSSID) being broadcast by another access point. When another access point is detected within a coverage area of a particular communication beam 214 (e.g., when an overlapping subnet is detected), scanning logic 1008 may interact with receive indicator enable information 1004 to mask out a corresponding receive indicator from a baseband unit 902 that corresponds to the particular communication beam 214. As a result, frequent receptions from the overlapping subnet do not constantly prevent baseband unit 902 and MAC 900 pairs on the same channel from transmitting.

[0149] In an exemplary implementation, multi-beam directed signal system 206 can be configured such that the receive indicators (1, 2, . . . , 13) correspond to the state of the clear channel assessment (CCA) output as detected by baseband units 902(1, 2, . . . , 13), and the constructive receive indicators (1, 2, . . . , 13) correspond to the state of the clear channel assessment input to MACs 900(1, 2, . . . , 13). Based on the values for receive indicators (1, 2, . . . , 13), channel assignment information 1002, and receive indicator enable information 1004, MAC coordinator logic 904 determines the constructive receive indicators (1, 2, . . . , 13) for each RF component 906 (FIG. 9) (as provided via MACs 900, baseband units 902, etc.).

[0150] In an exemplary implementation, MAC coordinator logic 904 is configured to operate such that an indicator "channel_wide_busy" for each channel is defined, where channel_wide_busy is affirmative (e.g., active) if the receive indicator from any baseband units operating on that channel indicates that a signal is being received, excluding those baseband units whose receive indicator enable information is not set (e.g., in masking register 1010). Further, MAC coordinator logic 904 sets the constructive receive indicator for a particular MAC 900 and

baseband unit 902 pair to affirmative (e.g., busy) if the receive indicator for that baseband unit 902 indicates affirmative (e.g., busy), or if "channel_wide_busy" for the channel of the particular MAC 900 and baseband unit 902 pair is affirmative (e.g., active).

[0151] FIG. 11 illustrates a state transition diagram 1100 for a MAC controller 900 as shown in FIGS. 9 and 10. MAC controller states include Defer 1102, BackOff 1104, Idle 1106, TransmissionRTS (TxRTS) 1108, WaitCTS 1110, Transmission Data (TxData) 1112, Wait Acknowledgement (WaitACK) 114, Receive 1116, Transmission Acknowledgement (TxACK) 1118, and TransmissionCTS (TxCTS) 1120. The state transition diagram 1100 also includes received frame types Data 1126 and RTS 1128, as well as procedures Transmission okay (TxOK( )) 1122 and Transmission fail (TxFail( )) 1124.

[0152] The TxOK( ) procedure 1122 removes bytes transmitted from an outgoing queue and resets retry counter(s) and a contention window. The TxFail( ) procedure 1124 increments a retry counter, checks that the number of retries has not been exceeded, and increases the contention window. The Receive state 1116 ends if there is a transmission or check error, if the carrier is lost, or when a duration indicated in a header has elapsed. If there is an error, the Defer state 1102 timeout is set to initiate. If a frame did not have an error and is not addressed to a particular station, and it's duration field is greater than the current timer value, then the timer is set to the value of the frame's duration field.

[0153] At the BackOff state 1104, a backoff counter is decremented every slot time and a backoff count is saved if this state is exited due to a channel becoming busy. When the backoff counter decrements to zero and MAC service data units are queued to transmit, the contention window and retry counts are reset. A MAC service data unit is the payload carried by a MAC (e.g., in an 802.11 implementation which will typically be an Ethernet frame). The MAC 900 adds a MAC header and a 32-bit CRC to the MAC service data unit to form a MAC protocol data unit.

[0154] Additionally, the state transition diagram 1100 includes various functions that return logical value(s) to control state transitions such as data( ), short( ), more( ), busy( ), error( ), notforus( ), and nav( ). The diagram 1100 also includes PHY indications that initiate a state transition such as busy, timeout, new, transmission end (txend), and receive end (rxend). The PHY indications are asynchronous events (e.g., interrupts) that terminate states for a MAC controller 900. An indication receive end (rxend) identifies that a receiver has detected the end of a frame or an error. An indication transmission end (txend) identifies that a receiver has completed sending a

frame. A busy indication is a receiver indication that a channel is busy. A timeout indication is generated when a transition state timer has expired. A new indication identifies that a new frame has been queued.

[0155] A busy( ) function returns a receiver indication that a channel is busy, and an error( ) function indicates that a received frame had a CRC error. A notforus( ) function indicates that a frame was not addressed to a particular station, and a nay( ) function indicates that a timer has not expired. A data( ) function indicates that data is queued to send, and a short( ) function indicates that a MAC protocol data unit is shorter than an RTS Threshold and that there are additional data fragments to be sent from a current MAC controller. A more( ) function facilitates obtaining the additional data fragments.

[0156] FIG. 12 illustrates an exemplary implementation 1200 of the multi-beam directed signal system 206 that weighs signals received via antenna array 302. Communication and/or data transfer signals are received from sources 1202 (e.g., sources A and B). The signals received from sources 1202 are considered desired signals because they are from nodes within the wireless routing network. Further, signals such as noise and WLAN interference associated with another external wireless system 1204 are not desired.

[0157] These signals, both desired and undesired, are received via antenna array 302 and are provided to the signal control and coordination logic 304 (shown in FIG. 3) from the receiver/transmitters (Rx/Tx) 824(0), 824(1), . . . , 824(N) (also shown in FIG. 8B). In this example, the signal control and coordination logic 304 includes the scanning receiver 822 that is configured to update routing information 1206 with regard to the received signals. For example, scanning receiver 822 may identify information about different classes of interferers (e.g., known and unknown types) within the routing information 1206. In this example, routing information 1206 includes connection indexed routing table(s) based on identification information, such as address information, CID, and the like. The routing table includes identifiers of the desired sources and other identifiers for the interferers ("Int"). Further, the routing table includes stored weighting values (w) each associated with a particular signal source 1202 (e.g., sources A and B). Other information such as "keep out" identifiers may also be included in this exemplary routing table.

[0158] A description of the received signal(s) can be stored in the routing table in the form of the pattern or weighting of the signal(s). In this example, a polynomial expansion in z, $w(z)=w_0+w_1z+w_2z^2+ w_3z^3+ w_4z^4+ \ldots + w_iz^i$ can be utilized to establish the values of the weights

(w_i) to be applied to a weight vector. The routing table(s) may store such weighing patterns as a function of θ, or the zeroes of the polynomial, for example. One advantage of zero storage is that the zeros represent directions for communication that should be nulled out to prevent self-interference or interfering with other nodes or possibly other known wireless communication systems, such as WLAN 1204 that is not part of the wireless routing network, but is operating within at least a portion of a potential coverage area 1208 and frequency bands.

[0159] The polynomial expansion in z, $w(z)$, and the zeroes may be calculated from each other and each may be stored. Updates can be generated frequently (e.g., in certain implementations, about every millisecond), and a zero storage system may be more advantageous in most wireless network environments because only a few values will change at a given time. Storing the weighting values will in general require changes to all of the weighting values $w(i)$ when any change in the pattern occurs. Note that $w(i)$ and $A(\theta)$ may be expressed as Fourier transform pairs (discrete due to the finite antenna element space). The $w(i)$ is equivalent to a time domain impulse response (e.g., a time domain unit sample response) and the $A(\theta)$ is equivalent to the frequency response (e.g., an evaluation of $w(z)$ sampled along a unit circle).

[0160] The stored weighting values associated with each connection, data signal, and/or source are utilized in a weighting matrix 1210 which operates to apply the latest weighting values to the received signals and also to transmitted signals. In this illustrative example, subsequently received signals will be processed using the most recent weighting values in the weighting matrix 1210. Thus, as described herein, the multi-beam directed signal system 206 is configured to control the transmission amplitude frequency band and directionality of data packets to other nodes and assist in reducing the effects associated with received noise and interference (e.g., self interference and/or external interference). This is accomplished with the signal control and coordination logic 304 within the multi-beam directed signal system 206.

[0161] FIG. 13 illustrates an exemplary multi-beam directed signal system 206 that includes an antenna array 302 and a Butler matrix 1300 implemented as a beam-forming network (e.g., transmit beam-forming network 808 and/or receive beam-forming network 810 shown in FIGS. 8A and 8B). The multi-beam directed signal system 206 also includes multiple signal processors (SPs) 1302 and one or more baseband processors (e.g., baseband units 902 described with reference to FIGS. 9 and 10). Baseband processors 902 accept communication signals from and provide communication signals to the multiple receiver/transmitters 824 (FIG. 8B). A separate

baseband processor 902 may be assigned to each signal processor 1302, or a single baseband processor 902 may be assigned to any number of the multiple signal processors 1302.

[0162] Exemplary Butler matrix 1300 is a passive device that forms, in conjunction with antenna array 302, communication beams 214 using signal combiners, signal splitters, and/or signal phase shifters. Butler matrix 1300 includes a first side with multiple antenna ports (designated by "A") and a second side with multiple transmit and/or receive signal processor ports (designated by "Tx/Rx"). The number of antenna ports and transmit/receive ports indicate the order of the Butler matrix 1300, which in this example, includes sixteen antenna ports and sixteen transmit/receive ports. Thus, Butler matrix 1300 has an order of sixteen.

[0163] Although Butler matrix 1300 is so illustrated, the antenna ports and transmit/receive ports need not be distributed on separate, much less opposite, sides of a Butler matrix. Also, although not necessary, Butler matrices typically have an equal number of antenna ports and transmit and/or receive signal processor ports. Furthermore, although Butler matrices are typically of an order that is a power of two (e.g., 2, 4, 8, 16, 32, 64, . . . , 2^n), they may alternatively be implemented with any number of ports.

[0164] The sixteen antenna ports of Butler matrix 1300 are identified or otherwise numbered from A(0, 1, . . . , 15). Similarly, the sixteen transmit/receive ports are numbered from Tx/Rx(0, 1, . . . , 15). Antenna ports A(0-15) are coupled to and populated with sixteen antenna elements 400(0), 400(1), . . . , 400(15), respectively. Likewise, transmit/receive ports Tx/Rx(0-15) are coupled to and populated with sixteen signal processors 1302(0), 1302(1), . . . , 1302(15), respectively. These signal processors 1302 are also directly or indirectly coupled to baseband processors 902. It should be noted that one or more active components (e.g., a power amplifier (PA), a low-noise amplifier (LNA), etc.) may also be coupled on the antenna port side of Butler matrix 1300.

[0165] In an exemplary transmission operation, communication signals are provided from baseband processors 902 to the multiple transmit and/or receive signal processors 1302. The multiple signal processors 1302 forward the communication signals to the transmit/receive ports Tx/Rx(0-15) of Butler matrix 1300. After signal processing (e.g., signal combination, signal splitting, signal phase shifting, and the like), Butler matrix 1300 outputs communication signals on the antenna ports A(0-15). Individual antenna elements 400 wirelessly transmit the communication signals, as altered by Butler matrix 1300, from the antenna ports A(0-15) in

predetermined communication beam patterns. The communication beam patterns are predetermined by the shape, orientation, constituency, etc. of antenna array 302 and by the Butler matrix 1300 signal processing. In addition to transmissions, wireless signals such as wireless communications 106 (FIG. 1) are received responsive to the communication beams 214 formed by antenna array 302 in conjunction with Butler matrix 1300 in an inverse process.

[0166] FIG. 14 further illustrates an exemplary modified Butler matrix 1300 for a complementary beam-forming, post-combining implementation, Complementary beam-forming is a technique to reduce the effect of communication beam nulls and increase sidelobe levels without a severe power penalty to the main beam. This is done to reduce the effect of the "hidden beam." As described below, increasing the range of 802.11 networks without increased transmit power and using standard clients is possible with adaptive antenna arrays, such as, for example, directional high-gain antennas. Using high gain antennas, it is possible to direct the energy in a given direction and hence increase the range in that direction.

[0167] Forming directional transmit communication beams has the side effect of hiding the transmitted energy from some client devices in a CSMA network (i.e., negatively impacting the carrier sense mechanism in the network). A client device measures the energy transmitted from access points and from other client devices. If the client device cannot detect the presence of other transmissions, it attempts to access the medium. Therefore, when directional communication beams are used, many client devices detect the medium as idle when in fact it is busy. This has an effect on the performance of the network and is referred to as the "hidden beam" problem.

[0168] In practice, a communication beam (e.g., directional beam) has a main beam whose width can be controlled by the size of the antenna aperture, and sidelobes which vary in different directions. However, these communication beams may have nulls in certain directions that affect the wireless network with a hidden beam. Since a given receiver's energy detect threshold is usually lower than it's decoding threshold, it is possible to direct a high power signal towards an intended client device and yet ensure a minimum transmit power towards other clients in the network so that the signal may be detected by other clients.

[0169] Complementary beam-forming ensures a minimum transmit power in all directions while preserving the shape of the main communication beam. The complementary beam-forming techniques also ensure that multiple transmit beams in arbitrary directions are complemented by

another beam in all other directions. The complementary beam does not interfere with the intended beams and increases the probability that other users in the network can detect the signal.

[0170] The modified Butler matrix 1300 includes the antenna ports 400(0, 1, . . . , N−1, N) and a gain mechanism 1400 configured to modify the signal at output port 400(0). A transmit signal is input to a corresponding input port of the Butler matrix and, in conjunction with the gain mechanism 1400, a complementary beam is formed due to the increase in gain. The result is a directional communication beam from the antenna in a given direction. A complementary beam-forming, pre-combining implementation can also be implemented.

[0171] Mathematically, a complementary beam-forming, post-combining implementation may be described as:

$$y_i = \begin{cases} \gamma_i & i = 0 \\ y_i & \gamma \geq 1 \end{cases} \qquad 0 \leq i \leq N\text{-}1$$

[0172] where y_i is the power applied to antenna element i and γ is the gain value contained in the gain mechanism 1400. To ensure the same output power as with no complementary beam-forming, the output voltage on all of the Butler matrix ports can be adjusted by a scaling factor:

$$G_s = \sqrt{\frac{N}{\gamma^2 + N - 1}}$$

[0173] The power for the main communication beam will then be:

$$\Delta P = \frac{(\gamma + N - 1)^2}{N(\gamma^2 + N - 1)}$$

[0174] or stated in terms of dB:

$$\Delta P_{dB} = 10 \log \left\{ \frac{(\gamma + N - 1)^2}{N(\gamma^2 + N - 1)} \right\}$$

[0175] For example, for a sixteen element antenna array 302, if γ=3.5, then the power loss is approximately 1 dB.

[0176] FIG. 15 illustrates a graph 1500 depicting the signal level output (dB) for certain ports of the modified Butler Matrix 1300 shown in FIG. 14. Graph 1500 depicts the shape of a

transmit communication beam 1502 without complementary beam-forming and a transmit communication beam 1504 with complementary beam-forming applied. In this example, the transmit communication beam is derived from a signal at port 400(0) of Butler Matrix 1300. As shown, the output with complementary beam-forming (e.g., transmit communication beam 1504) has higher sidelobes in all directions and removes all of the deep nulls except for the nulls on the main communication beam. The peak power of the main communication beam is approximately one dB lower than that without complementary beam-forming.

[0177] FIG. 16 illustrates a transition diagram 1600 for a roaming client device that transitions from one communication location within a wireless network system to another. For example, client device 202 (FIG. 2), while in wireless communication with access station 102 via directed communication beam 214(1) may roam (e.g., move, relocate, transition, etc.) such that communication with access station 102 would be facilitated via directed communication beam 214(2). A client device initially associates to one directed signal of the multi-beam directed signal system 206 by selecting the signal (e.g., communication beam) with the best signal at the time of association. However, because the client device may be portable and/or the wireless environment may change (e.g., due to device transitions, interference, etc.), the initially selected directed signal may not provide a continuous, or the best, communication channel over which to communicate information (e.g., in the data packets) and hence the client may have to roam and/or be associated with another directed communication beam.

[0178] Roaming is dependent on client device implementation, is initiated by a client device, and may not be directly controlled by the multi-beam directed signal system 206. In most commercially available client devices, roaming is triggered when the channel quality (SNR) falls below a threshold. The channel quality assessment (SNR measurement) is based on received strength of a directed communication beam. To ensure that a client device is associated with the best signal, the multi-beam directed signal system 206 directs the client device to roam to the directed communication beam with the best signal quality using a beam-switching algorithm.

[0179] Additionally, to ensure seamless roaming between communication beams, the multi-beam directed signal system 206 implements Inter-Access Point Protocol (IAPP) which is defined by IEEE 802.11f to support interoperability, mobility, handover messaging between directed communication beams 214, and coordination between access stations 102 in a wireless communications environment. Beam-switching can be implemented by the multi-beam controller

816 (FIG. 8B) in the multi-beam directed signal system 206 to ensure that client devices are associated with the directed communication beam 214 having the best signal level and IAPP to ensure client-initiated seamless roaming.

[0180] The beam-switching algorithm disassociates a client device once it moves out of an associated main communication beam. However, such movement of a client device is difficult to detect in the wireless environment and disassociation may result in data packet loss and a long association procedure. The effect is particularly significant for client devices located between adjacent directed communication beams. Hence, the beam-switching algorithm will disassociate a client device when there is a determinable difference between signal qualities on different communication beams.

[0181] With reference to FIG. 16, a client device may be described as being in a monitor state 1602, a correct beam test state 1604, and a force roam state 1606. In the monitor state 1602, a client device is associated with a directed communication beam 214 while the multi-beam directed signal system 206 (e.g., access station 102) continues to sample and collect receive strength signal indications (RSSI) values for each data packet received from the client device. The multi-beam controller 816 recalculates a new measure identified as a smoothed RSSI value (*SmoothedRSSIValue*) over an RSSI window size (*RSSIWindowSize*) and compares it to an RSSI lower control limit threshold (*RSSILowerControlLimit*).

[0182] In the correct beam test state 1604, the scanning receiver 822 measures the RSSIs and calculates a smoothed RSSI value (*SmoothedRSSIValue*) for the client device on each of the adjacent ports (e.g., communication beams). Samples of the RSSI window size (*RSSIWindowSize*) for the two adjacent ports are averaged and compared to the same parameter for the current communication beam to determine the best, or most effective, communication beam. In the force roam state 1606, the client device is temporarily disassociated so that it cannot associate to the current directed communication beam.

[0183] An association transition 1608 to the correct beam test state 1604 occurs when a client device associates a directed communication beam 214. From the correct beam test state 1604, a correct beam transition 1610 indicates that a current communication beam is the best communication link between the client device and the multi-beam directed signal system. New RSSI values are sampled and a new lower control limit (*LowerControlLimit*) is recalculated. A scan timeout transition 1612 from the correct beam test state 1604 indicates that the scanning

receiver 822 has been monitoring the adjacent communication beams for more than a roaming scan timeout duration (*RoamingScanTimeout*) without any decision about the correct beam.

[0184] From the monitor state 1602, a sample RSSI transition 1614 indicates that the smoothed RSSI value (*SmoothedRSSIValue*) and the RSSI lower control limit (*RSSILowerControlLimit*) are re-calculated. A smoothed RSSI drop transition 1616 from the monitor state 1602 drops the smoothed RSSI value (*SmoothedRSSIValue*) to an RSSI lower control limit (*RSSILowerControlLimit*). A wrong beam transition 1618 from the correct beam test state 1604 indicates a better communication beam is identified that has an RSSI that exceeds the RSSI of the current communication beam by a signal drop threshold dB (*SignalDropThreshold*). The client device is disassociated from the current communication beam and a timeout transition 1620 occurs after a roaming time out (*RoamingTimeOut*). The state information corresponding to the client device is then removed (e.g., deleted, discarded, etc.).

[0185] The lower control limit parameter (*LowerControlLimit*) is calculated using both the mean and the standard deviation of RSSI as follows:

$$LowerControlLimit = \overline{RSSI} - 2\sigma$$

$$\overline{RSSI} = \frac{1}{N}\sum_{i=0}^{N-1} RSSI_i \qquad N = RSSIWindow\ Size \text{ in frames}$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1}\left(RSSI_i - \overline{RSSI}\right)^2}$$

[0186] The $RSSI_i$ is the RSSI value reported for frame i. The $N-1th$ frame is the most recent frame. The smoothed RSSI value (*SmoothedRSSIValue* (S)) is calculated when RSSI values are sample when a data packet is received. The smoothed RSSI value is calculated as $S_j=0.1*RSSI_j + 0.9*S_{j-1}$. This value is then compared to the lower control limit (*LowerControlLimit*) and if it is larger than the limit, the client device enters the correct beam test state 1604. The IAPP seamless roaming enables seamless client-initiated roaming between communication beams within an

antenna panel, between antenna panels, and between an antenna panel and third party access points (e.g., access stations, multi-beam directed signal system, etc.).

[0187] Methods for directed wireless communication may be described in the general context of computer-executable instructions. Generally, computer-executable instructions include routines, programs, objects, components, data structures, and the like that perform particular functions or implement particular abstract data types. Methods for directed wireless communication may also be practiced in distributed computing environments where functions are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, computer-executable instructions may be located in both local and remote computer storage media, including memory storage devices.

[0188] FIG. 17 illustrates a method 1700 for directed wireless communication. The order in which the method is described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Furthermore, the method can be implemented in any suitable hardware, software, firmware, or combination thereof.

[0189] At block 1702, a directed wireless communication is generated for data communication with a client device. At block 1704, the directed wireless communication is received at an antenna assembly, and at block 1706, a directed communication beam is emanated for the data communication with the client device. For example, the multi-beam directed signal system 206 (shown in FIG. 2) generates a directed wireless communication for data communication with client device 202. Antenna assembly 208 receives the generated wireless communication and emanates a directed communication beam 214(1) for the data communication with client device 202. In an embodiment, the directed communication beam can be emanated from two or more antenna elements of the antenna assembly as an electromagnetic signal that includes transmission peaks and transmissions nulls within a coverage area of the directed communication beam 214(1).

[0190] At block 1708, the data communication is transmitted to the client device via the directed communication beam. At block 1710, a second directed communication beam is emanated for data communication reception from a second client device, and at block 1712, a second data communication is received from the second client device via the second directed communication beam. For example, an additional directed communication beam 214(N) can be emanated from

antenna assembly 208 for data communication reception from client device 204. The data communication transmission (at block 1708) can be controlled so as not to interfere with receiving the second data communication (at block 1712) and optionally, transmitting the data communication and receiving the second directed data communication is simultaneous.

[0191] FIG. 18 illustrates a method 1800 for directed wireless communication. The order in which the method is described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Furthermore, the method can be implemented in any suitable hardware, software, firmware, or combination thereof.

[0192] At block 1802, directed wireless communication is coordinated with client devices via directed communication beams emanated from an antenna assembly. For example, wireless communications are coordinated by the signal control and coordination logic 304 (shown in FIG. 3) with client devices 202 and 204 (FIG. 2) via directed communication beams 214(1) and 214(N), respectively, which are emanated from antenna assembly 208. A directed communication beam can be emanated as an electromagnetic signal that includes transmission peaks and transmission nulls within a coverage area of the directed communication beam. Further, energy can be transmitted on a side lobe of a directed communication beam corresponding to a first client device such that a second client device will detect the side lobe energy and recognize that a data communication transmission is being emanated to the first client device via the directed communication beam.

[0193] The directed wireless communication can be coordinated such that only client device 202 receives a first directed wireless communication via communication beam 214(1), and such that only client device 204 receives a second directed wireless communication via communication beam 214(N). Coordinating directed wireless communication can include simultaneous data communication transmission to client device 202 via directed communication beam 214(1) and a data communication reception from client device 204 via directed communication beam 214(N). Further, the data communication transmission is coordinated so as not to interfere with the data communication reception.

[0194] At block 1804, data communication transmissions are routed through a transmit beam-forming network to antenna elements of the antenna assembly such that a data communication transmission is communicated to a client device via a directed communication

beam. At block 1806, the directed communication beams are monitored for data communication receptions from the client devices. At block 1808, data communication receptions are received through a receive beam-forming network from the antenna elements of the antenna assembly such that a data communication reception is received from a client device via a directed communication beam. For example, a data communication reception can be received from a client device with scanning receiver 822 (shown in FIG. 8B).

[0195] At block 1810, a determination is made as to which of multiple channels provides acceptable data communication transmission and/or reception with a client device. At block 1812, information is maintained corresponding to one or more of the client devices. The information can include a transmit power level, a data transmit rate, an antenna direction, quality of service data, and timing data. Further, coordinating a directed wireless communication with a client device (as described in block 1802) can be based on the information that is maintained (at block 1812).

[0196] FIG. 19 illustrates a method 1900 for directed wireless communication. The order in which the method is described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Furthermore, the method can be implemented in any suitable hardware, software, firmware, or combination thereof.

[0197] At block 1902, a client device is associated with a directed communication beam. For example, a portable client device 202 (shown in FIG. 2) is associated with communication beam 214(1) (shown in FIGS. 2 and 3). At block 1904, signal strength indications are received for data packets received from the client device via the directed communication beam. At block 1906, a signal strength average for the client device is calculated from the received signal strength indications.

[0198] At block 1908, adjacent signal strength indications are sampled for an adjacent directed communication beam. At block 1910, a second signal strength average is calculated for the adjacent directed communication beam. For example, signal strength indications are sampled for an adjacent directed communication beam 214(2) (shown in FIGS. 2 and 3), and a signal strength average is calculated for the adjacent directed communication beam 214(2).

[0199] At block 1912, the signal strength average is compared to the second signal strength average and a determination is made as to which provides a more effective, or better, communication link. If the second signal strength average does not indicate that the adjacent

directed communication beam would provide a better communication link than the directed communication beam (i.e., no from block 912), then the client device association with the initial directed communication beam is maintained at block 914.

[0200] If the second signal strength average indicates that the adjacent directed communication beam would provide a better communication link than the directed communication beam (i.e., no from block 912), then the client device is disassociated with the directed communication beam at block 916. At block 918, the client device is re-associated with the adjacent directed communication beam. The method 1900 can then continue and be reiterated from block 1902. Additionally, the method 1900 can be implemented for any number of client devices in wireless communication with a directed wireless communication system.

[0201] Although wireless communication system(s) have been described in language specific to structural features and/or methods, it is to be understood that the subject of the appended claims is not necessarily limited to the specific features or methods described. Rather, the specific features and methods are disclosed as exemplary implementations of wireless communication system(s).

WHAT IS CLAIMED IS:

1. A data-communications networking apparatus, comprising:

a processor configured to:

generate a first sequence of symbols for transmission to a first client device; and

generate a second sequence of symbols for transmission to a second client device;

a transceiver operatively coupled to the processor and configured to:

transmit the first sequence of symbols to the first client device via an antenna;

transmit the second sequence of symbols to the second client device via the antenna,

wherein the antenna is operatively coupled to the transceiver;

wherein one or more of the processor, the transceiver, or the antenna is further configured to:

transmit the first sequence of symbols to the first client device via one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the first client device;

transmit the second sequence of symbols to the second client device via the one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the second client device;

receive feedback information regarding at least one of the one or more beams from at least one of the first or second client devices; and

modify at least one of the one or more beams based on the feedback information.

2. The data-communications networking apparatus as recited in Claim 1, wherein the transceiver is further configured to: transmit the first sequence of symbols and the second sequence of symbols at least partly simultaneously.

3. The data-communications networking apparatus as recited in Claim 1, wherein the transceiver is further configured to: transmit the first sequence of symbols and the second sequence of symbols at different times.

4. The data-communications networking apparatus as recited in Claim 1, wherein the processor is further configured to: compute a first weight to apply to a first beam of the one or more beams.

5. The data-communications networking apparatus as recited in Claim 4, wherein one or more of the processor, the transceiver, or the antenna are further configured to: modify the first beam by applying the first weight to the first beam to create a modified first beam.

6. The data-communications networking apparatus as recited in Claim 5, wherein the first weight is calculated based on the feedback information.

7. The data-communications networking apparatus as recited in Claim 6, wherein the feedback information comprises at least one of: a transmit power level, a data receive rate, an antenna direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, or timing data.

8. The data-communications networking apparatus as recited in Claim 5, wherein one or more of the processor, the transceiver, or the antenna are further configured to: transmit a third sequence of symbols to the first client device via the modified first beam.

9. The data-communications networking apparatus as recited in Claim 4, wherein the processor is further configured to: compute a second weight to apply to a second beam of the one or more beams, wherein the first weight and the second weight are different.

10. The data-communication networking apparatus as recited in Claim 9, wherein one or more of the processor, the transceiver, or the antenna are further configured to:

modify the second beam by applying the second weight to the second beam to create a modified second beam; and

transmit a fourth sequence of symbols to the second client device via the modified second beam.

11. A method of enabling data communications in a networking apparatus, the method comprising:

generating a first sequence of symbols for transmission to a first client device;

generating a second sequence of symbols for transmission to a second client device;

transmitting the first sequence of symbols to the first client device via one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the first client device;

transmitting the second sequence of symbols to the second client device via the one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the second client device;

receiving feedback information regarding at least one of the one or more beams from at least one of the first or second client devices; and

modifying at least one of the one or more beams based on the feedback information.

12. The method of enabling data communications in a networking apparatus as recited in Claim 11, further comprising: computing a first weight to apply to a first beam of the one or more beams.

13. The method of enabling data communications in a networking apparatus as recited in Claim 12, further comprising: modifying the first beam by applying the first weight to the first beam.

14. The method of enabling data communications in a networking apparatus as recited in Claim 13, wherein the first weight is calculated based on the feedback information.

15. The method of enabling data communications in a networking apparatus as recited in Claim 14, wherein the feedback information comprises at least one of: a transmit power level, a data receive rate, an antenna direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, or timing data.

16. A data-communications networking apparatus, comprising:

a processor configured to:

generate a first set of symbols for transmission to a first client device; and

generate a second set of symbols for transmission to a second client device;

a transceiver operatively coupled to the processor and to an antenna, the transceiver configured to:

transmit the first sequence of symbols to the first client device from the antenna via a first beam, wherein the first beam focuses transmit energy toward the first client device;

transmit the second sequence of symbols to the second client device from the antenna via a second beam, wherein the second beam focuses transmit energy toward the second client device; and

receive information regarding the first beam from the first client device,

wherein the processor is further configured to: modify the first beam based on the information.

17. The data-communications networking apparatus as recited in Claim 16, wherein the transceiver is further configured to: transmit the first sequence of symbols and the second sequence of symbols from the antenna at least partly simultaneously.

18. The data-communications networking apparatus as recited in Claim 16, wherein the transceiver is further configured to: transmit the first sequence of symbols and the second sequence of symbols from the antenna at different times.

19. The data-communications networking apparatus as recited in Claim 16, wherein the processor is further configured to: compute a first weight to apply to the first beam.

20. The data-communications networking apparatus as recited in Claim 19, wherein the transceiver is further configured to: modify the first beam by applying the first weight to the first beam to create a modified first beam.

21. The data-communications networking apparatus as recited in Claim 20, wherein the first weight is calculated based on the information.

22. The data-communications networking apparatus as recited in Claim 21, wherein the information comprises at least one of: a transmit power level, a data receive rate, an antenna

direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, or timing data.

23. The data-communications networking apparatus as recited in Claim 20, the transceiver is further configured to: transmit a third sequence of symbols to the first client via the modified first beam.

24. The data-communications networking apparatus as recited in Claim 19, wherein the processor is further configured to: compute a second weight to apply to the second beam, wherein the first weight and the second weight are different.

25. The data-communication networking apparatus as recited in Claim 24, wherein the transceiver is further configured to:

modify the second beam by applying the second weight to the second beam to create a modified second beam; and

transmit a fourth sequence of symbols to the second client device via the modified second beam.

26. A method of enabling data communications in a networking apparatus, the method comprising:

generating a first set of symbols for transmission to a first client device; and

generating a second set of symbols for transmission to a second client device;

transmitting the first sequence of symbols to the first client device via a first beam, wherein the first beam focuses transmit energy toward the first client device;

transmitting the second sequence of symbols to the second client device via a second beam, wherein the second beam focuses transmit energy toward the second client device; and

receiving information regarding the first beam from the first client device,

modifying the first beam based on the information.

27. The method of enabling data communications in a networking apparatus as recited in Claim 26, further comprising: computing a first weight to apply to the first beam.

28. The method of enabling data communications in a networking apparatus as recited in Claim 27, further comprising: modifying the first beam by applying the first weight to the first beam.

29. The method of enabling data communications in a networking apparatus as recited in Claim 28, wherein the first weight is calculated based on the information.

30. The method of enabling data communications in a networking apparatus as recited in Claim 29, wherein the information comprises at least one of: a transmit power level, a data receive rate, an antenna direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, or timing data.

DIRECTED WIRELESS COMMUNICATION

ABSTRACT

Disclosed herein are methods and apparatuses configured to direct wireless communication. In some embodiments, a networking apparatus is configured to generate a plurality of sequences of symbols for transmission to plurality of client devices; transmit the plurality of sequences to the plurality of client device via one or more beams focused toward the client devices; receive information regarding the one or more beams from the client devices; and modify at least one of the one or more beams based on the information.

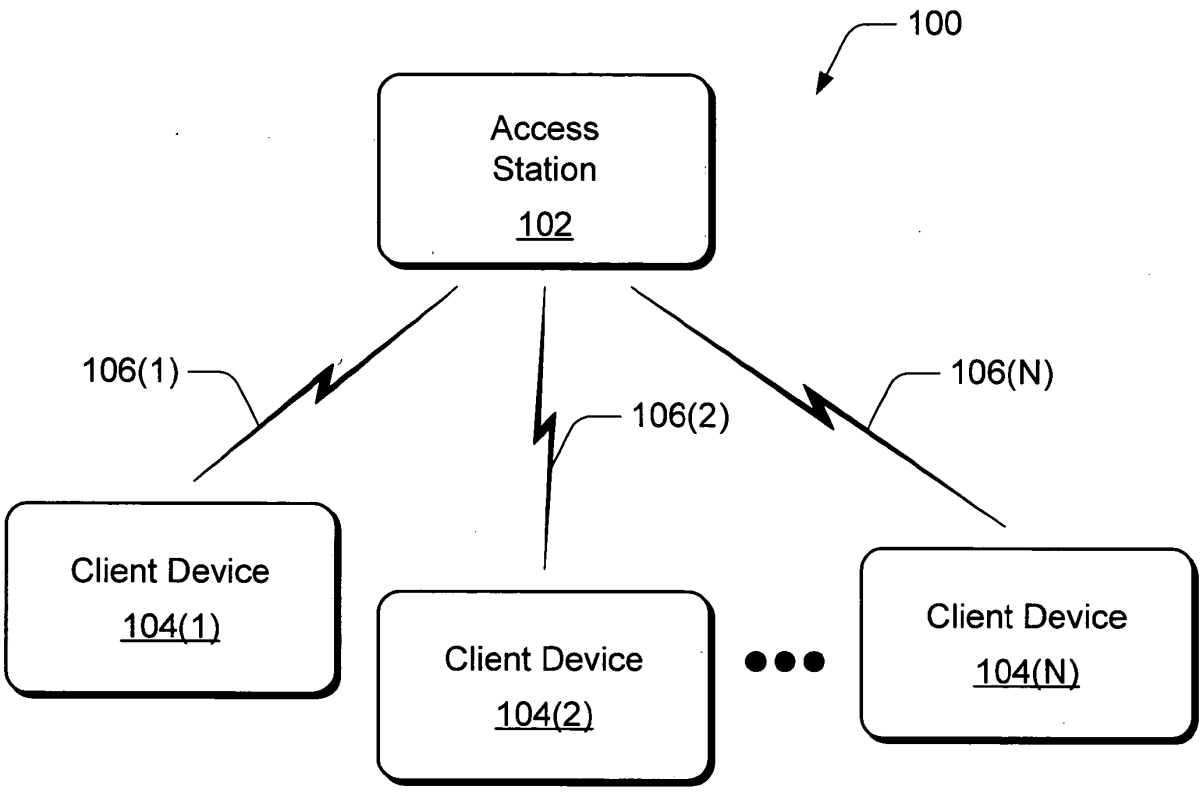

100
Access Station
102
106(1)
106(2)
106(N)
Client Device
104(1)
Client Device
104(2)
Client Device
104(N)

Fig. 1

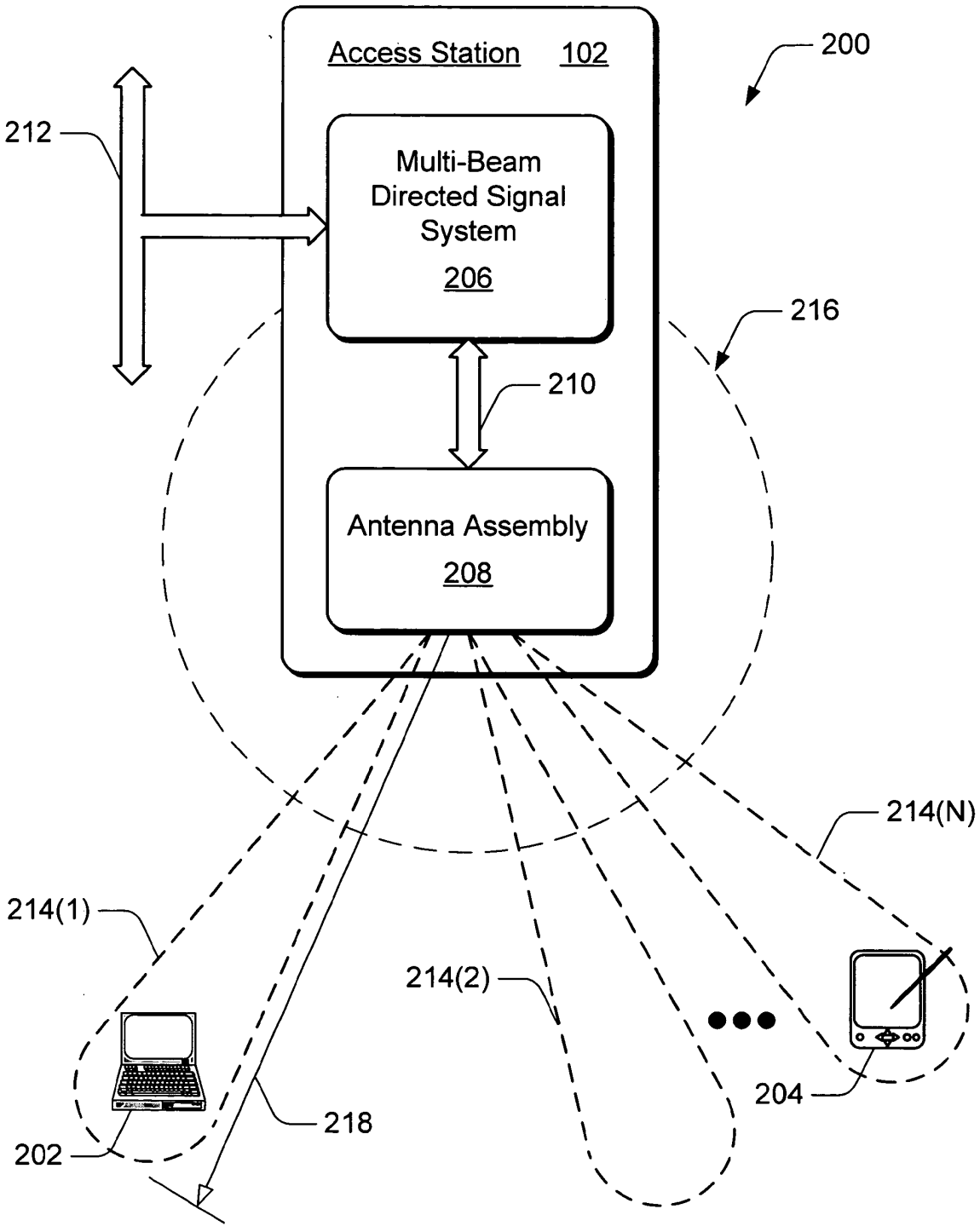

Access Station 102
200
212
Multi-Beam Directed Signal System 206
216
210
Antenna Assembly 208
214(N)
214(1)
214(2)
204
218
202

Fig. 2

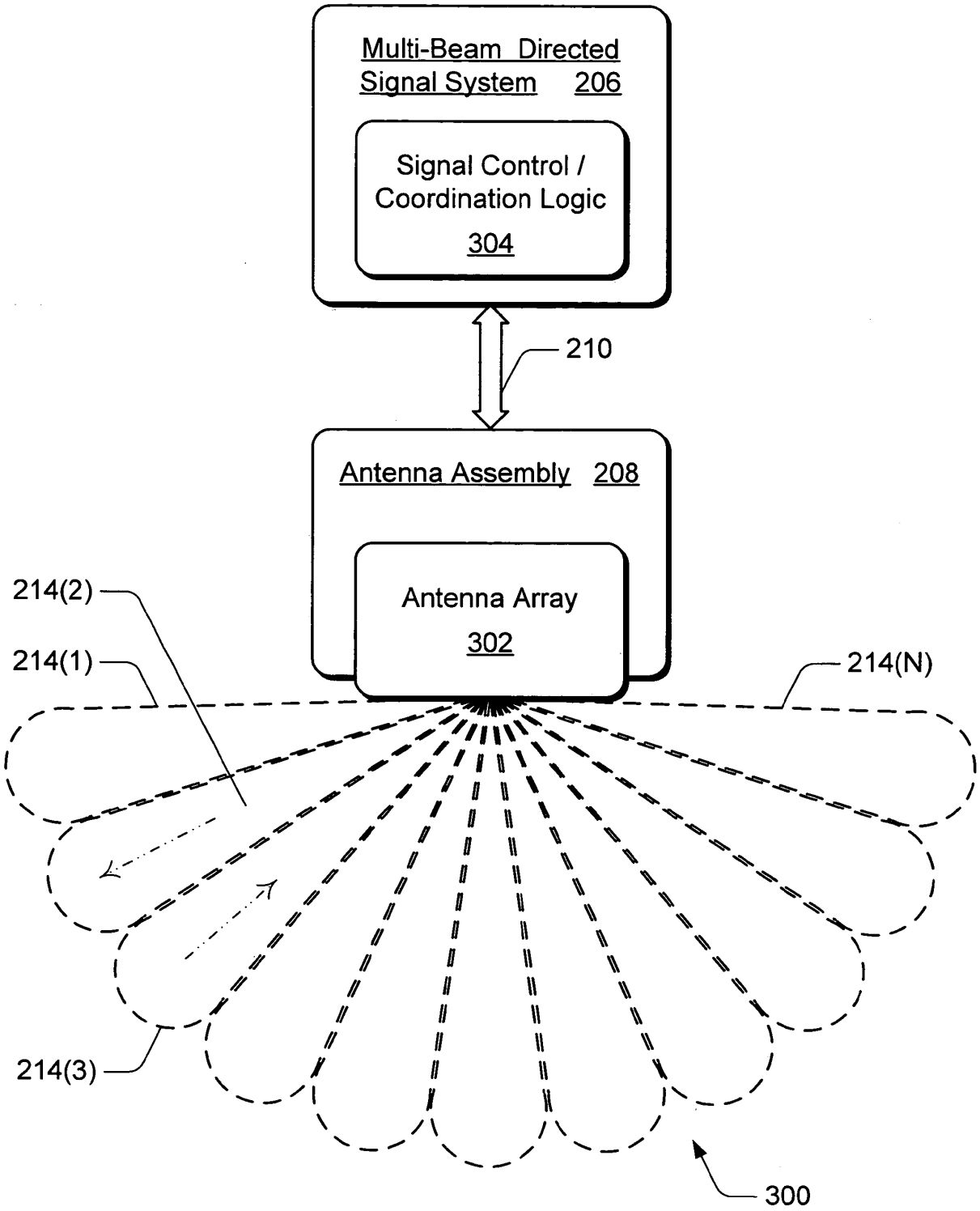

Multi-Beam Directed Signal System 206
Signal Control / Coordination Logic 304
210
Antenna Assembly 208
Antenna Array 302
214(2)
214(1)
214(N)
214(3)
300

Fig. 3

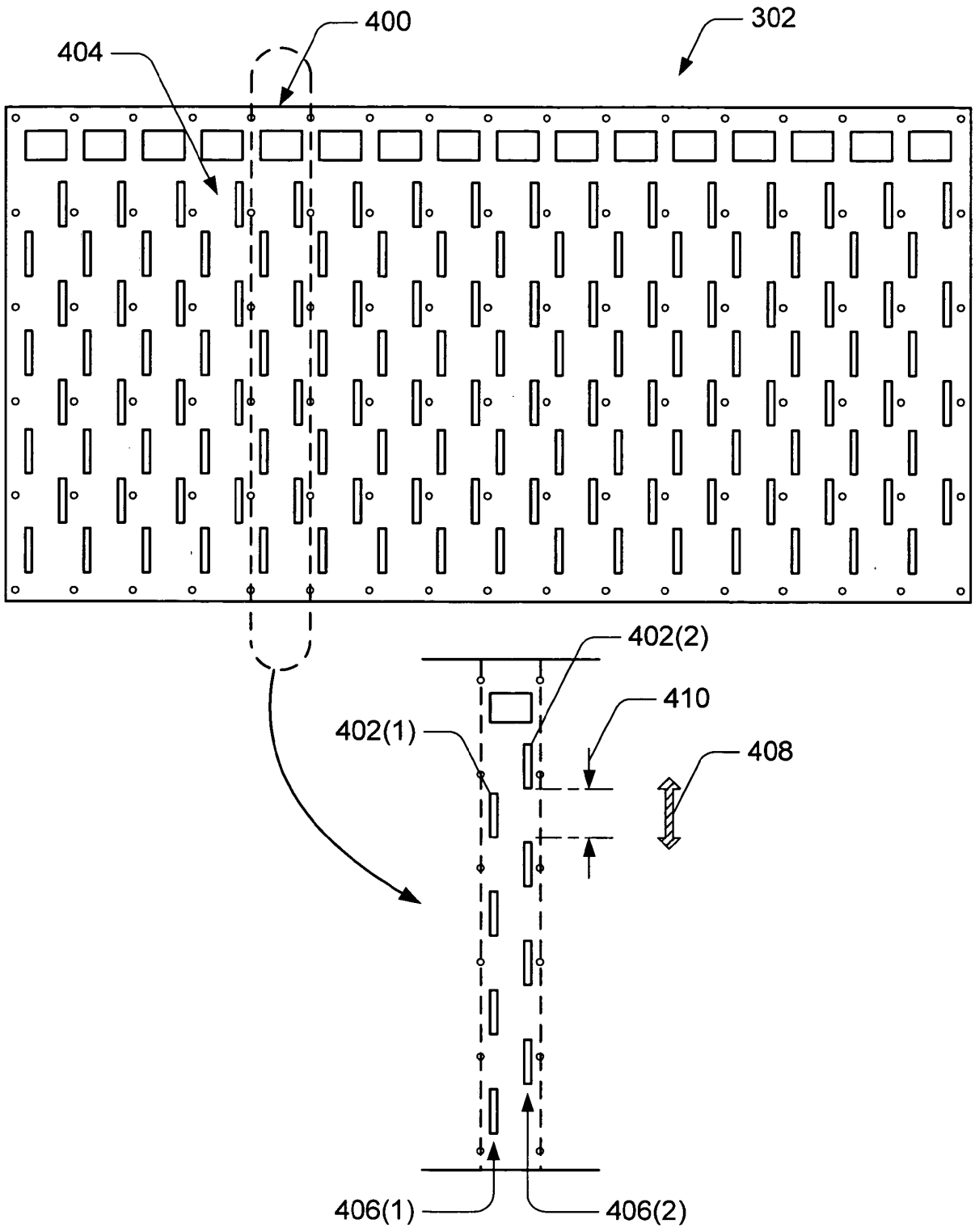


Fig. 4

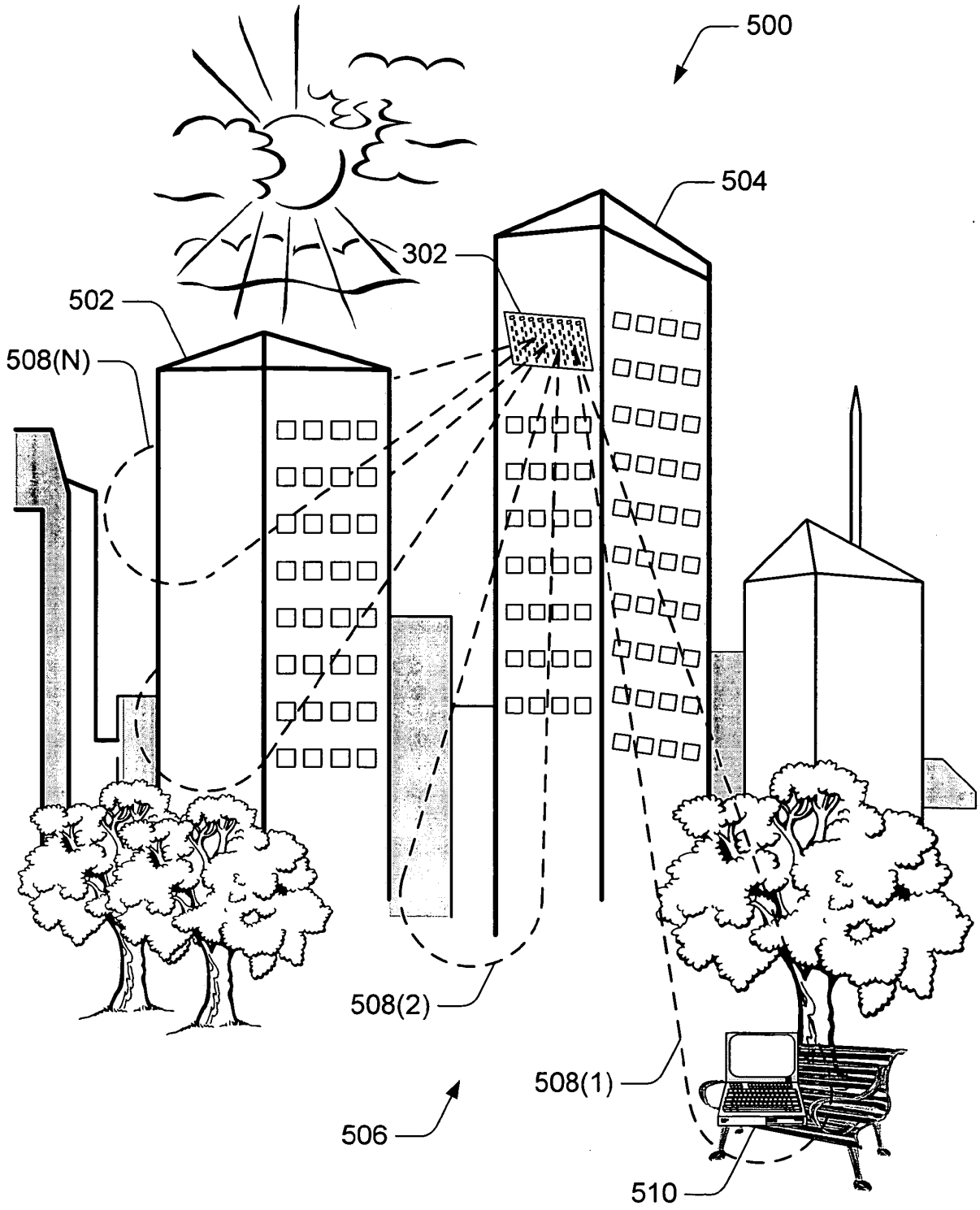


Fig. 5

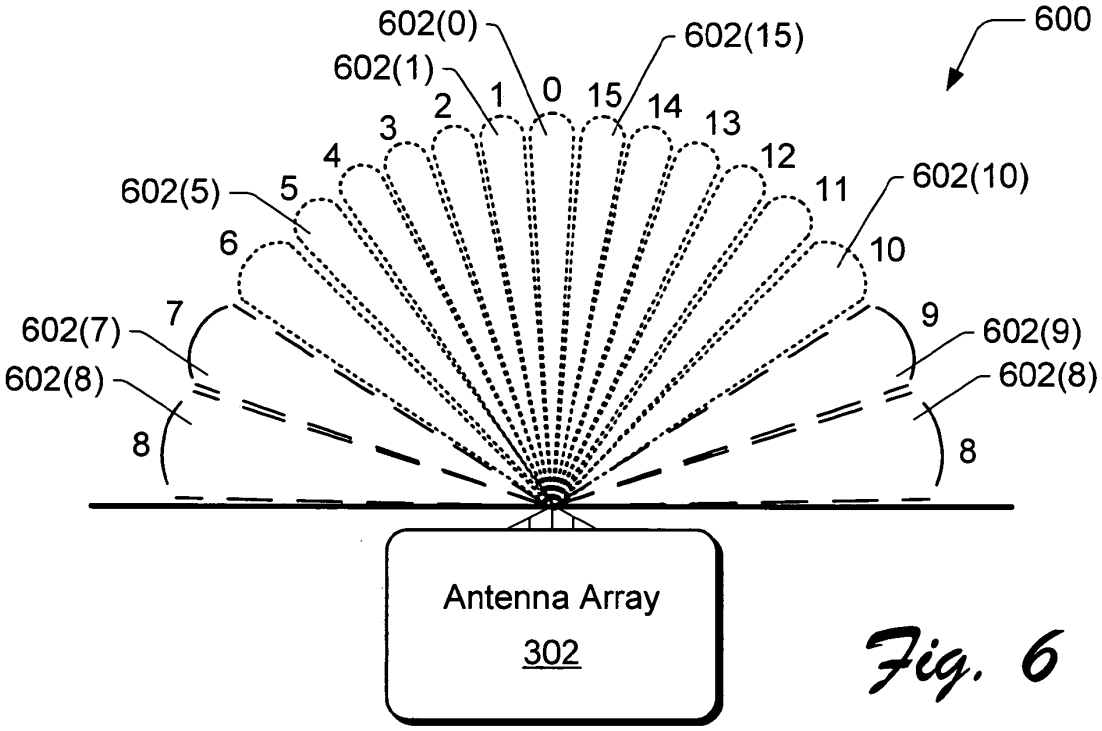

600
602(0)
602(1)
602(15)
602(5)
602(10)
602(7)
602(9)
602(8)
602(8)
0
1
2
3
4
5
6
7
8
8
9
10
11
12
13
14
15
Antenna Array
302

Fig. 6

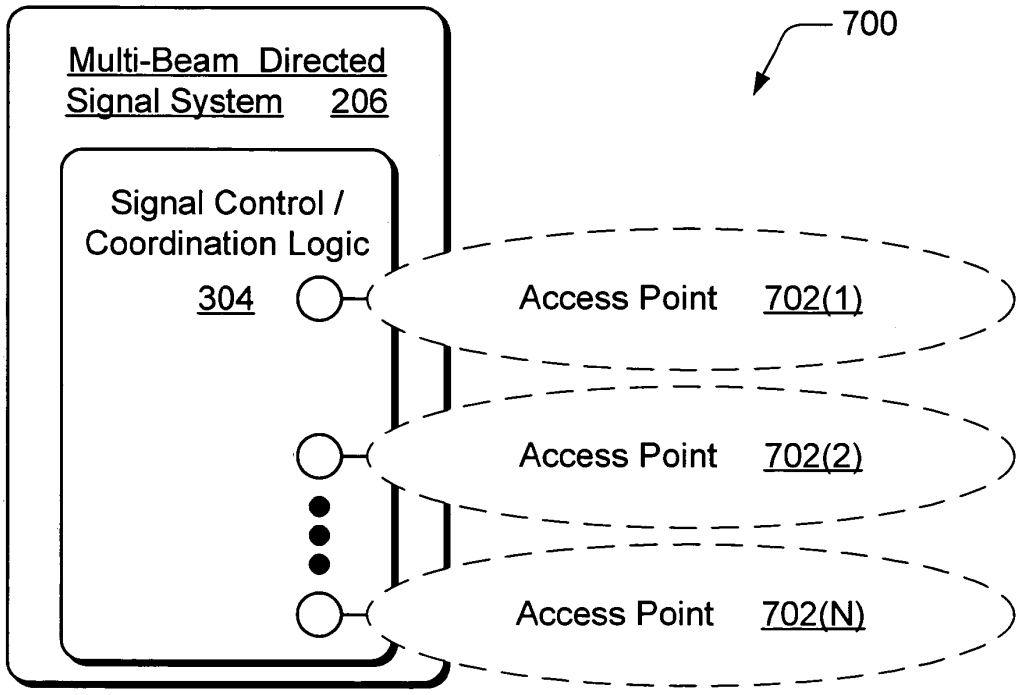

700
Multi-Beam Directed
Signal System 206
Signal Control /
Coordination Logic
304
Access Point 702(1)
Access Point 702(2)
Access Point 702(N)

Fig. 7

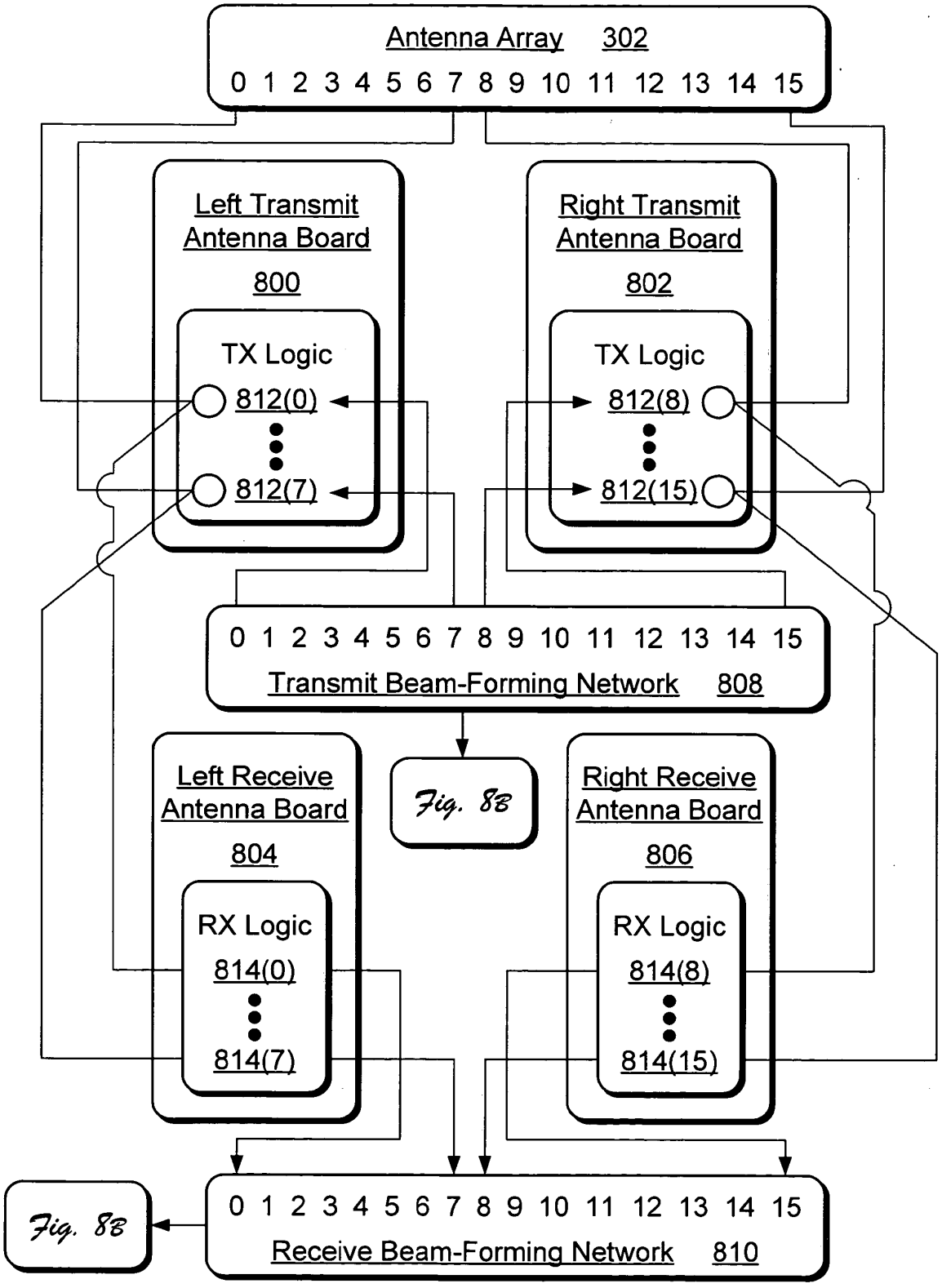

Antenna Array 302
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Left Transmit Antenna Board 800
TX Logic
812(0)
812(7)
Right Transmit Antenna Board 802
TX Logic
812(8)
812(15)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Transmit Beam-Forming Network 808
Fig. 8B
Left Receive Antenna Board 804
RX Logic
814(0)
814(7)
Right Receive Antenna Board 806
RX Logic
814(8)
814(15)
Fig. 8B
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Receive Beam-Forming Network 810

Fig. 8A

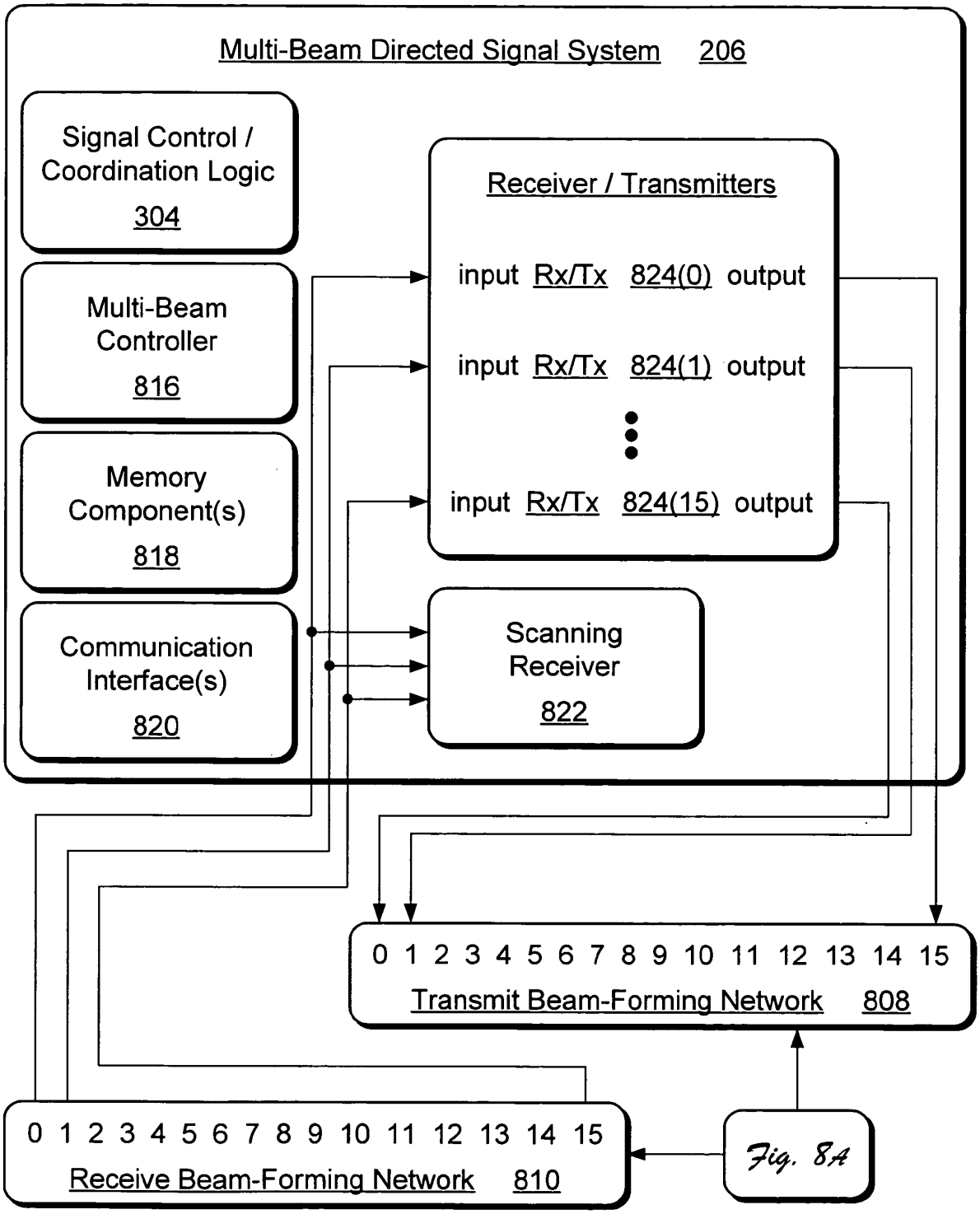

Multi-Beam Directed Signal System 206
Signal Control / Coordination Logic 304
Multi-Beam Controller 816
Memory Component(s) 818
Communication Interface(s) 820
Receiver / Transmitters
input Rx/Tx 824(0) output
input Rx/Tx 824(1) output
input Rx/Tx 824(15) output
Scanning Receiver 822
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Transmit Beam-Forming Network 808
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Receive Beam-Forming Network 810
Fig. 8A

Fig. 8B

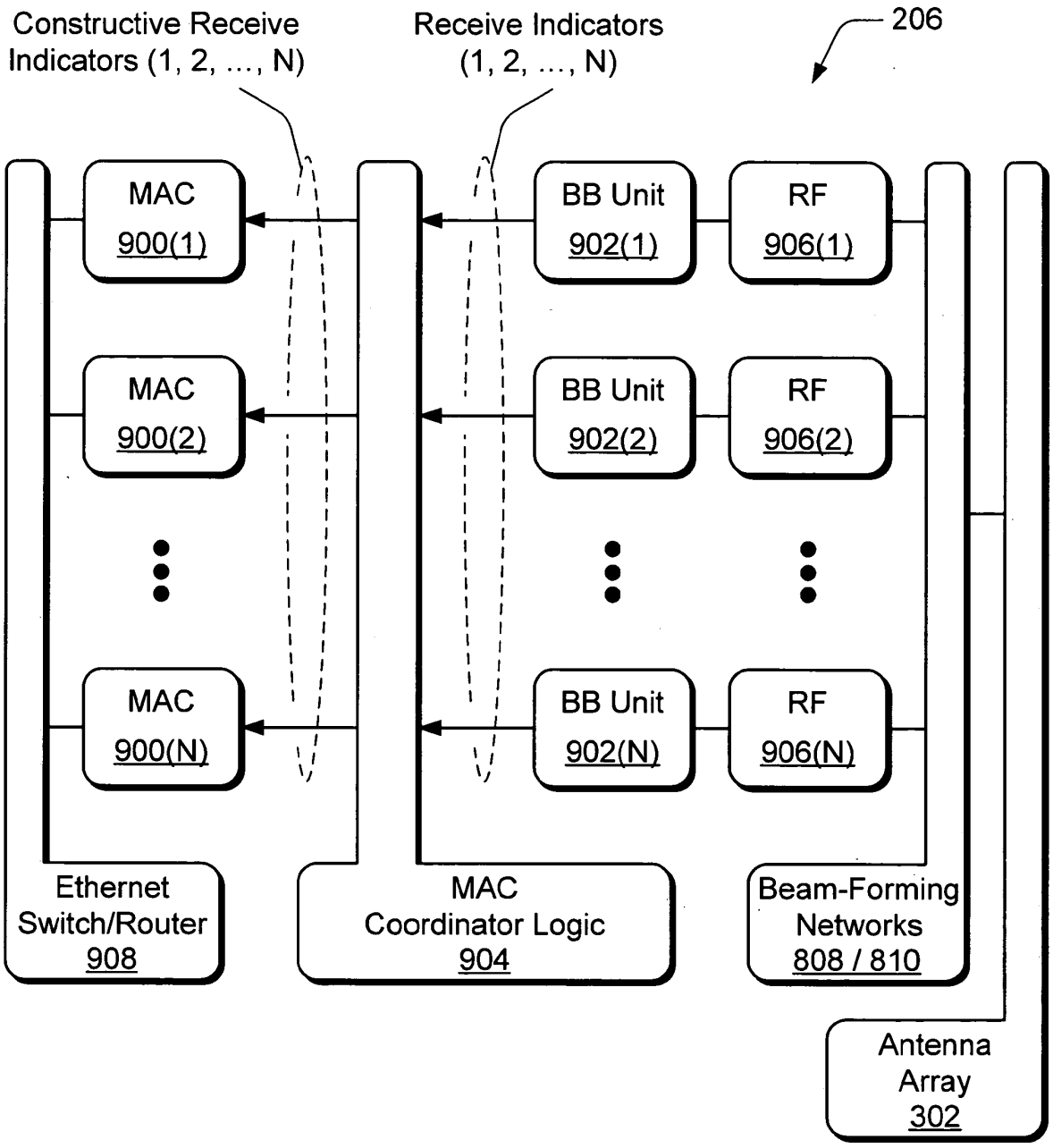


Fig. 9

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

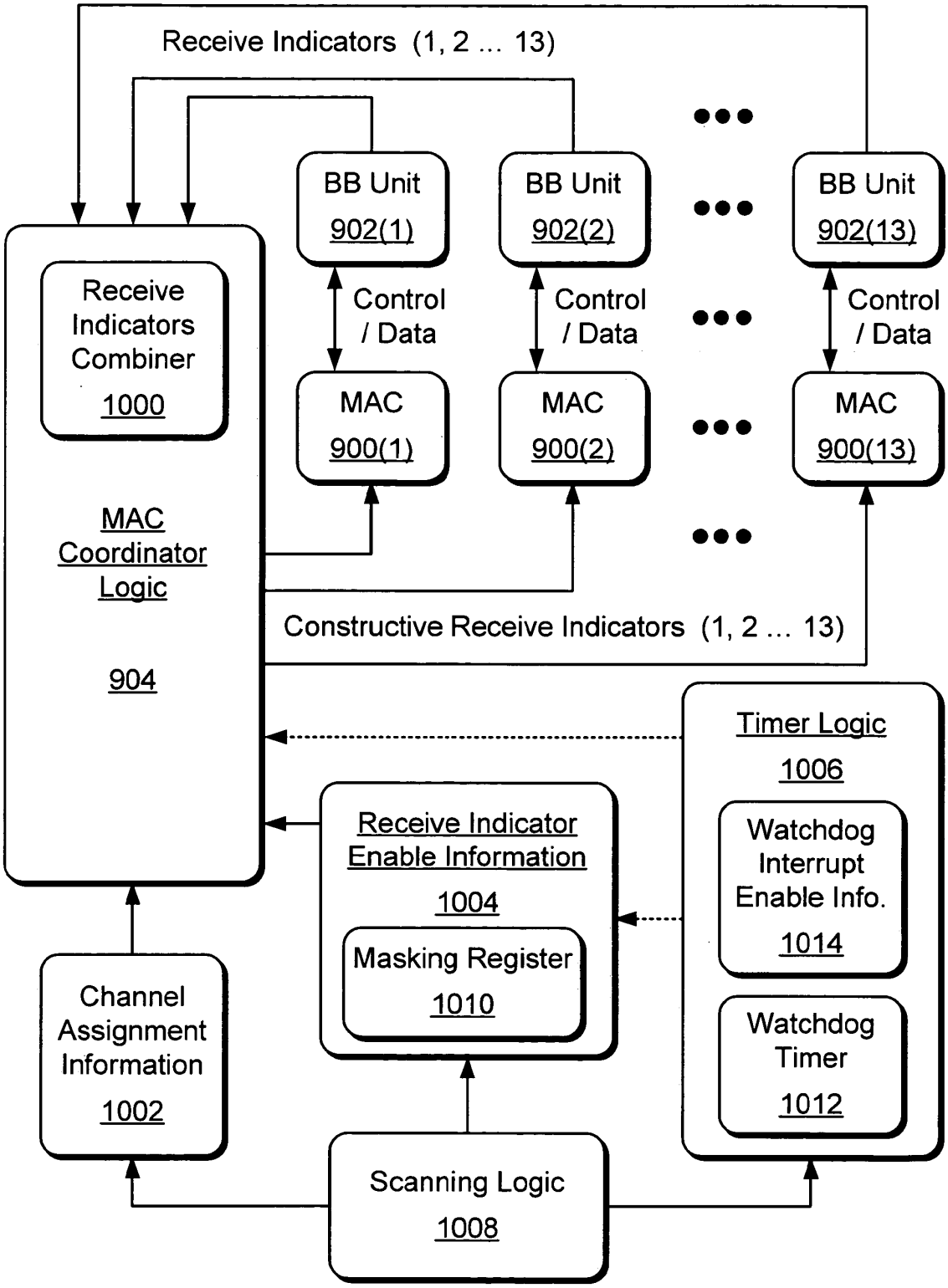

Receive Indicators (1, 2 ... 13)
BB Unit 902(1)
BB Unit 902(2)
BB Unit 902(13)
Receive Indicators Combiner 1000
Control / Data
Control / Data
Control / Data
MAC 900(1)
MAC 900(2)
MAC 900(13)
MAC Coordinator Logic 904
Constructive Receive Indicators (1, 2 ... 13)
Timer Logic 1006
Receive Indicator Enable Information 1004
Masking Register 1010
Watchdog Interrupt Enable Info. 1014
Watchdog Timer 1012
Channel Assignment Information 1002
Scanning Logic 1008

Fig. 10

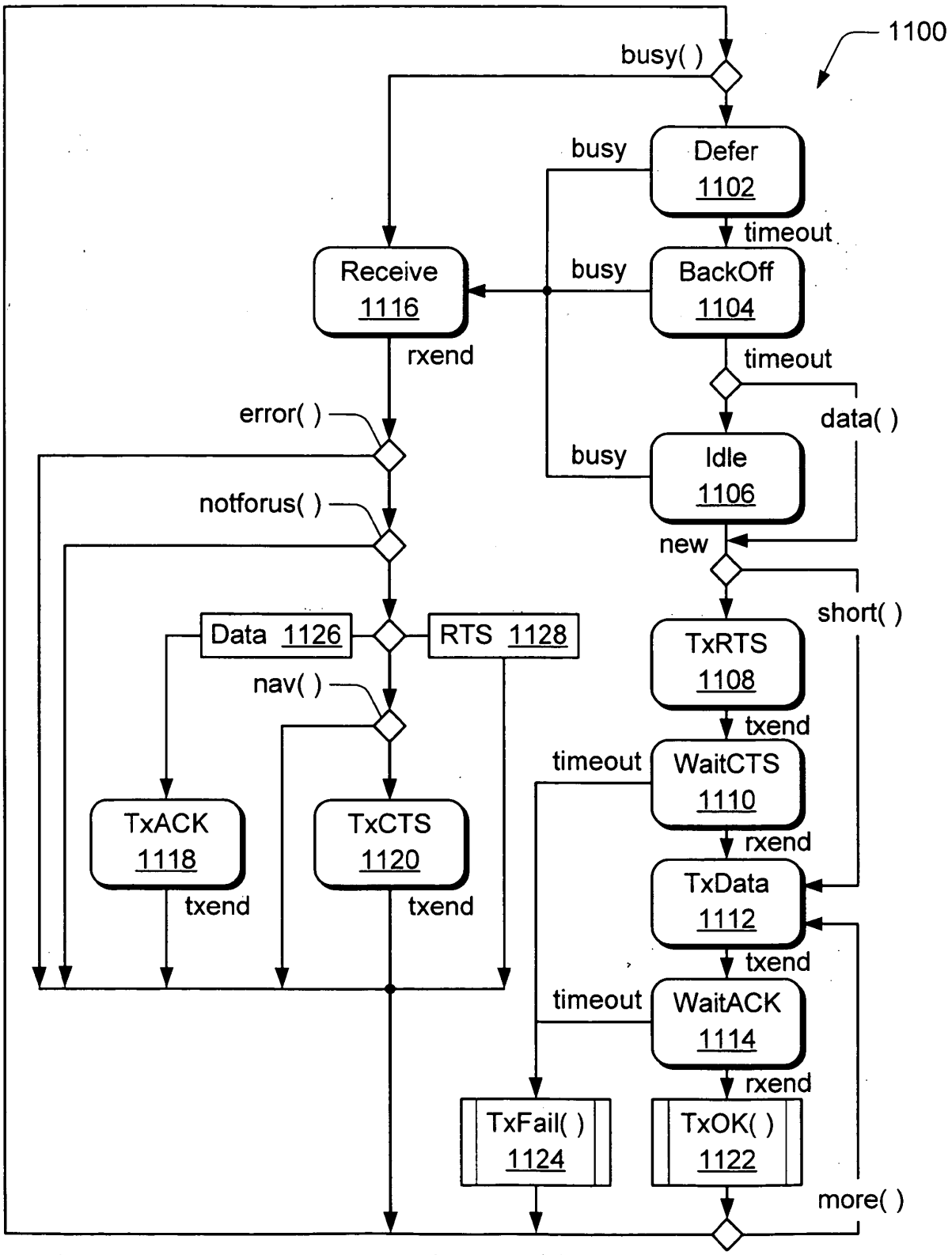

1100
busy( )
busy
Defer
1102
timeout
Receive
1116
busy
BackOff
1104
rxend
timeout
error( )
data( )
busy
Idle
1106
notforus( )
new
short( )
Data 1126
RTS 1128
TxRTS
1108
nav( )
txend
timeout
WaitCTS
1110
TxACK
1118
TxCTS
1120
rxend
txend
txend
TxData
1112
txend
timeout
WaitACK
1114
rxend
TxFail( )
1124
TxOK( )
1122
more( )

Fig. 11

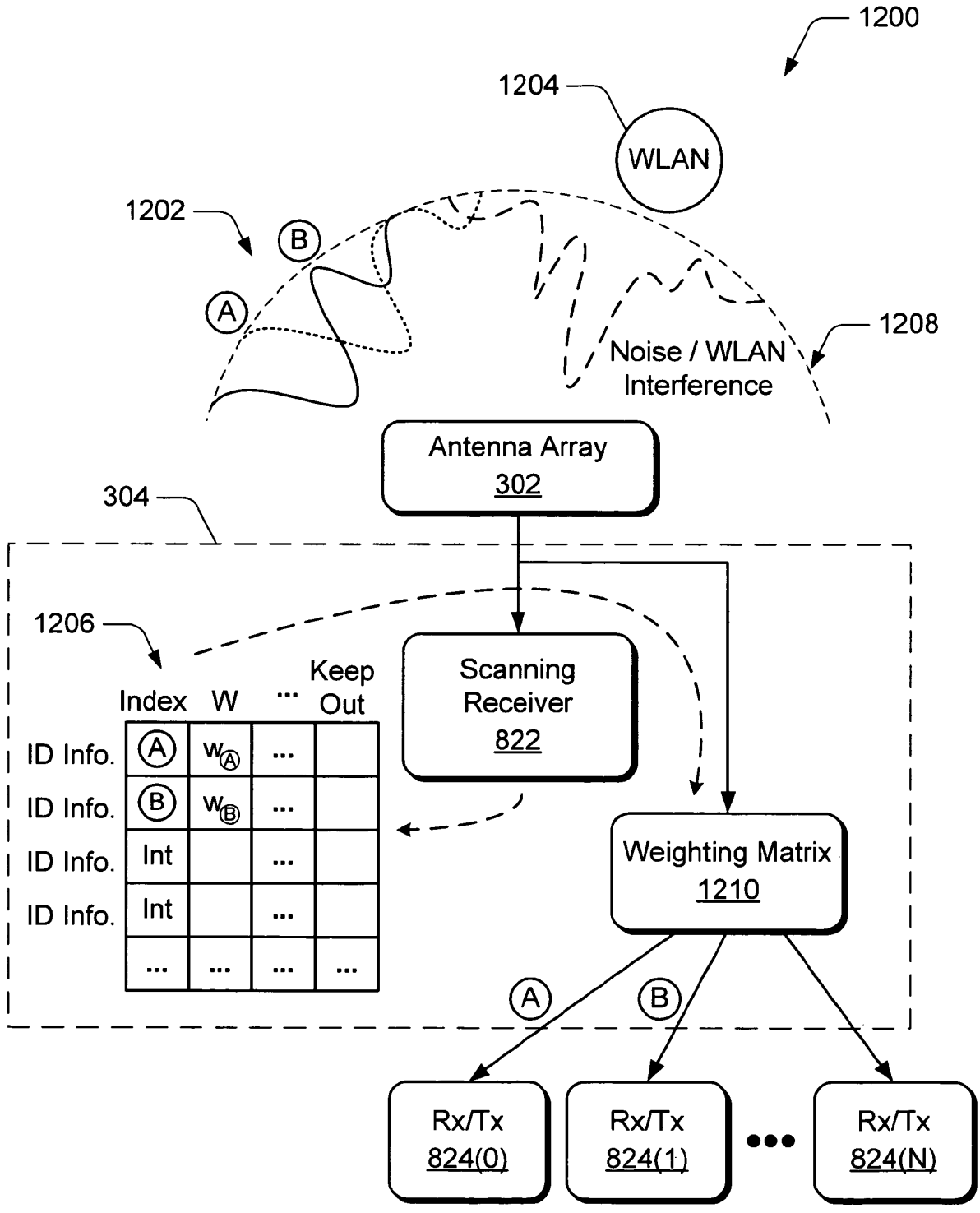

1200
1204
WLAN
1202
B
A
1208
Noise / WLAN
Interference
Antenna Array
302
304
1206
Index
W
...
Keep
Out
ID Info.
ID Info.
ID Info.
ID Info.
A
B
Int
Int
...
Scanning
Receiver
822
Weighting Matrix
1210
A
B
Rx/Tx
824(0)
Rx/Tx
824(1)
Rx/Tx
824(N)

Fig. 12

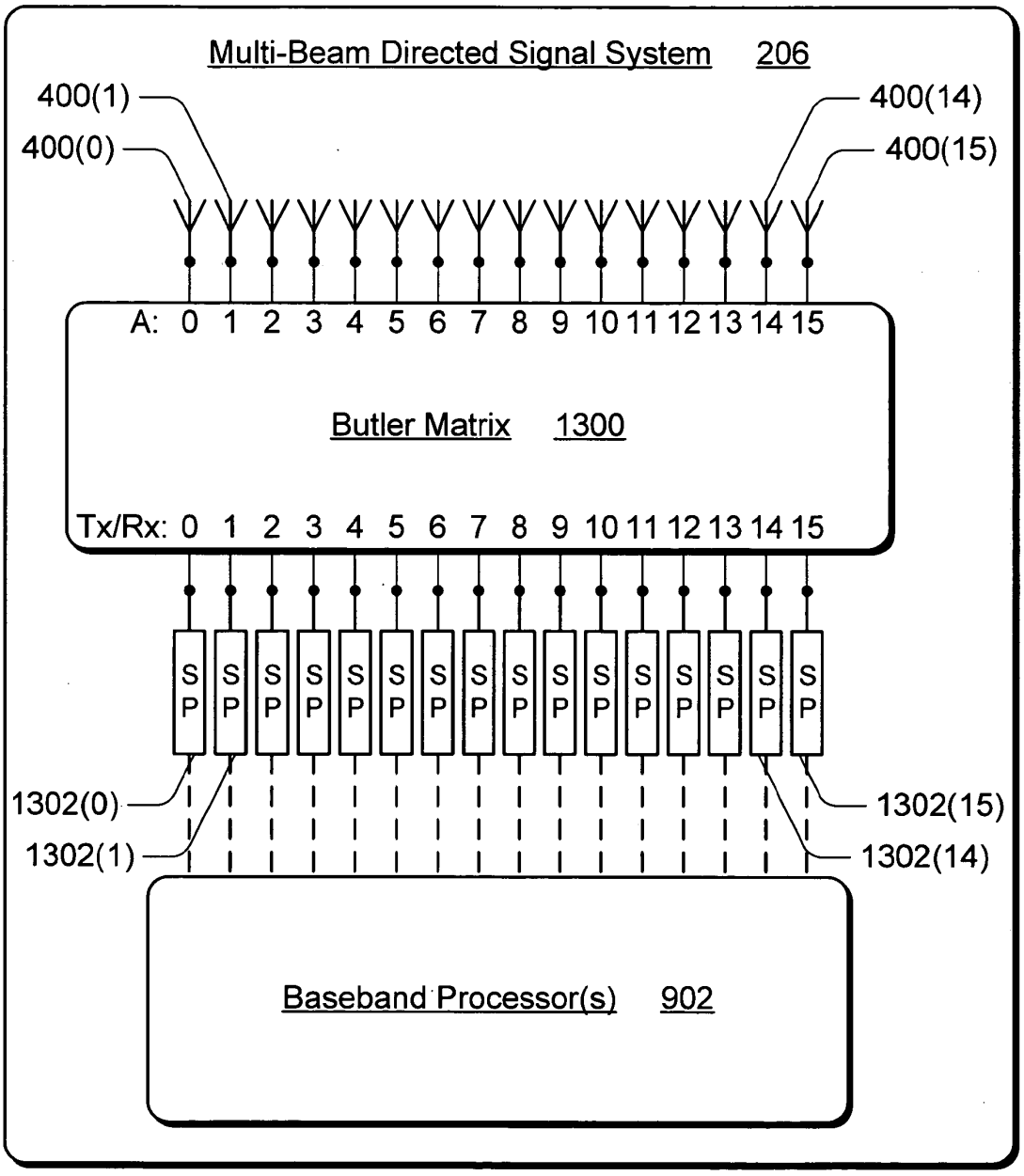

Multi-Beam Directed Signal System 206
400(1)
400(0)
400(14)
400(15)
A: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Butler Matrix 1300
Tx/Rx: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
SP
1302(0)
1302(1)
1302(15)
1302(14)
Baseband Processor(s) 902

Fig. 13

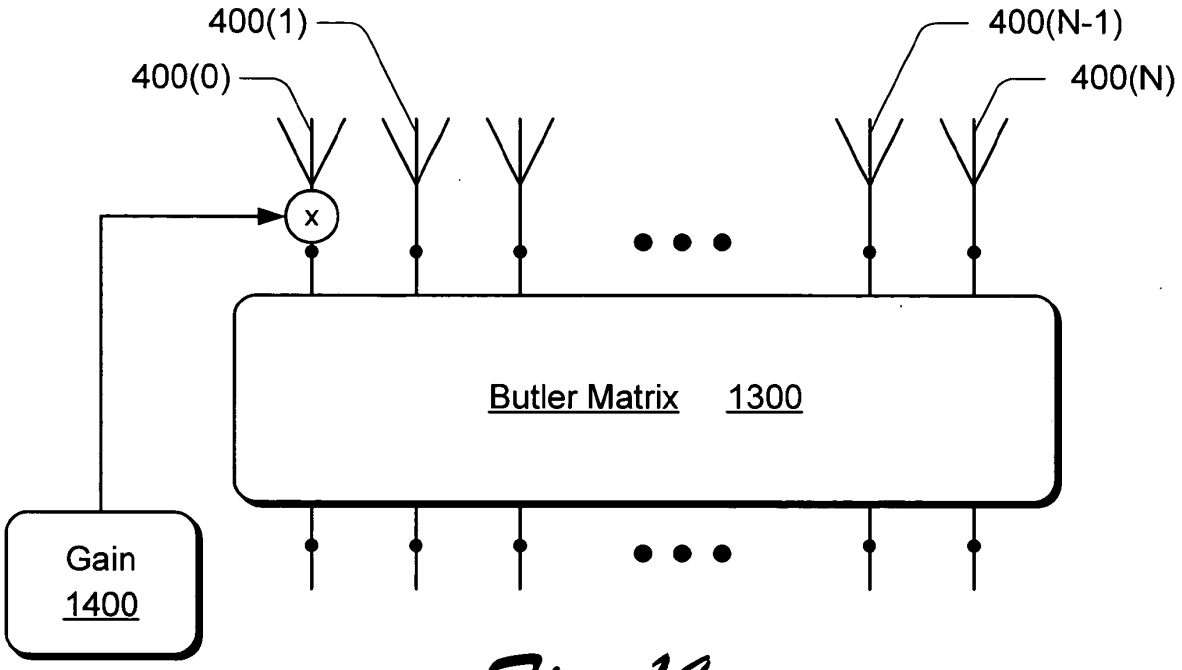

400(1)
400(0)
400(N-1)
400(N)
X
Butler Matrix 1300
Gain
1400

Fig. 14

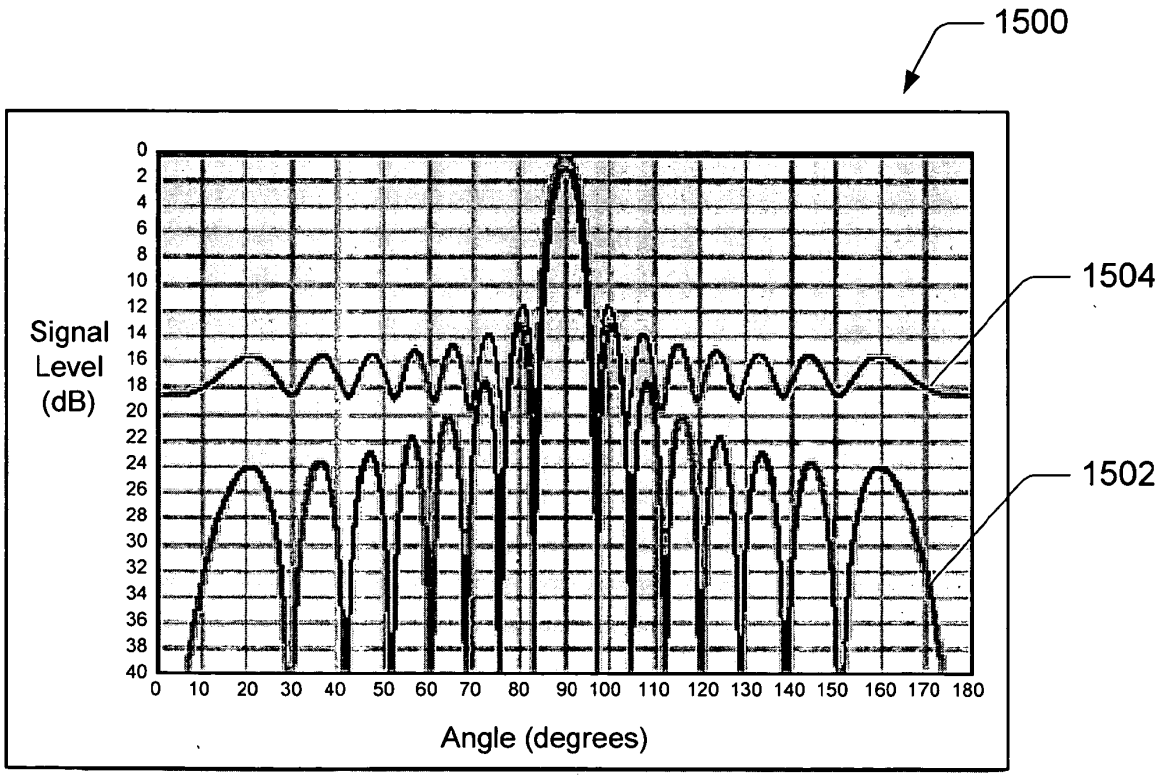

1500
1504
1502
Signal Level (dB)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
Angle (degrees)

Fig. 15

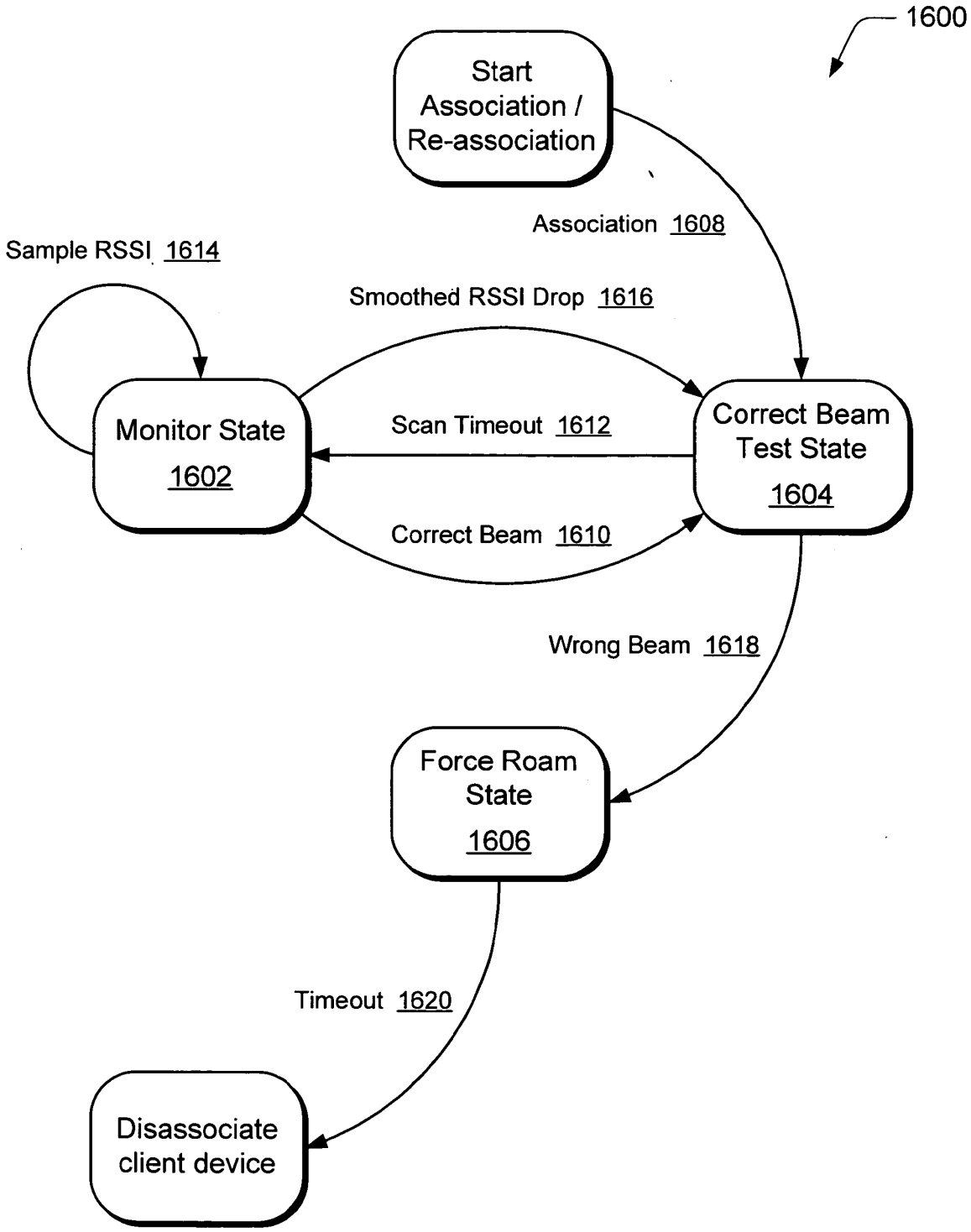

1600
Start Association / Re-association
Association 1608
Sample RSSI 1614
Smoothed RSSI Drop 1616
Monitor State 1602
Scan Timeout 1612
Correct Beam Test State 1604
Correct Beam 1610
Wrong Beam 1618
Force Roam State 1606
Timeout 1620
Disassociate client device

Fig. 16

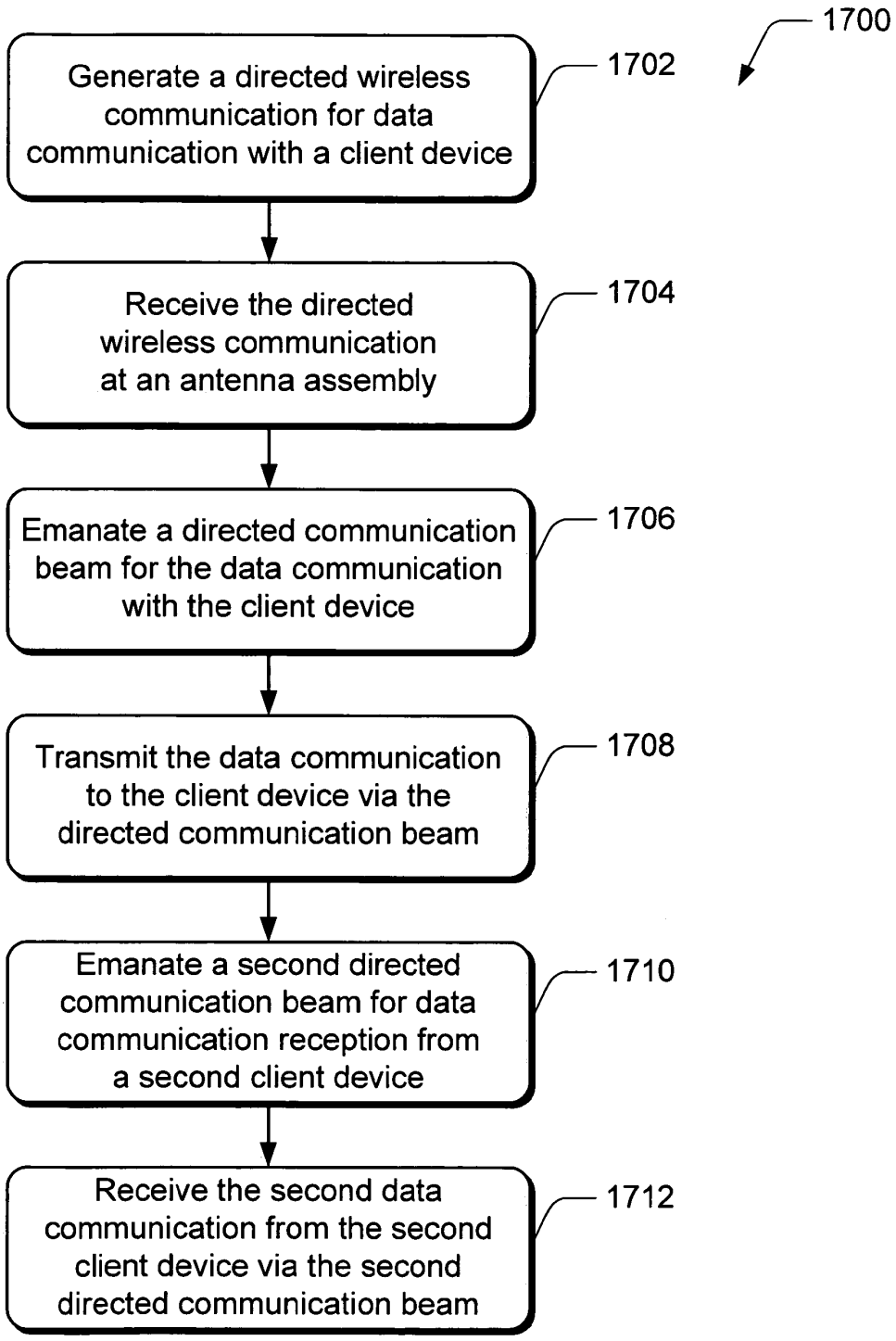

1700
Generate a directed wireless communication for data communication with a client device
1702
Receive the directed wireless communication at an antenna assembly
1704
Emanate a directed communication beam for the data communication with the client device
1706
Transmit the data communication to the client device via the directed communication beam
1708
Emanate a second directed communication beam for data communication reception from a second client device
1710
Receive the second data communication from the second client device via the second directed communication beam
1712

Fig. 17

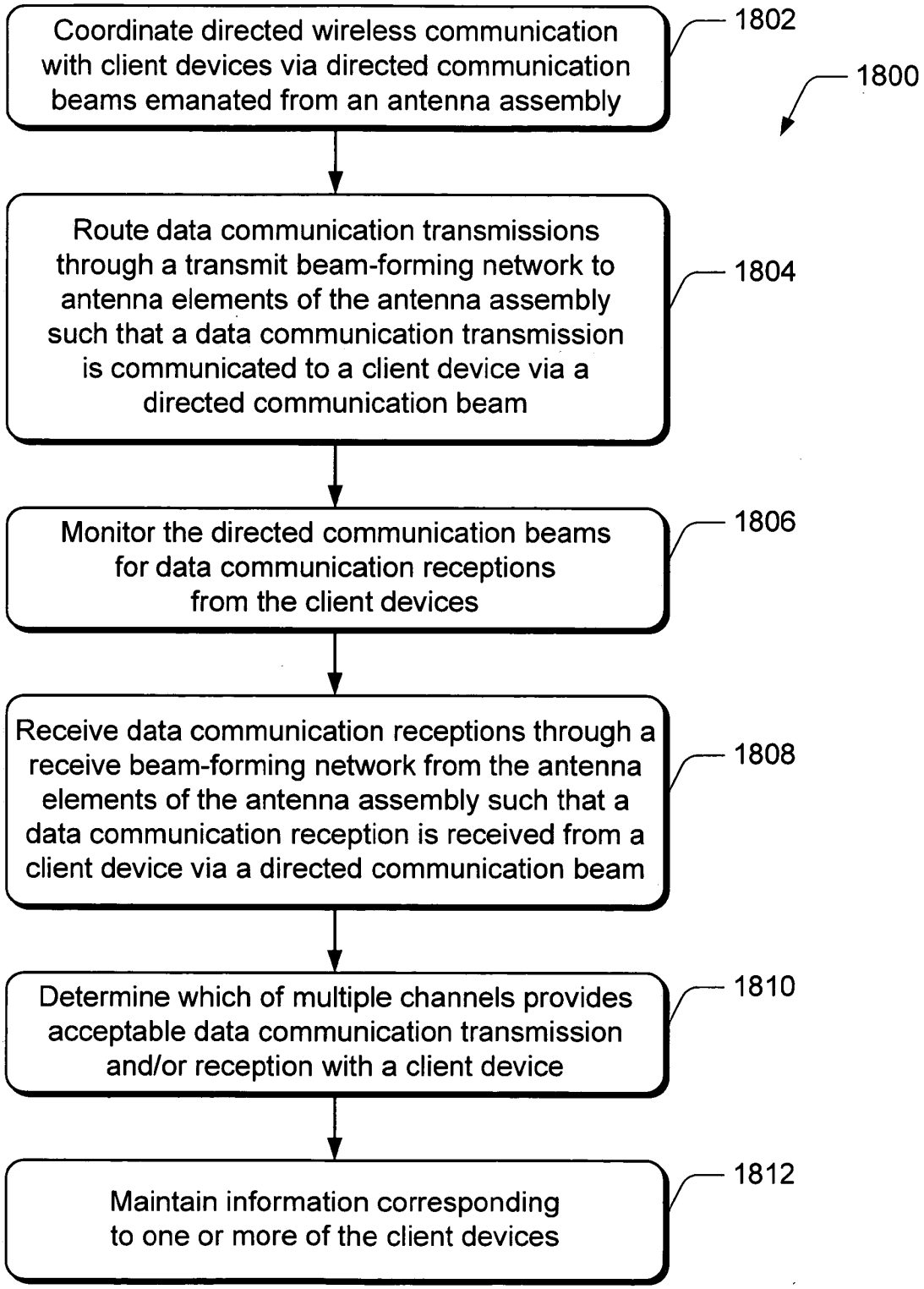

Coordinate directed wireless communication with client devices via directed communication beams emanated from an antenna assembly
1802
1800
Route data communication transmissions through a transmit beam-forming network to antenna elements of the antenna assembly such that a data communication transmission is communicated to a client device via a directed communication beam
1804
Monitor the directed communication beams for data communication receptions from the client devices
1806
Receive data communication receptions through a receive beam-forming network from the antenna elements of the antenna assembly such that a data communication reception is received from a client device via a directed communication beam
1808
Determine which of multiple channels provides acceptable data communication transmission and/or reception with a client device
1810
Maintain information corresponding to one or more of the client devices
1812

Fig. 18

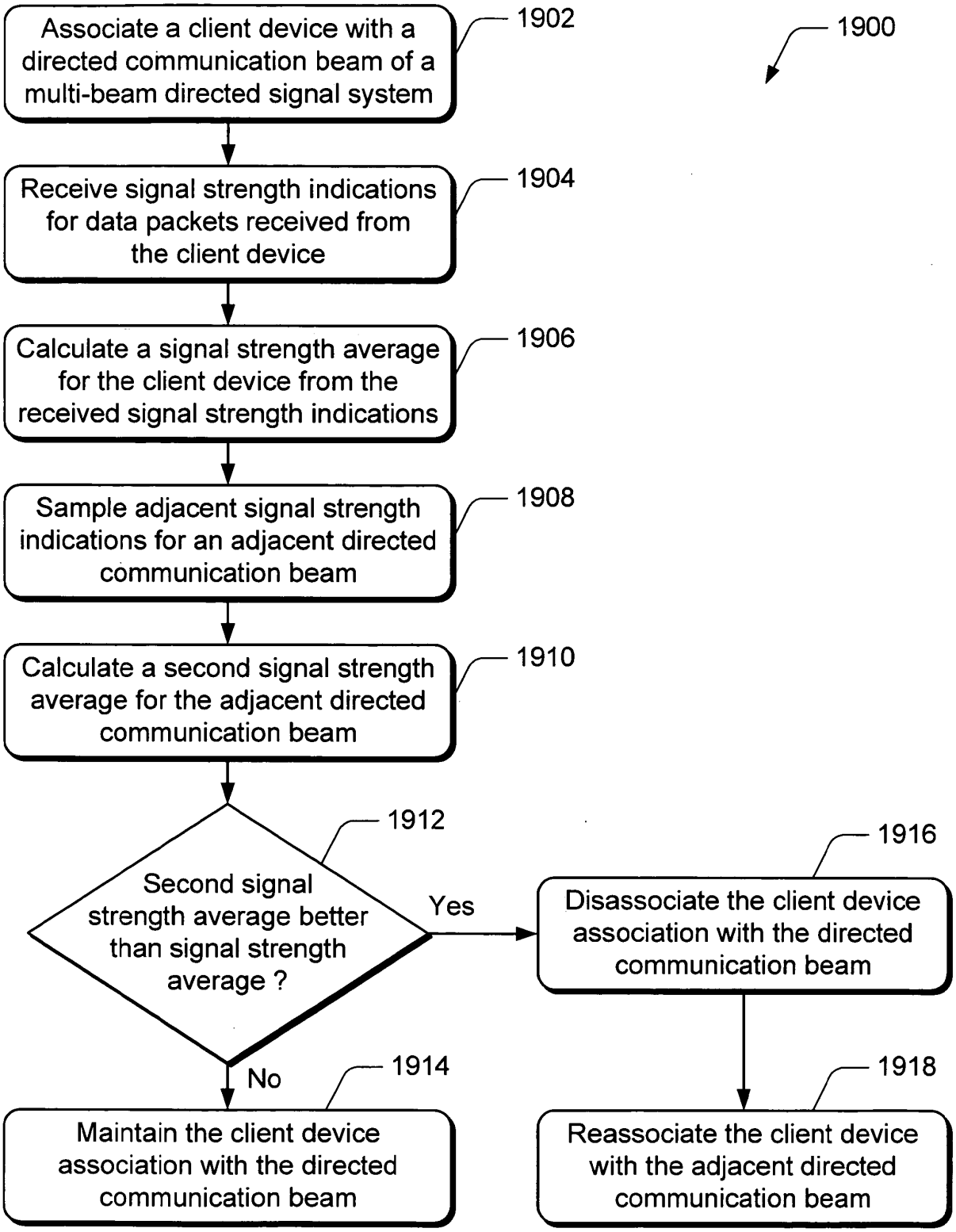

Associate a client device with a directed communication beam of a multi-beam directed signal system
1902
1900
Receive signal strength indications for data packets received from the client device
1904
Calculate a signal strength average for the client device from the received signal strength indications
1906
Sample adjacent signal strength indications for an adjacent directed communication beam
1908
Calculate a second signal strength average for the adjacent directed communication beam
1910
Second signal strength average better than signal strength average ?
1912
Yes
No
Disassociate the client device association with the directed communication beam
1916
Maintain the client device association with the directed communication beam
1914
Reassociate the client device with the adjacent directed communication beam
1918

Fig. 19

Document code: WFEE

United States Patent and Trademark Office
Sales Receipt for Accounting Date: 04/20/2017

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01 FC : 2051 70.00 DA

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/486,245	04/12/2017	2642	1410	E1027.800(T).US1D1C1D1C1	30	4

CONFIRMATION NO. 4888

FILING RECEIPT

114581
EIP US LLP
2468 Historic Decatur Road
Suite 200
San Diego, CA 92106

OC000000090800739

Date Mailed: 04/25/2017

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

Inventor(s)

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Vahid Tarokh, Cambridge, MA;
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Applicant(s)

XR Communications, LLC D/B/A Vivato Technologies, Solana Beach, CA;

Power of Attorney: The patent practitioners associated with Customer Number 114581

Domestic Priority data as claimed by applicant

This application is a CON of 15/260,147 09/08/2016
which is a CON of 13/855,410 04/02/2013 PAT 9462589
which is a DIV of 10/700,329 11/03/2003 PAT 8412106
which claims benefit of 60/423,660 11/04/2002

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

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

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

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The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/486,245**
Projected Publication Date: 08/03/2017
Non-Publication Request: No
Early Publication Request: No
**** SMALL ENTITY ****
Title

DIRECTED WIRELESS COMMUNICATION

Preliminary Class

455

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

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/486,245	04/12/2017	Marcus Da Silva	E1027.800(T).US1D1C1D1C1

CONFIRMATION NO. 4888

114581
EIP US LLP
2468 Historic Decatur Road
Suite 200
San Diego, CA 92106

INFORMAL NOTICE

OC000000090800760

Date Mailed: 04/25/2017

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  William J. Crilly

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

/amanalac/

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 15/486,245

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	70		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	300		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	360		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	30 minus 20 =	* 10	x 40 =	400	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1	x 210 =	210			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	1340		TOTAL	

APPLICATION AS AMENDED - PART II

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

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

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

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

CORRECTED ADS FORM

Application Number	15486245
Title of Invention	DIRECTED WIRELESS COMMUNICATION

Inventor Information

****If no data is shown, no data has been corrected****

	Data of Record	Updated Data
Order Number	1	
Name	Marcus Da Silva	
Residence Information		
Residency	us-residency	
City	Spokane	
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Country	US	

Corrected ADS 1.0

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

	Data of Record	Updated Data
Order Number	10	
Name	Vahid Tarokh	
Residence Information		
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Country of Residence	US	
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Country	US	

Corrected ADS 1.0

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

	Data of Record	Updated Data
Order Number	11	
Name	Praveen Mehrotra	
Residence Information		
Residency	us-residency	
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Country of Residence	US	
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Country	US	

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IPR2024-00148

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

	Data of Record	Updated Data
Order Number	2	
Name	~~William J. Crilly~~	William J. Crilly Jr.
Residence Information		
Residency	us-residency	
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Country	US	

Corrected ADS 1.0

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

	Data of Record	Updated Data
Order Number	3	
Name	James Brennan	
Residence Information		
Residency	us-residency	
City	Sammamish	
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Address 1	414 213th PL SE	
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Country	US	

Corrected ADS 1.0

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

	Data of Record	Updated Data
Order Number	4	
Name	Robert J. Conley	
Residence Information		
Residency	us-residency	
City	Liberty Lake	
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Country	US	

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

	Data of Record	Updated Data
Order Number	5	
Name	Siavash Alamouti	
Residence Information		
Residency	us-residency	
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State	WA	
Country of Residence	US	
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Country	US	

Corrected ADS 1.0

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

	Data of Record	Updated Data
Order Number	6	
Name	Eduardo Casas	
Residence Information		
Residency	non-us-residency	
City	Vancouver	
State		
Country of Residence	CA	
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Country	CA	

Corrected ADS 1.0

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

	Data of Record	Updated Data
Order Number	7	
Name	Hujun Yin	
Residence Information		
Residency	us-residency	
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State	WA	
Country of Residence	US	
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Address 2		
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Country	US	

Corrected ADS 1.0

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

	Data of Record	Updated Data
Order Number	8	
Name	Bobby Jose	
Residence Information		
Residency	us-residency	
City	Veradale	
State	WA	
Country of Residence	US	
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Address 1	15821 East 4th Ave., Apt F 125	
Address 2		
City,State/Province, Postal Code	Veradale WA 99037	
Country	US	

Corrected ADS 1.0

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

	Data of Record	Updated Data
Order Number	9	
Name	Yang-Seok Choi	
Residence Information		
Residency	us-residency	
City	Liberty Lake	
State	WA	
Country of Residence	US	
Mailing Address of Inventor		
Address 1	22809 East Country Vista Drive, Apt 438	
Address 2		
City,State/Province, Postal Code	Liberty Lake WA 99019	
Country	US	

Application Information

	Data of Record	Updated Data
Title of Invention	DIRECTED WIRELESS COMMUNICATION	
Attorney Docket Number	E1027.800(T).US1D1C1C1	
Entity Type	Small	

Domestic Benefit/National Stage Information

****If no data is shown, no data has been corrected****

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 this information in the application data sheet constitutes the specific reference required by 35 U.S. C. 119(e) or 120, and 37 CFR 1.78(a).

Corrected ADS 1.0

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

		Data of Record	Updated Data
	Prior Application Status		
	Application Number		
	Continuity Type		
	Prior Application Number		
	Filing Date (YYYY-MM-DD)		
	Patent Number		
	Issue Date (YYYY-MM-DD)		

Foreign Priority Information

****If no data is shown, no data has been corrected****

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) 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).

		Data of Record	Updated Data
	Application Number		
	Country		
	Filing Date		
	Access Code		

Applicant Information

****If no data is shown, no data has been corrected****
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.

	Data of Record	Updated Data
Applicant Type		

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is		
Name of the Deceased or Legally Incapacitated Inventor		
Applicant is an Organization		
Name		
Organization Name		
Address 1		
Address 2		
City,State/Province,Postal Code		
Country		
Phone Number		
Fax Number		
Email Address		

Assignee Information including Non-Applicant Assignee Information

****If no data is shown, no data has been corrected****
Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office

	Data of Record	Updated Data
Order		
Applicant is an Organization		
Name		

Organization Name		
Mailing Address		
Address 1		
Address 2		
City,State/Province,Postal Code		
Country		
Phone Number		
Fax Number		
Email Address		

Signature

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Nicholas R. Transier/	Registration Number	68743
First Name	Nicholas	Last Name	TRANSIER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	XR Communications, LLC D/B/A Vivato Technologies
Application No.:	15/486245
Filing Date:	April 12, 2017
Title:	DIRECTED WIRELESS COMMUNICATION
Examiner:	To be assigned
Art Unit:	2642
Confirmation No.:	4888

GENERAL TRANSMITTAL

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

Dear Sir:

In response to the Informational Notice dated April 25, 2017, Applicant respectfully submits the following:

- Corrected ADS updating inventor name from William J. CRILLY to William J. CRILLY, JR.
- A copy of the Substitute Statement in Lieu of an Oath or Declaration for William J. CRILLY, JR., which was previously submitted with the original applications papers on April 12, 2017 at pages 3-4 of the Oath or Declaration document.
- The processing fee of $70 as set forth in § 1.17(i).

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 506237.

Respectfully submitted,

EIP US LLP

Dated: April 27, 2017

By: / Nicholas R. Transier /
Nicholas R. TRANSIER
Registration No. 68,743
Attorney of Record
Customer No. 114581
(619) 795-1300

Electronic Patent Application Fee Transmittal

Application Number:	15486245
Filing Date:	12-Apr-2017
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	
Filer:	Nicholas R. Transier/Jenny Stedman
Attorney Docket Number:	E1027.800(T).US1D1C1C1

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
PROCESSING FEE, EXCEPT PROV. APPLS.	2830	1	70	70
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**70**

Electronic Acknowledgement Receipt	
EFS ID:	29055087
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	
Customer Number:	114581
Filer:	Nicholas R. Transier/Jenny Stedman
Filer Authorized By:	Nicholas R. Transier
Attorney Docket Number:	E1027.800(T).US1D1C1C1
Receipt Date:	27-APR-2017
Filing Date:	12-APR-2017
Time Stamp:	19:03:19
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$70
RAM confirmation Number	042817INTEFSW19031800
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	Crilly_Declaration.pdf	409199 58cba397c18d65b5ba635cd505a4d7a691fb70e7	no	2
Warnings:					
Information:					
2	Application Data Sheet to update/ correct info	CorrectedADS.pdf	150789 03f247f4c59dcb6692cb610da6bcfba6a759b2d9	no	14
Warnings:					
Information:					
3	Transmittal Letter	2017-04-27_Corrected_ADS_Transmittal_C1.pdf	16954 ce6aa35ddf8c1a0d342b0cb512f05c1541ddea69	no	1
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30414 2e36070c843bca3e7004cd2ed2c5699a170516c9	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	607356		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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

Doc code: Oath
Document Description: Oath or declaration filed

PTO/AIA/02 (07-13)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	Directed Wireless Communication

This statement is directed to:

[ ] The attached application,

OR

[X] United States application or PCT international application number 13/855,410 filed on 04/02/2013.

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

William J. Crilly, Jr.

Residence (except for a deceased or legally incapacitated inventor):

Liberty Lake	WA	United States of America
City	State	Country

Mailing Address (except for a deceased or legally incapacitated inventor):

23825 E. 2nd Avenue Ct.

Liberty Lake	WA	99019	United States of America
City	State	Zip	Country

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Relationship to the inventor to whom this substitute statement applies:

[ ] Legal Representative (for deceased or legally incapacitated inventor only),

[X] Assignee,

[ ] Person to whom the inventor is under an obligation to assign,

[ ] Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or

[ ] Joint Inventor.

PTO/SB/AIA02 (07-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

SUBSTITUTE STATEMENT

Circumstances permitting execution of this substitute statement:

- [ ] Inventor is deceased,
- [ ] Inventor is under legal incapacity,
- [x] Inventor cannot be found or reached after diligent effort, or
- [ ] Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- [x] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

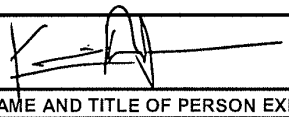
- [ ] An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

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 the 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.

PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name:	Date (Optional):
Kai Hansen	

Signature: 

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: XR Communications, LLC D/B/A Vivato Technologies

Title of Person Executing This Substitute Statement:

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City	State	Country
San Diego	CA	United States of America

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

6260 Sequence Drive; Suite 100

City	State	Zip	Country
San Diego	CA	92121	United States of America

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/486,245	04/12/2017	Marcus Da Silva	E1027.800(T).US1D1C1C1

CONFIRMATION NO. 4888

114581
EIP US LLP
2468 Historic Decatur Road
Suite 200
San Diego, CA 92106

37 CFR 1.48(f)
ACKNOWLEDGEMENT LETTER

OC000000091026800

Date Mailed: 05/02/2017

NOTICE OF ACCEPTANCE OF REQUEST UNDER 37 CFR 1.48(f)

This is in response to the applicant's request under 37 CFR 1.48(f) submitted on 04/27/2017.

The request under 37 CFR 1.48(f) to correct the inventorship, to correct or update the name of an inventor, or to correct the order of names of joint inventors is accepted.

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

/byemane/

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/486,245	04/12/2017	2464	1410	E1027.800(T).US1D1C1C1	30	4

CONFIRMATION NO. 4888

UPDATED FILING RECEIPT

114581
EIP US LLP
2468 Historic Decatur Road
Suite 200
San Diego, CA 92106

OC000000091026798

Date Mailed: 05/02/2017

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

Inventor(s)

Marcus Da Silva, Spokane, WA;
William J. Crilly JR., Liberty Lake, WA;
James Brennan, Sammamish, WA;
Robert J. Conley, Liberty Lake, WA;
Siavash Alamouti, Spokane, WA;
Eduardo Casas, Vancouver, CANADA;
Hujun Yin, Spokane, WA;
Bobby Jose, Veradale, WA;
Yang-Seok Choi, Liberty Lake, WA;
Vahid Tarokh, Cambridge, MA;
Praveen Mehrotra, Spokane, WA;

Applicant(s)

XR Communications, LLC D/B/A Vivato Technologies, Solana Beach, CA;

Power of Attorney: The patent practitioners associated with Customer Number 114581

Domestic Priority data as claimed by applicant

This application is a CON of 15/260,147 09/08/2016
which is a CON of 13/855,410 04/02/2013 PAT 9462589
which is a DIV of 10/700,329 11/03/2003 PAT 8412106
which claims benefit of 60/423,660 11/04/2002

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

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

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

Projected Publication Date: 08/03/2017
Non-Publication Request: No
Early Publication Request: No
**** SMALL ENTITY ****
Title

DIRECTED WIRELESS COMMUNICATION

Preliminary Class

370

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

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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

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

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

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

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative,

this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

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

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

NOT GRANTED

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

SelectUSA

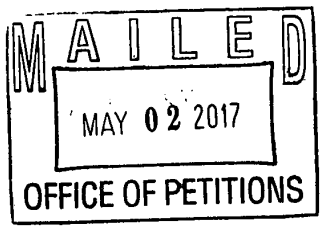
The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through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

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

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EIP US LLP
2468 HISTORIC DECATUR ROAD
SUITE 200
SAN DIEGO CA 92106



Doc Code: TRACK1.GRANT

Decision Granting Request for Prioritized Examination (Track I or After RCE)	Application No.: 15/486,245

1. THE REQUEST FILED 4/12/17 IS **GRANTED.**

The above-identified application has met the requirements for prioritized examination
- A. ☒ for an original nonprovisional application (Track I).
- B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination.** The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

- A. filing a **petition for extension of time** to extend the time period for filing a reply;
- B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims**, or a multiple dependent claim;
- C. filing a **request for continued examination**;
- D. filing a notice of appeal;
- E. filing a request for suspension of action;
- F. mailing of a notice of allowance;
- G. mailing of a final Office action;
- H. completion of examination as defined in 37 CFR 41.102; or
- I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to Cheryl Gibson-Baylor at (571)272-3213, Office of Petitions. In his/her absence, calls may be directed to Brian W. Brown, (571)272-5338.

Cheryl Gibson-Baylor
/Cheryl Gibson-Baylor/
[*Signature*]

Petitions Paralegal Specialist
(Title)

U.S. Patent and Trademark Office
PTO-2298 (Rev. 02-2012)

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	E1027.800(T).US1D1C1C1	4888

114581 7590 06/15/2017

EIP US LLP
2468 Historic Decatur Road
Suite 200
San Diego, CA 92106

EXAMINER	
GANGULY, SUMITRA	

ART UNIT	PAPER NUMBER
2411	

NOTIFICATION DATE	DELIVERY MODE
06/15/2017	ELECTRONIC

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

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

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

sandiego@eip.com

Office Action Summary	Application No. 15/486,245	Applicant(s) DA SILVA ET AL.	
	Examiner Sumitra Ganguly	Art Unit 2411	AIA (First Inventor to File) Status No

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *4/12/2017*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-30* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-30* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *4/12/17* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date *4/12/017*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

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

DETAILED ACTION

Double Patenting

2. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See

MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

3. Claims 1, 11, 16 and 26 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claim 39 of copending Application No. 15/260147. Although the claims at issue are not identical, they are not patentably distinct from each other because the claimed limitations are similar in scope with obvious wording variations.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

In the following table, feature-by-feature comparisons are provided between the independent claims 1, 11, 16 and 26 of instant application and their corresponding

conflicting claims of copending Application No. 15/260147. The comparisons show that the features of the independent claims of instant application are patentably indistinct from the features of their conflicting claims of copending Application No. 15/260147 and thus must be double patenting rejected.

Instant Application	US 15/260147
Claim 1, A data-communications networking apparatus, comprising: a processor configured to: generate a first sequence of symbols for transmission to a first client device; and generate a second sequence of symbols for transmission to a second client device; a transceiver operatively coupled to the processor and configured to:	Claim 39, A method, comprising:
transmit the first sequence of symbols to the first client device via an antenna;	routing data communication transmissions through a transmit beam-forming network to antenna elements of an antenna assembly such that a first data communication transmission is communicated to a first client device via a first directed communication beam;
transmit the second sequence of symbols to the second client device via the antenna,	receiving data communication receptions through a receive beam-forming network from the antenna elements of the antenna assembly such that a first data communication reception is received from a second client device via a second directed communication beam; and
wherein the antenna is operatively coupled to the transceiver; wherein one or more of the processor, the transceiver, or the antenna is further configured to:	
transmit the first sequence of symbols to the first client device via one or more beams, wherein at	transmitting energy on a side lobe of the first directed communication beam corresponding to the first client device such that the second client

least one of the one or more beams focuses transmit energy toward the first client device; transmit the second sequence of symbols to the second client device via the one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the second client device; *receive feedback information regarding at least one of the one or more beams from at least one of the first or second client devices; and modify at least one of the one or more beams based on the feedback information.*	device will detect the energy on the side lobe to determine that the first data communication transmission is directed to the first client device via the first directed communication beam.
Claim 11, A method of enabling data communications in a networking apparatus, the method comprising: generating a first sequence of symbols for transmission to a first client device; generating a second sequence of symbols for transmission to a second client device; *transmitting the first sequence of symbols to the first client device via one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the first client device;* *transmitting the second sequence of symbols to the second client device via the one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the second client device;* *receiving feedback information regarding at least one of the one or more beams from at least one of the first or second client devices; and modifying at least one of the one or more beams based on the feedback information.*	Claim 39, A method, comprising: routing data communication transmissions through a transmit beam-forming network to antenna elements of an antenna assembly such that a first data communication transmission is communicated to a first client device via a first directed communication beam; receiving data communication receptions through a receive beam-forming network from the antenna elements of the antenna assembly such that a first data communication reception is received from a second client device via a second directed communication beam; transmitting energy on a side lobe of the first

	directed communication beam corresponding to the first client device such that the second client device will detect the energy on the side lobe to determine that the first data communication transmission is directed to the first client device via the first directed communication beam.
Claim 16, A data-communications networking apparatus, comprising: a processor configured to: generate a first set of symbols for transmission to a first client device; and generate a second set of symbols for transmission to a second client device; a transceiver operatively coupled to the processor and to an antenna, the transceiver configured to:	Claim 39, A method, comprising:
transmit the first sequence of symbols to the first client device from the antenna via a first beam, wherein the first beam focuses transmit energy toward the first client device;	routing data communication transmissions through a transmit beam-forming network to antenna elements of an antenna assembly such that a first data communication transmission is communicated to a first client device via a first directed communication beam;
transmit the second sequence of symbols to the second client device from the antenna via a second beam, wherein the second beam focuses transmit energy toward the second client device; and	receiving data communication receptions through a receive beam-forming network from the antenna elements of the antenna assembly such that a first data communication reception is received from a second client device via a second directed communication beam; and
receive information regarding the first beam from the first client device, wherein the processor is further configured to: modify the first beam based on the information.	transmitting energy on a side lobe of the first directed communication beam corresponding to the first client device such that the second client device will detect the energy on the side lobe to determine that the first data communication transmission is directed to the first client device via the first directed communication beam.
Claim 27, A method of enabling data	Claim 39, A method, comprising: routing data

communications in a networking apparatus, the method comprising: generating a first set of symbols for transmission to a first client device; and generating a second set of symbols for transmission to a second client device;	communication transmissions through a transmit beam-forming network to antenna elements of an antenna assembly such that
transmitting the first sequence of symbols to the first client device via a first beam, wherein the first beam focuses transmit energy toward the first client device;	a first data communication transmission is communicated to a first client device via a first directed communication beam;
transmitting the second sequence of symbols to the second client device via a second beam, wherein the second beam focuses transmit energy toward the second client device; and	receiving data communication receptions through a receive beam-forming network from the antenna elements of the antenna assembly such that a first data communication reception is received from a second client device via a second directed communication beam; and
receiving information regarding the first beam from the first client device, modifying the first beam based on the information.	
	transmitting energy on a side lobe of the first directed communication beam corresponding to the first client device such that the second client device will detect the energy on the side lobe to determine that the first data communication transmission is directed to the first client device via the first directed communication beam.

4. Claims 1, 11, 16 and 26 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-19 of U.S. Patent No. 8,412,106 B2. Although the claims at issue are not identical, they are not patentably distinct from each other because the claimed limitations are similar in scope with obvious wording variations.

In the following table, feature-by-feature comparisons are provided between the independent claims 1, 11, 16 and 26 of instant application and their corresponding conflicting claims in U.S. 8,412,106 B2. The comparisons show that the features of the independent claims of instant application are patentably indistinct from the features of their conflicting claims in U.S. 8,412,106 B2 and thus must be double patenting rejected.

Instant Application	US Patent No. 8,412,106 B2
Claim 1, A data-communications networking apparatus, comprising: a processor configured to: generate a first sequence of symbols for transmission to a first client device; and generate a second sequence of symbols for transmission to a second client device; a transceiver operatively coupled to the processor and configured to:	Claim 1, A Wi-Fi switch comprising: a multi-channel, multi-beam directed signal system configured for 802.11 specification data packet wireless computing communication with both of a first 802.11 client computing device and a second 802.11 client computing device; and
transmit the first sequence of symbols to the first client device via an antenna;	an antenna assembly configured to (i) receive and emanate wireless communication within a first directed communication beam with the first computing device via a first channel, and
transmit the second sequence of symbols to the second client device via the antenna,	(ii) to receive and emanate a second directed communication beam for data communication reception from the second computing device via a second channel;
wherein the antenna is operatively coupled to the transceiver; wherein one or more of the processor, the transceiver, or the antenna is further configured to:	
transmit the first sequence of symbols to the first client device via one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the first client device; transmit the second sequence of symbols to the second client device via the one or more beams,	wherein: the multi-beam directed signal system is configured to determine and adjust, by complementary beam-forming, a transmission peak for a particular directed beam in a non-omni-directional manner based on operational information associated with signal routing and

wherein at least one of the one or more beams focuses transmit energy toward the second client device; receive feedback information regarding at least one of the one or more beams from at least one of the first or second client devices; and modify at least one of the one or more beams based on the feedback information.	further configured to direct a transmission null in a particular direction to maximize power associated with the transmission peak and minimize interference in the particular direction, and the second directed communication beam is at least partially received simultaneous with the emanating of the first directed communication beam.
Claim 11, A method of enabling data communications in a networking apparatus, the method comprising: generating a first sequence of symbols for transmission to a first client device; generating a second sequence of symbols for transmission to a second client device; *transmitting the first sequence of symbols to the first client device via one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the first client device;* *transmitting the second sequence of symbols to the second client device via the one or more beams, wherein at least one of the one or more beams focuses transmit energy toward the second client device;* *receiving feedback information regarding at least one of the one or more beams from at least one of the first or second client devices; and modifying at least one of the one or more beams based on the feedback information.*	Claim 10, A method, comprising: generating from a Wi-Fi switch a first directed wireless communication for 802.11 specification data packet communication with a first 802.11 client computing device; receiving the first directed wireless communication at an antenna assembly; emanating a first directed communication beam, associated with and adjusted for a transmission peak, which is adjusted relative to other beams of a multi-beam directed signal system by complementary beam-forming, in a non-omni-directional manner, for the data communication with the first computing device; directing a transmission null in a particular direction to maximize power associated with the transmission peak and minimize interference in the particular direction; and receiving a second data communication from a second computing device via a second directed communication beam, wherein the second directed communication beam is at least partially received simultaneous with the emanating of the first directed communication beam.
Claim 16, A data-communications networking apparatus, comprising: a processor configured to: generate a first set of symbols for transmission to a first client device; and generate a second set of symbols for transmission to a second client device; a transceiver operatively coupled to the processor	Claim 1, A Wi-Fi switch comprising: a multi-channel, multi-beam directed signal system configured for 802.11 specification data packet wireless computing communication with both of a first 802.11 client computing device and a second 802.11 client computing device; and

and to an antenna, the transceiver configured to:	
transmit the first sequence of symbols to the first client device from the antenna via a first beam, wherein the first beam focuses transmit energy toward the first client device;	an antenna assembly configured to (i) receive and emanate wireless communication within a first directed communication beam with the first computing device via a first channel, and
transmit the second sequence of symbols to the second client device from the antenna via a second beam, wherein the second beam focuses transmit energy toward the second client device; and	(ii) to receive and emanate a second directed communication beam for data communication reception from the second computing device via a second channel;
receive information regarding the first beam from the first client device, wherein the processor is further configured to: modify the first beam based on the information.	wherein: the multi-beam directed signal system is configured to determine and adjust, by complementary beam-forming, a transmission peak for a particular directed beam in a non-omni-directional manner based on operational information associated with signal routing and further configured to direct a transmission null in a particular direction to maximize power associated with the transmission peak and minimize interference in the particular direction, and the second directed communication beam is at least partially received simultaneous with the emanating of the first directed communication beam.
Claim 27, A method of enabling data communications in a networking apparatus, the method comprising: generating a first set of symbols for transmission to a first client device; and generating a second set of symbols for transmission to a second client device;	Claim 10, A method, comprising: generating from a Wi-Fi switch a first directed wireless communication for 802.11 specification data packet communication with a first 802.11 client computing device; receiving the first directed wireless communication at an antenna assembly;
transmitting the first sequence of symbols to the first client device via a first beam, wherein the first beam focuses transmit energy toward the first client device;	emanating a first directed communication beam, associated with and adjusted for a transmission peak, which is adjusted relative to other beams of a multi-beam directed signal system by complementary beam-forming, in a non-omni-directional manner, for the data communication with the first computing device; directing a transmission null in a particular direction to maximize power associated with the transmission peak and minimize interference in the particular

	direction; and
transmitting the second sequence of symbols to the second client device via a second beam, wherein the second beam focuses transmit energy toward the second client device; and	receiving a second data communication from a second computing device via a second directed communication beam, wherein the second directed communication beam is at least partially received simultaneous with the emanating of the first directed communication
receiving information regarding the first beam from the first client device, modifying the first beam based on the information.	

Claim Rejections - 35 USC § 112

5. The following is a quotation of 35 U.S.C. 112(b):

> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

> The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph: The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

6. Claims 1-15 and 27-30 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Regarding claim 1, line 21 recites in part ".....**information regarding at least one of the one or more**....". Shouldn't there be a "the" added before "at least one of the

one or more" so that the above recites ".....**information regarding the at least one of the one or more**...."?

Line 22 recites in part "....**one of the first or second client devices**.....". Shouldn't there be a "the" added before "second client" so that the above recites "....**one of the first or the second client devices**....."?

Line 23 recites in part "....**modify at least one of the one or more**.....". Shouldn't there be a "the" added before "at least" so that the above recites "....**modify the at least one of the one or more**....."?

Regarding claims 2-10, these claims depend on claim 1 and thus are rejected on the same ground(s) stated for claim 1 above. Furthermore, some dependent claims have their own indefiniteness issues and are additionally rejected as discussed below.

Regarding claim 5, line 1 recites in part ".....**wherein one or more of the**.....". Shouldn't there be a "the" added before "one or more" so that the above recites ".....**wherein the one or more of the**....."?

Regarding claim 8, line 1 recites in part ".....**wherein one or more of the**.....". Shouldn't there be a "the" added before "one or more" so that the above recites ".....**wherein the one or more of the**....."?

Regarding claim 10, line 1 recites in part ".....**wherein one or more of the**.....". Shouldn't there be a "the" added before "one or more" so that the above recites ".....**wherein the one or more of the**....."?

Regarding claim 11, line 11 recites in part ".....**information regarding at least one of the one or more**....". Shouldn't there be a "the" added before "at least one of the

one or more" so that the above recites ".....**information regarding the at least one of the one or more**...."?

Line 12 recites in part "....**one of the first or second client devices**.....". Shouldn't there be a "the" added before "second client" so that the above recites "....**one of the first or the second client devices**....."?

Line 13 recites in part "....**modifying at least one of the one or more**.....". Shouldn't there be a "the" added before "at least" so that the above recites "....**modifying the at least one of the one or more**....."?

Regarding claims 12-15, these claims depend on claim 11 and thus are rejected on the same ground(s) stated for claim 11 above. Furthermore, some dependent claims have their own indefiniteness issues and are additionally rejected as discussed below.

Regarding claim 12, line 1 recites in part ".....**data communications in a networking apparatus**.....". Shouldn't the above be ".....**data communications in the networking apparatus**....."?

Regarding claim 13, line 1 recites in part ".....**data communications in a networking apparatus**.....". Shouldn't the above be ".....**data communications in the networking apparatus**....."?

Regarding claim 14, line 1 recites in part ".....**data communications in a networking apparatus**.....". Shouldn't the above be ".....**data communications in the networking apparatus**....."?

Regarding claim 15, line 1 recites in part "…..**data communications in a networking apparatus**…..". Shouldn't the above be "…..**data communications in the networking apparatus**….."?

Regarding claim 27, line 1 recites in part "…..**data communications in a networking apparatus**…..". Shouldn't the above be "…..**data communications in the networking apparatus**….."?

Regarding claim 28, line 1 recites in part "…..**data communications in a networking apparatus**…..". Shouldn't the above be "…..**data communications in the networking apparatus**….."?

Regarding claim 29, line 1 recites in part "…..**data communications in a networking apparatus**…..". Shouldn't the above be "…..**data communications in the networking apparatus**….."?

Regarding claim 30, line 1 recites in part "…..**data communications in a networking apparatus**…..". Shouldn't the above be "…..**data communications in the networking apparatus**….."?

Claim Rejections - 35 USC § 102

7. The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
> (e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent.

8. Claims 1-30 are rejected under pre-AIA 35 U.S.C. 102(e) as being anticipated by Guo et. al. (US 2004/0014429 A1, Guo hereinafter).

Guo discloses “adaptive beam forming techniques for controlling the beam pattern of a transmission beam. In particular, but not exclusively, the present invention relates to adaptive beam forming techniques for use in the downlink of a mobile cellular communications system” [0001] lines 1-6, and “provides the advantage that simple feedback information may be used for adjusting the transmission beam pattern" [0014] lines 1-3.

Guo’s disclosure comprises the following features:

- **With respect to independent claims**

Regarding claim 1, **A data-communications networking apparatus** (e.g. “an overview of a mobile cellular communications system is shown in FIG. 1” [0082] lines 1-2, which “cellular communications system” is a data-communication network. Moreover, “referring to FIG. 1, base station 10 transmits signals to and receives signals from a plurality of mobile units 12, 14, 16, which are typically mobile telephones or portable data processing devices” [0083] lines 1-4, which “base station 10” is considered as the apparatus)**, comprising:**

a processor (e.g. “a processor programmed to control the beam former such that the transmission beam pattern is adjusted in dependence on the feedback signal” [0053] lines 1-3) **configured to:**

generate a first sequence of symbols for transmission (e.g. "in FIG. 4, base station 10 transmits signals to mobile units 12, 14, 16 using transmission beam patterns 20, 22 and 24 respectively. Each transmission beam pattern is produced by using an array of individual antenna elements provided at the base station to transmit different respective amplitude and/or phase adjusted versions of the transmission signal to be sent to the mobile unit concerned. The transmission beam patterns are directional, so that each transmission beam pattern points towards the corresponding mobile unit" [0090] lines 3-12, which signal to mobile unit 12 is considered as a first sequence of symbols and this first sequence of symbols must be generated before transmitting these symbols using beam pattern 20) **to a first client device** (e.g. Fig. 4, mobile unit 12); **and**

generate a second sequence of symbols for transmission (e.g. Fig. 4, signal associated with transmission beam pattern 22) **to a second client device** (e.g. Fig. 4, mobile unit 14);

a transceiver operatively coupled to the processor (e.g. Fig. 1, "base station 10 comprises ..... transmitter 22, antenna 24, receiver 25" [0084] lines 1-2, which combination of transmitter and receiver is the transceiver) **and configured to:**

transmit the first sequence of symbols (aforesaid transmission signals associated with beam 20) **to the first client device** (e.g. aforesaid mobile unit 12) **via an antenna** (e.g. Fig. 1, antenna 24);

transmit the second sequence of symbols (aforesaid transmission signals associated with beam 22) **to the second client device** (e.g. aforesaid mobile unit 14) **via the antenna** (e.g. Fig. 1, antenna 24),

wherein the antenna is operatively coupled to the transceiver (e.g. Fig. 1 showing the antenna is operatively coupled to the transceiver);

wherein one or more of the processor, the transceiver, or the antenna is further configured to:

transmit the first sequence of symbols (aforesaid transmission signals associated with beam 20) **to the first client device** (e.g. aforesaid mobile unit 12) **via one or more beams** (e.g. Fig. 4, beam 14, beam 16 and beam 20), **wherein at least one** (e.g. beam 20) **of the one or more beams focuses transmit energy toward the first client device** (e.g. Fig. 4 showing transmission beam 20 transmitting energy toward mobile unit 12. Furthermore, "the transmission beam patterns are directional, so that each transmission beam pattern points towards the corresponding mobile unit" [0090] lines 9-12);

transmit the second sequence of symbols (aforesaid transmission signals associated with beam 22) **to the second client device** (e.g. aforesaid mobile unit 14) **via the one or more beams** (e.g. Fig. 4, beam 14, beam 16 and beam 20), **wherein at least one** (e.g. beam 22) **of the one or more beams focuses transmit energy toward the second client device** (e.g. Fig. 4 showing transmission beam 22 transmitting energy toward mobile unit 14);

receive feedback information regarding at least one of the one or more beams from at least one of the first or second client devices (e.g. "the transmitting apparatus" comprises "means for receiving from the receiving apparatus a feedback signal based on measures of a quality of the transmission beams received at the receiving apparatus" [0012] lines 1-4); **and**

modify at least one of the one or more beams based on the feedback information (e.g. "the transmitting apparatus" comprises "means for adjusting the transmission beam pattern in dependence on the feedback signal" [0013] lines 1-2)**.**

Regarding claim 11, **A method of enabling data communications** (e.g. "there is provided a method of transmitting a transmission signal from a transmitting apparatus to a receiving apparatus" [0058] lines 2-4) **in a networking apparatus** (e.g. Fig. 1, base station 10)**, the method comprising:**

generating a first sequence of symbols for transmission (e.g. "in FIG. 4, base station 10 transmits signals to mobile units 12, 14, 16 using transmission beam patterns 20, 22 and 24 respectively. Each transmission beam pattern is produced by using an array of individual antenna elements provided at the base station to transmit different respective amplitude and/or phase adjusted versions of the transmission signal to be sent to the mobile unit concerned. The transmission beam patterns are directional, so that each transmission beam pattern points towards the corresponding mobile unit" [0090] lines 3-9, which signal to mobile unit 12 is considered as a first sequence of

symbols and this first sequence of symbols must be generated before transmitting these symbols using beam pattern 20) **to a first client device** (e.g. Fig. 4, mobile unit 12);

generating a second sequence of symbols for transmission (e.g. Fig. 4, transmission beam pattern 22) **to a second client device** (e.g. Fig. 4, mobile unit 14);

transmitting the first sequence of symbols (aforesaid transmission signals associated with beam 20) **to the first client device** (e.g. Fig. 4, mobile unit 12) **via one or more beams** (e.g. Fig. 4, beam 14, beam 16 and beam 20)**, wherein at least one** (e.g. beam 20) **of the one or more beams focuses transmit energy toward the first client device** (e.g. Fig. 4 showing transmission beam 20 transmitting energy toward mobile unit 12. Furthermore, "the transmission beam patterns are directional, so that each transmission beam pattern points towards the corresponding mobile unit" [0090] lines 9-12);

transmitting the second sequence of symbols (aforesaid transmission signals associated with beam 22) **to the second client device** (e.g. Fig. 4, mobile unit 14) **via the one or more beams** (e.g. Fig. 4, beam 14, beam 16 and beam 20)**, wherein at least one** (e.g. beam 22) **of the one or more beams focuses transmit energy toward the second client device** (e.g. Fig. 4 showing transmission beam 22 transmitting energy toward mobile unit 14);

receiving feedback information regarding at least one of the one or more beams from at least one of the first or second client devices (e.g. "the transmitting apparatus" comprises "means for receiving from the receiving apparatus a feedback

signal based on measures of a quality of the transmission beams received at the receiving apparatus" [0012] lines 1-4); and

modifying at least one of the one or more beams based on the feedback information (e.g. "the transmitting apparatus" comprises "means for adjusting the transmission beam pattern in dependence on the feedback signal" [0013] lines 1-2).

Regarding claim 16, **A data-communications networking apparatus** (e.g. "an overview of a mobile cellular communications system is shown in FIG. 1" [0082] lines 1-2, which "cellular communications system" is a data-communication network. Moreover, "referring to FIG. 1, base station 10 transmits signals to and receives signals from a plurality of mobile units 12, 14, 16, which are typically mobile telephones or portable data processing devices" [0083] lines 1-4, which "base station 10" is considered as the apparatus), **comprising:**

a processor (e.g. "a processor programmed to control the beam former such that the transmission beam pattern is adjusted in dependence on the feedback signal" [0053] lines 1-3) **configured to:**

generate a first set of symbols for transmission (e.g. "in FIG. 4, base station 10 transmits signals to mobile units 12, 14, 16 using transmission beam patterns 20, 22 and 24 respectively. Each transmission beam pattern is produced by using an array of individual antenna elements provided at the base station to transmit different respective amplitude and/or phase adjusted versions of the transmission signal to be sent to the mobile unit concerned. The transmission beam patterns are directional, so that each

transmission beam pattern points towards the corresponding mobile unit" [0090] lines 3-12, which signal to mobile unit 12 is considered as a first sequence of symbols and this first sequence of symbols must be generated before transmitting these symbols using beam pattern 20) **to a first client device** (e.g. Fig. 4, mobile unit 12); **and**

generate a second set of symbols for transmission (e.g. Fig. 4, transmission beam pattern 22) **to a second client device** (e.g. Fig. 4, mobile unit 14);

a transceiver operatively coupled to the processor (e.g. "base station 10 comprises ..... transmitter 22, antenna 24, receiver 25" [0084] lines 1-2, which combination of transmitter and receiver is the transceiver) **and to an antenna** (e.g. Fig. 1, antenna 24), **the transceiver configured to:**

transmit the first sequence of symbols (aforesaid transmission signals associated with beam 20) **to the first client device** (e.g. aforesaid mobile unit 12) **from the antenna via a first beam** (e.g. aforesaid beam 20), **wherein the first beam focuses transmit energy toward the first client device** (e.g. Fig. 4 showing transmission beam 20 transmitting energy toward mobile unit 12. Furthermore, "the transmission beam patterns are directional, so that each transmission beam pattern points towards the corresponding mobile unit" [0090] lines 9-12);

transmit the second sequence of symbols (aforesaid transmission signals associated with beam 22) **to the second client device** (e.g. aforesaid mobile unit 14) **from the antenna via a second beam** (e.g. aforesaid beam 22), **wherein the second beam focuses transmit energy toward the second client device** (e.g. Fig. 4 showing transmission beam 22 transmitting energy toward mobile unit 14); **and**

receive information regarding the first beam from the first client device (e.g. "the transmitting apparatus" comprises "means for receiving from the receiving apparatus a feedback signal based on measures of a quality of the transmission beams received at the receiving apparatus" [0012] lines 1-4, which feedback signal is considered as the information),

wherein the processor is further configured to: modify the first beam based on the information (e.g. "the transmitting apparatus" comprises "means for adjusting the transmission beam pattern in dependence on the feedback signal" [0013] lines 1-2).

Regarding claim 26, **A method of enabling data communications** (e.g. "there is provided a method of transmitting a transmission signal from a transmitting apparatus to a receiving apparatus" [0058] lines 2-4) **in a networking apparatus** (e.g. Fig. 1, base station 10), **the method comprising:**

generating a first set of symbols for transmission (e.g. "in FIG. 4, base station 10 transmits signals to mobile units 12, 14, 16 using transmission beam patterns 20, 22 and 24 respectively. Each transmission beam pattern is produced by using an array of individual antenna elements provided at the base station to transmit different respective amplitude and/or phase adjusted versions of the transmission signal to be sent to the mobile unit concerned. The transmission beam patterns are directional, so that each transmission beam pattern points towards the corresponding mobile unit" [0090] lines 3-9, which signal to mobile unit 12 is considered as a first sequence of symbols and this first sequence of symbols must be generated before transmitting these

symbols using beam pattern 20) **to a first client device** (e.g. Fig. 4, mobile unit 12); **and**

generating a second set of symbols for transmission (e.g. Fig. 4, transmission beam pattern 22) **to a second client device** (e.g. Fig. 4, mobile unit 14);

transmitting the first sequence of symbols (aforesaid transmission signals associated with beam 20) **to the first client device** (e.g. aforesaid mobile unit 12) **via a first beam** (aforesaid beam 20), **wherein the first beam focuses transmit energy toward the first client device** (e.g. Fig. 4 showing transmission beam 20 transmitting energy toward mobile unit 12. Furthermore, "the transmission beam patterns are directional, so that each transmission beam pattern points towards the corresponding mobile unit" [0090] lines 9-12);

transmitting the second sequence of symbols (aforesaid transmission signals associated with beam 22) **to the second client device** (e.g. aforesaid mobile unit 14) **via a second beam** (aforesaid beam 22), **wherein the second beam focuses transmit energy toward the second client device** (e.g. Fig. 4 showing transmission beam 22 transmitting energy toward mobile unit 14); **and**

receiving information regarding the first beam from the first client device (e.g. "the transmitting apparatus" comprises "means for receiving from the receiving apparatus a feedback signal based on measures of a quality of the transmission beams received at the receiving apparatus" [0012] lines 1-4, which feedback signal is considered as the information),

modifying the first beam based on the information (e.g. "the transmitting apparatus" comprises "means for adjusting the transmission beam pattern in dependence on the feedback signal" [0013] lines 1-2).

- **With respect to dependent claims**

Regarding claim 2, **The data-communications networking apparatus as recited in Claim 1, wherein the transceiver is further configured to: transmit the first sequence of symbols and the second sequence of symbols at least partly simultaneously** (e.g. "the various signals to and from the base station are transmitted in the same frequency band using code division multiple access (CDMA). In CDMA, each signal is spread over a wide spectrum at the transmitter using a unique spreading code. At the receiver, the signal is despread back to the original signal using a replica of the spreading code. By using a different spreading code (or a different combination of spreading and scrambling codes) for each signal, the various signals are distinguishable despite being transmitted simultaneously in the same frequency band" [0083] lines 6-15).

Regarding claim 3, **The data-communications networking apparatus as recited in Claim 1, wherein the transceiver is further configured to: transmit the first sequence of symbols and the second sequence of symbols at different times** (e.g. "the invention is not limited to use with cellular mobile communications systems, but may be applied to any communications system where a signal is transmitted with a

certain degree of directionality. The invention may be used with multiplexing techniques other than CDMA, such as Time Division Multiple Access (TDMA), Frequency Division Multiplexing (FDM) or any other appropriate multiplexing technique" [0164] lines 1-8, which TDMA is associated with transmission at different times).

Regarding claim 4, **The data-communications networking apparatus as recited in Claim 1, wherein the processor is further configured to: compute a first weight to apply to a first beam of the one or more beams** (e.g. "within each beam former, a set of three multipliers is provided to multiply the input signal by three complex weight values. The complex weight values are set by the beam former control unit 36. By appropriate adjustment of the complex weight values within each, beam former, directional transmission beams 20_U, 20_M, 20_L are output from antenna elements 34_1, 34_2, 34_3" [0122] lines 1-7, which complex weight is associated with first weight, wherein applying a weight to a beam is adjusting the "amplitude and phase" of the beam [0140] line19 and "beam former control unit 36 operates in dependence on the feedback signal fed back from the mobile unit to the base station" [0125] lines 1-3).

Regarding claim 5, **The data-communications networking apparatus as recited in Claim 4, wherein one or more of the processor, the transceiver, or the antenna are further configured to: modify the first beam by applying the first weight to the first beam to create a modified first beam** (e.g. Fig. 4, "as the mobile units 12, 14, 16 roam within the area of coverage of the base station 10, the direction and power of the transmission beam patterns 20, 22, 24 are controlled adaptively to

ensure that the mobile units remain within the corresponding transmission beams. For example, if the mobile unit 12 moves to a location indicated by 12', then it will no longer be within the area of coverage of transmission beam pattern 20. In this case, the direction of transmission beam pattern 20 must be adapted as the mobile unit 12 moves, as indicated by the dashed transmission beam pattern 20', to ensure continuous coverage" [0090] lines 15-26, which dashed transmission beam pattern 20' is considered as the modified first beam and which adaption or modification is done by beam former unit 30 in accordance with a control signal setting the weight value from beam former control unit 36 in accordance with the feedback signal as discussed in Fig. 7).

Regarding claim 6, **The data-communications networking apparatus as recited in Claim 5, wherein the first weight is calculated based on the feedback information** (e.g. "beam former control unit 36 operates in dependence on the feedback signal fed back from the mobile unit to the base station" [0125] lines 1-3).

Regarding claim 7, **The data-communications networking apparatus as recited in Claim 6, wherein the feedback information comprises at least a signal to noise ratio** (e.g. "the means for producing measures of the quality of the transmission beams may be adapted to estimate the signal-to-interference-and-noise ratio of received signals and/or the power level of received signals, or to measure the quality of the transmission beams in any other way" [0043] lines 1-5. Note that there are multiple options in the claim and this option is considered here).

Regarding claim 8, **The data-communications networking apparatus as recited in Claim 5, wherein one or more of the processor, the transceiver, or the antenna are further configured to: transmit a third sequence of symbols to the first client device via the modified first beam** (e.g. note that the data transmitted to mobile unit 12 via the modified first beam 20' of Fig. 4 is considered as the third sequence of symbols).

Regarding claim 9, **The data-communications networking apparatus as recited in Claim 4, wherein the processor is further configured to: compute a second weight to apply to a second beam of the one or more beams, wherein the first weight and the second weight are different** (e.g. note that just like the first weight is associated with the first beam of the first client device, a second weight is associated with the second beam of the second client device and since the weights depend on the feedback received from the respective client devices, the first weight and the second weights are different).

Regarding claim 10, **The data-communication networking apparatus as recited in Claim 9, wherein one or more of the processor, the transceiver, or the antenna are further configured to:**

modify the second beam by applying the second weight to the second beam to create a modified second beam; and

transmit a fourth sequence of symbols to the second client device via the modified second beam (e.g. aforesaid adaption or modification of a beam is done by

beam former unit 30 in accordance with a control signal setting the weight value from beam former control unit 36 in accordance with the feedback signal as discussed in Fig. 7. Thus the second beam is modified by applying the second weight to it and the data send by the modified second beam is the fourth sequence of symbols).

Regarding claim 12, **The method of enabling data communications in a networking apparatus as recited in Claim 11, further comprising: computing a first weight to apply to a first beam of the one or more beams** (Note that this claim is similar to claim 4 except that it is a method claim and thus the same reasoning as applied to claim 4 applies here as well).

Regarding claim 13, **The method of enabling data communications in a networking apparatus as recited in Claim 12, further comprising: modifying the first beam by applying the first weight to the first beam** (Note that this claim is similar to claim 5 except that it is a method claim and thus the same reasoning as applied to claim 5 applies here as well).

Regarding claim 14, **The method of enabling data communications in a networking apparatus as recited in Claim 13, wherein the first weight is calculated based on the feedback information** (Note that this claim is similar to claim 6 except that it is a method claim and thus the same reasoning as applied to claim 6 applies here as well).

Regarding claim 15, **The method of enabling data communications in a networking apparatus as recited in Claim 14, wherein the feedback information comprises at least a signal to noise ratio** (Note that this claim is similar to claim 6 except that it is a method claim and thus the same reasoning as applied to claim 6 applies here as well).

Regarding claim 17, **The data-communications networking apparatus as recited in Claim 16, wherein the transceiver is further configured to: transmit the first sequence of symbols and the second sequence of symbols from the antenna at least partly simultaneously** (Note that this claim is similar to claim 2 and thus the same reasoning as applied to claim 2 applies here as well).

Regarding claim 18, **The data-communications networking apparatus as recited in Claim 16, wherein the transceiver is further configured to: transmit the first sequence of symbols and the second sequence of symbols from the antenna at different times** (Note that this claim is similar to claim 3 and thus the same reasoning as applied to claim 3 applies here as well).

Regarding claim 19, **The data-communications networking apparatus as recited in Claim 16, wherein the processor is further configured to: compute a first weight to apply to the first beam** (Note that this claim is similar to claim 4 and thus the same reasoning as applied to claim 4 applies here as well).

Regarding claim 20, **The data-communications networking apparatus as recited in Claim 19, wherein the transceiver is further configured to: modify the first beam by applying the first weight to the first beam to create a modified first beam** (Note that this claim is similar to claim 5 and thus the same reasoning as applied to claim 5 applies here as well).

Regarding claim 21, **The data-communications networking apparatus as recited in Claim 20, wherein the first weight is calculated based on the information** (Note that this claim is similar to claim 6 and thus the same reasoning as applied to claim 6 applies here as well).

Regarding claim 22, **The data-communications networking apparatus as recited in Claim 21, wherein the information comprises at least a signal to noise ratio** (Note that this claim is similar to claim 7 and thus the same reasoning as applied to claim 7 applies here as well).

Regarding claim 23, **The data-communications networking apparatus as recited in Claim 20, the transceiver is further configured to: transmit a third sequence of symbols to the first client via the modified first beam** (Note that this claim is similar to claim 8 and thus the same reasoning as applied to claim 8 applies here as well).

Regarding claim 24, **The data-communications networking apparatus as recited in Claim 19, wherein the processor is further configured to: compute a**

second weight to apply to the second beam, wherein the first weight and the second weight are different (Note that this claim is similar to claim 9 and thus the same reasoning as applied to claim 9 applies here as well).

Regarding claim 25, **The data-communication networking apparatus as recited in Claim 24, wherein the transceiver is further configured to:**

modify the second beam by applying the second weight to the second beam to create a modified second beam; and

transmit a fourth sequence of symbols to the second client device via the modified second beam (Note that this claim is similar to claim 10 and thus the same reasoning as applied to claim 10 applies here as well).

Regarding claim 27, **The method of enabling data communications in a networking apparatus as recited in Claim 26, further comprising: computing a first weight to apply to the first beam** (Note that this claim is similar to claim 4 except that it is a method claim and thus the same reasoning as applied to claim 4 applies here as well).

Regarding claim 28, **The method of enabling data communications in a networking apparatus as recited in Claim 27, further comprising: modifying the first beam by applying the first weight to the first beam** (Note that this claim is similar to claim 5 except that it is a method claim and thus the same reasoning as applied to claim 5 applies here as well).

Regarding claim 29, **The method of enabling data communications in a networking apparatus as recited in Claim 28, wherein the first weight is calculated based on the information** (Note that this claim is similar to claim 6 except that it is a method claim and thus the same reasoning as applied to claim 6 applies here as well).

Regarding claim 30, **The method of enabling data communications in a networking apparatus as recited in Claim 29, wherein the information comprises at least a signal to noise ratio** (Note that this claim is similar to claim 7 except that it is a method claim and thus the same reasoning as applied to claim 7 applies here as well).

Conclusion

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Sumitra Ganguly whose telephone number is (571)272-0813. The examiner can normally be reached on Monday to Friday, 8 A.M to 5 P.M.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Andrew Lai can be reached on 571 272 9741. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/S. Ganguly/
Examiner, Art Unit 2411

/Andrew Lai/
Supervisory Patent Examiner, Art Unit 2411

Notice of References Cited	Application/Control No. 15/486,245	Applicant(s)/Patent Under Reexamination DA SILVA ET AL.	
	Examiner Sumitra Ganguly	Art Unit 2411	Page 1 of 1

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*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8,412,106 B2	04-2013	da Silva; Marcus	H04B7/04	455/501
*	B	US-2004/0014429 A1	01-2004	Guo, Yingjie Jay	H04B7/0632	455/73
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
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	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15486245	DA SILVA ET AL.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/05/2017								
	1	✓								
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	30	✓								

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S721	25	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S722	38	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S723	333	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S724	58	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S725	92	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S726	34	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S727	262	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S728	7	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S729	118	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S730	166	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S731	10	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S732	4	S721 and S722 and S723 and S724 and S725 and S726 and S727 and S728 and S620 and S730 and S731	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S733	1900401	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S734	15	(VIVATO).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S735	1	S732 and S734	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S736	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" |	US-PGPUB; USPAT;	OR	ON	2017/06/05 14:57

		"6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	USOCR			
S737	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S738	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S739	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S740	0	S736 and S737 and S738 and S739	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S741	9	S736 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S742	5	S737 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S743	5	S738 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S744	1	S739 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S745	0	S736 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S746	0	S736 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S747	9	S736 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S748	882	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S749	21	peak same null same (coverage area) with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S750	186	peak same null with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S751	1004	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S752	374	peak with null with (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S753	1	"20030114196".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S754	4687	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57

S755	2307	(sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S756	163	(detect$3 identify$3 observ$3 recogniz$3 find$3) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S757	111	((transmit$4 send$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S758	157	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S759	50	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power) and @ad<="20021104"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S760	1	"3747109".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S761	2	S736 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna) and computer	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S762	6	(null with maxim$4 near3 power with minim$3 near3 interference)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S763	713	(null with power with interference)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S764	106	(null with power with interference) with beam	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S765	1	"20030064752".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S766	1	"8412106".PN.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S767	1	S766 and (monitor$3)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S768	65381	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data))	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S769	8458	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S770	109	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) same S769	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S771	1	S766 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57

S772	1	S766 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S773	5	S770 and (side near2 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S774	268	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S775	11	S774 and (side near3 lobe near3 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S776	82	S774 and (side near3 lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S777	8	S769 and S774	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S778	19	S768 and S774	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S779	28395	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S780	39223	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal user)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S781	22937	(coordinat$3 mang$3 perform$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S782	66	S780 same S781	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S783	1292	S780 and S781	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S784	176	S780 same3 S781	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S785	36202	(coordinat$3 manag$3 perform$3 arrang$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S786	80	S780 same S785	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S787	195	S780 same2 S785	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S788	3	"13855410"	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S789	3	S788 and (side adj lobe)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S790	1102	signal with control with coordinat$3 with logic	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S791	909230	((direct$5 focuss4$ angular$4) near4 (beam communicat$3))	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57

S792	16	S790 same S791	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S793	9617	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with (coordinat$4)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S794	48	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with ((coordinat$4) near3 (logic circuit))	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S795	1391	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S796	156	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam) and multi$1beam	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S797	39	S796 and null	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S798	268	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S799	18858	H04W16/$.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S800	27	S798 and S799	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S801	6	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S802	3	"13855410"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S803	3	S802 and first	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S804	6	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S805	0	"8412106" and (first adj directed adj beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S806	4	"8412106" and (first adj directed)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S807	4	"8412106" and (side adj lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S808	25	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S809	38	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S810	333	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S811	58	((Robert) near2 (Conley)).INV.	US-PGPUB;	OR	ON	2017/06/05

			USPAT; USOCR			14:57
S812	92	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S813	34	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S814	262	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S815	7	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S816	118	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S817	166	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S818	10	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S819	4	S808 and S809 and S810 and S811 and S812 and S813 and S814 and S815 and S816 and S817 and S818	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S820	1900401	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S821	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S822	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S823	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S824	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S825	0	S823 and S821 and S822 and S824	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S826	0	S823 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S827	25	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S828	38	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S829	333	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT;	OR	ON	2017/06/05 14:57

			USOCR			
S830	58	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S831	92	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S832	34	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S833	262	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S834	7	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S835	118	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S836	166	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S837	10	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S838	4	S827 and S828 and S829 and S830 and S831 and S832 and S833 and S834 and S835 and S836 and S837	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S839	1900401	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S840	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S841	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S842	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S843	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S844	0	S842 and S840 and S841 and S843	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S845	0	S842 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S846	0	S842 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S847	882	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57

S848	1004	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S849	4687	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S850	25	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S851	38	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S852	333	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S853	58	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S854	92	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S855	34	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S856	262	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S857	7	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S858	118	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S859	166	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S860	10	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S861	4	S850 and S851 and S852 and S853 and S854 and S855 and S856 and S857 and S858 and S859 and S860	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S862	1900401	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S863	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S864	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S865	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S866	1	("5327143").PN.	US-PGPUB;	OR	ON	2017/06/05

			USPAT; USOCR			14:57
S867	0	S865 and S863 and S864 and S866	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S868	20	("20010033600" | "20020158801" | "20030073465" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611895" | "6628235" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S869	4687	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S870	2	S869 and S868	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S871	2838	H04W16/28.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S872	1203	H04W72/046.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S873	1556	H04B7/04.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S874	53	S869 and S871	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S875	11	S869 and S872	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S876	8	S869 and S873	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S877	25	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S878	38	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S879	333	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S880	58	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S881	92	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S882	34	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S883	262	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57

S884	7	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S885	118	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S886	166	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S887	10	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S888	4	S877 and S878 and S879 and S880 and S881 and S882 and S883 and S884 and S885 and S886 and S887	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S889	1900401	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S890	15	(VIVATO).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S891	1	S888 and S890	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S892	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S893	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S894	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S895	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S896	0	S892 and S893 and S894 and S895	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S897	9	S892 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S898	5	S893 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S899	5	S894 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S900	1	S895 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S901	0	S892 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S902	0	S892 and ((direct$5 focuss4$	US-PGPUB;	OR	ON	2017/06/05

		angular$4) near4 beam) and (antenna near4 assembly)	USPAT; USOCR			14:57
S903	9	S892 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S904	882	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S905	21	peak same null same (coverage area) with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S906	186	peak same null with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S907	1004	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S908	374	peak with null with (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S909	1	"20030114196".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S910	4687	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S911	2307	(sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S912	163	(detect$3 identify$3 observ$3 recogniz$3 find$3) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S913	111	((transmit$4 send$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S914	157	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S915	50	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power) and @ad<="20021104"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S916	1	"3747109".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S917	2	S892 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna) and computer	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S918	6	(null with maxim$4 near3 power with minim$3 near3 interference)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S919	713	(null with power with interference)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57

S920	106	(null with power with interference) with beam	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S921	1	"20030064752".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S922	1	"8412106".PN.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S923	1	S922 and (monitor$3)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S924	65381	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data))	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S925	8458	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S926	109	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) same S925	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S927	1	S922 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S928	1	S922 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S929	5	S926 and (side near2 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S930	268	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S931	11	S930 and (side near3 lobe near3 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S932	82	S930 and (side near3 lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S933	8	S925 and S930	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S934	19	S924 and S930	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S935	28395	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S936	39223	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57

		user)				
S937	22937	(coordinat$3 mang$3 perform$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S938	66	S936 same S937	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S939	1292	S936 and S937	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S940	176	S936 same3 S937	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S941	36202	(coordinat$3 manag$3 perform$3 arrang$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S942	80	S936 same S941	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S943	195	S936 same2 S941	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S944	3	"13855410"	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S945	3	S944 and (side adj lobe)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S946	1102	signal with control with coordinat$3 with logic	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S947	909230	((direct$5 focuss4$ angular$4) near4 (beam communicat$3))	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S948	16	S946 same S947	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S949	9617	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with (coordinat$4)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S950	48	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with ((coordinat$4) near3 (logic circuit))	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S951	1391	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S952	156	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam) and multi$1beam	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S953	39	S952 and null	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S954	268	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S955	18858	H04W16/$.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S956	27	S954 and S955	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S957	6	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S958	3	"13855410"	US-PGPUB; USPAT;	OR	ON	2017/06/05 14:57

			USOCR			
S959	3	S958 and first	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S960	6	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S961	0	"8412106" and (first adj directed adj beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S962	4	"8412106" and (first adj directed)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S963	4	"8412106" and (side adj lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S964	20	("20010033600" | "20020158801" | "20030073465" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611895" | "6628235" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S965	0	S964 and (enrgy power) near3 (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S966	0	S964 and (energy power) near3 (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S967	0	S964 and (energy power) with (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S968	0	S964 and (energy power) with (side near3 (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S969	2	S964 and (energy power) with (second near3 (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S970	14	S964 and ((energy power) with (lobe	US-PGPUB;	OR	ON	2017/06/05

		beam))	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			14:57
S971	1	S964 and ((energy power) with (directed near3 beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S972	2	S964 and ((energy power) with (second near2 beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S973	3	"13855410"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S974	25	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S975	38	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S976	333	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S977	58	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S978	92	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S979	34	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S980	262	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S981	7	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S982	118	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S983	166	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S984	10	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT;	OR	ON	2017/06/05 14:57

			USOCR			
S985	4	S974 and S975 and S976 and S977 and S978 and S979 and S980 and S981 and S982 and S983 and S984	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S986	1900401	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S987	15	(VIVATO).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S988	1	S985 and S987	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S989	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S990	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S991	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S992	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S993	0	S989 and S990 and S991 and S992	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S994	9	S989 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S995	5	S990 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S996	5	S991 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S997	1	S992 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S998	0	S989 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S999	0	S989 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1000	9	S989 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1001	882	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1002	21	peak same null same (coverage area) with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57

S1003	186	peak same null with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1004	1004	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1005	374	peak with null with (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1006	1	"20030114196".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1007	4687	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1008	2307	(sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1009	163	(detect$3 identify$3 observ$3 recogniz$3 find$3) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1010	111	((transmit$4 send$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1011	157	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1012	50	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power) and @ad<="20021104"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1013	1	"3747109".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1014	2	S989 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna) and computer	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1015	6	(null with maxim$4 near3 power with minim$3 near3 interference)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1016	713	(null with power with interference)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1017	106	(null with power with interference) with beam	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1018	1	"20030064752".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1019	1	"8412106".PN.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1020	1	S1019 and (monitor$3)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1021	65381	(maintain$3 stor$3) with ((transmit	US-PGPUB;	OR	ON	2017/06/05

		near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data))	USPAT			14:57
S1022	8458	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1023	109	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) same S1022	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1024	1	S1019 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1025	1	S1019 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1026	5	S1023 and (side near2 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1027	268	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1028	11	S1027 and (side near3 lobe near3 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1029	82	S1027 and (side near3 lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1030	8	S1022 and S1027	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1031	19	S1021 and S1027	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1032	28395	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1033	39223	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal user)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1034	22937	(coordinat$3 mang$3 perform$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1035	66	S1033 same S1034	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1036	1292	S1033 and S1034	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1037	176	S1033 same3 S1034	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1038	36202	(coordinat$3 manag$3 perform$3 arrang$3) with (direct$3 near5	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57

		communication)				
S1039	80	S1033 same S1038	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1040	195	S1033 same2 S1038	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1041	3	"13855410"	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1042	3	S1041 and (side adj lobe)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1043	1102	signal with control with coordinat$3 with logic	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1044	909230	((direct$5 focuss4$ angular$4) near4 (beam communicat$3))	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1045	16	S1043 same S1044	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1046	9617	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with (coordinat$4)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1047	48	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with ((coordinat$4) near3 (logic circuit))	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1048	1391	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1049	156	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam) and multi$1beam	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1050	39	S1049 and null	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1051	268	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1052	18858	H04W16/$.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1053	27	S1051 and S1052	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1054	6	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1055	3	"13855410"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1056	3	S1055 and first	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1057	6	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1058	0	"8412106" and (first adj directed adj beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1059	4	"8412106" and (first adj directed)	US-PGPUB;	OR	ON	2017/06/05

			USPAT; USOCR			14:57
S1060	4	"8412106" and (side adj lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1061	25	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1062	38	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1063	333	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1064	58	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1065	92	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1066	34	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1067	262	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1068	7	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1069	118	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1070	166	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1071	10	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1072	4	S1061 and S1062 and S1063 and S1064 and S1065 and S1066 and S1067 and S1068 and S1069 and S1070 and S1071	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1073	1900401	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1074	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1075	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1076	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1077	1	("5327143").PN.	US-PGPUB;	OR	ON	2017/06/05

			USPAT; USOCR			14:57
S1078	0	S1076 and S1074 and S1075 and S1077	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1079	0	S1076 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1080	25	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1081	38	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1082	333	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1083	58	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1084	92	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1085	34	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1086	262	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1087	7	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1088	118	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1089	166	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1090	10	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1091	4	S1080 and S1081 and S1082 and S1083 and S1084 and S1085 and S1086 and S1087 and S1088 and S1089 and S1090	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1092	1900401	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1093	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1094	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1095	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" |	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57

		"6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.				
S1096	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1097	0	S1095 and S1093 and S1094 and S1096	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1098	0	S1095 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1099	0	S1095 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1100	882	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1101	1004	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1102	4687	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1103	25	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1104	38	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1105	333	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1106	58	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1107	92	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1108	34	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1109	262	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1110	7	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1111	118	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1112	166	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1113	10	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1114	4	S1103 and S1104 and S1105 and	US-PGPUB;	OR	ON	2017/06/05

		S1106 and S1107 and S1108 and S1109 and S1110 and S1111 and S1112 and S1113	USPAT; USOCR			14:57
S1115	1900401	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1116	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1117	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1118	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1119	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1120	0	S1118 and S1116 and S1117 and S1119	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1121	20	("20010033600" | "20020158801" | "20030073465" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611895" | "6628235" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1122	4687	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1123	2	S1122 and S1121	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1124	2838	H04W16/28.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1125	1203	H04W72/046.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1126	1556	H04B7/04.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1127	53	S1122 and S1124	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1128	11	S1122 and S1125	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1129	8	S1122 and S1126	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1130	3	("20020158801" | "20030073465" | "6611695").PN.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1131	24	("5327143" | "5771017" | "5809141"	US-PGPUB;	OR	ON	2017/06/05

		| "6049307" | "6104935" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611695" | "6628235" | "6631277" | "6850741" | "6907269" | "7346365" | "20010033600" | "20020103013" | "20020158801" | "20030064752" | "20030073465" | "20030114196").PN.	USPAT			14:57
S1132	1	"15260147"	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1133	294	H04B7/00.cpc.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1134	1203	H04W72/046.cpc.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1135	15	S1134 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1136	15	S1134 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1137	28	("5327143" | "5771017" | "5809141" | "6049307" | "6104935" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611695" | "6628235" | "6631277" | "6850741" | "6907269" | "7346365" | "20010033600" | "20020103013" | "20020158801" | "20030064752" | "20030073465" | "20030114196" | "4231040" | "5987037" | "6091788" | "20040063468").PN.	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1138	22	S1137 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1139	1	S1137 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1140	20051	((detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with beam)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1141	28	((detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with (side near3 (beam lobe)) with transmission)	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1142	294	(detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with (side near3 (beam lobe))	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1143	0	S1137 and (detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with (side near3 (beam lobe))	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1144	0	(("XR") near3 ("COMMUNICATIONS") near3 ("LLC") near3 ("D/B/A") near3 ("VIVATO") near3 ("TECHNOLOGIES")).AANM.	USPAT	OR	ON	2017/06/05 14:57
S1145	28	(("DA") near3 ("SILVA") near3 ("Marcus")).INV.	US-PGPUB; USPAT;	OR	ON	2017/06/05 14:57

			USOCR			
S1146	38	(("CRILLY") near3 ("William")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1147	336	(("BRENNAN") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1148	58	(("CONLEY") near3 ("Robert")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1149	92	(("ALAMOUTI") near3 ("Siavash")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1150	34	(("CASAS") near3 ("Eduardo")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1151	262	(("YIN") near3 ("Hujun")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1152	7	(("JOSE") near3 ("Bobby")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1153	118	(("CHOI") near3 ("Yang-Seok")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1154	166	(("TAROKH") near3 ("Vahid")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1155	10	(("MEHROTRA") near3 ("Praveen")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1156	5	S1145 and S1146 and S1147 and S1148 and S1149 and S1150 and S1151 and S1152 and S1153 and S1154 and S1155	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1157	11	"XR COMMUNICATIONS".AS.	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1158	3	S1156 and S1157	US-PGPUB; USPAT; USOCR	OR	ON	2017/06/05 14:57
S1159	3	(modify$3 alter$3 chang$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1160	33	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1161	33	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (antenna near3 beam) with	US-PGPUB; USPAT; USOCR;	OR	ON	2017/06/05 14:57

		feedback	FPRS; EPO; JPO; DERWENT; IBM_TDB			
S1162	9	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (antenna near3 beam) with (feedback near3 information)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1163	159	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback near3 information)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1164	891	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1165	21	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback near3 information) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1166	908	(transmit$4 send$3 transmission) near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1167	7	(transmit$4 send$3 transmission) near3 second near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1168	114	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1169	2682	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information signal quality interference feedback) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1170	83	(modify$3 alter$3 chang$3 adjust$3	US-PGPUB;	OR	ON	2017/06/05

		adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information signal quality interference feedback) near3 (UE WTRU mobile client user device) same (directional)	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			14:57
S1171	2	"10700329"	US-PGPUB	OR	ON	2017/06/05 14:57
S1172	48	"6611695" "20030114196" "20030064752" "5327143"	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1173	13	"7151951"	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1174	1	"20020158801"	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1175	1	"20030073465"	US-PGPUB; USPAT	OR	ON	2017/06/05 14:57
S1176	210	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1177	654	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback quality interference) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1178	882	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near5 (beam) with (feedback quality interference) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1179	279	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1180	16	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information signal quality interference feedback) near3 (UE WTRU mobile client user device) same (directional) and (different adj times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1181	1	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) with different near2 times	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1182	1	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3	US-PGPUB; USPAT;	OR	ON	2017/06/05 14:57

		(beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) same different near2 times	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S1183	13	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) same (different near2 times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57
S1184	18	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile MS client user device) same (different near2 times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/06/05 14:57

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15/486,245	04/12/2017 RULE	370	2411	E1027.800(T).US1D1C1C1

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

This application is a CON of 15/260,147 09/08/2016
which is a CON of 13/855,410 04/02/2013 PAT 9462589
which is a DIV of 10/700,329 11/03/2003 PAT 8412106
which claims benefit of 60/423,660 11/04/2002

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

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Foreign Priority claimed	35 USC 119(a-d) conditions met	Verified and Acknowledged	Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ Yes ☑ No	☐ Yes ☐ No	/SUMITRA GANGULY/ Examiner's Signature	☐ Initials	WA	18	30	4

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
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First Named Inventor	Marcus DA SILVA
Art Unit	TBD
Examiner Name	TBD
Attorney Docket Number	E1027.800(T).US1D1C1D1C1

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4231040		1980-10-28	Walker	
	2	5327143		1994-07-05	Goetz et al.	
	3	5771017		1998-06-23	Dean et al.	
	4	5809141		1998-09-15	Dent et al.	
	5	5987037		1999-11-16	Gans	
	6	6049307		2000-04-11	Lim	
	7	6091788		2000-07-18	Keskitalo et al.	
	8	6104935		2000-08-15	Smith et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
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	First Named Inventor	Marcus DA SILVA
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	E1027.800(T).US1D1C1D1C1

	9	6108323		2000-08-22	Gray	
	10	6141335		2000-10-31	Kuwahara et al.	
	11	6169910		2001-01-02	Tamil et al.	
	12	6311075		2001-10-30	Bevan et al.	
	13	6337659		2002-01-08	Kim	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Marcus DA SILVA
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	E1027.800(T).US1D1C1D1C1

	20	6907269		2005-06-14	Yamaguchi et al.	
	21	7346365		2008-03-18	Hovers et al.	
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20010033600	A1	2001-10-25	Yang et al.	
	2	20020103013	A1	2002-08-01	Watson et al.	
	3	20020158801	A1	2002-10-31	Crilly et al.	
	4	20030064752	A1	2003-04-03	Adachi et al.	
	5	20030073465	A1	2003-04-17	Li	
	6	20030114196	A1	2003-06-19	Chitrapu	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Marcus DA SILVA
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	E1027.800(T).US1D1C1D1C1

	7	20040063468	A1	2004-04-01	Frank	

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	1	9921391	WO	A2	1999-04-29	Radio Design Innovation Tj Ab		

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	1	Anastasi, et. al., "MAC Protocols for Widcband Wireless Local Access: Evolution Towards Wireless ATM", IEEE Personal Communications Magazine, pp. 53-64, Oct. 1998.	
	2	Berg, J., "Building penetration loss along urban street microcells," in Proceedings of PIMRC '96--7th International Symposium on Personal, Indoor, and Mobile Communications, 3:795-797 (1996).	
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	First Named Inventor	Marcus DA SILVA
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	E1027.800(T).US1D1C1D1C1

	6	German et al., "Wireless Indoor Channel Modeling: Statistical Agreement of Ray Tracing Simulations and Channel Sounding Measurements," in Proceeding of 2001 IEEE International Conference on Acoustics, Speech, and Signal Processing, 4:2501-2504 (2001).	
	7	Gucsalla, R., "Characterizing the Variability of Arrival Processes with Indexes of Dispersion", IEEE JSAC, 9(2):203-211 (1990).	
	8	Hashemi, H., "The Indoor Propagation Channel," Proceedings of the IEEE, 81 (7): 943-968 (1993).	
	9	Jakes, W.C., ed., Microwave Mobile Communications. Wiley, 1974. 645 pages.	
	10	Kivinen et al., "Empirical Characterization of Wide hand Indoor radio Channel at 5.3 GHz," IEEE Transactions on Antennas and ProtJagation, 49(8): 1192-1203 (2001).	
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	12	Medbo, J. and J. Berg, "Simple and accurate path loss modeling at 5 GHz in indoor environments with corridors," in Vehicular Technology Conference Fall 2000. IEEE VTS Fall VTC2000. 52nd Vehicular Technology Conference, 1:30-36 (2000).	

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Examiner Signature	/SUMITRA GANGULY/	Date Considered	06/05/2017

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number	
	Filing Date	
	First Named Inventor	Marcus DA SILVA
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	E1027.800(T).US1D1C1D1C1

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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See attached certification statement.

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☒ A certification statement is not submitted herewith.

SIGNATURE

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

Signature	/Nicholas R. Transier/	Date (YYYY-MM-DD)	2017-04-12
Name/Print	Nicholas R. TRANSIER	Registration Number	68743

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15486245	DA SILVA ET AL.
	Examiner	Art Unit
	SUMITRA GANGULY	2411

CPC- SEARCHED		
Symbol	Date	Examiner
H04B7/00, H04W16/28	6/5/17	S.G

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor, Assignee and Teaxt search in EAST. See search history printout for details.	6/5/17	S.G.

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(Not for submission under 37 CFR 1.99)

Application Number	15486245
Filing Date	2017-04-12
First Named Inventor	Marcus DA SILVA
Art Unit	2411
Examiner Name	Sumitra GANGULY
Attorney Docket Number	E1027.800(T).US1D1C1C1

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	1	5933421	A	1999-08-03	ALAMOUTI et al	
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	Art Unit	2411
	Examiner Name	Sumitra GANGULY
	Attorney Docket Number	E1027.800(T).US1D1C1C1

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Name/Print	Nicholas R. TRANSIER	Registration Number	68743

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Electronic Acknowledgement Receipt

EFS ID:	29719905
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	114581
Filer:	Nicholas R. Transier/Jenny Stedman
Filer Authorized By:	Nicholas R. Transier
Attorney Docket Number:	E1027.800(T).US1D1C1C1
Receipt Date:	07-JUL-2017
Filing Date:	12-APR-2017
Time Stamp:	17:50:08
Application Type:	Utility under 35 USC 111(a)

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/486,245	04/12/2017	Marcus Da Silva	E1027.800(T).US1D1C1C1

CONFIRMATION NO. 4888

114581
EIP US LLP
2468 Historic Decatur Road
Suite 200
San Diego, CA 92106

PUBLICATION NOTICE



Title:DIRECTED WIRELESS COMMUNICATION

Publication No.US-2017-0222705-A1
Publication Date:08/03/2017

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IPR2024-00148

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Inventor:	Marcus Da Silva
Application No.:	15/486,245
Filed:	April 12, 2017
For:	DIRECTED WIRELESS COMMUNICATION
Examiner:	Sumitra GANGULY
Art Unit:	2411
Confirmation No.:	4888

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

Dear Commissioner:

In response to the Non-Final Office Action issued on June 15, 2017, Applicant amends this application as follows:

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

Amendments to the Drawings begins on page 5 of this paper.

Amendments to the Claims begin on page 6 of this paper.

Remarks/Arguments begin on page 19 of this paper.

AMENDMENTS TO THE SPECIFICATION

Please amend paragraph [0032] of the specification as follows:

[0032] FIG. 1 illustrates an exemplary wireless communications ~~environ merit~~ environment 100 that is generally representative of any number of different types of wireless communications environments, including but not limited to those pertaining to wireless local area networks (LANs) or wide area networks (WANs) (e.g., Wi-Fi compatible) technology, cellular technology, trunking technology, and the like. In wireless communications environment 100, an access station 102 communicates with remote client devices 104(1), 104(2), . . . , 104(N) via wireless communication or communication links 106(1), 106(2), . . . , 106(N), respectively. Although not required, access station 102 is typically fixed, and remote client devices 104 may be fixed or mobile. Although only three remote client devices 104 are shown, access station 102 can wirelessly communicate with any number of different client devices 104.

Please amend paragraph [0065] of the specification as follows:

[0065] The channel assignments coordinated by the signal control and coordination logic 304 provide[[s]] the best channel assignment for a signal based on given measurement information. Parameters of a channel assignment algorithm include:

Please amend paragraph [0085] of the specification as follows:

[0085] $Ne_{ij}(t)$ which is a number of uplink data packets with Physical Layer Convergence Procedure (PLCP) or data Cyclic Redundancy Check (CRC) errors in the *i*th beam on the *j*th channel and which is measured by the scanning receiver 822 and averaged over the *MeasurementDuration* period. This is also referred to as the Unidentified Interference Metric (UIM); and

Please amend paragraph [0099] of the specification as follows:

[0099] A combination index R with the least peak communication load is then selected such that $PL_{max}(R)=\min\{PL_{max}(k)\}$ where $(0\leq k\leq 71)$ which is the combination of channels and

beams that minimize the peak load on any channel. If the peak load on a channel is not less than the *PeakLoadLimit*, then a three channel assignment can be implemented. Initially, the thirteen communication beams are divided into three blocks of which there are sixty-six possible combinations. For each combination, the channel selections can be $f_1f_6f_{11}$, $f_1f_{11}f_6$, $f_6f_1f_{11}$, $f_6f_{11}f_1$, $f_{11}f_1f_6$, or $f_{11}f_6f_1$ such that there are a total of three-hundred, ninety-six block and channel combinations. Assuming that the *k*th block-channel combination has a configuration as follows:

Please amend paragraph [0107] of the specification as follows:

[0107] When taking into account intermodulation such that channel combinations f_1f_6 and f_6f_{11} are to be avoided, then f_6 is avoided. Initially, the thirteen communication beams are divided into two blocks of which there are twelve possible combinations. For each combination, the channel selections can be f_1f_{11} and $f_{11}f_1$ such that there are a total of twenty-four block and channel combinations. Assuming that the *k*th block-channel combination has a configuration as follows:

Please amend paragraph [0132] of the specification as follows:

[0132] The receive indicators forwarded to MAC coordinator logic 904 may be comprised of any one or more different indications from the baseband units 902. For example, the receive indicators may comprise clear channel assessment (CCA) or busy/non-busy indications. Alternatively, the receive indicators may comprise indications of signal reception based on energy signals, cross-correlation signals, data signals, other transmit and/or control signals, ~~seine~~ some combination thereof, and so forth. Furthermore, a receive indicator may comprise an analog or digital indication (of one or more bits), the driving of one or more lines, the presentation of one or more messages, some combination thereof, and so forth.

Please amend paragraph [0155] of the specification with as follows:

[0155] A busy( ) function returns a receiver indication that a channel is busy, and an error( ) function indicates that a received frame had a CRC error. A notforus( ) function indicates

that a frame was not addressed to a particular station, and a ~~nav( )~~ nav( ) function indicates that a timer has not expired. A data( ) function indicates that data is queued to send, and a short( ) function indicates that a MAC protocol data unit is shorter than an RTS Threshold and that there are additional data fragments to be sent from a current MAC controller. A more( ) function facilitates obtaining the additional data fragments.

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

AMENDMENTS TO THE DRAWINGS

Replacement Sheet for Figure 16 is included in the Appendix.

Exhibit 1002
Page 0253 of 1285

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

AMENDMENTS TO THE CLAIMS

1. (**Currently Amended**) A data-communications networking apparatus, comprising:

a processor configured to:

generate a probing signal for transmission to at least a first client device and a second client device;

generate a first ~~sequence of symbols~~data stream for transmission to the~~a~~ first client device; and

generate a second data stream~~sequence of symbols~~ for transmission to the~~a~~ second client device; and

a transceiver operatively coupled to the processor and configured to:

transmit the probing signal to at least the first client device and the second client device via a smart antenna;

~~transmit the first sequence of symbols to the first client device via an antenna;~~

~~transmit the second sequence of symbols to the second client device via the antenna,~~

wherein the smart antenna is operatively coupled to the transceiver and comprises a first antenna element and a second antenna element;

wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:

receive a first feedback information from the first client device in response to the transmission of the probing signal;

receive a second feedback information from the second client device in response to the transmission of the probing signal;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and second feedback information;

transmit the first data stream ~~sequence of symbols~~ to the first client device via the one or more spatially distributed patterns of electromagnetic signals~~beams, wherein at least one of the one or more beams focuses transmit energy toward the first client device~~;

transmit the second data stream~~sequence of symbols~~ to the second client device via the one or more spatially distributed patterns of electromagnetic signals~~beams, wherein at least one of the one or more beams focuses transmit energy toward the second client device~~;

wherein the transmissions of the first data stream and the second data stream occur at least partly simultaneously; and

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device~~receive feedback information regarding at least one of the one or more beams from at least one of the first or second client devices; and~~

~~modify at least one of the one or more beams based on the feedback information~~.

2. **(Canceled)**

3. **(Canceled)**

4. **(Currently Amended)** The data-communications networking apparatus as recited in Claim 1, wherein one or more of the processor~~–~~, the transceiver, or the smart antenna are~~is~~ further configured to: determine~~compute~~ a first set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals ~~a first beam of the one or more beams~~.

5. **(Currently Amended)** The data-communications networking apparatus as recited in Claim 1~~4~~, wherein one or more of the processor, the transceiver, or the smart

antenna are further configured to: modify the one or more spatially distributed patterns of electromagnetic signals ~~first beam by~~ based on adjustment of~~applying~~ a~~the~~ first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals~~first beam to create a modified first beam~~.

6. **(Canceled)**

7. **(Currently Amended)** The data-communications networking apparatus as recited in Claim ~~6~~1, wherein the first feedback information and the second feedback information comprise~~s~~ at least one of: a transmit power level, a data receive rate, an antenna direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, ~~or~~ timing data, or an index to a routing table.

8. **(Currently Amended)** The data-communications networking apparatus as recited in Claim ~~1~~5, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to: transmit a third data stream ~~sequence of symbols~~ to the first client device via the modified one or more spatially distributed patterns of electromagnetic signals~~first beam~~.

9. **(Currently Amended)** The data-communications networking apparatus as recited in Claim ~~4~~5, wherein one or more of the processor, the transceiver, or the smart antenna are~~is~~ further configured to: determine~~compute~~ a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals~~a second beam of the one or more beams~~, wherein the first set of weights and the second set of weights are different.

10. **(Currently Amended)** The data-communications networking apparatus as recited in Claim ~~9~~5, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to:

modify the one or more spatially distributed patterns of electromagnetic signals~~second beam by~~ based on adjustment of~~applying~~ a~~the~~ second set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals~~second beam to create a modified second beam~~; and

transmit a ~~fourth~~ third data stream~~sequence of symbols~~ to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals~~second beam~~.

11. **(Canceled)**

12. **(Canceled)**

13. **(Canceled)**

14. **(Canceled)**

15. **(Canceled)**

16. **(Currently Amended)** A data-communications networking apparatus, comprising:

a processor configured to:

generate a probing signal for transmission to at least a first client device and a second client device;

generate a first data stream~~set of symbols~~ for transmission to the~~a~~ first client device; and

generate a second data stream~~set of symbols~~ for transmission to the~~a~~ second client device; and

a transceiver operatively coupled to the processor ~~and to an antenna~~ , ~~the~~ ~~transe~~and~~eiver~~ configured to:

transmit the probing signal to at least the first client device and the second client device via a smart antenna;

~~transmit the first sequence of symbols to the first client device from the antenna via a first beam, wherein the first beam focuses transmit energy toward the first client device;~~

~~transmit the second sequence of symbols to the second client device from the antenna via a second beam, wherein the second beam focuses transmit energy toward the second client device; and~~

wherein the smart antenna is operatively coupled to the transceiver and comprises a first antenna element and a second antenna element;

wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:

receive a first feedback information ~~regarding the first beam~~ from the first client device;

receive a second feedback information from the second client device;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and second feedback information;

transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals;

transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;

wherein the transmissions of the first data stream and the second data stream occur at least partly simultaneously; and

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device a second transmission peak at a location of the second client device, and a first transmission null at a location of a third device.~~,~~

~~wherein the processor is further configured to: modify the first beam based on the information.~~

17. **(Canceled)**

18. **(Canceled)**

19. **(Currently Amended)** The data-communications networking apparatus as recited in Claim 16, wherein one or more of the processor, the transceiver, or the smart antenna are ~~is~~ further configured to: determine~~compute~~ a first set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals~~first beam~~.

20. **(Currently Amended)** The data-communications networking apparatus as recited in Claim 16~~9~~, wherein one or more of the processor, the transceiver, or the smart antenna are ~~is~~ further configured to: modify the one or more spatially distributed patterns of electromagnetic signals ~~first beam by~~based on adjustment of ~~applying~~ ~~the~~a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals~~first beam to create a modified first beam~~.

21. **(Canceled)**

22. **(Currently Amended)** The data-communications networking apparatus as recited in Claim 16~~21~~, wherein the first feedback information and the second feedback information comprises at least one of: a transmit power level, a data receive rate, an antenna direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, ~~or~~ timing data, or an index to a routing table.

23. **(Currently Amended)** The data-communications networking apparatus as recited in Claim 20, wherein one or more of the processor, the transceiver, or the smart antenna are ~~is~~ further configured to: transmit a third data stream~~sequence of symbols~~ to the first client via the modified one or more spatially distributed patterns of electromagnetic signals~~first beam~~.

24. **(Currently Amended)** The data-communications networking apparatus as recited in Claim 20~~19~~, wherein one or more of the processor, the transceiver, or the smart antenna are ~~is~~ further configured to: determine~~compute~~ a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals~~second beam~~, wherein the first set of weights and the second set of weights are different.

25. **(Currently Amended)** The data-communication networking apparatus as recited in Claim 20~~24~~, wherein one or more of the processor, the transceiver, or the smart antenna are ~~is~~ further configured to:

modify the one or more spatially distributed patterns of electromagnetic signals ~~second beam by~~ based on adjustment of~~applying~~ a~~the~~ second set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals~~second beam to create a modified second beam~~; and

transmit a ~~fourth~~ third data stream~~sequence of symbols~~ to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals~~second beam~~.

26. **(Canceled)**

27. **(Canceled)**

28. **(Canceled)**

29. **(Canceled)**

30. **(Canceled)**

31. **(New)** The data-communications networking apparatus as recited in Claim 1, wherein the one or more spatially distributed patterns of electromagnetic signals are further configured to exhibit a first transmission null at a location of a third device.

32. **(New)** The data-communications networking apparatus as recited in Claim 31, wherein the one or more spatially distributed patterns of electromagnetic signals are further configured to exhibit a second transmission null at a location of a fourth device.

33. **(New)** A data-communications networking apparatus, comprising:

a processor configured to:

generate a probing signal for transmission to at least a first client device and a second client device;

generate a first data stream for transmission to the first client device; and

generate a second data stream for transmission to the second client device; and

a transceiver operatively coupled to the processor and configured to:

transmit the probing signal to at least the first client device and the second client device via a smart antenna;

wherein the smart antenna is operatively coupled to the transceiver;

wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:

receive a first feedback information from the first client device;

wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first index to a routing table;

receive a second feedback information from the second client device;

wherein the second feedback information comprises one or more of: a second amplitude information, a second phase information, a second routing information, or a second index to a routing table;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and second feedback information;

transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals;

transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;

wherein the transmissions of the first data stream and the second data stream occur at least partly simultaneously; and

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

34. **(New)** The data-communications networking apparatus as recited in Claim 33, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to: determine a first set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals.

35. **(New)** The data-communications networking apparatus as recited in Claim 33, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to: modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals.

36. **(New)** The data-communications networking apparatus as recited in Claim 35, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to: transmit a third data stream to the first client device via the modified one or more spatially distributed patterns of electromagnetic signals.

37. **(New)** The data-communications networking apparatus as recited in Claim 34, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to: determine a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals, wherein the first set of weights and the second set of weights are different.

38. **(New)** The data-communications networking apparatus as recited in Claim 35, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to:

modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a second set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals; and

transmit a third data stream to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals.

39. **(New)** The data-communications networking apparatus as recited in Claim 36, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to: determine a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals, wherein the first set of weights and the second set of weights are different.

40. **(New)** The data-communications networking apparatus as recited in Claim 39, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to:

modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of the second set of weights to the one or more spatially distributed patterns of electromagnetic signals; and

transmit a fourth data stream to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals.

41. **(New)** The data-communications networking apparatus as recited in Claim 33, further comprising a memory, wherein the determination of where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals is further based on part on information contained within the routing table, wherein the routing table is stored in the memory.

42. **(New)** The data-communications networking apparatus as recited in Claim 41, wherein the routing table comprises weighting values.

43. **(New)** The data-communications networking apparatus as recited in Claim 42, wherein the weighting values are stored as a function of θ or as the zeroes of the polynomial expansion in z: $w(z)=w0+w1z+w2z^2+w3z^3+w4z^4+\ldots+wiz^i$.

44. **(New)** A data-communications networking apparatus, comprising:

a processor configured to:

generate a probing signal for transmission to at least a first client device and a second client device;

generate a first data stream for transmission to the first client device; and

generate a second data stream for transmission to the second client device;

a transceiver operatively coupled to the processor and configured to:

transmit the probing signal to at least the first client device and the second client device via a smart antenna;

wherein the smart antenna is operatively coupled to the transceiver; and

a memory operatively coupled to one or more of the processor or the transceiver;

wherein a routing table is stored in the memory;

wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:

receive a first feedback information from the first client device;

wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first index to a routing table;

receive a second feedback information from the second client device;

wherein the second feedback information comprises one or more of: a second amplitude information, a second phase information, a second routing information, or a second index to a routing table;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first feedback information and the second feedback information;

transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals;

transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;

wherein the transmissions of the first data stream and the second data stream occur at least partly simultaneously; and

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device a second transmission peak at a location of the second client device, and a first transmission null at a location of a third device.

45. **(New)** The data-communications networking apparatus as recited in Claim 44, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to: determine a first set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals.

46. **(New)** The data-communications networking apparatus as recited in Claim 44, wherein one or more of the processor, the transceiver, or the smart antenna are further configured to: modify the one or more spatially distributed patterns of electromagnetic

signals based on adjustment of a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals.

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

REMARKS

This paper is responsive to the Office Action issued on June 15, 2017 (the "Office Action"). By the foregoing amendments, Applicant amends claims 1, 4, 5, 7–10, 16, 19, 20, and 22–25. New claims 31–46 have been added. No new matter has been added. Claims 2, 3, 6, 11–15, 17, 18, 21, and 26–30 are canceled without prejudice or disclaimer. Upon entry of these amendments, claims 1, 4, 5, 7–10, 16, 19, 20, 22–25, and 31–46 are pending.

In view of the foregoing amendments and following remarks, Applicant respectfully submits that the application is in condition for allowance.

Discussion of Amendments to the Specification

Applicant has corrected typographical errors as indicated above. No new matter has been added by these amendments.

Discussion of Amendments to the Drawings

Applicant is submitting replacement Figure 16 to correct the direction of the arrow for transition 1610. No new matter has been added by this amendment.

Discussion of Amendments to the Claims

Amendments to claims 1, 4, 5, 7–10, 16, 19, 20, and 22–25 and new claims 31–46 are supported, but not limited, at least by paragraphs 38–43, 47, 113–115, 157–159, 189 of the specification and Figures 2, 3, and 12. In addition, amendments and new claims are supported, but not limited, at least by the disclosure in provisional application 60/423,660 at F4–F8 and G14–G15.

Discussion of Double Patenting Rejection

The Office Action provisionally rejected claims 1, 11, 16, and 26 on the ground of non-statutory double patenting as being unpatentable over claim 39 of co-pending Application No. 15/260,147 and over claims 1-19 of U.S. Patent No. 8,412,106.

Applicant respectfully traverses these rejections. In view of the foregoing amendments, Applicant respectfully requests withdrawal of these rejections.

Discussion of Claim Rejections under 35 U.S.C. § 112

The Office Action rejected Claims 1–15 and 27–30 under § 112, second paragraph as being indefinite. While Applicant respectfully disagrees, Applicant has amended the claims to address the rejections. Therefore, Applicant respectfully requests withdrawal of these rejections.

Discussion of Claim Rejections under 35 U.S.C. § 102

The Office Action rejected claims 1–30 under § 102(e) as being anticipated by U.S. Patent Publication No. 2004/0014429 ("Guo"). Applicant respectfully traverses there rejections,

In the interest of advancing prosecution, Applicant has amended independent claims 1 and 16. Applicant respectfully submits that Guo does not disclose or suggest the subject matter of amended claims 1 and 16.

For example, Guo does not disclose or suggest at least the following limitations of amended claim 1:

> wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:
>
> receive a first feedback information from the first client device in response to the transmission of the probing signal;
>
> receive a second feedback information from the second client device in response to the transmission of the probing signal;
>
> determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and second feedback information;
>
> transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals;
>
> transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;
>
> wherein the transmissions of the first data stream and the second data stream occur at least partly simultaneously; and

> wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

For instance, Guo does not disclose a networking apparatus "wherein one or more of the processor, the transceiver, or the smart antenna" is configured to "determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals" as recited in amended claim 1. Guo is at most concerned with "determin[ing] which of the main beam and the auxiliary beam is received with the best quality." *Guo*, paragraph [0129]. After this determination in Guo, "the main beam [will] move[] to the location of the auxiliary beam if the feedback signal indicates that the auxiliary beam was received with the best quality; otherwise the main beam is unchanged." *Id.* At a minimum, Guo does not disclose or suggest transmission nulls, much less making the determination of where to place "transmission nulls."

Further, Guo does not disclose or suggest a networking apparatus wherein "one or more of the processor, the transceiver, or the smart antenna" is configured to "determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and second feedback information." First, Guo does not disclose multiple client devices. Even if Guo disclosed multiple client devices, Guo does not disclose or suggest determining "where to place transmission peaks and transmission nulls" based "in part on the first **and** second feedback information" (emphasis added) received from first and second client devices.

For at least the foregoing reasons, Applicant respectfully submits that Guo does not disclose or suggest amended claim 1.

Further, Applicant has amended independent claim 16 to recite, among other limitations:

> wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:
>
> receive a first feedback information from the first client device;
>
> receive a second feedback information from the second client device;

> determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and second feedback information;
>
> transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals;
>
> transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;
>
> wherein the transmissions of the first data stream and the second data stream occur at least partly simultaneously; and
>
> wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device a second transmission peak at a location of the second client device, and a first transmission null at a location of a third device.

For at least the foregoing reasons, Applicant respectfully submits that Guo does not disclose or suggest claim 16.

Accordingly, Applicant respectfully submits that claims 1 and 16 are patentable and requests withdrawal of the rejections.

In addition, each of the dependent claims depends from a patentable independent claim and also recites limitations that represent additional patentable distinctions over Guo. Accordingly, Applicant respectfully submits that the dependent claims are patentable and requests withdrawal of the rejections.

Discussion of New Claims

New independent claim 33 recites, among other limitations:

> wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:
>
> receive a first feedback information from the first client device;
>
> wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first index to a routing table;
>
> receive a second feedback information from the second client device;
>
> wherein the second feedback information comprises one or more of: a second amplitude information, a second phase

information, a second routing information, or a second index to a routing table;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and second feedback information;

transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals;

transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;

wherein the transmissions of the first data stream and the second data stream occur at least partly simultaneously; and

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

New independent claim 44 recites, among other limitations:

wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:

receive a first feedback information from the first client device;

wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first index to a routing table;

receive a second feedback information from the second client device;

wherein the second feedback information comprises one or more of: a second amplitude information, a second phase information, a second routing information, or a second index to a routing table;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first feedback information and the second feedback information;

transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals;

transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;

wherein the transmissions of the first data stream and the second data stream occur at least partly simultaneously; and

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

> wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device a second transmission peak at a location of the second client device, and a first transmission null at a location of a third device.

For at least the foregoing reasons, Applicant respectfully submits that claims 33 and 44 are patentable. In addition, Applicant respectfully submits that new dependent claims are patentable because each such new claims depends from a patentable independent claim and also recites limitations that represent additional patentable distinctions over Guo.

Conclusion

For the foregoing reasons, Applicant respectfully submits that the application is in condition for allowance. Should any issues remain which may be addressed in a phone call, the Examiner is invited to call the undersigned at 949-721-5308.

No Disclaimers or Disavowals

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: September 15, 2017

By:/Vladislav Z. Teplitskiy/
Vladislav Z. Teplitskiy
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26667863

Replacement Sheet

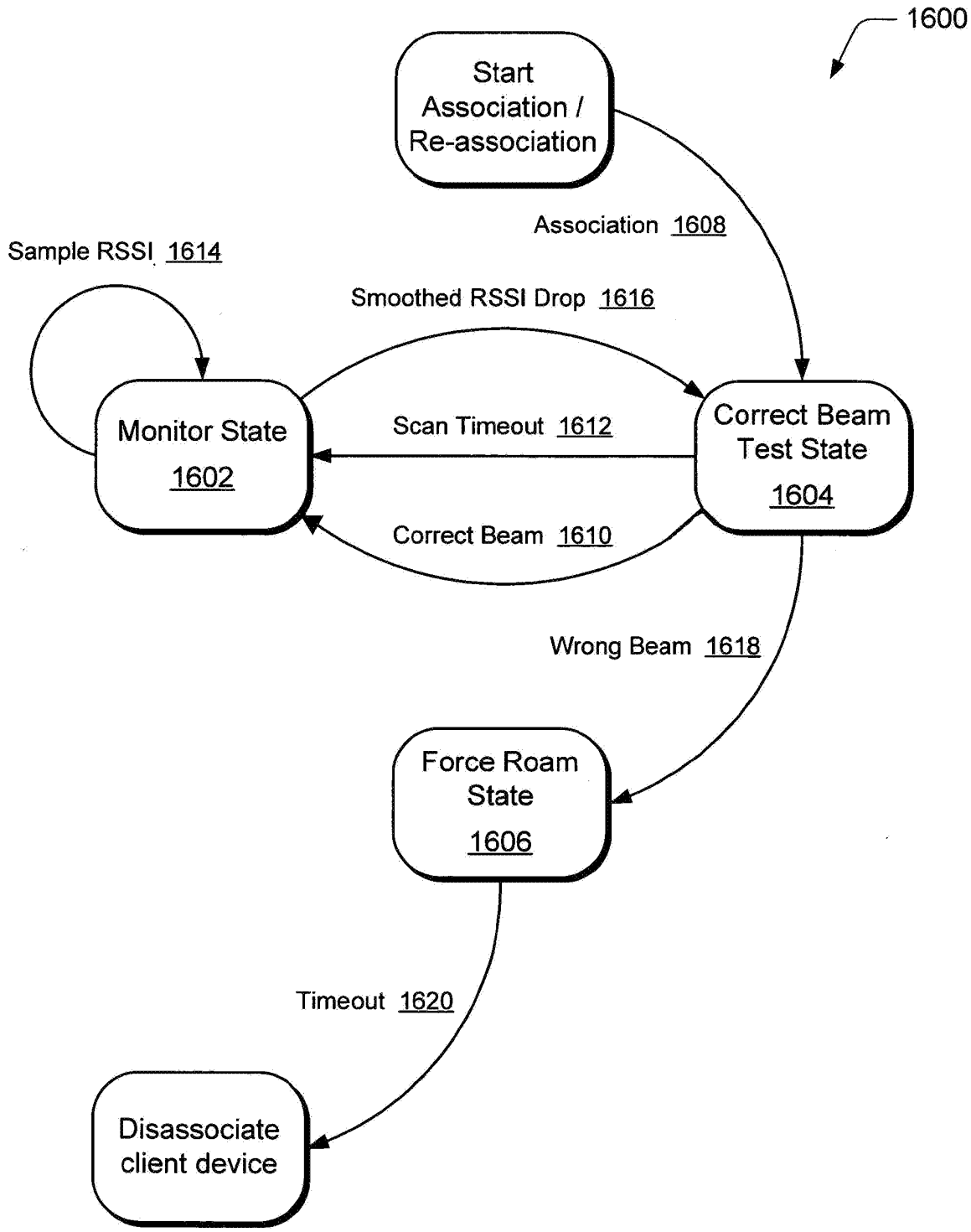


Fig. 16

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	15/486245
Filing Date	April 12, 2017
First Named Inventor	Marcus Da Silva
Title	DIRECTED WIRELESS COMMUNICATION
Art Unit	2411
Examiner Name	Ganguly, Sumitra
Attorney Docket Number	XRCOM.001C3

SIGNATURE of Applicant or Patent Practitioner

Signature	/Vladislav Z. Teplitskiy/	Date (Optional)	
Name	VLADISLAV Z. TEPLITSKIY	Registration Number	68069
Title (if Applicant is a juristic entity)			
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 1 forms are submitted.

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

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

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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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: 20995

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):

XR Communications, LLC d/b/a Vivato Technologies

☐ 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)	September 12th, 2017
Name	Kai Hansen		
Title	Managing Member		

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 1 forms are submitted.

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

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

Electronic Acknowledgement Receipt

EFS ID:	30379235
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	114581
Filer:	Vladislav Z. Teplitskiy/Chelsea Burdeno
Filer Authorized By:	Vladislav Z. Teplitskiy
Attorney Docket Number:	E1027.800(T).US1D1C1C1
Receipt Date:	15-SEP-2017
Filing Date:	12-APR-2017
Time Stamp:	16:24:21
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Amend_XRCOM.pdf	118099 a163719579f62542995b8bf8a8fd5b4942d4d021	yes	25

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Specification	2	4
	Drawings-only black and white line drawings	5	5
	Claims	6	18
	Applicant Arguments/Remarks Made in an Amendment	19	25

Warnings:					
Information:					
2	Drawings-other than black and white line drawings	Figures_XRCOM.pdf	737235 8f4ee8590d9eac5c72cf87889afdbbcb5fa5929d	no	1
Warnings:					
Information:					
3	Power of Attorney	POA_XRCOM.pdf	431600 c0fc7d27fcded8b3be5005010a7d8bf6bcfc9521	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1286934		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/486,245	Filing Date 04/12/2017	☐ To be Mailed

ENTITY: ☐ LARGE ☒ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	09/15/2017	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 30	Minus	** 30	= 0	X $40 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	***4	= 0	X $210 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

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

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

SLIE
NICOL D. SCOTT

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

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/486,245	04/12/2017	Marcus Da Silva	XRCOM.001C3

CONFIRMATION NO. 4888

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

POA ACCEPTANCE LETTER

OC000000094141703

Date Mailed: 09/19/2017

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 09/15/2017.

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

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

/vnguyen/

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/486,245	04/12/2017	Marcus Da Silva	E1027.800(T).US1D1C1C1

CONFIRMATION NO. 4888

POWER OF ATTORNEY NOTICE

114581
EIP US LLP
2468 Historic Decatur Road
Suite 200
San Diego, CA 92106

OC000000094141690

Date Mailed: 09/19/2017

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 09/15/2017.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

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

/vnguyen/

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 1 OF 8	Attorney Docket No.	1640-001.201

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	4,750,147	06-07-1998	Roy, III et al.	
	2	4,965,732	10-23-1990	Roy, III et al.	
	3	5,095,531	03-10-1992	Ito	
	4	5,345,599 A	09-06-1994	Paulraj et al.	
	5	5,471,647	11-28-1995	Gerlach et al.	
	6	5,515,378 A	05-07-1996	Roy, III et al.	
	7	5,546,090	08-13-1996	Roy, III et al.	
	8	5,553,074	09-03-1996	Acampora	
	9	5,592,490	01-07-1997	Barratt et al.	
	10	5,602,555	02-11-1997	Searle et al.	
	11	5,603,089	02-11-1997	Searle et al.	
	12	5,634,199	05-27-1997	Gerlach et al.	
	13	5,642,353 A	06-24-1997	Roy, III et al.	
	14	5,649,293	07-15-1997	Reed	
	15	5,687,194 A	11-11-1997	Paneth et al.	
	16	5,697,066	12-09-1997	Acampora	
	17	5,739,788	04-14-1998	Dybdal et al.	
	18	5,828,658 A	10-27-1998	Ottersten et al.	
	19	5,886,988	03-23-1999	Yun et al.	
	20	5,890,067	03-30-1999	Chang et al.	
	21	5,914,946 A	06-22-1999	Avidor et al.	
	22	5,966,094	10-12-1999	Ward et al.	
	23	6,006,110	12-21-1999	Raleigh	
	24	6,067,290	05-23-2000	Paulraj et al.	
	25	6,101,399	08-08-2000	Raleigh et al.	
	26	6,219,561	04-17-2001	Raleigh	
	27	6,233,466	05-15-2001	Wong et al.	
	28	6,330,460	12-11-2001	Wong et al.	
	29	6,345,188	02-05-2002	Keskitalo et al.	

Examiner Signature	Date Considered

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

T[1] - Place a check mark in this area when an English language Translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 2 OF 8	Attorney Docket No.	1640-001.201

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	30	6,351,499	02-26-2002	Paulraj et al.	
	31	6,438,376	08-20-2002	Elliott et al.	
	32	6,564,036	05-13-2003	Kasapi	
	33	6,611,695	08-26-2003	Periyalwar	
	34	6,665,545 B1	12-16-2003	Raleigh et al.	
	35	6,667,712	12-23-2003	Ericson et al.	
	36	6,687,492	02-03-2004	Sugar et al.	
	37	6,694,154	02-17-2004	Molnar et al.	
	38	6,748,216	06-08-2004	Lee	
	39	6,795,409	09-21-2004	Youssefmir et al.	
	40	6,823,174	11-23-2004	Masenten et al.	
	41	6,850,741	02-01-2005	Lei et al.	
	42	6,853,333	02-08-2005	Ericson et al.	
	43	7,020,110	03-28-2006	Walton et al.	
	44	7,031,336	04-18-2006	Scherzer et al.	
	45	7,054,662	05-30-2006	Judson	
	46	7,062,294	06-13-2006	Rogard et al.	
	47	7,133,380	11-07-2006	Winters et al.	
	48	7,289,826	10-30-2007	Hovers et al.	
	49	7,346,365	03-18-2008	Hovers et al.	
	50	7,492,743	02-17-2009	Uhlik	
	51	7,529,305	05-05-2009	Tong et al.	
	52	2001/0033600	10-25-2001	Yang et al.	
	53	2002/0034967	03-21-2002	Taniguchi et al.	
	54	2003/0017853	01-23-2003	Kanamaluru et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]

Examiner Signature	Date Considered

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

T[1] - Place a check mark in this area when an English language Translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 3 OF 8	Attorney Docket No.	1640-001.201

FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	55	WO 00/38455 A1	06-29-2000	Telefonaktiebolaget LM Ericsson		
	56	WO 00/72464 A1	11-30-2000	Nokia Networks		
	57	WO 01/10156 A1	02-08-2001	Gigabit Wireless, Inc.		
	58	WO 01/010156 A1	02-08-2001	Iospan Wireless, Inc.		
	59	WO 03/075396 A2	09-12-2003	Cognio, Inc.		
	60	WO 96/21117	07-11-1996	Automotive Products France S.A.		
	61	WO 97/00543 A1	01-03-1997	Watkins-Johnson Company		
	62	WO 97/33388 A1	09-12-1997	Watkins-Johnson Company		
	63	WO 98/09381 A1	03-05-1998	The Board of Trustees of the Leland Standford Junior University		
	64	WO 98/18271 A3	04-30-1998	Watkins Johnson Company		
	65	WO 99/21391 A2	04-29-1999	Radio Design Innovation TJ AB		
	66	EP 0817517 A1	01-07-1998	NTT Mobile Communications Network Inc.		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	67	"Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band", Supplement to IEEE Standard for Information technology - Telecommunications and information exchange between systems – Local and metropolitan area networks - Specific requirements. IEEE Std 802.11b-1999(R2003); Sponsor LAN/MAN Standards Committee of the IEEE Computer Society; Reaffirmed 12 June 2003, Approved 16 September 1999, IEEE-SA Standards Board. (0001)	
	68	MARTIN COOPER, "A Layman's Guide to Cellular, Annual Review of Communications", 1996, pages 993-997. (0097; 2478)	
	69	ANDERSON et al., "An Adaptive Array for Mobile Communication Systems", IEEE Transactions On Vehicular Technology, Vol. 40, No. I, February 1991, pages 230-236. (0102; 2415)	
	70	RICHARD H. ROY, "Application of Smart Antenna Technology in Wireless Communication Systems", pages 1-6. (0109; 0115; 3059)	
	71	BJORN OTTERSTEN, "Array Processing for Wireless Communications", 8th IEEE Signal Processing Workshop on Statistical Signal and Array Processing. (0121; 2974)	
	72	G. J. FOSCHINI et al., "BLAST: Bell Labs Layered Space-Time, An Architecture for Realizing Very High Data Rates Over Fading Wireless Channels", https://web.archive/org/web/19990221074508/https://www.bell-labs.com/pr, Lucent Technologies, 1998, 3 pages. (0130; 2528)	

Examiner Signature	Date Considered

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

T[1] - Place a check mark in this area when an English language Translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 4 OF 8	Attorney Docket No.	1640-001.201

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	73	BRANDENBURG, L. H. et al., "Capacity of the Gaussian Channel With Memory: The Multivariate Case", The Bell System Technical Journal, Vol. 63, No. 5, May-June 1974, pages 745-764. (0133; 2436)	
	74	Dean CHAPMAN, "First-Hand: Sidelobe Cancellers and the Like", http:ethw.org/First-Hand:Sidelobe_Cancellers_and_the_Like, April 12, 2017, 4 pages. (0167; 2474)	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 5 OF 8	Attorney Docket No.	1640-001.201

NON PATENT LITERATURE DOCUMENTS			
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	Art Unit	2411
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SHEET 7 OF 8	Attorney Docket No.	1640-001.201

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	153	Exhibits A1 – A30	
	154	Exhibits B1 – B27	
	155	Exhibits C1 – C27	

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Information Disclosure Statement Transmittal

Docket Number
1640-001.201

Address To
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P.O. Box 1450
Alexandria, Virginia 22313-1450

In Re Application Of:

Da Silva et al.

Application No.	15/486,245
Filing Date	April 12, 2017
Examiner	Ganguly, Sumitra
Art Unit	2411

Title of Invention

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BASIS FOR FILING (Select 1, 2 or 3 below.)

37 CFR 1.97(b)

1) ☐ The Information Disclosure Statement submitted herewith is being filed within three months of the filing of a national application other than a continued prosecution application under 37 CFR 1.53 (d); within three months of the date of entry of the national stage as set forth in 37 CFR 1.491 in an international application; before the mailing of a first Office Action on the merits, or before the mailing of a first Office Action after the filing of a request for continued examination under 37 CFR 1.114.

37 CFR 1.97(c)

2) ☒ The Information Disclosure Statement submitted herewith is being filed after the period specified in 37 CFR 1.97(b), but before the mailing date of a Final Action under 37 CFR 1.113, a Notice of Allowance under 37 CFR 1.311, or an Action that otherwise closes prosecution in the application, and is accompanied by one of:

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The present application claims priority to US Ser. No. 60/423,660. Two issued patents - US Pat. Nos. 7,062,296 and 7,729,728 - also claim priority to US Ser. No. 60/423,660, but are otherwise unrelated to the present application.
The '296 and '728 patents are currently the subject of litigation in the Central District of California - XR Communications, LLC, dba Vivato Technologies v. D-Link Systems, Inc., et al., 8:17-cv-0596-AG (JCGx).
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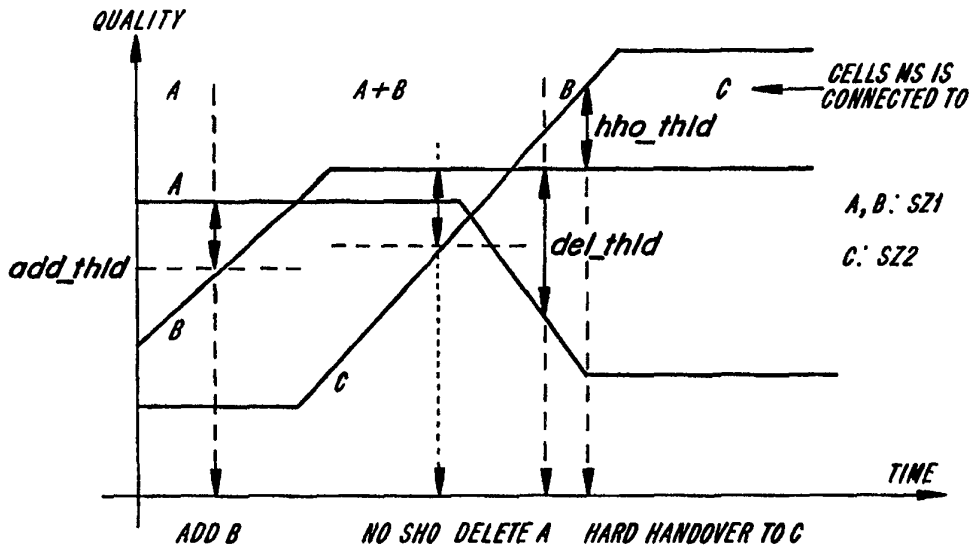
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(54) Title: METHODS AND SYSTEMS FOR CONTROLLING HARD AND SOFT HANDOFFS IN RADIO COMMUNICATION SYSTEMS



(57) Abstract

A method, controller and system for controlling handoffs in radio communication systems using a softzone concept are described. Soft handoff is permitted between members of a particular softzone, but not between members of different softzones. Hard handoff is permitted between members of different softzones, but not between members of the same softzone.

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METHODS AND SYSTEMS FOR CONTROLLING HARD AND SOFT HANDOFFS IN RADIO COMMUNICATION SYSTEMS

BACKGROUND

The present invention relates generally to methods and systems for radiocommunications and, more particularly, to such systems in which a connection can be handed over from one channel or base station to another.

The cellular telephone industry has made phenomenal strides in commercial operations in the United States as well as the rest of the world. Growth in major metropolitan areas has far exceeded expectations and is rapidly outstripping system capacity. If this trend continues, the effects of this industry's growth will soon reach even the smallest markets. Innovative solutions are required to meet these increasing capacity needs as well as maintain high quality service and avoid rising prices.

In cellular systems, the capability is typically provided to transfer handling of a connection between, for example, a mobile station and a base station to another base station, as the mobile station changes its position and so moves out of the coverage area of one base station and into the coverage area of another base station. This type of handoff is commonly referred to as an "intercell" handoff as the coverage areas associated with base stations are commonly referred to as "cells". Depending upon the quality of the current channel, it may also be desirable to transfer a connection from one channel of the base station to another channel supported by the same base station, which handoffs are commonly referred to as "intracell" handoffs.

So-called "hard" handoffs refer to handoffs which are performed wherein there is no overlap in time between transmissions received from an original, serving base station and transmissions received from a new, target base station. As shown in Figure 1(a), during hard handoff, the mobile station (MS) typically first breaks its connection to its original base station (BTS1) and then establishes a connection to its new base station (BTS2).

By way of contrast, "soft" handoffs refer to handoffs wherein, for some period of time, a mobile station receives substantially the same information from two (or more) transmission sources. An exemplary soft handoff scenario is illustrated in Figure 1(b). Therein, before starting soft handoff, the MS is connected to BTS1. During the soft handoff, the MS establishes a connection to BTS2 without dropping the connection to BTS1. Each base station which is concurrently communicating with a particular mobile station may be referred to as a member of that mobile station's "active set". At some time after the connection to BTS2 is set up, the connection to BTS1 will be released which is the termination of the soft handover procedure. The overlapping transmissions from BTS1 and BTS2 permit the mobile station to smoothly switch from receiving information from its original, serving base station to receiving information from its new, target base station. During soft handoff, the mobile station may also take advantage of the fact that it is receiving substantially the same information from two sources to improve its received signal quality by performing diversity selection/combining of the two received signals.

For the sake of simplicity, the foregoing examples of the hard and soft handoff were described in the context of base stations employing omnidirectional antennas, i.e., wherein each base station transmits signals which propagate in a

substantially circular direction, i.e., 360 degrees. However, as will be appreciated by those skilled in the art, other antenna structures and transmission techniques may also be employed in radiocommunication systems. For example, a cell can be subdivided into several sectors, e.g., into three sectors where each sector covers a 120 degree angle as shown in Figure 2. Alternatively, the system or cell may employ an array antenna structure as shown in Figure 3. Therein, an exemplary radio communication system 200 includes a radio base station 220 employing a fixed-beam phased array (not shown). The phased array generates a plurality of fixed narrow beams (B_1, B_2, B_3, B_4, etc.) which radially extend from the base station 220, at least one of which (B_1) is used to communicate with MS 210. Preferably, the beams overlap to create a contiguous coverage area to service a radio communication cell. Although not shown, the phased array can actually consist of three phased array sector antennas.

Of course, the principles described above with respect to hard and soft handoff for omnidirectional antennas in Figures 1(a) and 1(b) can be directly mapped to other systems which employ sectorized and/or array antennas. In these latter types of systems, hard and soft handoffs can be performed between sectors or beams of the same base station as well as between sectors or beams associated with different base stations.

Both types of handoff have their drawbacks and advantages. On the one hand, soft handoff provides a robust mechanism for changing the connection from one base station to another. However, since the mobile station is connected to more than one base station during soft handoff, soft handoff requires more system resources than hard handoff. An advantage of hard handoff, therefore, is a reduced

need for system resources, while its drawback is a higher probability of dropped calls when compared to soft handoff.

Both hard and soft handoffs are employed in some radiocommunication systems. For example, Figure 4 illustrates a system described in WO 96/02117, wherein soft and hard handoff are applied sequentially. Therein, a system containing two base station controllers, BSC1 and BSC2, is shown. BSC1 controls base stations BTS11, BTS12 and BTS13, while BSC2 controls base stations BTS21, BTS22, and BTS23. The area that is served by all of the base stations coupled to a BSC is called a "BSC area".

Assume for this example, that the mobile station (MS) moves from cell A served by the base station BTS12 to cell B, which is at the border between two BSC areas. Cell B is served by two overlapping base stations, BTS11 and BTS21. BTS11 is coupled to controller BSC1, and BTS21 is coupled to base station controller BSC2. As the MS moves to cell B, it carries out a soft handoff controlled by BSC1 to a traffic channel of base station BTS11.

Assume further that the MS continues onward toward cell C and finally enters into its area of radiocommunication coverage. The base station BTS22, serving cell C, is under the control of BSC2. Before it is possible to activate the base station BTS22 for the handoff, the call control must first be switched to base station controller BSC2 from the previous controller BSC1. This is accomplished by performing a hard handoff. The MS performs a hard handoff from the base station BTS11 to the base station BTS21, and consequently, the base station controller change from BSC1 to BSC2 takes place. Finally, a soft handoff from BTS21 to BTS22 is performed.

However, these techniques described in WO 96/02117 do not provide a mechanism for controlling the use of either soft or hard handoff. Instead, these techniques are simply provided as an intended mechanism for reducing interference and signaling overhead associated with the handoff of a mobile area from a service area under the control of a first BSC to a service area under the control of a second BSC. Thus, these techniques do not provide any solution for controlling the usage of soft and hard handoff between cells *per se*.

According to European Patent Application 817 517 A1, as illustrated in Figure 5, a technique is presented for determining an appropriate type of handoff for a mobile station. In the Figure, the received perch channel (i.e., a type of broadcast control channel) level is shown for the cell where the MS resides initially (solid line) as well as for a neighboring cell (dashed line). The received levels are given with respect to the position of the mobile station.

According to EP 817 517 A1, the handoff type judgement method for a CDMA mobile communication system provides different types of handoff with different handoff start conditions. A type of handoff for which a handoff start condition is weakest, among the available types of handoff at a mobile station, is evaluated first. It is determined whether the handoff start condition for this type of handoff is satisfied or not at the mobile station. Each base station is notified for carrying out that type of handoff when the handoff start condition for that handoff is satisfied.

However, the techniques described in EP 817 517 A1 require that the mobile station be informed for each sector regarding which type of handoff is available. Hence out of a number of possible cells/sectors suitable for handoff with, possibly, different available handoff types, the mobile station first has to select all

cells/sectors that are available for the handoff type with weakest start condition. In a second step, a judgement among all of these cells/sectors will be performed. Thus, these techniques suffer from the drawbacks of having a two step procedure that requires intense signalling between the network (i.e., the base station) and the mobile station and that it is also quite complex to implement.

Accordingly, there is a need to develop enhanced techniques to determine when a handoff is appropriate, and which type of handoff is appropriate, to efficiently utilize system resources under different operating conditions.

SUMMARY

These, and other, problems, drawbacks, and limitations of conventional handoff techniques, are overcome according to the present invention in which a mechanism is provided for controlling the usage of soft and hard handoffs. According to exemplary embodiments of the present invention, methods and systems determine which handoff type is preferred at a specific location under current radio conditions. Another object of the present invention is to control hard and soft handoff while at the same time minimizing the overhead signalling between the network and the mobile station. Yet another object is to provide control methods and systems which are applicable to radiocommunication systems that use more than one frequency band to support communications in a cell/sector at the same time.

These, and other objects of the present invention are attained by a method for controlling handoff of a mobile station to a target transmission source in a radiocommunication system which comprises the steps of:

grouping a number of transmission sources into a group;

assigning, to an active set associated with said mobile station, at least one transmission source from said group;

selecting a first type of handoff to occur to at least one target transmission source if said at least one target transmission source is within said group; and

selecting a second type of handoff to occur to said at least one target transmission source if said first type of handoff is not selected.

In the method, a grouping of transmission sources (e.g., cells, sectors, base stations, beams or combinations thereof) is performed into groups which are denoted as softzones. Each softzone has its own softzone identity. Softzone identities can be reused for sectors which are not too close to each other. All members in the active set have the same softzone identity. However, each transmission source may belong to multiple softzones, i.e. it is possible that a transmission source is assigned to different groups.

Softzone handoff mechanisms according to the present invention provide a number of benefits. For example, the overhead signalling between the mobile station and the network associated with controlling handoff type selection will be reduced as compared, for example, to the techniques described in EP 817 517 A1. This is due to the fact that cells/sectors are grouped into different softzones instead of treating each cell/sector separately for the purpose of determining which type of handoff, if any, is appropriate. Moreover, these techniques provide a one-step procedure which permits great flexibility in the number of different handoff types that can be used.

Cell planners can use the softzone concepts described herein as a tool to take into account that between certain cells hard handoff might be more reasonable while

between other cells a soft handover might be most suitable. Moreover, the grouping of transmission sources into particular softzones need not be static, e.g., a network operator may adjust softzone assignments based on changes to system structure (e.g., cell addition or cell splitting), changing load conditions, etc. Softzones can also be automatically regrouped by way of a dynamic regrouping algorithm, e.g., based on current network resources, air interface resources and loading patterns.

In a preferable embodiment of the method said first type of handoff is a soft handoff. In a soft handoff, at least one transmission source of the active set and at least one target transmission source in the handoff transmit substantially the same information to a mobile station at substantially the same time. The second type of handoff is preferably a hard handoff wherein a mobile station ceases receiving transmissions from one transmission source prior to receiving transmissions from a target transmission source. In an exemplary embodiment, soft handoffs may only be performed with transmission sources having the same softzone id as current members of the active set. Likewise, hard handoffs may only be performed to transmission sources having a different softzone id than current members of the active set.

Examples of suitable transmission sources include a cell, a base station, a frequency band, a beam associated with an antenna array and a sector. Preferably, the membership of transmission sources to a group can be readjusted.

A base station operating in a radiocommunication system can support communication on two or more different frequency bands. In this case, a suitable

choice of the groups is that transmission sources in a first frequency band supported by said base station are assigned to one group.

The step of selecting a type of handoff preferably comprises the step of measuring a quality level associated with transmission sources a group. The measured quality levels can then be evaluated in conjunction with at least one threshold. The membership in the active set of the mobile station can in this way be based on a result of the evaluating step. A preferable threshold can be adjusted. It can vary, for example, as a function of a quality level associated with a member of said active set.

Preferable quantities for the measurement of the quality level are for example the downlink signal-to-interference ratio, downlink received signal strength, downlink pathloss or downlink pathloss plus uplink interference. Combinations of different quantities can be used.

Preferably, group identifiers of transmission sources are transmitted to the mobile station.

A controller for controlling handoff of a mobile station to a target transmission source in a radiocommunication system comprises, according to the invention, preferably a processor selecting a soft handoff of a connection from at least one first transmission source, having a first group identification assigned thereto, to at least one second transmission source, having a second group identification assigned thereto, when said first and second group identifications are the same. A transmission source can include for example one or more beams of an antenna array

or one or more sectors associated with one or more base stations. A hard handoff of said connection from one of the first transmission sources to one of the second transmission sources is selected when said first and second group identifications are different. It is possible that a transmission source is assigned to both said first and second groups.

In a preferable embodiment, the transmission sources comprise transceivers disposed within a same base station but which support communications on different frequency bands.

In a preferable embodiment, a processor in the controller can reassign a transmission source from a first group identification to another group identification. The processor can be identical to or different form the processor selecting the transmission device.

The controller can be disposed in a switch of the communication network. Switches are nodes in the network of the communication system for controlling connections like for example a BSC (base station controller) or an MSC (mobile switching center) according to GSM or UMTS specifications or an RNC (radio network controller). The controller can also be disposed in a mobile station.

A preferable radiocommunication system according to the invention comprises at least one first transmission source, having a first group identification assigned thereto and supporting a connection with a mobile station. A second transmission source has a second group identification assigned thereto. A processor associated

with a network controller, e.g. a switch, for controlling operations of the transmission sources and said mobile station selects a soft handoff of the connection from one of the first transmission sources to one of the second transmission sources when the group identifications are the same. When said first and second group identifications are different, a hard handoff of said connection from a first transmission source to a second transmission source is selected.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing, and other, objects, features and advantages of the present invention will be more readily understood upon reading the following detailed description in conjunction with the drawings in which:

Figure 1(a) is an illustration of hard handoff;

Figure 1(b) is an illustration of soft handoff;

Figure 2 depicts a base station employing sector antennas;

Figure 3 shows a base station employing an array antenna;

Figure 4 is an illustration of a conventional technique for performing sequential hard and soft handoffs to handoff a connection involving two base station controllers;

Figure 5 depicts another conventional technique for controlling different types of handoff;

Figure 6 is a block diagram showing various functional blocks of an exemplary mobile station;

Figure 7 is a graph illustrating various handoff algorithm conditions for adding, deleting and replacing sectors;

Figure 8 shows three cells grouped into two softzones used to describe exemplary embodiments of the present invention; and

Figure 9 is a graph of measured quality versus time used to explain handoff techniques according to exemplary embodiments of the present invention.

DETAILED DESCRIPTION

In the following description, for purposes of explanation and not limitation, specific details are set forth, such as particular circuits, circuit components, techniques, etc. in order to provide a thorough understanding of the invention. However it will be apparent to one skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed descriptions of well-known methods, devices, and circuits are omitted so as not to obscure the description of the present invention with unnecessary details. For example, although not described in detail herein, the present invention is applicable to radiocommunication systems which employ any type of access methodology, e.g., Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), or any hybrid thereof.

Moreover, this specification describes techniques that are applicable to different types of handoffs. However, these techniques can be applied to handoffs from or to any transmission source, e.g., a cell, a base station, a sector, a beam, a transceiver, etc. Accordingly, although the term "cell" is used primarily herein to illustrate how handoff mechanisms according to the present invention operate, it will

be appreciated by those skilled in the art that these techniques apply equally to any type of transmission source.

Prior to describing the details of the present invention, an example of the construction of a mobile station which can operate to perform the signal quality measurements described above is illustrated in Figure 6. This block diagram has been simplified to illustrate only those components relevant to the measurement of downlink signal strength, however those skilled in the art will be well aware of the other major functional blocks associated with mobile stations. In Figure 6, incoming radio signals are received by transmitter/receiver TRX 500. The timing is synchronized to the received symbol sequence by microprocessor controller 530. The strength of the received signals are measured by a signal strength measuring part 520, the value of which is then passed to microprocessor controller 530. The bit error rate (BER) of the received signal can also be determined as an indication of received signal quality as reflected by block 540. This measurement of received signal quality is particularly relevant in determining when an intracell handoff is desirable. Of course, the present invention is applicable to systems which use any type of quality measurement parameter, e.g., signal-to-interference ratio, received signal strength or pathloss. The mobile station will also have input/output devices, such as a keyboard and display 535, as well as a microphone and speaker unit (not shown), which enables information to be exchanged between the mobile station and the base station.

When the mobile station receives a list of channel numbers, codes or other channel identifying information in a measurement command, it will measure the received signal quality associated with each of those channels. Once the mobile station has made the requested measurements, at least two different evaluation

techniques can be employed. First, if network evaluated handoff (NEHO) is employed, then the mobile station will report the measurements to the system which will then evaluate the various sectors using a handoff algorithm. Alternatively, if mobile evaluated handover (MEHO) is employed, then the mobile station itself will evaluate the various sectors.

An example is provided in Figure 7 to illustrate how the active set may change over time based on applying a handoff algorithm to these measurements. Taking as a given that there are four sectors (A,B,C,D) of interest in the handoff scenario of Figure 7, it is initially assumed that only sector A belongs to the active set. The measurement set in this example contains all sectors of the active set and all the neighbors of the active set, in this example A, B and C. Generally speaking, the measurement set contains all of the transmission sources for which the mobile station makes measurements. The measurement set typically includes all members of the active set, as well as transmission sources which are neighbors of the transmission sources in the active set. The measurement set is also typically defined by the network and periodically transmitted to the mobile station.

This exemplary handoff algorithm dictates that different handoff actions will be triggered according to the conditions stated below:

1. Add a sector: A sector X is added to the current active set if its quality Q_x meets the following condition:

$Q_x > Q_{best}$ - add_th

where Q_{best} represents the quality of the sector with the best quality in the Active Set and add_th is a threshold value. For example, as shown in Figure 7, sector B is added to the active set at the time instant marked 'Add B' since the

difference between its quality level and the quality level received from sector A falls below add_th. Note that after time 'Add B', sector D is added to the measurement set because it is a neighbor to sector B.

2. Delete a sector: A sector X is deleted from the current active set if its quality Q_x meets the following condition:

$$Q_x < Q_{best} - \text{delete\_th}$$

where delete_th represents the deletion threshold. An example of this condition occurring may be found at time instant marked 'Remove C' in Figure 7, wherein sector C is removed from the active set since the difference between its received quality level and that of sector B exceeds delete_th.

3. Replace a sector: The maximum number of cells allowed in the active set is limited. Once this maximum number is reached , the active set is said to be full. A sector X replaces the sector with the worst quality in the active set if the active set is full and the following condition holds:

$$Q_x > Q_{worst} + \text{replace\_th}$$

where replace_th represents the threshold used for sector replacement. Provided that the maximum number of sectors in the active set is two in Figure 7, sector C should replace sector A at time instant marked 'Replace A with C' in Figure 7.

4. Perform a hard handover: A hard handover from the current active set to a new sector is carried out if the quality Q_x of sector X fulfills the following condition:

$$Q_x > Q_{best} + \text{hho\_th}$$

where hho_th represents the threshold used for hard handover, i.e., all connections of the current active set will be removed and a new connection to sector X will be set up. This is, for example, the case at the time instant marked 'hard handover to D' in Figure 7.

The actions described in this handoff algorithm to add, delete or replace a sector occur as soft handoffs in this example, unless the hard handoff threshold is exceeded in which case hard handoff takes precedence. However, according to exemplary embodiments of the present invention, additional control mechanisms are established to determine whether a soft or hard handoff is appropriate. More specifically, the present invention adopts an overlay mechanism referred to herein as a "softzone". The softzone is a group of cells, base stations or other transmission sources (e.g., sectors, beams, etc.) which can be identified by, for example, a softzone identification number (softzone id). Soft handoffs are then permitted only between members within the group having the same softzone id. The active set has a softzone identity which is referred to herein as the "active softzone identity". The softzone ids will be distributed from the network to the mobile station on either common or dedicated channels. Thus, the handoff rules described above with respect to Figure 7 are modified according to this exemplary embodiment such that:

1. When the quality of a measured cell (base station, transmission source, beam, sector, etc.) exceeds the value Q_{best} - add_th (the addition threshold), and the measured cell has a softzone identity which is identical to the active softzone identity, then the cell will be added to the active set in a soft handoff action. If the measured cell has a different softzone identity than the active set cells, the measured

cell will not be added to the active set, even though the quality of the measured cell exceeds Q_{best} - add_th.

2. When the quality of a measured cell (base station, transmission source, beam, sector, etc.) drops below the value of Q_{best} - delete_th (the deletion threshold), and the measured cell belongs to the current active set, then the cell will be deleted from the current active set as part of a soft handoff operation.

3. When the quality of a measured cell (base station, transmission source, beam, sector, etc.) exceeds the value of Q_{best} + hho_th (the hard handover threshold), and the measured cell does not have a softzone identity which is identical to the active softzone identity, then a hard handoff will be performed to the measured cell. If the measured cell has the same softzone identity as the active set cells, no handoff action will be taken.

4. When the quality of a measured cell (base station, transmission source, beam, sector, etc.) exceeds the value of Q_{worst} + rpl_th (the replacement threshold), and the measured cell has a softzone identity which is identical to the active softzone identity, then the measured cell will replace the active set cell with the worst quality.

Of course, the softzone identities must be known in the mobile station (in the case of MEHO) or in the network (in the case of NEHO). Thus, in the former case, the

softzone identities will be transmitted to the mobile station beforehand. The values of the various handoff thresholds described herein may be fixed or may be variable with respect to, for example, the quality level of the best cell (base station, transmission source, beam, sector, etc.) in the active set.

An illustrative example is provided in Figures 8 and 9 to further explain softzone handoff concepts according to exemplary embodiments of the present invention. In Figure 8, three cells (A, B and C) are depicted that belong to two different softzones SZ1 and SZ2 and, therefore have different softzone ids. Initially, for this example, assume that a mobile station (not shown in Figure 8) is only connected to cell A. When the quality of cell B satisfies the condition to add a cell, i.e., at time instant "add B" in Figure 9, a connection to cell B is added, since cells A and B both belong to softzone SZ1. Although the quality of cell C exceeds the addition threshold as well, i.e., at time instant "no SHO" in Figure 9, cell C is not added by way of soft handoff since cell C has a different softzone identity than the current members of the active set A and B.

After cell A has been deleted from the active set, i.e., at time instant "delete A" in Figure 9, the quality of cell C exceeds the hard handoff threshold. Thus a hard handoff will be performed that removes cell B from the active set and adds cell C thereto at time instant "hard handover to C" in Figure 9, since cell C belongs to softzone SZ2, while cell B belongs to softzone SZ1. Of course, if cells B and C had belonged to the same softzone, then no action would have been taken at time instant "hard handover to C" in Figure 9 because in this case cell c would have been added to the active set at time instant "no sho".

Softzone handoff mechanisms according to the present invention provide a number of benefits. For example, the overhead signalling between the mobile

station and the network associated with controlling handoff type selection will be reduced as compared, for example, to the techniques described in EP 817 517 A1. This is due to the fact that cells/sectors are grouped into different softzones instead of treating each cell/sector separately for the purpose of determining which type of handoff, if any, is appropriate. Moreover, these techniques provide a one-step procedure which permits great flexibility in the number of different handoff types that can be used.

Cell planners can use the softzone concepts described herein as a tool to take into account that between certain cells hard handoff might be more reasonable while between other cells a soft handover might be most suitable. In rural areas, for example, line of sight links between mobile stations and base stations are rather frequent. Typically, even in case of hard handoff, a reliable handoff will be performed. On the other hand, in urban areas, line of sight links are rather rare. Furthermore, connection quality may be poor due to shadowing effects. For these reasons, a call is likely to get dropped during a hard handoff, thus creating a preference for soft handoff under these circumstances. In such a scenario, one softzone identity could be assigned to several adjacent urban cells while several different softzone identities could be assigned to rural cells.

Moreover, the grouping of transmission sources into particular softzones need not be static, e.g., a network operator may adjust softzone assignments based on changes to system structure (e.g., cell addition or cell splitting), changing load conditions, etc. Softzones can also be automatically regrouped by way of a dynamic regrouping algorithm, e.g., based on current network resources, air interface resources and loading patterns.

Further, it is anticipated that system capacity will most likely be increased by implementation of the present invention, since the present invention offers the possibility to control soft and hard handoff whereby efficient use of system resources is promoted.

The above-described exemplary embodiments are intended to be illustrative in all respects, rather than restrictive, of the present invention. For example, although the preceding exemplary embodiments do not reference multiple frequency bands, it will be apparent to those skilled in the art that the present invention is applicable to systems employing multiple frequency bands for communication and, therefore, to either intrafrequency or interfrequency band handoff. Moreover, the same or different softzone ids may be provided for different frequency bands used by the same base station to provide communication services. Of course, for mobile stations having only a single receiver, i.e., which can only tune to a single frequency band at a given time, it would then be preferable to provide different softzone ids to different frequency bands employed by a particular base station, i.e., to force hard handoffs rather than soft handoffs therebetween.

Thus the present invention is capable of many variations in detailed implementation that can be derived from the description contained herein by a person skilled in the art. All such variations and modifications are considered to be within the scope and spirit of the present invention as defined by the following claims.

CLAIMS

1. A method for controlling handoff of a mobile station to a target transmission source in a radiocommunication system comprising the steps of:
grouping a number of transmission sources into a group;
assigning, to an active set associated with said mobile station, at least one transmission source from said group;
selecting a first type of handoff to occur to at least one target transmission source if said at least one target transmission source is within said group; and
selecting a second type of handoff to occur to said at least one target transmission source if said first type of handoff is not selected.

2. Method according to claim 1, wherein said first type of handoff is soft handoff wherein said at least one transmission source of said active set and said at least one target transmission source transmit substantially the same information to said mobile station at substantially the same time.

3. Method according to claim 1 or 2, wherein said second type of handoff is hard handoff wherein said mobile station ceases receiving transmissions from said at least one transmission source prior to receiving transmissions from said at least one target transmission source.

4. Method according to any preceding claim, wherein said transmission sources include at least one of: a cell, a base station, a frequency band, a beam associated with an antenna array and a sector.

5. Method according to any preceding claim, further comprising the step of adjusting membership of transmission sources of said group.

6. Method according to any preceding claim, wherein a base station operating in said radiocommunication system supports communication on at least two different frequency bands and wherein said step of grouping further comprises: grouping a first frequency band associated with said base station in said group.

7. Method according to any preceding claim, wherein said step of selecting a first type of handoff further comprises the steps of:
measuring a quality level associated with transmission sources in said group;
evaluating said measured quality levels in conjunction with at least one threshold; and
adjusting membership in said active set based on a result of said evaluating step.

8. Method according to claim 7, wherein said at least one threshold is variable.

9. Method according to claim 7 or 8, wherein said quality level is one of downlink signal-to-interference ratio, downlink received signal strength, downlink pathloss and downlink pathloss plus uplink interference.

10. Method according to claim 8 or 9, wherein said at least one threshold varies as a function of a quality level associated with a member of said active set.

11. Method according to any preceding claim further comprising the step of distributing group identifiers of transmission sources to said mobile station.

12. Method according to any preceding claim, wherein at least one transmission source is assigned to different groups.

13. A controller for controlling handoff of a mobile station to a target transmission source in a radiocommunication system with a processor for:
- selecting a soft handoff of a connection from at least one first transmission source, having a first group identification assigned thereto, to at least one second transmission source, having a second group identification assigned thereto, when said first and second group identifications are the same; and
- selecting a hard handoff of said connection from said at least one first transmission source to said at least one second transmission source when said first and second group identifications are different.

14. Controller according to claim 13, wherein said at least one first and said at least one second transmission sources are transceivers disposed within a same base station but which support communications on different frequency bands.

15. Controller according to any of the claims 13 or 14, wherein a processor can reassign said at least one first transmission source from said first group identification to another group identification.

16. Controller according to any of the claims 13 to 15, wherein the controller is disposed in a mobile station.

17. Controller according to any of the claims 13 to 15, wherein said controller is disposed in a switch.

18. A radiocommunication system comprising:
at least one first transmission source, having a first group identification assigned thereto and supporting a connection with a mobile station;
at least one second transmission source, having a second group identification assigned thereto;
a network controller for controlling operations of said at least one first and said at least one second transmission sources; and
a processor, associated with one of said network controller and said mobile station for:
- selecting a soft handoff of said connection from said at least one first transmission source to said at least one second transmission source when said first and second group identifications are the same; and
- selecting a hard handoff of said connection from said at least one first transmission source to said at least one second transmission source when said first and second group identifications are different.

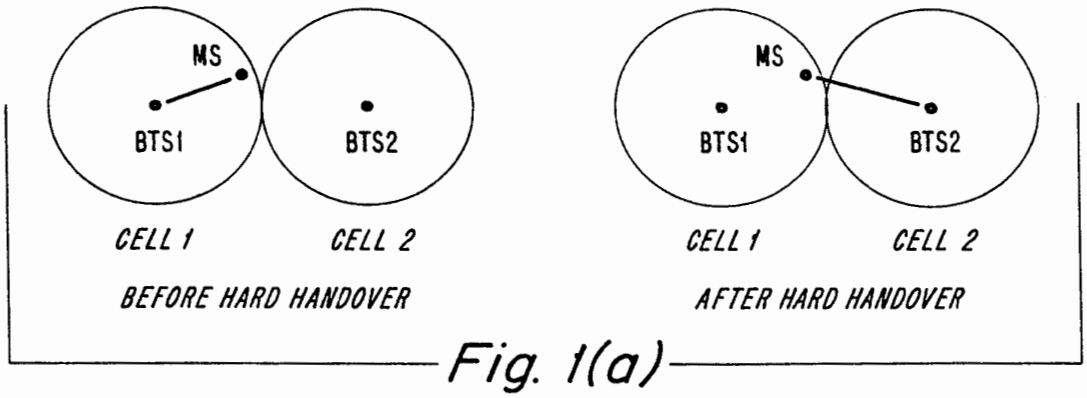


Fig. 1(a)

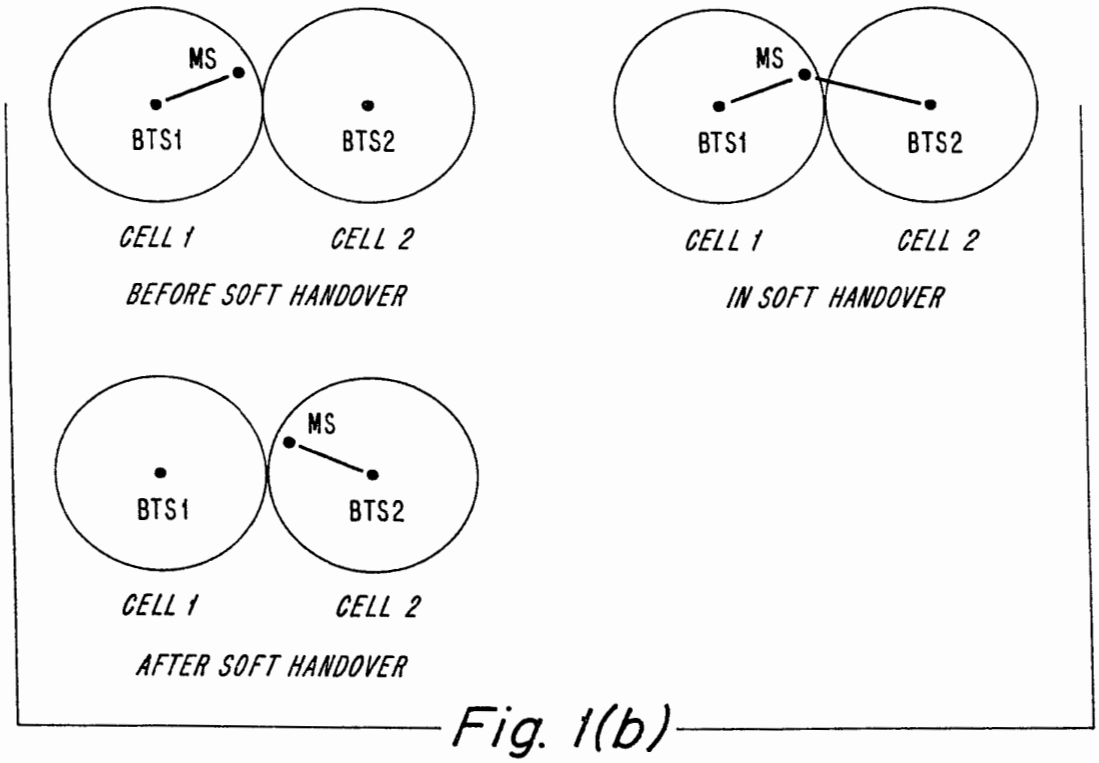


Fig. 1(b)

Exhibit 1002
Page 0319 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

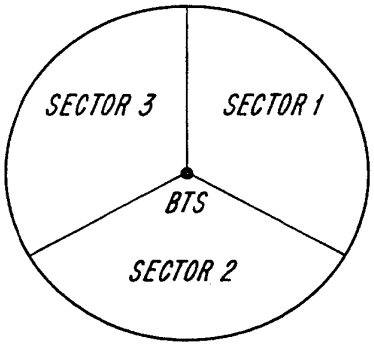


Fig. 2

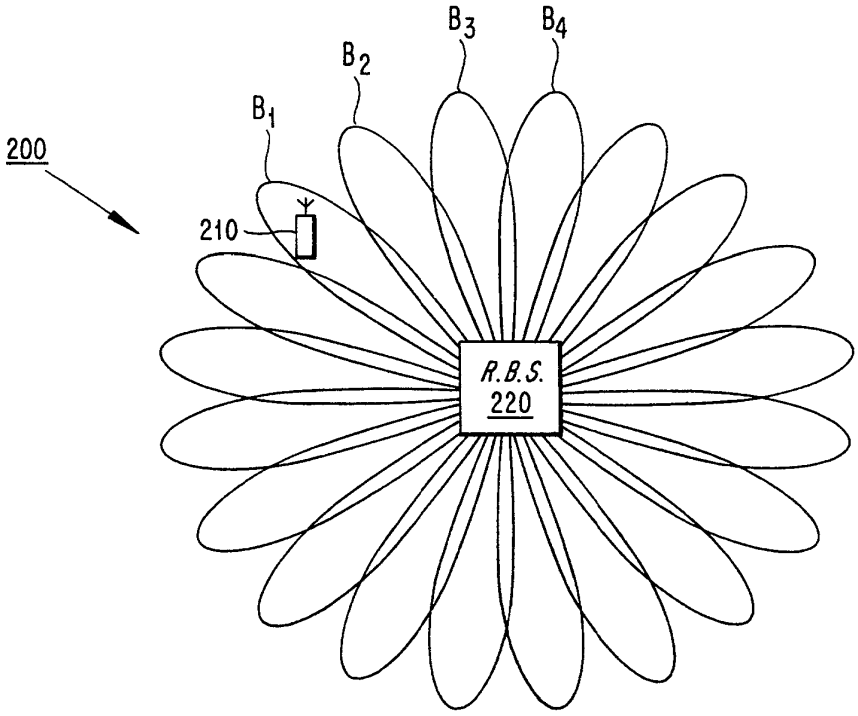


Fig. 3

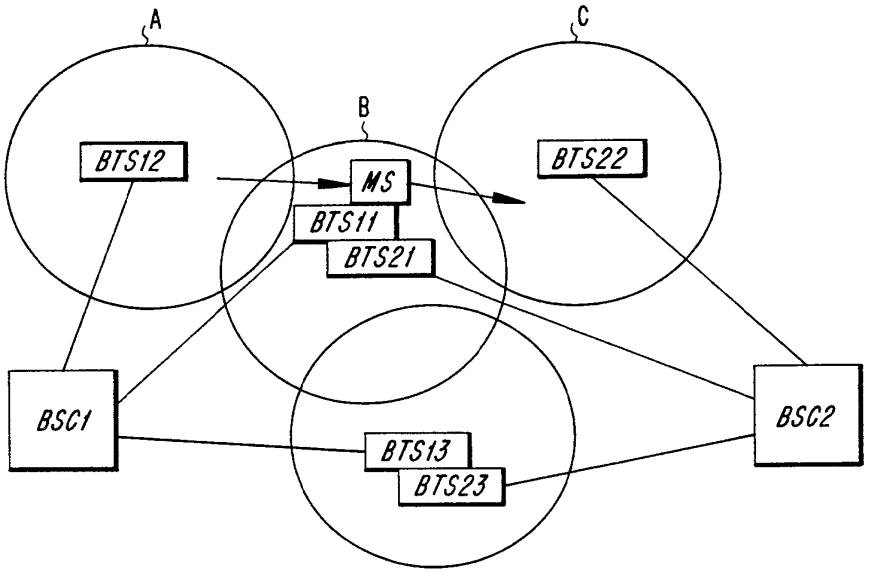


Fig. 4
(PRIOR ART)

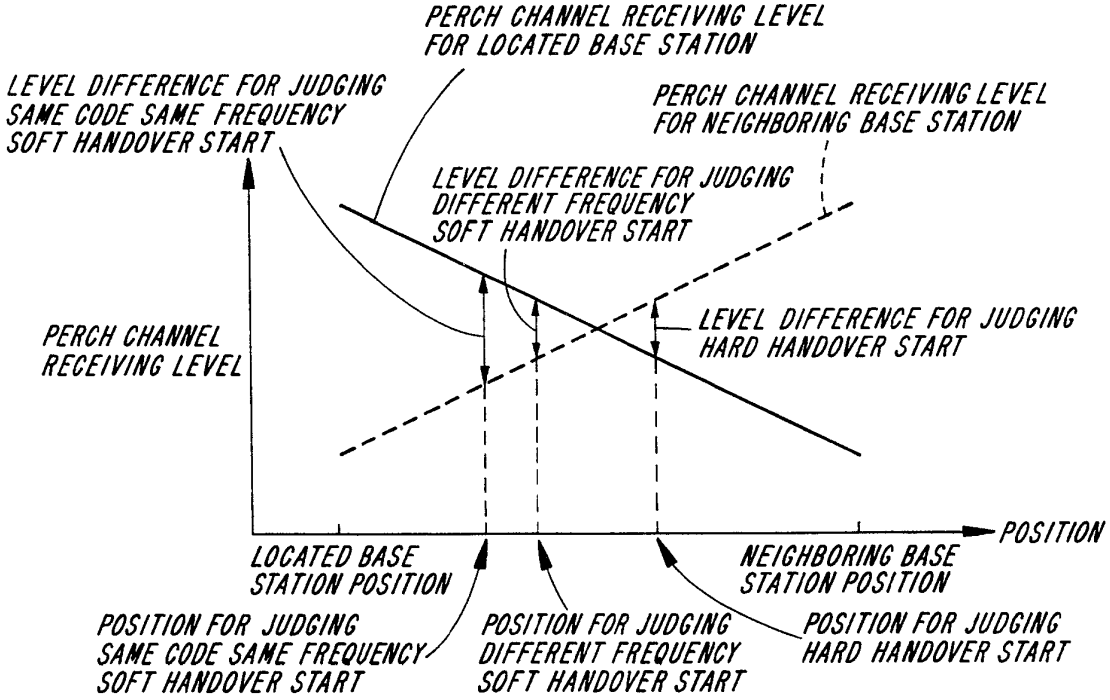


Fig. 5
(PRIOR ART)

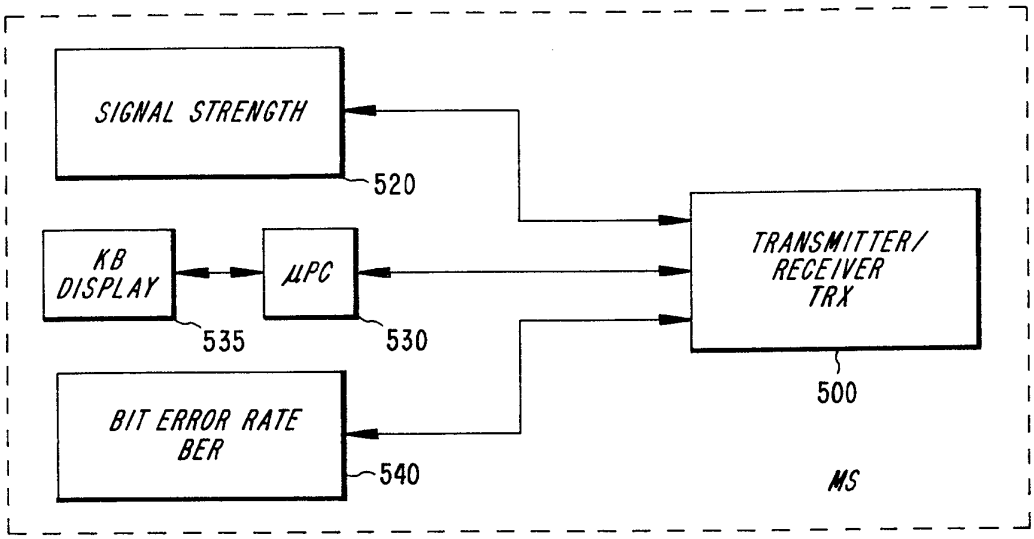

SIGNAL STRENGTH
520
KB DISPLAY
535
µPC
530
TRANSMITTER/ RECEIVER TRX
500
BIT ERROR RATE BER
540
MS

Fig. 6

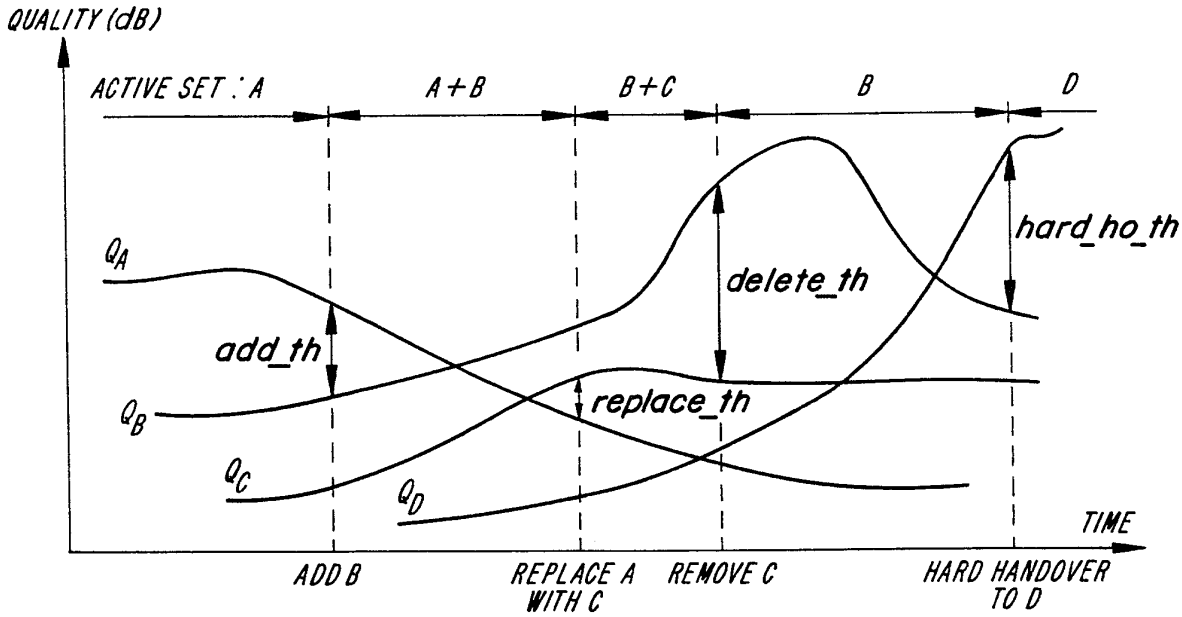

QUALITY (dB)
ACTIVE SET : A
A+B
B+C
B
D
Q_A
Q_B
Q_C
Q_D
add_th
delete_th
replace_th
hard_ho_th
TIME
ADD B
REPLACE A WITH C
REMOVE C
HARD HANDOVER TO D

Fig. 7

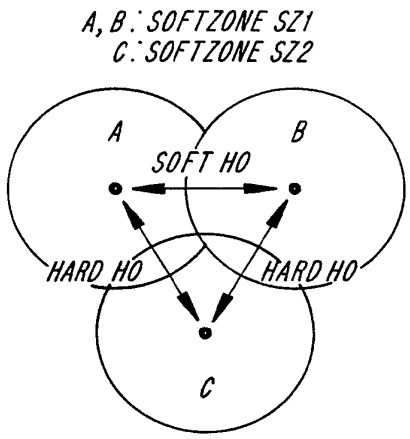

A, B: SOFTZONE SZ1
C: SOFTZONE SZ2
A
B
SOFT HO
HARD HO
HARD HO
C

Fig. 8

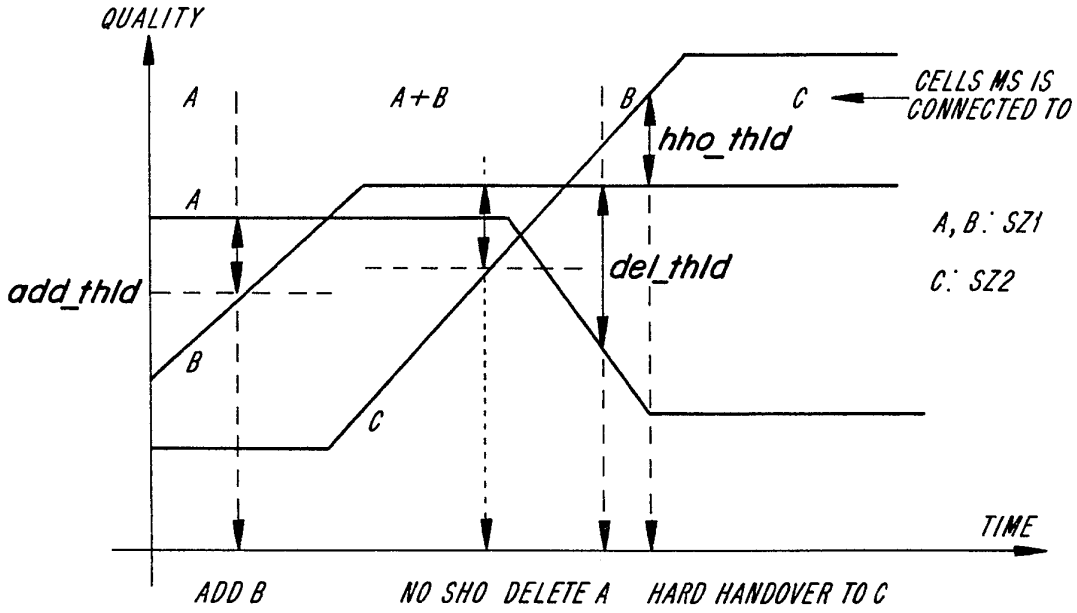

QUALITY
A
A+B
B
C
CELLS MS IS CONNECTED TO
hho_thld
A
A, B: SZ1
C: SZ2
add_thld
del_thld
B
C
TIME
ADD B
NO SHO
DELETE A
HARD HANDOVER TO C

Fig. 9

INTERNATIONAL SEARCH REPORT

Inte[illegible]nal Application No
PCT/EP 99/10083

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 31078 A (QUALCOMM INC) 3 October 1996 (1996-10-03)	1-7, 9-11,13, 14,16-18
A	page 2, line 10 - line 17 page 6, line 32 - line 34 page 7, line 30 - line 37 page 9, line 29 - line 38 page 14, line 25 - line 33	8,12,15

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

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 May 2000	07/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Janyszek, J-M

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IPR2024-00148

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/EP 99/10083

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9631078 A	03-10-1996	US 5594718 A	14-01-1997
		AU 697734 B	15-10-1998
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		CA 2216635 A	03-10-1996
		EP 0818117 A	14-01-1998

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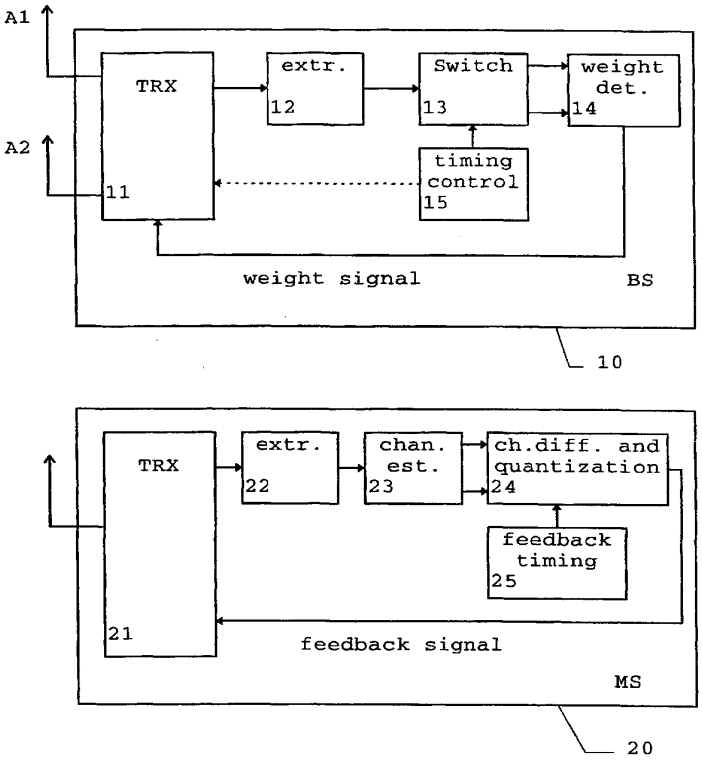
(74) Agents: **PELLMANN, Hans-Bernd** et al.; Tiedtke-Bühling-Kinne, Bavariaring 4, D-80336 München (DE).

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[Continued on next page]

(54) Title: TRANSMIT DIVERSITY METHOD AND SYSTEM



(57) Abstract: The invention relates to a transmit diversity method for a wireless communication system comprising a transmitting element and at least one receiver, wherein a transmission signal is transmitted from the transmitting element to the at least one receiver in accordance with a weight information determined in response to a feedback information. The feedback information is derived from the response at the at least one receiver to the transmission signal, and is fed back using multiplexed feedback signals. Multiple feedback signal quantization constellations and/or constellation specific feedback subchannels can be used for channel probing, such that the total feedback resolution and robustness can be enhanced, while maintaining low signaling capacity of the feedback channel.

WO 00/72464 A1

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

Transmit diversity method and system

FIELD OF THE INVENTION

The present invention relates to a transmit diversity method and system for a wireless communication system, such as the Universal Mobile Telecommunications System (UMTS) comprising a transmitting element and at least one receiver.

BACKGROUND OF THE INVENTION

Wideband Code Division Multiple Access (WCDMA) has been chosen as the radio technology for the paired bands of the UMTS. Consequently, WCDMA is the common radio technology standard for third-generation wide-area mobile communications. WCDMA has been designed for high-speed data services and, more particularly, Internet-based packet-data offering up to 2Mbps in indoor environments and over 384 kbps for wide-area.

The WCDMA concept is based on a new channel structure for all layers built on technologies such as packet-data channels and service multiplexing. The new concept also includes pilot symbols and a time-slotted structure which has led to the provision of adaptive antenna arrays which direct antenna beams at users to provide maximum range and minimum interference. This is also crucial when implementing wideband technology where limited radio spectrum is available.

The uplink capacity of the proposed WCDMA systems can be enhanced by various techniques including multi-antenna reception and multi-user detection or interference cancellation. Techniques that increase the downlink

capacity have not been developed with the same intensity. However, the capacity demand imposed by the projected data services (e.g. Internet) burdens more heavily the downlink channel. Hence, it is important to find techniques that improve the capacity of the downlink channel.

Bearing in mind the strict complexity requirements of terminals, and the characteristics of the downlink channel, the provision of multiple receive antennas is not a desired solution to the downlink capacity problem. Therefore, alternative solutions have been proposed suggesting that multiple antennas or transmit diversity at the base station will increase downlink capacity with only minor increase of complexity in terminal implementation.

According to the WCDMA system, a transmit diversity concept is under consideration which is mainly focused on the closed-loop (feedback) mode.

Fig. 1 shows an example of such a feedback mode for a downlink transmission between a base station (BS) 10 and a mobile terminal or mobile station (MS) 20. In particular, the BS 10 comprises two antennas A1 and A2, and the MS 20 is arranged to estimate the channel on the basis of two transmission signals received from the two antennas A1 and A2. Then, the MS 20 feeds back the discretized channel estimate to the BS 10. Naturally, it is desired to develope a robust and low-delay feedback signaling concept.

In WCDMA, three modes are suggested for the closed-loop concept which is optimized for two antennas. In the feedback (FB) mode 1 (also referred to as Selective Transmit Diversity (STD)), one bit per time slot is used to signal the "best" antenna from each terminal. The remaining closed-loop FB modes 2 and 3 provide a slower feedback

link, where feedback weights used for controlling the antennas A1 and A2 are modified after two or four 0.625 ms slots, respectively. In this case, the antennas A1 and A2 are co-phased so that transmitted signals sum up coherently in the MS 20, to thereby provide the best performance with low mobility "low multipath" environments.

Fig. 2 shows a table indicating characteristic parameters of the above FB modes 1 to 3. In particular, N_{FB} designates the number of feedback bits per time slot, N_W the number of bits per feedback signaling word, Na the number of feedback bits for controlling an amplification or power at the antennas A1 and A2, and Np the number of feedback bits for controlling a phase difference between the antennas A1 and A2. As can be gathered from the table of Fig. 2, one bit is fed back per time slot in each of the FB modes 1 to 3.

In the FB mode 1 (i.e. STD), the bit length of the feedback signaling word is one bit, which leads to an update rate of 1600/s (i.e. an update is performed at the BS 10 in every time slot). The feedback bit rate is 1600 bps and the feedback signaling word is used for controlling the power supplied to the antennas A1 and A2.

In the FB mode 2, the feedback signaling word comprises two bits, which leads to an update rate of 800/s, since an update is performed after both feedback bits have been received, i.e. after two time slots. The feedback signaling word is only used for controlling the phase difference between the two antennas A1 and A2.

In the FB mode 3, the bit length of the feedback signaling word is four, such that an update rate of 400/s is obtained, i.e. an update is performed every four time slots. In particular, one bit of the feedback signaling

word is used for controlling the amplification (power) at the antennas A1 and A2, and three bits are used for controlling their phase difference.

Fig. 3A shows a table indicating the feedback power control performed in the FB mode 1 or STD. Here, the MS 20 has to estimate the antenna with the smallest path loss. To this effect, the MS 20 estimates the channel power of all "competing antennas", and determines the one with the highest power. The required channel estimates are obtained e.g. from a common pilot channel transmitted with a known power from each antenna. The table in Fig. 3A shows the relationship between the feedback value and the power P_{A1} supplied to the antenna A1 and the power P_{A2} supplied to the antenna A2. Accordingly, one of the two antennas A1 and A2 is selected at the BS 10 in response to the feedback signaling value.

It is to be noted that the FB mode 1 may be implemented in an analog manner in the beam domain. In this case, the MS 20 signals to the BS 10 whether to rotate channel symbols transmitted from the antenna A2 by 180°. In this case, the BS 10 transmits simultaneously from both antennas A1 and A2. Thus, the phase difference between the antennas A1 and A2 is switched between 0° and 180° in response to the feedback value.

The other FB modes 2 and 3 relate to a feedback concept referred to as Transmission Antenna Array (TxAA), in which the MS 20 transmits estimated and quantized channel parameters to the BS 10 which then weights the transmitted signals accordingly.

Fig. 3B shows the feedback control performed in the FB mode 2. In the FB mode 2, only a phase weight feedback value

comprising two bits is fed back to the BS 10. The phase difference indicated in the table of Fig. 3B defines the phase difference (in degree) between the antennas A1 and A2, which is to be established by the BS 10 in order to obtain an optimum coherence at the MS 20.

Fig. 3C shows the feedback control of the FB mode 3, wherein one bit, i.e. amplification bit, of the feedback signaling word is used for controlling the power of the antennas A1 and A2, and the other three bits, i.e. phase bits, are used for controlling the phase difference between the antennas A1 and A2. The left-hand table indicates the power control based on the amplification bit, wherein the power P_{A1} and P_{A2} supplied to the antennas A1 and A2, respectively, is switched between 20% and 80% of a predetermined value. The right-hand table shows the feedback control based on the three phase bits, wherein the phase difference can be quantified into eight different phase difference values to be established by the BS 10 in order to obtain an optimum coherence in the MS 20.

As regards the table of Fig. 2, it is to be noted that an equal power is applied to the antennas A1 and A2 in each case where Na = 0. Furthermore, the antennas A1 and A2 are uniquely defined by their respective pilot codes of the CCPCH (Common Control Physical Channel) of the UMTS. The derived amplitude and phase applied to the antennas A1 and A2 is called a weight and the set of weights is grouped into a weight vector. Specifically, the weight vector for the present case of two antennas is given by

$$\underline{w} = \left[\frac{\sqrt{P_{A1}}}{\sqrt{P_{A2}} \cdot \exp(j\pi\Delta\varphi / 180)} \right]$$

wherein $\Delta\varphi$ denotes the phase difference (phase weight) fed back to the BS 10. In case the dimension of $\underline{w}$ becomes larger than two, more than two antennas, i.e. an antenna array, are required, wherein a directional antenna is achieved by using relative phases between antennas. The estimated phase of the feedback signal in the complex plane is then used for controlling the transmit direction.

Hence, the current WCDMA transmit diversity feedback concept uses a 2, 4 or 8 phase constellation to signal the channel difference to the BS 10. However, the higher channel resolution provided by a higher constellation order is obtained at the expense of feedback signaling capacity. Thus, the resolution of the feedback signaling is limited by the feedback signaling capacity. Furthermore, the current concept imposes a delay of one or more slots in executing the weight change and this restricts applicability only to very slow fading channels.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method and system for transmit diversity or transmit beamforming, by means of which the resolution of the feedback signaling can be increased without increasing the feedback signaling capacity.

This object is achieved by a transmit diversity method for a wireless communication system comprising a transmitting element and at least one receiver, said method comprising the steps of:
transmitting from said transmitting element to said at least one receiver a transmission signal in accordance with a weight information determined in response to a feedback information;

deriving said feedback information from the response at said at least one receiver to said transmission signal;
feeding back said feedback information using multiplexed feedback signals.

Additionally, the above object is achieved by a transmit diversity system for a wireless communication system, comprising:
transmitting means for transmitting a transmission signal from a transmitting element in accordance with a weight information determined in response to a feedback information; and
at least one receiver for receiving said transmission signal and deriving said feedback information from the response to said transmission signal;
wherein said at least one receiver comprises a feedback means for feeding back said feedback information using multiplexed feedback signals.

Furthermore, the above object is achieved by a transmitter for a wireless communication system, comprising:
extracting means for extracting a feedback information from a received signal;
transmitting means for transmitting a transmission signal from a transmitting element in accordance with a weight information;
determining means for determining the weight information in response to the extracted feedback information; and
control means for controlling the determining means so as to determine said weight information in accordance with multiplexed feedback signals used for feeding back said feedback information.

Moreover, the above object is achieved by a receiver for a wireless communication system, comprising:

receiving means for receiving a transmission signal;
deriving means for deriving a feedback information from the response to said transmission signal; and
feedback means for feeding back said feedback information using multiplexed feedback signals.

Accordingly, the transmit resolution can be enhanced by maintaining the feedback channel resolution and capacity signaled from the receiver and performing a suitable feedback filtering at the transmitter in accordance with the time-varying feedback signal constellation. Thereby, the effective resolution of the total feedback signaling can be improved while maintaining the signaling channel capacity, since the feedback information can be divided and spread over different sets of time slots in accordance with the time-varying signal constellation, or by using multiple different constellations. The filtering is applied to at least two subchannels. The transmitting signal may comprise a probing signal used for channel measurements and channel quantization and an information transmitted via the dedicated channel on the basis of the transmit weights.

According to the invention, multiplexed feedback signals can be used for representing the quantized state of the channel. Thereby, the type, coding, partitioning or allocation of the feedback signals may differ in different multiplex subchannels defined by a time division, frequency division, or code division multiplexing scheme.

Thus, the weights applied to the antennas A1 and A2 can be demultiplexed from the feedback channel and need not be identical with the feedback signaling of the current time slot received from the receiver. In particular, a multiplex timing can be arranged such that the current FB modes still can be established. Each subchannel may independently

define a basic resolution, and the subchannels may jointly define an increased resolution. According to the invention, at least two feedback subchannels are used. The multiplexed feedback signals are demultiplexed at the transmitting element and then filtered in order to obtain the desired transmit weights. Thus, a flexible feedback concept is achieved, in which the transmit weights are derived from the feedback signals but need not match them exactly.

Furthermore, a higher transmit weight resolution and robustness can be achieved e.g. by multiplexing different feedback signals which are to be combined in a suitable way, e.g. by a Finite Impulse Response (FIR) filtering or an Infinite Impulse Response (IIR) filtering, at the transmitter. The filtering can also take into account the reliability of the received feedback signals. Then, the filter can determine the weights based on a higher weighting of the reliable feedback signals. Therefore, the present FB mode 3 can be achieved, since it can be established on the basis of e.g. the present FB mode 2 by multiplexing two different feedback signals and filtering them suitably. In this case, the feedback signaling and the channel estimation can be maintained, while slightly changing the feedback signal determination. However, no changes are required to the common channels.

The length of the filter impulse response should be matched to the channel characteristics (e.g. Doppler spread) in the sense that longer filters can be used when channel changes are slow. The type of filter can be determined from the received signal or it can be negotiated between the transmitter and the receiver. Furthermore, the demultiplexing and subsequent filtering can be performed on the feedback signal or on the transmit weights to which the feedback signals correspond, or both. In particular, gain

and phase information can be filtered separately or jointly. The filter can operate as a predictor, so that transmit weights can be predicted based on the available smoothed information until the command is transmitted, current weights and/or previous weights and/or received feedback commands. In addition, the filtering can be linear or non-linear. Furthermore, a robust filtering, e.g. using a median filtering, can be applied, which is preferred, since feedback errors may cause "outliers" weights, i.e. erroneous weights due to a wrong index rather than an estimation error in determining the index/quantization.

Hence, the channel is quantized to a plurality of feedback signal quantization constellations, and each quantized value is transmitted via different multiplexed feedback subchannels. Thereby, a user may use different channel quantization constellations at different quantization intervals which may possibly overlap. The different quantization constellations may be independent, e.g. suitable rotations of each other, or may be formed in a dependent or hierarchical manner by a set partitioning, wherein the dependent constellations are jointly used to define the feedback signal with increasing accuracy (e.g. the first two bits transmitted in a first subchannel may designate a weight quadrant, and the third bit transmitted in a second subchannel may specify one of two weight points within the weight quadrant). Furthermore, different quantization constellations can be provided for different users.

Preferably, the multiplexed feedback signals may comprise a first feedback signal having a first constellation and a second feedback signal having a second constellation. The first and second feedback signals may be transmitted in different time slots and/or by using different codes.

The first feedback signal may define a first phase weight determined on the basis of a channel estimate, and the second feedback signal may define a second phase weight determined on the basis of a rotated constellation. In particular, the second phase weight may be based on a rotated channel estimate of the same constellation, or on a rotated channel estimate of another constellation, or on the basis of a quantization of the channel estimate to the second (rotated) constellation. The first and second feedback signals may be fed back in successive time slots. Moreover, the first feedback signal may define a real part of the weight information, and the second feedback signal may define an imaginary part of the weight information.

Alternatively, the first feedback signal may define a first feedback information to be used for updating a first beam of the transmitting element, and the second feedback signal may define a second feedback information to be used for updating a second beam of the transmitting element. In this case, the first feedback signal can be fed back during odd time slots and the second feedback signal during even time slots. The odd and even time slots may be used for controlling the same antenna (when the channel difference is used) or a first antenna and a second antenna, respectively, in different time instants. In the latter case, the first and second antennas are alternately used as a reference. Controlling both antennas, e.g. by transmitting control commands in an alternate manner to the transmitting element, is preferred in cases where the effective transmitting power of the controlled antenna can be reduced by the filtering. When both antennas are generally controlled, the effective transmitting power is distribuited evenly and this simplifies the designs of a provided power amplifier. Another possible solution is to

use transmit diversity techniques where different users may control different antennas.

Furthermore, the first feedback signal may define a quadrant in a 4-PSK constellation, and the second feedback signal may define a constellation within said quadrant defined by said first feedback signal. The second feedback signal may define a differential change, a Gray-encoded sub-quadrant, or a combination thereof.

The multiplexed feedback signals may be transmitted by at least two users having different feedback signal constellations. Thereby, a flexible and readily adaptable transmit diversity system can be achieved. The at least two users may comprise a first set of users controlling weights at a first antenna of the transmitting element, and a second set of users controlling weights at a second antenna of said transmitting element. In this case, a useful balancing of the transmitting power between the first and second antennas can be provided, since some filtering or demultiplexing techniques may result in lower transmission power requirements at the controlled antenna.

Furthermore, the control means provided in the transmitter may comprise a switching means for alternately switching the first feedback signal and the second feedback signal to the determining means. The determining means may be arranged to derive the weight information from the first and second feedback signal.

Moreover, the control means may be arranged to control the transmitting means so as to alternately update a first beam of the transmitting element by using a first weight information determined on the basis of the first feedback signal, and a second beam of the transmitting element by

using a second weight information determined on the basis of the second feedback signal.

The transmitting element may be an antenna array. In this case, the feedback information can be used for controlling the direction of transmission of the array antenna. The transmission direction may be derived from at least one of the multiplexed feedback signals. Furthermore, the transmission direction may be derived from a phase estimate obtained from at least one feedback signal.

Furthermore, the deriving means of the receiver may comprise extracting means for extracting a probing signal transmitted with a known power, channel estimation means for performing a channel estimation on the basis of the extracted probing signal, and generating means for generating the multiplexed feedback signals on the basis of the channel estimation. The generating means may be arranged to generate the first and second feedback signal, wherein the feedback means may be arranged to feed back the first and second feedback signals as the multiplexed feedback signals. The first and second feedback signals may be fed back alternately by the feedback means, wherein a quantization of the feedback information is based on the latest channel estimate and an available one of the first and second constellation.

Moreover, the generating means may be arranged to generate the first feedback signal based on the channel estimate and the second feedback signal based on a rotation of the channel estimate by a predetermined angle. This can be implemented also by quantizing the same channel estimate to two constellations where, in this case, the second one is a rotated copy of the first one.

Alternatively, the generating means may be arranged to generate the first feedback signal based on a real part of the feedback information, and the second feedback signal based on an imaginary part of the feedback information.

As a further alternative, extracting means may be arranged to alternately extract a probing signal corresponding to a first beam and a probing signal corresponding to a second beam, and the generating means may be arranged to alternately generate the first feedback signal based on a channel estimate for the first beam, and the second feedback signal based on a channel estimate for the second beam.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the present invention will be described in greater detail on the basis of a preferred embodiment with reference to the accompanying drawings, in which:

Fig. 1 shows a principle block diagram of a closed-loop transmit diversity system comprising a base station and a mobile station,

Fig. 2 shows a table indicating characteristic parameters of the FB modes 1 to 3,

Figs. 3A to 3C show tables indicating characteristic parameters relating to the feedback control of the FB modes 1, 2 and 3, respectively,

Fig. 4 shows tables indicating characteristic parameters of the transmit diversity concept according to a first example of the preferred embodiment of the present invention,

Fig. 5 shows a principle block diagram of a base station and a mobile station according to the preferred embodiment of the present invention,

Fig. 6 shows a diagram of complex weight parameters according to the first example of the preferred embodiment,

Fig. 7 shows tables indicating characteristic parameters of the transmit diversity concept according to a second example of the preferred embodiment,

Fig. 8 shows a diagram of complex weight parameters according to the second example of the preferred embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following, the preferred embodiment of the method and system according to the present invention will be described on the basis of a connection between the BS 10 and the MS 20 of the UMTS, as shown in Fig. 1.

According to the preferred embodiment of the present invention, the feedback information is transmitted from the MS 20 to the BS 10 using a feedback concept based on time multiplexing. This means that the constellation of the feedback signals is changed and signaled to the BS 10 in different time slots. However, any other multiplex scheme such as frequency multiplexing or code multiplexing may be used as well in the feedback channel.

In particular, the feedback signal constellation may be changed with respect to the coding, type, partitioning or allocation of the feedback information. Thus, with the present time multiplexed feedback subchannels, the

signaling capacity required in the feedback channel can be maintained, while the feedback information as such is spread over the time axes, i.e. transmitted in two or more (sets of) time slots which may be allocated according to a predefined rule, known to both the BS 10 and the MS 20.

In the following, three examples of the preferred embodiment are described with reference to Figs. 4 to 8, wherein the feedback information is spread over successive time slots.

Fig. 4 shows two tables indicating a refined mode 2 concept. According to this example, two reference channels, i.e. the channel estimate and a rotated channel estimate, are used in the MS 20 in order to derive the feedback information. Thereby, an 8-phase signaling can be implemented by using the mode 2 feedback signaling, i.e. two feedback bits. In particular, a first feedback information relating to the channel estimate is transmitted in two successive time slots, and a second feedback information relating to the rotated channel estimate is transmitted in the following two successive time slots. Thus, the whole feedback information is transmitted in four successive time slots. Accordingly, the phase difference relating to the channel estimate is transmitted in slots S1 = {1, 2, 5, 6, 9, 10, ...} defining a first feedback subchannel, and the phase difference quantized to the rotated constellation is transmitted in slots S2 = {3, 4, 7, 8, 11, 12, ...} defining a second feedback subchannel, wherein the rotated channel estimate relates to a 45° rotated channel estimate, assuming a 4-phase constellation is used.

Thus, the effective phase differences for the phase bits transmitted in the slots S1 is indicated by the upper table

of Fig. 4, and the phase difference defined by the phase bits transmitted in the slots S2 is indicated in the lower table of Fig. 4. Accordingly, the phase difference can be quantized into 8 values while using only two bits of feedback information at a time, as in the FB mode 2. The resulting feedback resolution obtained by a filtering or demultiplexing operation at the BS 10 corresponds to the FB mode 3, with the exception that a constant power is used for each of the antennas A1 and A2. Thus, the feedback resolution can be increased while maintaining the feedback signaling capacity of the FB mode 2.

Fig. 5 shows a principle block diagram of the MS 20 and the BS 10 according to the preferred embodiment of the present invention.

According to the Fig. 5, the BS 10 comprises a transceiver (TRX) 11 arranged for feeding the two antennas A1 and A2 and connected to an extracting unit 12 provided for extracting the feedback information transmitted from the MS 20 via the corresponding feedback channel(s). The extracted feedback information is supplied to a switch 13 which is controlled by a timing control unit 15 in accordance with the timing scheme underlying the multiplex scheme of the feedback signal constellation used by the MS 20. Thereby, a demultiplexing or filtering function for extracting the feedback information is provided. In the present example, the switch 13 is controlled by the timing control unit 15 so as to supply the feedback information relating to the slots S1 to one of its output terminals and the feedback information transmitted in the slots S2 to the other one of its output terminals.

It is noted that the above demultiplexing or filtering function may alternatively be achieved by providing filter

and demodulating unit or a decoding unit, in case a frequency or, respectively, code multiplex scheme is used.

The output terminals of the switch 13 are connected to respective input terminals of a weight determination unit 14 which determines a weight signal on the basis of the tables shown in Fig. 4. In particular, the weight determination unit 14 determines the required phase difference between the antennas A1 and A2 by averaging the feedback information of the two slot types S1 and S2 received via the respective input terminals. However, any other combination of the two feedback informations may be provided.

The determined weight signal, e.g. phase difference, is supplied to the TRX 11 which performs a corresponding phase control of the antennas A1 and A2 to thereby establish the required phase difference leading to an optimum coherence of the transmission signals in the MS 20.

The MS 20 comprises a transceiver (TRX) 21 for receiving the transmission signals from the antennas A1 and A2 of the BS 10 via an antenna connected thereto. Furthermore, the TRX 21 is connected to an extracting unit 22 provided for extracting the pilot channel signal and supplying the extracted pilot channel signal to a channel estimation unit 23 which calculates the required channel estimates. In particular, the channel estimation unit 23 is arranged to calculate the channel estimate and the rotated channel estimate both corresponding to the received pilot channel signal. The channel estimation unit 23 outputs the two channel estimates at respective output terminals thereof which are connected to corresponding input terminals of a channel difference deriving and quantization unit 24 for deriving a phase difference based on the channel estimate

and the rotated channel estimate obtained from the channel estimation unit 23 and performing a corresponding quantization. As already mentioned, the rotated channel estimate is obtained by rotating the channel estimate by an angle of 45°.

Furthermore, a feedback timing unit 25 is provided which controls the phase difference deriving and quantization unit 24 so as to output one of the phase differences derived from the channel estimate and the rotated channel estimate in accordance with the predetermined feedback timing. In the present case, the phase difference corresponding to the channel estimate, i.e. conventional FB mode 2, is outputted during the time slots S1, and the phase difference corresponding to the rotated channel estimate is outputted during the time slots S2. The phase differences are supplied as a multiplexed feedback signal to the TRX 21 in order to be transmitted via the corresponding feedback channel to the BS 10.

It is to be noted that the transmit diversity concept according to the first example of the preferred embodiment is compatible with the known FB mode 2, in case the BS 10 assumes each feedback information as derived only from the channel estimate which has not been rotated, i.e. the known BS 10 controlled according to the FB mode 2.

In case a frequency or code multiplex feedback scheme is used, the feedback timing unit 25 may be replaced by a modulating unit or, respectively, a coding unit.

Fig. 6 shows a diagram of the complex weights or end points of the weight vectors used as the feedback information in the first example of the preferred embodiment. In particular, the circles in the diagram of Fig. 6 indicate

the weights obtained in the slots S1, i.e. the weight of the conventional FB mode 2, and the crosses indicate the additional weights obtained in the time slots S2. Thus, a phase difference quantization as provided in the FB mode 3 can be obtained without increasing the feedback channel signaling capacity.

Fig. 7 shows a second example of the preferred embodiment, wherein the feedback resolution of the FB mode 2 is obtained while using only a single feedback bit. Thus, this example relates to a refined FB mode 1. In particular, the MS 20 performs a continuous measurement or channel estimation, e.g. on the basis of a sliding window, and the phase difference deriving unit 24 quantizes the phase difference in accordance with the FB mode 2 phase constellation. In the present case, the feedback bits for the real and imaginary part of the complex weight, determined by the phase difference, are transmitted in successive slots, e.g. the real part bit in the odd slots used as a first feedback subchannel and the imaginary part bit in the even slots used as a second subchannel. A corresponding control is performed by the feedback timing unit 25 of the MS 20.

Correspondingly, the timing control unit 15 of the BS 10 controls the switch 13 so as to supply the successive real and imaginary part of the feedback information to respective input terminals of the weight determination unit 14 which determines the corresponding weight signal supplied to the TRX 11 in order to establish the required phase difference.

In case the BS 10 is not controlled in accordance with this time control scheme, i.e. the current FB mode 1 is used, the conventional control is obtained. If the new timing

control is provided, the weight determination unit 14 averages over two slots and changes the weight signal correspondingly.

Thus, an FB mode 2 resolution is obtained with an FB mode 1 feedback capacity. Moreover, an antenna verification can be incorporated separately for the successive bits, which corresponds to the STD concept.

Thus, as can be gathered from Fig. 7, the feedback information provided in the odd slots S_{odd} indicates a phase difference of 0° or 180°, and the feedback information provided in the even slots S_{even} indicates a phase difference of -90° or +90°.

Fig. 8 shows a diagram of the complex weights which can be fed back in the second example of the preferred embodiment, wherein the crosses indicate the weight information transmitted in the slots S_{even} and the circles indicate the weights transmitted in the slots S_{odd}.

According to a third example of the preferred embodiment, a beam diversity concept can be adopted by the feedback scheme in order to provide an enhanced robustness against erroneous signaling. In the third example, it is assumed that a space time coding (STTD) is used at the MS 20, wherein encoded channel symbols are divided into two-element blocks and transmitted as b[2n], b[2n+1] and -b*[2n+1], b*[2n] from the antennas A1 and A2, respectively, during time instants 2n and 2n+1 using the same spreading code. This simple symbol level orthogonal coding scheme doubles the time diversity, wherein the receiver uses a simple linear decoding to detect the transmitted symbols. In the present case, two weight vectors are used, which are a function of the received signaling. In case of the FB

mode 1 feedback signaling, the following processing is performed.

Two beams B1 and B2 are transmitted by the antennas A1 and A2 of the BS 10 in each time slot. The update rate of the beams B1 and B2 is 800 Hz, i.e. the TRX 11 is updated every other time slot. In particular, the beam B1 is modified during odd slots and the beam B2 during even slots, where each weight modification is effective over two time slots, i.e. a sliding window weight change is provided. Hence, the extracting unit 22 of the MS 20 is arranged to extract the corresponding probing or pilot signals received from the the beams B1 and B2, and to successively supply them to the channel estimation unit 23. Then, the feedback timing unit 25 controls the phase difference deriving unit 24 so as to output the respective phase differences at timings corresponding to their allocated time slots.

It is to be noted that the filtering function provided by the switch unit 13 and the timing control unit 15 of the BS 10 is not required in the present case, if the TRX 11 is arranged to determine and correspondingly allocate successively received weight signals to their respective beams B1 or B2. However, if this is not the case, the timing control unit 15 controls the switch 13 so as to switch the weight signal of the beam B1 (transmitted in an odd slot) to one of its output terminals and the weight signal of the beam B2 (transmitted in an even slot) to the other output terminal and the weight determination unit 14 determines the corresponding weight signal. In addition, the timing control unit 15 is arranged to control the TRX 11 so as to allocate the received weight signal to the corresponding one of the beams B1 and B2. This control feature is indicated by the broken error shown in the block diagram of the BS 10 of Fig. 5.

It is to be noted that the above described units of the block diagram shown in Fig. 5 may as well be established as software features of a control program controlling a microprocessor such as a CPU provided in the BS 10 and the MS 20.

Furthermore, any kind of signal set partitioning (e.g. for trellis codes) may be used to improve the performance. Furthermore, the different feedback signal constellations may be dependent by using a progressive signaling. For example, a first time slot or subchannel can be used for feeding back an information indicating a quadrant in a 4-PSK constellation with higher reliability, and a subsequent second time slot or subchannel can be used for feeding back an information determining the constellation within this quadrant. The feedback information of the second subchannel may be based on a differential change, a Gray-encoded sub-quadrant, or any combination thereof. Here, the transmit weights can be changed as soon as the feedback bits specifying the quadrant have arrived at the BS 10, and the refined subquadrant can be adjusted thereafter based on the most recent channel estimate, which was not available when the quadrant index was transmitted (e.g. using Gray encoding). Thereby, additional delay caused in the current concept by waiting for the receipt of all feedback bits can be prevented. Furthermore, abrupt changes (180 degree in case of one bit feedback, 90 degrees in case of two bit feedback, and so on), as in the current concepts, which cannot be followed by the MS 20 estimating the dedicated channel parameters do not occur. Hence, applying the feedback information incrementally not only reduces delay, but also enables more efficient channel estimation and receiver performance. The feedback information may also refer to the phase difference of successive slots.

Furthermore, the present invention is not limited to two antennas A1 and A2, but can be applied to any multi-antenna transmitter in order to provide a higher resolution feedback. Moreover, as already mentioned, any kind of multiplex scheme can be used, provided the BS 10 is arranged to correspondingly filter or select the feedback information.

Furthermore, the present invention may be applied to any wireless communication system comprising a transmit diversity or transmit beamforming concept used between a transmitting element and at least one receiver. Therefore, the above description of the preferred embodiment and the accompanying drawings are only intended to illustrate the present invention. The preferred embodiment of the invention may vary within the scope of the attached claims.

In summary, the invention relates to a transmit diversity method for a wireless communication system comprising a transmitting element and at least one receiver, wherein a transmission signal is transmitted from the transmitting element to the at least one receiver in accordance with a weight information determined in response to a feedback information. The feedback information is derived from the response at the at least one receiver to the transmission signal, and is fed back using multiplexed feedback signals. Thus, multiple quantization constellations and/or constellation specific feedback subchannels can be used for channel probing, such that the total feedback resolution can be enhanced, while maintaining low signaling capacity of the feedback channel.

Claims

1. A transmit diversity method for a wireless communication system comprising a transmitting element and at least one receiver, said method comprising the steps of:

a) transmitting from said transmitting element to said at least one receiver a transmission signal in accordance with a weight information determined in response to a feedback information;

b) deriving said feedback information from the response at said at least one receiver to said transmission signal;

c) feeding back said feedback information using multiplexed feedback signals.

2. A method according to claim 1, wherein said multiplexed feedback signals comprises a first feedback signal having a first quantization constellation and a second feedback signal having a second quantization constellation.

3. A method according to claim 2, wherein said first and second feedback signals are transmitted in different time slots.

4. A method according to claim 2 or 3, wherein said first and second feedback signals are transmitted using different codes.

5. A method according to anyone of claims 2 to 4, wherein said first feedback signal defines a first weight determined on the basis of a channel estimate quantized to said first constellation, and said second feedback signal defines a second weight determined on the basis of a channel estimate quantized to said second constellation.

6. A method according to claim 5, wherein said second constellation is a rotated copy of said first constellation.

7. A method according to claim 5, wherein said second feedback signal is based on a rotated channel estimate quantized to said first constellation.

8. A method according to claims 2 or 3, wherein said first and second feedback signals are fed back in successive time slots.

9. A method according to anyone of claims 2, 3 or 8, wherein said first feedback signal defines a real part of said weight information, and said second feedback signal defines an imaginary part of said weight information.

10. A method according to anyone of claims 2, 3 or 8, wherein said first feedback signal defines a first feedback information to be used for updating a first beam of said transmitting element, and said second feedback signal defines a second feedback information to be used for updating a second beam of said transmitting element.

11. A method according to claim 9 or 10, wherein said first feedback signal is fed back during odd time slots, and said second feedback signal is fed back during even time slots.

12. A method according to anyone of claims 2, 3 or 8, wherein said first feedback signal defines a quadrant in a 4-PSK constellation, and said second feedback signal defines a constellation point within said quadrant defined by said first feedback signal.

13. A method according to claim 12, wherein said second feedback signal defines a differential change, a Gray-encoded sub-quadrant, or a combination thereof.

14. A method according to claim 1, wherein said multiplexed feedback signals are transmitted by at least two users having different signal constellations.

15. A method according to claim 14, wherein said at least two users comprise a first set of users controlling weights at a first antenna of said transmitting element, and a second set of users controlling weights at a second antenna of said transmitting element.

16. A method according to claim 1, wherein said feedback information is used for controlling a transmit weight of one of two antennas.

17. A method according to claim 1, wherein said feedback information is used for controlling transmit weights of two antennas.

18. A method according to claim 17, wherein control commands for controlling said two antennas are transmitted alternately to said transmitting element.

19. A method accoring to claim 1, wherein said transmitting element comprises an antenna array.

20. A method according to claim 19, wherein said feedback information is used for controlling the direction of transmission of said antenna array.

21. A method according to claim 20, wherein the direction of transmission is derived from at least one feedback signal.

22. A method according to claim 21, wherein the direction of transmission is derived from a phase estimate of at least one extracted feedback signal.

23. A method according to claim 1, wherein said weight information and/or a direction of transmission are determined on the basis of a feedback signal filtering operation.

24. A method according to claim 23, wherein said filtering operation comprises a robust filtering, an FIR filtering, an IIR filtering, a linear filtering, a non-linear filtering, or a smoothing and prediction.

25. A method according to anyone of the preceding claims, wherein a reliability of said multiplexed feedback signals is used for weight determination.

26. A method according to claim 23 or 24, wherein a transmission filtering is adapted to a transmission channel characteristic and changed dynamically.

27. A transmit diversity system for a wireless communication system, comprising:

a) transmitting means **(10)** for transmitting a transmission signal from a transmitting element **(A1, A2)** in accordance to with a weight information determined in response to a feedback information; and

b) at least one receiver **(20)** for receiving said transmission signal and deriving said feedback information from the response to said transmission signal;

c) wherein said at least one receiver **(20)** comprises feedback means **(24, 25)** for feeding back said feedback information using multiplexed feedback signals.

28. A system according to claim 27, wherein said feedback means **(24, 25)** is arranged to generate a first feedback signal having a first constellation and a second feedback signal having a second constellation.

29. A system according to claim 28, wherein said first feedback signal defines a first phase weight determined on the basis of a channel estimate, and said second feedback signal defines a second phase weight determined on the basis of a rotated constellation of said first feedback signal.

30. A system according to claim 28, wherein said first feedback signal defines a real part of said weight information, and said second feedback signal defines an imaginary part of said weight information.

31. A system according to claim 28, wherein said first feedback signal defines a first feedback information to be used by said transmitting means **(10)** for updating a first beam of said transmitting element **(A1, A2)**, and said second feedback signal defines a second feedback information to be used by said transmitting means **(10)** for updating a second beam of said transmitting element **(A1, A2)**.

32. A system according to claim 30 or 31, wherein said feedback means **(24, 25)** is arranged to feed back said first feedback signal during odd time slots and said second feedback signal during even time slots.

33. A transmitter for a wireless communication system, comprising:

a) extracting means **(12)** for extracting a feedback information from a received signal;

b) transmitting means **(11)** for transmitting a transmission signal from a transmitting element **(A1, A2)** in accordance with a weight information;

c) determining means **(14)** for determining said weight information in response to said extracted feedback information; and

d) control means **(13, 15)** for controlling said determining means **(14)** so as to determine said weight information in accordance with multiplexed feedback signals used for feeding back said feedback information.

34. A transmitter according to claim 33, wherein said control means **(13, 15)** comprises a switching means **(13)** for alternately switching a first feedback signal having a first constellation and a second feedback signal having a second constellation to said determining means **(14).**

35. A transmitter according to claim 34, wherein said determining means **(14)** is arranged to derive said weight information from said first and second feedback signals.

36. A transmitter according to claim 34, wherein said control means **(13, 15)** is arranged to control said transmitting means **(11)** so as to alternately update a first beam of said transmitting element **(A1, A2)** by using a first weight information determined on the basis of said first feedback signal, and a second beam of said transmitting element **(A1, A2)** by using a second weight information determined on the basis of said second feedback signal.

37. A transmitter according to anyone of claims 33 to 36, wherein said transmitting element is an antenna array **(A1, A2).**

38. A receiver for a wireless communication system, comprising:
a) receiving means **(21)** for receiving a transmission signal;
b) deriving means **(22, 23, 24)** for deriving a feedback information from the response to said transmission signal; and
c) feedback means **(24, 25)** for feeding back said feedback information using multiplexed feedback signals.

39. A receiver according to claim 38, wherein said deriving means **(22, 23, 24)** comprises extracting means **(22)** for extracting a probing signal transmitted with a known power, channel estimation means **(23)** for performing a channel estimation on the basis of said extracted probing signal, and generating means **(24)** for generating said multiplexed feedback signals on the basis of said channel estimation.

40. A receiver according to claim 39, wherein said generating means **(24)** is arranged to generate a first feedback signal having a first constellation and a second feedback signal having a second constellation, wherein said feedback means **(24, 25)** is arranged to feed back said first and second feedback signals as said multiplexed feedback signals.

41. A receiver according to claim 40, wherein said feedback means (24, 25) is arranged to alternately feed back said first and second feedback signals, wherein a quantization of the feedback information is based on the

latest channel estimate and an available one of said first and second constellation.

42. A receiver according to claim 40, wherein said generating means **(24)** is arranged to generate said first feedback signal based on said channel estimation and said second feedback signal based on a rotation of said channel estimation by a predetermined angle.

43. A receiver according into claim 40, wherein said generating means **(24)** is arranged to generate said first feedback signal based on a real part of said feedback information, and said second feedback signal based on an imaginary part of said feedback information.

44. A receiver according to claim 40, wherein said extracting means **(22)** is arranged to alternately extract a probing signal corresponding to a first beam and a probing signal corresponding to a second beam, and said generating means **(24)** is arranged to alternately generate said first feedback signal based on a channel estimate for said first beam, and said second feedback signal based on a channel estimate for said second beam.

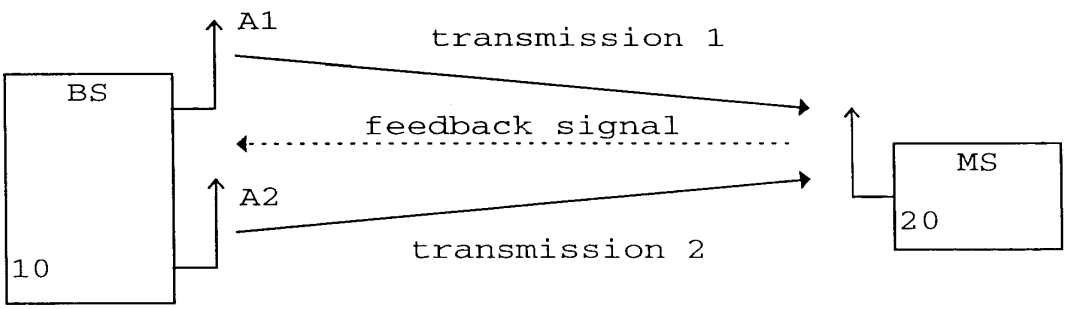


Fig. 1

FB mode	N_{FB}	N_W	update rate	feedback bit rate	Na	Np
1	1	1	1600/s	1600bps	1	0
2	1	2	800/s	1600bps	0	2
3	1	4	400/s	1600bps	1	3

Fig. 2

feedback value	P_{A1}	P_{A2}
0	0	1
1	1	0

Fig. 3A

feedback value	phase - diff.
0 0	180°
0 1	-90°
1 1	0°
1 0	90°

Fig. 3B

ampl. bit	P_{A1}	P_{A2}
0	0.2	0.8
1	0.8	0.2

phase bits	phase diff.
0 0 0	180°
0 0 1	-135°
0 1 1	-90°
0 1 0	-45°
1 1 0	0°
1 1 1	45°
1 0 1	90°
1 0 0	135°

Fig. 3C

phase bits (slots S1)	phase difference
0 0	180°
0 1	-90°
1 1	0°
1 0	90°

phase bits (slots S2)	phase difference
0 0	-135°
0 1	-45°
1 1	45°
1 0	135°

Fig. 4

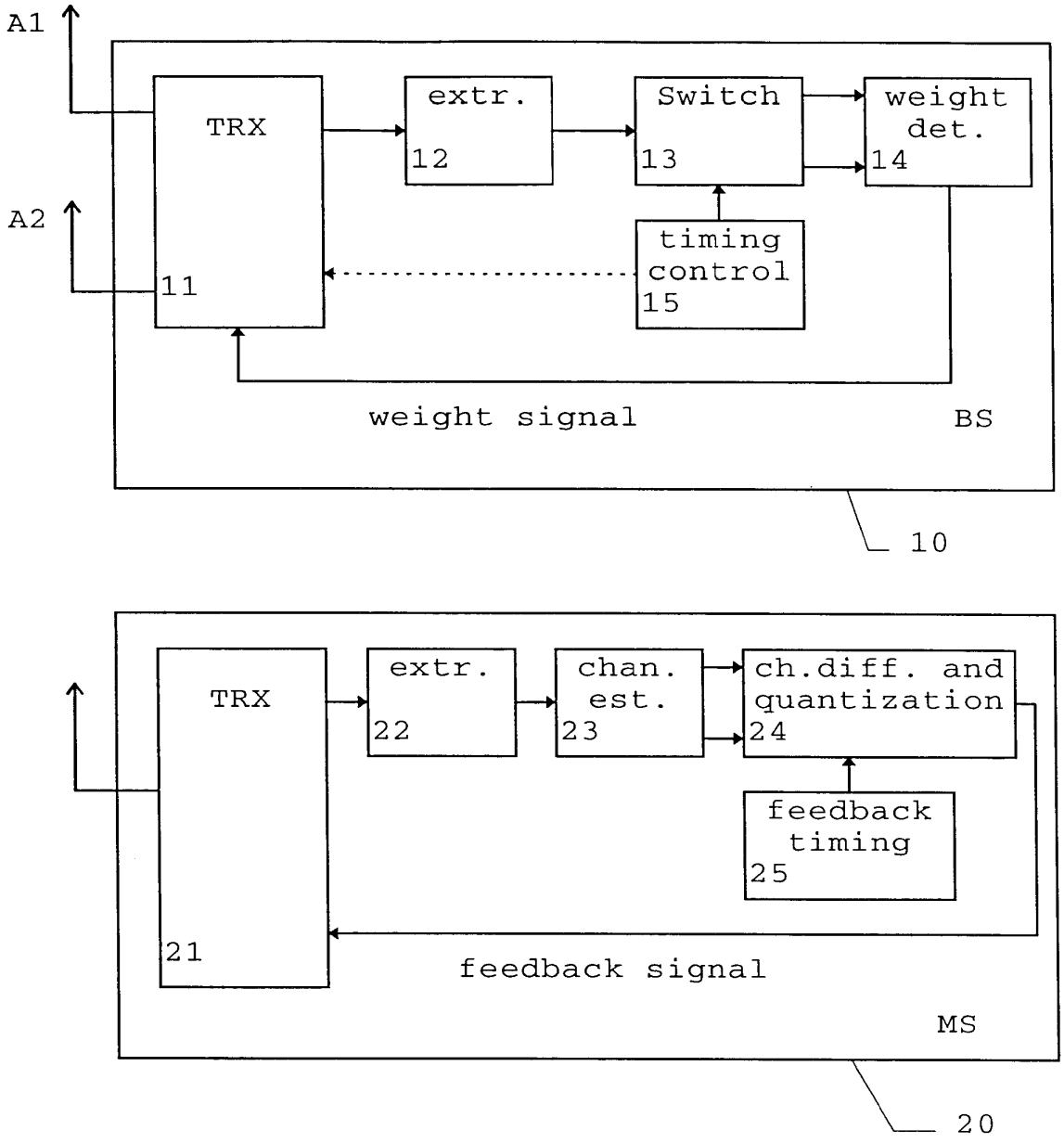

A1
A2
TRX
11
extr.
12
Switch
13
weight
det.
14
timing
control
15
weight signal
BS
10
TRX
21
extr.
22
chan.
est.
23
ch.diff. and
quantization
24
feedback
timing
25
feedback signal
MS
20

Fig. 5

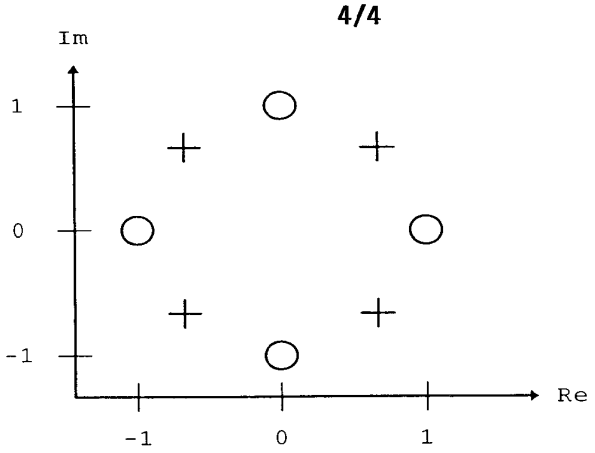


Fig. 6

phase bit (S_{odd})	phase difference
0	180°
1	0°

phase bit (S_{even})	phase difference
0	-90°
1	+90°

Fig. 7

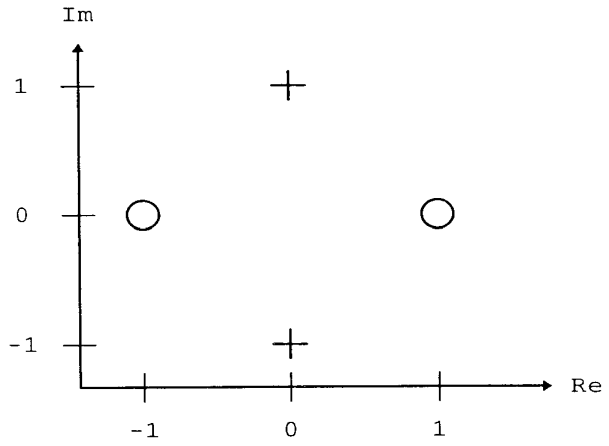


Fig. 8

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/EP 99/03440

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/06 H04L5/12 H04L1/16

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04L H04Q

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 755 127 A (NIPPON ELECTRIC CO) 22 January 1997 (1997-01-22) column 3, line 18-39 claims 1-5 figures 1,2 --- -/--	1,27,33, 38

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 January 2000	08/02/2000

Name and mailing address of the ISA	Authorized officer
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Inte onal Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document. with indication.where appropriate. of the relevant passages	Relevant to claim No.
A	H. ANDOH; M. SAWAHASHI; F. ADACHI: "Channel Estimation Using Time Multiplexed Pilot Symbols for Coherent Rake Combining for DS-CDMA Mobile Radio" PERSONAL, INDOOR AND MOBILE RADIO COMMUNICATIONS, 8TH IEEE INTL SYMPOSIUM, 'Online! vol. 3, 1 - 4 September 1997, pages 954-958, XP002128851 Retrieved from the Internet: <URL:http://iel.ihs.com> 'retrieved on 2000-01-26! page 954, column 1, paragraph 1 -page 955, column 1, paragraph 1 figures 1,2 ---	1,27,33, 38
A	GB 2 324 932 A (MOTOROLA LTD) 4 November 1998 (1998-11-04) abstract claim 1 figure 6 -----	1,27,33, 38

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Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

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Information on patent family members

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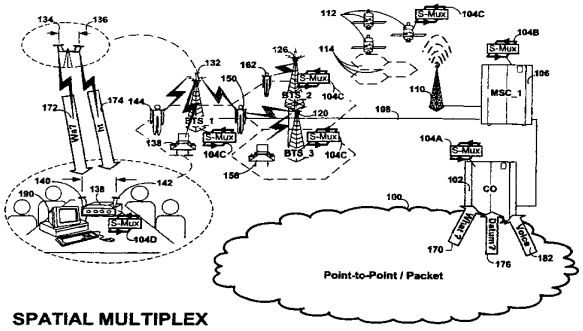
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(54) Title: SPATIAL MULTIPLEXING IN A CELLULAR NETWORK



SPATIAL MULTIPLEX

(57) Abstract: The present invention provides methods and apparatus for implementing spatial multiplexing in conjunction with the one or more multiple access protocols during the broadcast of information in a wireless network. A wireless cellular network for transmitting subscriber datastream(s) to corresponding ones among a plurality of subscriber units located within the cellular network is disclosed. The wireless cellular network includes base stations and a logic. The base stations each include spatially separate transmitters for transmitting, in response to control signals, selected substreams of each subscriber datastream on an assigned channel of a multiple access protocol. The logic assigns an available channel on which to transmit each subscriber datastream. The logic routes at least a substream of each datastream to at least a selected one of the base stations. The logic also generates control signals to configure the at least a selected one of the base stations to transmit the selected substreams to a corresponding one among the plurality of subscriber units on the assigned channel. A subscriber unit for use in a cellular system is also disclosed. The subscriber unit includes a plurality of spatially separate antennas and a transmitter for transmitting a plurality of substreams of a datastream on an assigned channel or slot of a multiple access protocol. The transmitter is arranged to apply each substream to an associated one of the spatially separate antennas.

WO 01/10156 A1

SPATIAL MULTIPLEXING IN A CELLULAR NETWORK

BACKGROUND OF THE INVENTION

1. Field of Invention

The field of the present invention relates in general to the field of wireless broadcast of information using one or more multiple access protocols and in particular to methods and apparatus for implementing spatial multiplexing in conjunction with the one or more multiple access protocols during the broadcast of information.

2. Description of the Related Art

In wireless broadcast systems, information generated by a source is transmitted by wireless means to a plurality of receivers within a particular service area. The transmission of such information requires a finite amount of bandwidth, and in current state of the art transmission of information from different sources, must occur in different channels.

Since there are quite a few services (e.g. television, FM radio, private and public mobile communications, etc.) competing for a finite amount of available spectrum, the amount of spectrum which can be allocated to each channel is severely limited. Innovative means for using the available spectrum more efficiently are of great value. In current state of the art systems, such as cellular telephone or broadcast television, a suitably modulated signal is transmitted from a single base station centrally located in the service area or cell and propagated to receiving stations in the service area surrounding the transmitter. The information transmission rate achievable by such broadcast transmission is constrained by the allocated bandwidth. Due to attenuation suffered by signals in wireless propagation, the same frequency channel can be re-used in a different geographical service area or cell. Allowable interference levels determine the minimum separation between base stations using the same channels. What is needed is a way to improve data transfer speed in the

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

multiple access environments currently utilized for wireless communications within the constraints of available bandwidth.

SUMMARY OF THE INVENTION

The present invention provides methods and apparatus for implementing spatial multiplexing in wireless networks such as cellular networks. In various embodiments unique network configuration, base stations and remote (subscriber) units are described. A wide variety of different applications of spatial multiplexing are also described.

In some embodiments the wireless cellular network includes base stations having spatially separate transmitters for transmitting in response to control signals and selected substreams of each subscriber datastream on an assigned channel of a multiple access protocol. From the standpoint of the network, the spatially separate transmitters can be located at a single base station or may be located on multiple base stations. Logic assigns an available channel on which to transmit each subscriber datastream. The logic routes at least a substream of each datastream to at least a selected one of the base stations. The logic also generates control signals to configure at least a selected one of the base stations to transmit the selected substreams to a corresponding one among the plurality of subscriber units on the assigned channel. Appropriate receivers are also described.

In other embodiments of the invention, subscriber units for use in cellular systems are disclosed. The subscriber units typically will have both spatially separate transmitters and receivers, although that is not a fixed requirement. In some embodiments subscriber unit includes spatially separate receivers, a spatial processor, and a combiner. The spatially separate receivers receive the assigned channel composite signals resulting from the spatially separate transmission of the subscriber downlink datastream(s). The spatial processor is configurable in response to a control signal transmitted by the base station to separate the composite signals into estimated substreams based on information obtained during the transmission of known data patterns from at least one of the base stations or by using blind training techniques. The spatial processor signals the base stations when a change of a spatial transmission configuration is required in order to resolve the composite signals into estimated

downlink datastream(s). The combiner combines the estimated substreams into a corresponding subscriber datastream.

Exhibit 1002
Page 0370 of 1285

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the present invention will become more apparent to those skilled in the art from the following detailed description in conjunction with the appended drawings in which:

FIG. 1 shows a wireless cellular network incorporating spatial multiplexing and multiple access according to the current invention.

FIG. 1B is a detailed view of selected cells within the cellular network shown in FIG. 1A.

FIG. 1C shows a cell architecture that provides overlapping regions suitable for multi-base spatial multiplexing.

FIGS. 2A-G show alternate embodiments for the subscriber units utilized in the wireless cellular network shown in FIGS. 1A-B.

FIG. 3A shows a detailed hardware block diagram of a single base station and subscriber unit for use in the wireless cellular network shown in FIGS. 1A-B.

FIG. 3B shows a detailed hardware block diagram of a single base station and subscriber unit as in Fig. 3A, wherein the subscriber unit interfaces with a local area network.

FIGS. 4A-J show detailed hardware block diagrams of the multiple access hardware for controlling the transmission of subscriber datastream(s) from one or more of the base stations within the wireless network.

FIGS. 5A-B show detailed hardware block diagrams of the hardware associated with the receipt of multiple subscriber datastream(s) at the base stations of the wireless network of the current invention.

FIG. 6 shows a detailed view of the signals and the symbols associated with the transmission and receipt of spatially multiplexed signals according to an embodiment of the current invention.

FIGS. 7A-B show detailed hardware block diagrams of the configurable spatial processor associated with the receiver circuitry receiver, according to an embodiment of the current invention.

FIGS. 7C-D show detailed hardware block diagrams of a configurable space and space-time processor associated with the configurable spatial receiver according to an embodiment of the current invention.

FIG. 8 shows in-band training and data signals for calibrating the spatially configurable receiver during the transmission of spatially multiplexed data, according to an embodiment of the current invention.

FIGS. 9A-B are respectively detailed hardware block diagrams of a spatially multiplexed transmitter and receiver implementing a time-division multiple access protocol (TDMA), according to an embodiment of the current invention.

FIGS. 10A-B are respectively detailed hardware block diagrams of a spatially multiplexed transmitter and receiver implementing a frequency-division multiple access protocol (FDMA), according to an embodiment of the current invention.

FIGS. 11A-B are respectively detailed hardware block diagrams of a spatially multiplexed transmitter and receiver implementing a code-division multiple access protocol (CDMA), according to an embodiment of the current invention.

FIGS. 12A-B are respectively detailed hardware block diagrams of a spatially multiplexed transmitter and receiver implementing a space-division multiple access protocol (SDMA), according to an embodiment of the current invention.

FIGS. 13A-B are process flow diagrams showing the acts associated with respectively the spatially multiplexed transmission and reception of datastream(s) in any one of a number of multiple access protocols, according to an embodiment of the invention.

FIG. 14 is a diagrammatic illustration of a hybrid DSL/wireless link that incorporates a spatially multiplexed remote wireless device.

FIG. 15 is a diagrammatic illustration of a hybrid cable/wireless link that incorporates a spatially multiplexed remote wireless device in a network access unit.

FIG. 16 is a diagrammatic illustration of a repeater BTS that utilizes a spatially multiplexed remote wireless device.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Exhibit 1002
Page 0372 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

A method and apparatus is disclosed which allows for both spatial multiplexed and non-spatial wireless communications between portable units and corresponding selected ones among a plurality of base stations. The methods and apparatus of the current invention may be implemented on a dedicated wireless infrastructure or may be superimposed on existing wireless communications systems, such as cellular telephone and paging services, which are currently in place around the world. The methods and apparatus include implementation in any of a number of multiple access protocols.

Spatial Multiplexing and Multiple Access

Spatial multiplexing (SM) is a transmission technology which exploits multiple antennas at both the base station(s) and at the subscriber units to increase the bit rate in a wireless radio link with no additional power or bandwidth consumption. Under certain conditions, spatial multiplexing offers a linear increase in spectrum efficiency with the number of antennas. Assuming, for example, N=3 antennas are used at the transmitter and receiver, the stream of possibly coded information symbols is split into three independent substreams. These substreams occupy the same channel of a multiple access (MA) protocol, the same time slot in a time-division multiple access (TDMA) protocol, the same frequency slot in frequency-division multiple access (FDMA) protocol, the same code/key sequence in code-division multiple access (CDMA) protocol or the same spatial target location in space-division multiple access (SDMA) protocol. The substreams are applied separately to the N transmit antennas and launched into the radio channel. Due to the presence of various scattering objects (buildings, cars, hills, etc.) in the environment, each signal experiences multipath propagation. The composite signals resulting from the transmission are finally captured by an array of receive antennas with random phase and amplitudes. For every substream the set of N received phases and N received amplitudes constitute its spatial signature.

At the receive array, the spatial signature of each of the N signals is estimated. Based on this information, a signal processing technique is then applied to separate the signals, recover the original substreams and finally merge the symbols back together. Linear or nonlinear receivers can be used providing a range of performance and complexity trade-offs. A linear spatial multiplexing receiver can be viewed as a

bank of superposed spatial weighting filters, where every filter aims at extracting one of the multiplexed substreams by spatially nulling the remaining ones. This assumes, of course, that the substreams have different signatures.

If the transmitter is equipped with M antennas, while the receiver has N antennas, the rate improvement factor allowed by spatial multiplexing is the minimum of these two numbers. Additional antennas on the transmit or receive side are then used for diversity purposes and further improve the link reliability by improving, for example, the signal-to-noise ratio or allowing for smaller fading margins, etc. Effectively spatial multiplexing allows a transmitter receiver pair to communicate in parallel through a single MA channel, hence allowing for a possible N-fold improvement of the link speed. More improvement is actually obtained if we take into account the diversity gain offered by the multiple antennas (for instance, in a Raleigh fading channel). Such performance factors are derived ideally under the assumption that the spatial signatures of the substreams are truly independent from each other. In reality, the level of independence between the signatures will determine the actual link performance. The performance, however, usually exceeds that obtained by a single antenna at the transmitter and receiver. For example, at two GHz, assuming the base station and the subscriber unit are spaced apart by one mile and using three antennas at each end of the link, a scattering radius of about 30 feet (both ends) is enough to achieve maximum performance.

FIG. 1A shows a plurality of subscriber units wirelessly coupled over a cellular network to a network 100. Network 100 may include: a local area network (LAN), a wide area network (WAN), a public switched telephone network (PSTN), Public Land Mobile Network (PLMN), an adhoc network, a virtual private network, an intranet or the internet. The wireless system includes: a central office (CO) 102, a master switch center (MSC) 106, a ground based relay station 110, satellites (112), base stations 120, 126 and 132 (BTS) and subscriber units 156, 138, 144, 150 and 162. The subscriber units may be mobile, fixed or portable. The base stations may be fixed or mobile. The base stations may include: a tower, satellites, balloons, planes, etc. The base station may be located indoors/outdoors. The cellular network includes one or more base stations, where each base station includes one or more spatially separate transmitters.

The central office 102 is coupled to the network 100. Network 100 may be circuit switched (e.g. point-to-point) or packet switched network. The central office is coupled to a master switching center 106. The MSC in traditional cellular systems is alternately identified as: a mobile telephone switching office (MTSO) by Bell Labs, an electronic mobile Xchange (EMX) by Motorola, an AEX by Ericcson, NEAX by NEC, a switching mobile center (SMC) and a master mobile center (MMC) by Novatel. The MSC is coupled via data/control line 108 to the satellites via relay station 110 and to the base stations. In an alternate embodiment of the invention, base station controllers (BSC) may serve as intermediary coupling points between the MSC and the base stations. In the embodiment shown, each of the BTS includes an array of spatially separate antennas for transmission and/or reception. The BTS may also include traditional antenna for whichever of the receive/transmit side of its communication capability lacks spatially separate antenna and associated circuitry. Antennas of a transmitter/receiver are defined to be spatially separate if they are capable of transmitting/receiving spatially separate signals. Physically separate antenna may be used to transmit/receive spatially separate signals. Additionally, a single antenna may be used to transmit/receive spatially separate signals provided it includes the ability to transmit/receive orthogonal radiation patterns. Hereinafter, the phrase "spatially separate" shall be understood to include any antenna or transmitter or receiver capable of communicating spatially separate signals. The base stations are configured to communicate with subscriber units of a traditional type, i.e. those lacking either spatially separate transmission/reception as well as spatially enabled subscriber units, i.e. those including either or both spatially separate reception and transmission capabilities.

In operation, distinct subscriber datastream(s) 170, 176 and 182 are received by CO 102. The CO performs the initial routing of the data streams to the appropriate one of a plurality of MSCs which may be located across the country. The MSC performs several functions. It controls the switching between the PSTN or network 100 and the BTSs for all wireline-to-subscriber, subscriber-to-wireline and subscriber-to-subscriber calls. It processes/logic data received from BTSs concerning subscriber unit status, diagnostic data and bill compiling information. In an embodiment of the invention, the MSC communicates with the base stations and/or satellites with a datalink using the X.25 protocol or IP protocol. The MSC also implements a portion

of the spatial multiplexing and multiple access processes/logic (SM_MA) 104B of the current invention. Each BTS operates under the direction of the MSC. The BTS and satellites 112 manage the channels at the site, supervise calls, turn the transmitter/receiver on/off, inject data onto the control and user channels and perform diagnostic tests on the cell-site equipment. Each BTS and satellite also implement a portion of the SM_MA processes/logic 104C. The subscriber units may be both traditional and spatially enabled and may still communicate over the system. Those subscriber units that are spatially enabled on either/both the transmit/receive side of communications implement SM_MA processes/logic 104D as well.

The SM_MA processes/logic allow high bit rate communications with any of the SM_MA enabled subscriber units within existing bandwidth constraints and within any of the multiple access (MA) protocols common to wireless communications or combinations thereof. Those MA protocols include: time-division multiple access (TDMA), frequency-division multiple access (FDMA), code-division multiple access (CDMA), space-division multiple access (SDMA) and many other multiple access protocols known to those skilled in the art. The SM_MA processes/logic include the ability to selectively allocate spatially separate downlink or uplink capability to any spatially enabled subscriber within a multiple access environment. This capability allows, as to that subscriber, the elevation of bit rates well above those currently available. Thus, a whole new range of subscribers can be anticipated to take advantage of this capability. Utilizing this invention, it will be possible to provide a wireless medium for connecting workstations, servers and tele-video conferences using the existing cellular infrastructure with the adaptations provided by this invention. The SM_MA processes/logic involve splitting subscriber datastream(s) destined for spatial multiplexing into substreams and intelligently routing and re-routing the substreams during a call session so as to maintain consistent quality of service (QoS). The substreams are communicated on the same channel using the same access protocol, thus not requiring additional resources or bandwidth to implement. The processes/logic include: access protocol assignment, channel assignment, monitoring of spatial separation, determination/re-determination of spatial signatures for each communication link, routing/re-routing between single-BTS and multi-BTS, handoff and control of substream parsing/combining.

Exhibit 1002
Page 0376 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

In FIG. 1A, datastream(s) 170, 176 and 182 are shown originating on network 100. The SM_MA processes/logic 104 have parsed and routed subscriber data stream 170 into substreams 172-174, which are transmitted on a single channel of a multiple access protocol over the spatially separate antenna 134-136 of BTS 132. Subscriber unit 138, via spatially separate antenna 140-142, receives composite signals 172-174 resulting from the substream transmission and utilizing SM_MA processes/logic 104D, derives the substream and original datastream 170 therefrom. In the embodiment shown, the data is delivered to the computer 190 to which the fixed subscriber desktop unit 138 is coupled. The cellular environment may also be implemented utilizing aerial equivalents of the base stations. In the embodiment shown, a plurality of satellites 112 generally deliver subscriber datastream(s) via spatially separate antennae on each of the satellites to a cellular network, i.e. 114.

In a circuit-switched embodiment of the invention, a call over a cellular network may require using two channels simultaneously; one called the user channel and one called the control channel. The BTS(s) transmit and receive on what is called a forward/downlink control channel and the forward/downlink voice/data channel and the subscriber unit transmit/receive on the reverse/ uplink control and voice/data channels. Completing a call within a cellular radio system is quite similar to the PSTN. When a subscriber unit is first turned on, it performs a series of startup procedures and then samples the received signal strength on all user channels. The unit automatically tunes to the channel with the strongest receive signal strength and synchronizes to the control data transmitted by the BTS(s). The subscriber unit interprets the data and continues monitoring the controlled channels. The subscriber unit automatically re-scans periodically to ensure that it is using the best control channel. Within a cellular system, calls can take place between a wireline party and a subscriber unit or between two subscriber units. For wireline-to-subscriber unit calls, the MSC receives a call from either a wireline party or in the form of a call setup packet from the network 100. The MSC determines whether the subscriber unit to which the call is destined is on/off hook. If the subscriber unit is available, the MSC directs the appropriate BTS to page the subscriber unit. The subscriber unit responds to the BTS indicating its availability and spatial multiplexing capabilities, receive and/or transmit. Following the page response from the subscriber unit, the MSC/BTS switch assigns an idle channel, configures spatial processing capability on both the

Exhibit 1002
Page 0377 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

subscriber unit and BTS(s) if appropriate, and instructs the subscriber unit to tune to that channel. The subscriber unit sends a verification of channel tuning to the BTS(s) and then sends an audible call progress tone to the subscriber I/O unit causing it to ring. The switch terminates the call progress tone when it receives positive indication the subscriber has answered and the conversation or communication has begun.

Calls between two subscriber units are also possible in the cellular radio system. To originate a call to another subscriber unit, the calling party enters the called number into the unit's memory via the touch pad and then presses the send key. The MSC receives the caller's identification number and the called number then determines if the called unit is free to receive the call. The MSC switch sends a page command to all base stations and the called party, who may be anywhere in the service area, receives the page. The MSC determines the spatial multiplexing capability of both subscribers. Following a positive page from the called party, the switch assigns each party an idle user channel and instructs each party to tune into that respective channel. Then the called party's phone rings. When the system receives notice the called party has answered the phone, the switch terminates the call progress tone and a communication can begin between two subscriber units. If spatial multiplexing is enabled, the communication link will include that capability.

One of the most important features of the cellular system is its ability to transfer calls that are already in progress from one cell site/base station to another as a subscriber unit moves from cell to cell or coverage area to coverage area within the cellular network. This transfer process is called a handoff. Computers at the BTS transfer calls from cell to cell with minimal disruption and no degradation in quality of transmission. The handoff decision algorithm is based on variations in signal strength. When a call is in progress, the MSC monitors the received signal strength of each user channel. If the signal level on an occupied channel drops below a predetermined threshold for more than a given time interval, the switch performs a handoff provided there is a vacant channel. In a traditional non-SM cellular system a traditional handoff involves switching the transmission point of a subscriber session (datastream) from one BTS to another. In the current invention various types of handoff, e.g. partial and full may take place. The handoff operation may involve the MSC re-routing the call and the entire datastream or selected substreams thereof to different antennas of the same BTS or to a new BTS/BTSs in whole or in part. Where

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

the re-routing is partial, at least one substream communication path is left unchanged while other of the substreams are re-routed to antennas on another BTSs. Where the handoff is full the multiple substreams transmitted from one or more BTSs are re-routed to other BTS(s).

In an embodiment of the invention utilizing a packet switched architecture, call setup may be implemented using protocols including: ALOHA, slotted-ALOHA, carrier sense multiple access (CSMA), TDMA, FDMA, CDMA, SDMA, etc., or any combination thereof.

BTS 132, in the embodiment shown, includes spatially separate antenna array. There may be any number of antennas. In some spatial environments, baud rates for spatially multiplexed communications on a single channel will increase linearly with the number of antennas allocated by subscriber unit and BTSs to a call session. In the embodiment shown, each BTSs array includes at least two antennas 134 and 136. The BTS may include either or both spatial multiplexing capability on the downlink (transmit) or uplink (receive) side. In the embodiment shown, each BTS includes spatial multiplexing capability on both the downlink and uplink. Although each of the following embodiments utilizes two antennas to implement SM, any number of antennas on a single BTS or multiple BTSs may be utilized without departing from the scope of the invention.

FIG. 1B shows a more detailed view of the BTS and subscriber units shown in FIG. 1A. Each BTS includes two spatially separate antennas. BTS 120 includes antennas 122-124. BTS 126 includes antennas 128-130. BTS 132 includes antennas 134-136. In the embodiment shown, many of the subscriber units also include at least two spatially separate antennas. Subscriber unit 150 includes spatially separate antennas 152-154. In the embodiment shown, the MSC handles the routing of subscriber datastream(s) 170, 176 and 182 from network 100 to the appropriate BTSs for transmission to the appropriate subscriber unit. In an embodiment of the invention, the SM_MA processes/logic include the ability to determine whether to implement or not implement spatial multiplexing (SM), based on either the presence/absence of SM capabilities in the corresponding subscriber unit and/or on the nature of the datastream. If, for example, the subscriber lacks SM capability on either or both the uplink/downlink, then the corresponding datastream will not be

Exhibit 1002
Page 0379 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

parsed into substreams. Alternately, even if the subscriber unit and BTS have SM capability on both downlink and uplink, certain types of datastream(s) may not require SM processing. Examples of these might include: traditional voice call sessions, call sessions which require only low QoS or datastream(s) which require only very low bit rates or are susceptible to buffering and delayed transmission.

In the example shown in FIG. 1B, datastream 182 is traditional mode traffic, e.g. a subscriber telephone call between an upstream subscriber and the subscriber unit 144. Subscriber unit 144 is located within a cell serviced by BTS 132. Under the control of MSC 106, the datastream 182 is transmitted over signal line 108 directly to the corresponding base station 132 without being split or parsed into associated substreams. In the example shown, datastream(s)182 is transmitted from a single antenna, e.g. antenna 134, without any SM techniques. That transmission is received by the subscriber unit 144. As discussed above, subscriber unit 144 may be a traditional cell phone lacking SM capability. Alternately, subscriber unit 144 may be SM enabled but, nevertheless, receives the call in traditional mode after appropriately configuring itself to opt out of SM receive side processes/logic, electing instead traditional mode.

In the example shown, datastream(s) 170 is handled using SM_MA processes/logic 104_. The datastream 170 and/or substreams thereof, depending on the embodiment, is routed by the MSC to BTS 132. The processes/logic 104 provide to each antenna 134-136 of BTS 132 a single substream derived from the original datastream 170, on a common channel within the appropriate access protocol. Those substreams are received as composite signals by the spatially separate antenna 140-142 (see FIG. 2B) of subscriber unit 138. The subscriber unit 138, utilizing SM-MA processes/logic 104D, derives the substreams from the composite signals and combines these into the initially transmitted datastream(s) 170.

Datastream(s) 176 is also subject to SM_MA processes/logic 104_. The datastream 176 and/or substreams thereof, depending on the embodiment, is routed by the MSC, initially to BTS 132 for single-base transmission to subscriber unit 150. SM-MA processes/logic implemented collectively at the MSC 106 and BTS 132 result in the splitting/parsing of the datastream(s) 176 into substreams 178-180. Initially those substreams are received as composite signals by the spatially separate

antenna 152-154 (see FIG. 2C) of subscriber unit 150. The subscriber unit 150, utilizing SM_MA processes/logic 104D, derives the substreams from the composite signals and combines these into the initially transmitted datastream(s) 176.

Implementing SM or SM_MA communications between the BTS and the associated subscriber unit may be either line-of-site (LOS) or multipath. Multipath communications are likely in environments, such as a city, where buildings and other objects deflect signals transmitted from the BTS many times before their arrival at the subscriber unit. Under certain conditions, it may be the case that transmissions originating from spatially separate antennas of a single BTS may arrive at a subscriber unit along signal paths which cannot be spatially separated by the antenna array on the subscriber unit. Where this is the case, it may be necessary for the processes/logic to reconfigure the spatial transmission characteristics of the substreams so that they may be received at the corresponding portable unit in a manner which is spatially separable. In the example shown, the substreams 180 and 178_S are transmitted initially from a single BTS 132. When a determination is made, either by the BTS or subscriber unit that separation of the substreams is not possible, a spatial reconfiguration is initiated by the spatial multiplexing processes/logic 104. The determination might, for example, result from the subscriber unit signaling the BTS or from the BTS determining that the bit error rate (BER) of the transmission exceeded an acceptable level. In an alternate embodiment of the invention in which base and subscriber communicate over a common channel, the signaling from the subscriber to the base station(s) for a change of a spatial transmission configuration is simplified. The BTS may, by analyzing the received signals, determine that they can not be adequately separated and in response, alter the spatial configuration of the transmissions to the subscriber unit with which it shares a channel. In the example shown, this reconfiguration results in a change of spatial configuration to multi-base transmission. Substream 178_M is re-routed through BTS 120 and specifically antenna 122. Because subscriber unit 150 is positioned in an area in which the transmissions from BTS 120 and 132 overlap, the change in spatial configuration is possible. The increased spatial separation on the transmit side increases likelihood that the substreams can be spatially separated by the subscriber unit 150 and its associated SM-MA processes/logic 104D.

Exhibit 1002
Page 0381 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

FIG. 1C shows another embodiment of the current invention in which a cell architecture which provides overlapping regions suitable for multi-base spatial multiplexing is shown. As in normal cellular structure, co-channel interference is avoided by ensuring that cells operating in the same frequency are spaced apart. In the example shown, BTSs 186A-C form an overlapping region between them in which they are shown in spatially multiplexed communication with subscriber unit 138. BTSs 186C-E form an overlapping region between them, in which they are shown in spatially multiplexed communication with subscriber unit 150A. BTSs 186C, F-G also form an overlapping region between them, in which they are shown in spatially multiplexed communication with subscriber unit 150B. The communications with subscriber units 138, 150A-B are conducted on separate channels to avoid co-channel interference. Diversity techniques can be simultaneously implemented. More distant cells may re-use the same channels provided co-channel interference is tolerable.

FIGS. 2A-G show alternate embodiments of subscriber units which may be either fixed, portable or mobile. FIG. 2A shows a mobile cellular phone 144 with a single antenna 146. In an embodiment of the invention, the single antenna includes the capability of transmitting and/or receiving spatially separable signals utilizing orthogonal di-poles. In an alternate embodiment of the invention, subscriber unit 144 is a traditional cellular phone which does not have the capability of transmitting/receiving a spatially separable signal. Either embodiment may be compatible with the system shown in FIGS. 1A-B, provided that system includes an embodiment of the invention with the ability to detect the transceiver capabilities of the subscriber units and to configure communications between that unit and the corresponding BTS accordingly.

FIG. 2B shows a fixed subscriber unit 138 coupled to a computer 190. In this embodiment, high-speed data communications between computer 190 and a wireless communication network with spatial multiplexing capabilities is enabled by fixed subscriber unit 138. Fixed subscriber unit 138 is shown with an antenna array including antennas 140-142. In the embodiment shown, additional antennas are provided. These may be utilized either for spatial multiplexing or to implement receive/transmit processing, e.g. diversity techniques, beam forming, interference cancellation, etc., the latter for the purpose of improving communication quality and

Exhibit 1002
Page 0382 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

link budget. The current state of the art requires a minimum separation between antennas 140-142, i.e. D1 equivalent to 1/2 the carrier wavelength. Further improvements in signal processing may avoid this requirement.

FIG. 2C shows a mobile subscriber unit, i.e. a cellular telephone 150, reconfigured for implementation of SM or SM_MA on either or both of the transmit (uplink) or receive (downlink) side of its communication with the BTSs. To this end, the antennas 152-154 are provided.

FIG. 2D shows a personal digital assistant (PDA) 200 and associated docking station 202 configured to implement SM or SM_MA communications on either or both the transmit and receive portions of its communications. To this end, the antenna array, which in the embodiment shown, includes two antennas 204-206 is provided. An example of personal digital assistants currently on the market that could be configured to utilize the current invention is the Palm Pilot ™ product sold by 3Com Corporation.

FIG. 2E shows a mobile subscriber unit 210 implemented as part of an automobile 216. The antenna array associated with this unit is not shown. The use of SM or SM_MA wireless communications between vehicles and base stations can provide such benefits as vehicle navigation, routing, and diagnostics.

FIG. 2F shows a notebook computer 220 configured for SM or SM_MA communication utilizing an antenna array with antennas 222-224 and associated hardware and processes/logic.

FIG. 2G shows a fixed subscriber unit 138 incorporated into a wireless router or bridge 235, which is coupled to a wired network 240. In this embodiment, the subscriber unit 138 serves as a high speed wireless connection between the wired network and the wireless communication network. The network 240 can take any suitable form including a local area network, a wide area network, an intranet, etc. It should be appreciated that in this arrangement, a wireless link is simply being used to connect two networks and such wireless links can be used in a wide variety of applications. For example, the wireless link can be used to provide high speed Internet access to the network 240. In the embodiment shown, the fixed subscriber unit 138 is shown as being incorporated into a router or bridge 235. However, it should be appreciated that the subscriber unit can readily be incorporated into a

variety of network components having a variety of functionalities. For example, the router or bridge can further include firewall capabilities, etc.

FIG. 3A is a detailed hardware block diagram of a subscriber unit 138 and a BTS 132. The BTS 132 includes: a multiple access spatial transmitter 310, a multiple access spatial receiver 330, a controller module 320 and upstream processes/logic 300, further details of which are provided in the accompanying FIGS. 4-5. The subscriber unit 138 includes: a multiple access spatially configured receiver 380, a multiple access spatially configured transmitter 350 and a control unit 370. The multiple access spatial transmitter 310 includes: a selector 312, a final transmission stage 316 and optionally may include transmit processes/logic 314. The final stage transmitter 316 is coupled to a spatially separate antenna array which includes antennas 134T-136T.

In operation, the subscriber datastream(s) and/or substreams thereof are provided to the selector 312 from the upstream processes/logic 300. Utilizing either in band or out of band control signals embodied in the datastream(s)/substreams themselves or separately communicated from the SM_MA processes/logic at the MSC 106 or elsewhere, the selector implements the MA protocol utilized by the wireless network. That protocol, as discussed above, may include: TDMA, FDMA, CDMA or SDMA, for example. The selector places each of the datastream(s)/substreams on the appropriate channel. Each of the datastream(s)/substreams are then passed through the optional transmit processes/logic, in which any of a number of well-known prior art signal processing techniques may be implemented to improve the quality of transmission. These techniques include, but are not limited to, diversity processing, space coding, space-time coding, space-frequency coding, and beam forming and interference canceling. The datastream(s)/substreams are then passed to the final transmit stage 316. Traditional mode traffic may be routed by the SM_MA processes/logic 104 to the appropriate antenna 134T-136T for transmission. If diversity processing is implemented, even traditional mode traffic may be transmitted using multiple antennas. Spatial mode traffic, i.e. the individual substreams thereof, will be routed to the appropriate one of the two antennas 134T-136T.

On the receive side, the subscriber unit SM_MA configurable receiver 380 includes: receiver first stage 382, optional receive processes/logic 384, spatial/space-

Exhibit 1002
Page 0384 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

time processor 386, decoder 388, combiner 390 and I/O module 392. The receiver first stage is coupled to a spatially separate antenna array, e.g. antennas 140R-142R. Utilizing in/out of band control signals, the SM_MA configurable receiver 380 of the subscriber unit 138, in the embodiment shown, may be configured for spatial/traditional mode signal reception on the requisite channel within the multiple access protocol. In the case of spatial mode communications, the antenna array, e.g. antennas 140R-142R, detect downlink composite signals derived from the spatially separate transmission of the substreams through antennas 134T-136T. These composite signals are down converted, demodulated and sampled by the receiver first stage 382. The composite signals are then passed to the receive processing module 384 and may be subject to receive side processing if implemented. From the receive processing module, the composite signals are passed to the spatial processor 386. The spatial/space-time processor via in/out band control signals is also configured to derive the appropriate number of substreams, i.e. equivalent to the number transmitted, from the BTS(s). Utilizing logic associated with space/space-time processing (see FIGS. 7A-D), that processor, in conjunction with decoder 388, generates estimated source substreams which are passed to the combiner 390. The combiner 390 via in/out band control signals is also configured to combine the substreams into an estimated subscriber datastream(s) corresponding to that transmitted from the BTS 132. The datastream(s) are passed to the I/O module for presentment/delivery as, e.g., audio, image or data. Where communications are asymmetric, the uplink may, in an embodiment of the invention, not include SM capability, leaving that capability to the downlink alone. This asymmetric capability may be implemented on either the downlink or the uplink without departing from the scope of this invention.

The uplink from the subscriber unit 138 to the BTS 132 may use the same or different hardware/firmware/processes/logic to that utilized for the downlink. In an embodiment of the invention, the uplink is traditional with no SM_MA capability. In the embodiment shown in FIG. 3A, the uplink includes both SM and MA processes/logic. The datastream(s) received by the I/O module 352 are passed to parser 354. In an embodiment of the invention, the parser is configurable to generate a traditional datastream or a variable number of substreams thereof. In another embodiment of the invention, the parser parses all datastream(s) into a fixed number

of substreams. Where there are no SM uplink capabilities there is no parser. In other embodiments of the invention, the configurable parser also includes a mode detector to determine whether the datastream(s) should be split into substreams. That determination, as discussed above, may be based on any number of criteria including, but not limited to, traditional vs. spatial mode, QoS, bit rate requirement, feasibility, etc. In such an embodiment, when the mode detector determines that spatial mode transmission of the datastream is appropriate, the parser will split the datastream(s) into a plurality of substreams, the number of which may itself be configurable. These substreams are then passed to the selector 356. The selector responsive to in/out of band control signals implements the appropriate access protocol, including the placement of the datastream(s) and/or substreams onto the appropriate channel within that protocol. The datastream(s) and/or substreams thereof are then optionally passed to transmit processes/logic 358, which may implement any number of well-known prior art signal processing techniques, including the above discussed diversity methodology, to improve signal reception. The substreams and/or datastream(s) are then passed to the final transmit stage 360 where they are encoded, modulated, and up-converted for transmission on a single channel through spatially separate transmit antennas 140T-142T. Composite signals corresponding thereto are received by antennas 134R-136R of the SM_MA configurable receiver 330 of the BTS.

As discussed above, where the uplink is asymmetric, the BTS may not implement or require SM on the uplink. Nevertheless, in the embodiment shown, the receiver 330 is SM_MA configurable. The receiver 330 includes a first stage receiver 332, mobility detector 334, receive processes/logic 336, spatial/space-time processor 338 and a decoder 340. The composite signals are passed by antennas 134 R-136 R to the first stage receiver. This is configurable to receive the communications on the appropriate channel within the MA protocol as determined by SM_MA processes/logic 104. These composite signals are down-converted/demodulated and sampled. In an embodiment of the invention, the mobility detector 334 monitors the composite signals for Doppler shift/spread. Doppler shift/spread of the composite signals correlates with the mobility or lack thereof of the subscriber unit. The absence of a Doppler shift/spread indicates that the subscriber unit is fixed. This determination on the part of the mobility detector may be used to initiate one or more of the following processes/logic: spatial reconfiguration, training/retraining of the

Exhibit 1002
Page 0386 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

spatial/space-time processors and/or handoff. In an embodiment of the invention in which non-blind in band training is implemented, training/retraining may include varying the training interval or duration or selection of a different training sequence. The composite signals are then passed to the optional receiver processes/logic 336. These processes/logic, as described above, may include any of a number of well-known techniques including diversity processing. The composite signals are then passed to the configurable space/space-time processor 338. Utilizing in/out of band control signals from the MSC and/or the subscriber unit, the space/space-time processor configures itself to generate a number of substreams or a single datastream(s) equivalent to those transmitted from the corresponding subscriber unit. These estimated subscriber substreams/datastream(s) are then passed to the decoder 340. The decoder decodes the symbols to their corresponding binary equivalent. The datastream(s) and/or substreams are then passed to upstream processes/logic 300.

Both the subscriber unit 138 and the BTS 132 are shown to include respectively control modules 370 and 320. These control modules implement a subset of the control processes/logic 104 required to implement the SM_MA processes, such as training of the space/space-time processors 338 and 386, etc.

Training

Training refers to the requirement that, in order to implement a space/space-time processing on the receive side of whichever link down/up is implementing SM, it is necessary that the space/space-time processor be equipped with an appropriate model of the spatial characteristics of the environment in which the signals will be passed between the subscriber unit and the associated BTS(s). Different types of training methodology may be appropriate, depending on whether the subscriber units are fixed/mobile, and if mobile, depending on the speed at which they are moving. Where a subscriber unit is fixed, training may be accomplished on installation of the unit, at setup of a call or during a call session. Where a subscriber unit is mobile, training/retraining must take place continuously or intermittently. Training for a fixed subscriber unit may take place intermittently as well, although generally at a lower frequency than that associated with a mobile subscriber unit.

Training is generally categorized as blind or non-blind. Training is non-blind when it is incorporated intermittently/continuously using in/out of band training

signals, e.g. known sequences such as Walsh codes, transmitted between subscriber unit and BTS(s). Training is blind when it takes place without such signals, relying instead on non-Gaussianity, CM, FA, cyclostationarity or the spatial structure, such as the array manifold. The performance of blind methods will, of course, be sensitive to the validity of structural properties assumed. An excellent reference on the subject, which is incorporated herein by reference as if fully set forth herein, is found in: "*Space-Time Processing for Wireless Communications*", Arogyaswami J. Paulraj and Papadias, IEEE Signal Processing Magazine, November 1997, at pages 49-83. In an embodiment of the invention, non-blind training methods are utilized to configure the space/space-time processors. Further details on the space/space-time processor will be provided in the following FIGS. 7A-D and accompanying text.

Control module 320 includes: processor 324, clock 326, training module 328 and memory 322 for the storage of weights/parameters for the space/space-time processor 338. Control module 370 in the subscriber unit 138 includes: processor 374, clock 376, training module 378 and memory 372 for the storage of weights/parameters for the space/space-time processor 386. In the embodiment of the invention shown in FIG. 3, the CPU implements the training portion of the control processes/logic 104. In alternate embodiments of the invention, the CPU may be utilized to implement other of the control processes/logic. In still other embodiments of the invention, the training portion of the control processes/logic is handled upstream at such locations as the MSC or the CO.

In an embodiment of the invention which implements non-blind training, the mobility detector 334 signals the CPU 324 when a subscriber unit exhibits minimal Doppler shift/spread, e.g. is fixed. In an embodiment of the invention, the CPU 324 directs the transmit module 310 to signal subscriber unit 138 at call setup, or at the start of a call session, to use stored parameters from an earlier training session or to process a setup training session transmitted by the BTS. In another embodiment of the invention, the CPU may reduce the frequency or duration of a training sequence responsive to a determination that the Doppler shift/spread is minimal.

On the BTS side, the training module 328 inserts a known training sequence, e.g. Walsh code, into the downlink transmissions and these are processed by the CPU 374 of the subscriber unit and weights derived therefrom which allow the

Exhibit 1002
Page 0388 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

space/space-time processor 386 to separate the training sequence spatially broadcast from the antenna array of the BTS(s). Similarly, where the uplink implements SM, the subscriber unit training module 378 inserts a known training sequence into the uplink transmissions as well. These are in turn processed by the CPU 324 and appropriate weights derived therefrom stored in the spatial processor 338 for use with the uplink communications during the call/data-transfer session. Whenever training/re-training takes place, weights are recalculated and stored for use in subsequent SM communications.

Where the mobility detector 334 determines that the subscriber unit is mobile, an alternate non-blind training methodology may be implemented. In an embodiment of the invention, that methodology shown in FIG. 8 involves inserting into in/out of band downlink communications the known training sequence. This allows updating of the spatial parameters/weights by the corresponding subscriber unit and its space/space-time processor. This capability allows spatial multiplexing to be implemented in both a mobile and a fixed environment. In still another embodiment of the invention, the duration/frequency at which the training intervals are inserted into the up/down link communications may be varied depending on the mobility of the subscriber unit.

In still another embodiment of the invention, blind training methods may be implemented. These unsupervised methods do not need training signals because they exploit the inherent structure of the communication signals.

As will be obvious to those skilled in the art, the processes/logic 104 and the associated modules/blocks discussed above and in the following disclosure may be implemented in hardware, software, firmware or combinations thereof without departing from the teachings of this invention. They may be implemented on a single chip, such as a digital signal processor (DSP), or application specific integrated circuits (ASIC). On the upstream side (i.e., BTS, MSC, CO, etc.), the SM_MA processes/logic 104 may physically reside in any one or all upstream units. The processes/logic may be implemented using master-slave control relationship between CO/MSC and BTS or peer-to-peer control relationship between BTSs alone, or distributed control between CO/MSC and BTS.

FIG. 3B illustrates a detailed hardware block diagram of a subscriber unit 138 and a BTS 132 similar to the system described in FIG. 3A. The difference in this embodiment is that the subscriber unit is connected to a network 240 and thus the I/O modules 352 and 392 in the transmitter 350 and receiver 380 respectively are coupled to the network 240. Of course, the subscriber unit could readily communicate with any type of network or network device.

FIGS. 4A-F show an embodiment of the BTS/MSC/CO side of the processes/logic 104_ for implementing SM_MA. FIGS. 4A-B and 4D-E show a partial handoff.

FIG. 4A shows BTSs 120 and 132 coupled to MSC 106 and to the associated upstream processes/logic 300 of processes/logic 104_. The BTS 120 is shown with the associated final transmission stage 316B and the selector 312B. The BTS 132 is shown coupled to the final transmission stage 316A and to the selector 312A. The upstream processes/logic 300 include a detector 400, parser unit 402 and router 420. The parser unit 402 includes a parser module 404 and clock 406 as well as a stretcher 408 and its clock 410. The MSC 106 is shown coupled via its data/control line 108 to each of the above-discussed modules.

As will be obvious to those skilled in the art, the coupling between the MSC and each of the above-discussed hardware and software modules represents a master/slave embodiment of the current invention. In alternate embodiments of the invention, peer-to-peer control methodology may be utilized instead. In still another embodiment of the invention, distributed control methodology may be implemented, e.g. each of the above-discussed modules may contain additional intelligence, sufficient to signal downstream/upstream modules as to the appropriate configuration to adopt, responsive to the datastream(s)/substreams being processed, the channel and access methodology to be utilized.

Datastream(s) 176 is delivered to mode detector 400. In this embodiment of the invention, a mode detection is utilized. As discussed above, this module provides the capability of distinguishing datastream(s). Datastream(s) might, as discussed, be categorized as traditional vs. spatial, or on the basis of QoS or bit rate requirement. In the embodiment shown, the detector 400 determines that the datastream(s) 176 is destined for spatial mode processing. Responsive to that determination, the parser

Exhibit 1002
Page 0390 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

404 is configured to parse the datastream(s) 176 into a plurality of the substreams. In the example shown, the two substreams 450-452 are generated by the parser. The substreams each contain a portion of the actual data from the original datastream(s). The function of the stretcher 408, to which the substreams are passed, is to effectively lower the baud rate at which the substreams are transmitted. Figuratively, this is accomplished by clocks 406 and 410 which are coupled to respectively the parser and the stretcher. Clock 410 operates at a rate which is a fraction of the rate of clock 406. The specific fraction is determined by the number of substreams generated by the parser 404. For example, if parser 404 generates from a single datastream(s) two substreams, then each of the substreams will be transmitted at a baud rate which is effectively 1/2 that of the original datastream(s). The stretched substreams are then passed to the router 420. In an alternate embodiment of the invention, the substreams need not be stretched, rather buffered and transmitted at the same baud rate in bursts, if the channel will support the resultant communication rate. The router operating, in the embodiment shown, under the control of the MSC 106 sends the selected substreams 454 and 456 to a single BTS 132 for single-base spatial transmission from each of the spatially separate antenna of that BTS. Those substreams passed through the selector 312 are injected on an appropriate channel within the multiple access protocol. The channel determination is made by the SM_MA processes/logic 104 that portion of which may be localized in a master/slave control implementation at the MSC. The substreams are then passed to the final transmission stage 316A for transmission to the subscriber unit 150 (see FIG. 6).

FIG. 4B shows hardware/software modules identical to those discussed above in connection with FIG. 4A. The router 420, responsive to a signal from, for example, the MSC 106 has re-routed one of the substreams to BTS 120. That substream 454 is passed to the selector 312B associated with BTS 120. The corresponding substream 456 is presented to selector 312A associated with BTS 132. Under the control of the MSC, each selector is directed to place the substreams on the same MA channel on each of the base stations. The final transmission stages 316A-B of each BTS places the substreams on one antenna of its spatially separate antenna array for transmission to the subscriber 150. The subscriber 150 is in a location in which the signals from base stations 120 and 132 overlap. The composite signals 180 and 178_M resulting from the transmission of spatially distinct subscriber substreams are received with

Exhibit 1002
Page 0391 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

spatially separable signatures by the subscriber unit 150 which, as discussed above, is equipped with spatially separate antennas.

The determination to move from a single-base spatial transmission (see FIG. 4A) to multi-base spatial transmission, as shown in FIG. 4B, may be made as a result of any one of the number of distinct determination methods. In the first of these methods, an evaluator portion of either the space/space-time processor 386 or the decoder 388 of the subscriber unit 138 determines that an incoming composite signal cannot be spatially separated into the required number of substreams. In response to this determination, the subscriber unit signals the BTS that a change of spatial configuration is required. This signal is processed by the BTS and may be passed to the MSC 106. In response, the MSC directs the router and selected BTSs, e.g. BTSs 120 and 132, to prepare for and transmit the substreams on an assigned channel. This transition from single-base to multi-base spatial transmission is handled transparently to the subscriber, in order to maintain a consistent QoS throughout the transmission by increasing the spatial separation of the transmitted substreams.

FIG. 4C shows an alternate embodiment of the invention that includes the capability of mode detecting between, for example, traditional and spatial mode datastreams. Datastream(s) 182 is presented to detector 400 via data/control line 108. The datastream(s) might, for example, be a traditional subscriber telephone call or a datastream which has both a low bit rate and QoS requirement. To minimize resources, it may be advantageous for the parser unit 402 to be configurable, so as not to subject all incoming datastream(s) to parsing or, if parsed, so as not to parse into a fixed number of substreams. In the embodiment shown, such capability is implemented. The detector determines that the datastream is traditional mode. That determination may result in the parser avoiding the parsing of the datastream 182. The datastream(s) 182 is passed unparsed to the router 420. The router 420 passes the datastream(s) 182 to the selector 312A of the associated BTS 132. Under the control of the MSC the selector and the final transmissions stage 316A inject the datastream(s) 182 on the appropriate channel of the appropriate multiple access protocol and transmit it via a selected one of the antennas, within the array from which it is received, by subscriber unit 144. That subscriber unit may be a traditional mobile phone lacking any spatial transmission characteristics. Alternately, the subscriber unit may be spatially configurable as well (see FIG. 2A). In this latter

Exhibit 1002
Page 0392 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

case, BTS 132 injects a control signal to the spatially configurable subscriber unit 144 and, in particular, to the configurable space/space-time processor thereof, indicating that the incoming composite signals are to be treated as a single datastream(s). As will be obvious to those skilled in the art, traditional mode datastreams including, for example, traditional voice telephone calls, may be subject to SM.

As will be obvious to those skilled in the art, each of the above-discussed datastream(s) 178, 176, 182 may include multiple subscriber sessions, time-division multiplexed for example. In this case, all the above-mentioned methodology may be practiced successively on each of the subscriber sessions of a single datastream.

FIG. 4D shows multiple subscriber datastream(s) presented to the detector 400. Specifically datastream(s) 176 and 182 are shown. The first of these datastream(s) is destined for spatial treatment and the second of these datastream(s) 182 is destined for non-spatial treatment. This determination is made by the mode detector 400 based on criteria including, but not limited to, those discussed above. The parsing unit 402 is, in this embodiment of the invention, configurable to concurrently handle multiple subscriber sessions. Upon receipt of control information received either directly from the detector 400 or indirectly from the MSC 106, the parsing module 402 performs the following concurrent operations. The traditional mode datastream(s) 182 is left unparsed and passed directly to the router 420. The spatial mode datastream(s) 176 is parsed by parser 404 into substreams 450-452. These substreams are stretched in stretcher 408, as discussed above, and passed to router 420. The router 420, operating under the control of the MSC, for example, directs each of the datastream(s) and substreams to a single BTS 132 and specifically the associated selector 312A of that BTS.

These substreams generated by the parser are labeled 450-452. The substreams passed by the router are labeled 454-456. This change in reference number is meant to indicate that the initial parsing operation may be accompanied by a lowering of the bit rate or stretching of the clock on which these substreams are transmitted. As will be obvious to those skilled in the art, an alternate methodology for implementing the invention would be to maintain the same the bit rate, provided it was compatible with the bandwidth of the wireless channel on which the transmission

Exhibit 1002
Page 0393 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

was to take place, and to buffer the data accordingly for transmission in bursts, along with other similarly processed datastream(s)/substreams.

Under the direction of the MSC, for example, the selector 312A and final transmission stage 316A of BTS 132 transmit the substreams 454-456 on a common channel and, depending on the access methodology, may transmit the datastream(s) 182 on the same or another channel. Signal 182 is transmitted from an antenna of BTS 132 to subscriber unit 144. The individual substreams and the associated signals 180, 178_S of the spatial mode datastream(s) 176 are transmitted to the subscriber unit 150.

FIG. 4E shows an embodiment of the invention identical to that described and discussed above in connection with FIG. 4D. Router 420 re-routes one of the substreams 454-456 of the spatially processed datastream(s) 176 to form a multi-base spatial transmission configuration. That determination to re-route, as discussed above, may originate either from signals received from the corresponding one of the subscriber units which is unable to spatially separate the substreams or alternately may result from a determination by the BTS initially implementing single-base transmission that the bit error rate (BER) is unacceptably high. In this example, subscriber unit 144 continues to receive composite datastream(s) 182 from an antenna on BTS 132. The composite signals received by subscriber 150 now, however, originate from a multi-base configuration. The substream 454 has been re-routed by router 420 to BTS 120, so the composite signals 180, 178_M originate from BTSs 132,120, respectively.

As will be obvious to those skilled in the art of the reference, in single or a multi-base spatial transmission, discussion to a substream been transmitted from a single antenna, should not be interpreted as a limitation on the teachings of this invention. A single substream in single or multi-base configuration may be transmitted from more than one antenna, if diversity or beam forming transmit processes are implemented in addition to spatial multiplexing.

FIGS. 4F-J show an alternate embodiment of the invention in which the router, as described and discussed above in connection with FIGS. 4A-E, is positioned upstream of the parsing unit rather than downstream of that unit. Consequently, each

Exhibit 1002
Page 0394 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

of the base stations has associated with it a corresponding parsing unit. FIGS. 4F-G and FIGS. 4I-J show a partial handoff.

FIG. 4F shows MSC 106, BTSs 120 and 132 and the upstream processes/logic 300. Each of the base stations 120 and 132 includes selectors and final transmission stages. Within the upstream processes/logic 300, the detector 400 communicates directly to the router 422. The router, in turn, communicates directly with the parsing units 402A-B associated with BTSs 132 and 120, respectively. Single-base spatial processing of subscriber datastream(s) 176 is shown. The subscriber datastream(s) 176 is received by the detector 400. The detector determines that the mode of the datastream(s) is spatial and that information is passed to the router 422. The router routes the datastream(s) 176 to the appropriate parsing unit 402A. The parsing module 404A of that unit parses the datastream(s) into substreams, e.g. substreams 450-452. Those substreams are passed to stretcher 408A which is coupled to selector 312A. The selector places both the stretched substreams 454-456 on the appropriate channel of the selected MA protocol. Those substreams are transmitted by the final transmit stage 316A of the BTS 132. The signals 178_S and 180 are transmitted to subscriber unit 150, along with the control information necessary for that subscriber unit to properly process the incoming communication.

FIG. 4G shows a multi-base implementation of the configuration described and discussed above in connection with FIG. 4F. The detector 400 determines that the datastream(s) 454-456 require spatial processing. Additionally, multi-base transmission is determined to be necessary based, for example, on a subscriber unit signal or on the BER detected by a BTS. The router 422, responsive to that determination, routes the datastream to parsing units 402A-B. Each of the parsing modules 404A-B is presented information, not only that the datastream(s) needs to be parsed, but also which substreams are to be discarded at each parsing unit in order to implement a multi-base spatial transmission. In an embodiment of the invention, those in control instructions are generated by the MSC 106. The parsing module 404A generates substream 452. The parsing module 404B generates substream 450. Collectively, substreams 450-452 contain all the information from the original datastream(s) 176 from which they were parsed. The selected substreams are passed to the corresponding stretching modules 408A-B. These stretching modules in turn pass the substreams with a reduced bit rate or in bursts as substreams 456-454 to the

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

corresponding selectors 312A-B of the associated BTSs 132 and 120. The substreams are placed on the same channels of the multiple access protocol implemented by each BTS. These substreams are transmitted by the corresponding final transmissions stages 316A-B. Signal 180 corresponding to substream 456 is transmitted by at least an antenna on BTS 132 to subscriber unit 150. Signal 178_M corresponding to substream 454 is transmitted by at least an antenna of BTS 120 to subscriber unit 150. The inclusion of both single-base and multi-base spatial transmission capabilities in the system allows consistent QoS to be delivered to the subscribers.

FIG. 4H shows an implementation of the current invention in which the detector 400 includes the capability of distinguishing the mode of the datastream(s), e.g. traditional mode and spatial mode. The detector 400, upon determining that datastream(s) 182 can be processed in traditional mode, passes that information to the router 422. The router passes the datastream(s) 182 to the appropriate parsing unit 402. The parser unit 402A and specifically parser module 404A thereof avoids parsing the datastream(s) and passes it to the corresponding selector 312A associated with BTS 132. In the manner described and discussed above, the channel and antenna on which that datastream(s) is to be transmitted from BTS 132 is determined by the processes/logic 104, e.g. at the MSC. The associated signal 182 is passed from the BTS to the subscriber unit 144.

FIG. 4I shows the introduction of multiple subscriber datastream(s), i.e. datastream(s) 176 and 182 into the embodiment described and discussed above in connection with FIGS. 4F-H. The detector 400 determines that datastream(s) 182 may be processed in the traditional mode while datastream(s) 176 may be processed in the spatial mode. In this example, both the datastream(s) are routed by router 422 to a single BTS for, respectively, non-spatial and spatial transmission. Stretched datastream(s) 454-456 derived from substreams 450-452 of datastream(s) 176 are presented to the selector associated with BTS 132. Signals 178_S and 180 are transmitted to subscriber unit 150 on the same channel of the MA protocol implemented by the BTS. Traditional mode datastream(s) may be transmitted on the same or another channel.

FIG. 4J shows a multi-base spatial transmission of the datastream(s) 176 discussed above in connection with FIG. 4I. A change from single to multi-base

Exhibit 1002
Page 0396 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

transmission is initiated by the processes/logic 104_ in response to, for example, a degradation in the bit error rate or to signals from subscriber unit 150 which indicate that a change in spatial configuration is required. This might include changing the antenna selection on the array of a single BTS. The selection might involve a reduction/increase in the number of transmitting antennas. Alternately, in the example shown, a partial handoff is implemented. To implement the partial handoff, router 422 routes the datastream(s) 176 to both parsing units 402A-B. Control information, indicating which of the substreams generated by the respective parsing unit is to be passed on to the associated BTS, may also be generated. Responsive to that information, the parsing modules 404A-B each generate only one of the substreams which can be generated from the datastream(s) 176. Each selected substream is stretched by the corresponding stretcher and passed to the corresponding BTS. BTS 132 continues to transmit the traditional mode datastream(s) 182 and the signal corresponding thereto to subscriber unit 144. BTS 132 transmits one of the stretched substreams 456 in the form of signal 180 to subscriber unit 150. The other of the substreams 454 is passed to the subscriber unit 150 as signal 178_M from the BTS 120.

As will be obvious to those skilled in the art, the above-mentioned arrangements of detector, router and parsing units represent only some of the possible configurations of these modules/logic which may be utilized to implement the current invention. In an embodiment of the invention, the wireless network may not support both traditional and spatial transmission together. In that embodiment, the detector may not be required, since all datastream(s) will be handled by spatially transmitting them. In still another embodiment of the invention, multi-base operation may not be implemented, allowing only for single-base SM. In still another embodiment of the invention, the routing may be accomplished by a single BTS which uses in/out of band channels to wirelessly relay one or more substreams to other BTSs for re-transmissions on the assigned channel.

FIGS. 5A-B show the upstream modules associated with the processing of datastream(s) and substreams received by the BTSs. That information may be destined for another subscriber unit or for the network 100 (see FIG. 1A).

Exhibit 1002
Page 0397 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

FIG. 5A shows the base stations 120,132, the upstream processes/logic 300 and the MSC 106. In the example shown, single-base SM is implemented. The subscriber unit 150 is shown transmitting signals 178_S and 180. These are received by BTS 132 and processed by the associated modules of its configurable SM receiver 330 (see FIG. 3). From the decoder 340A, substreams 454-456 are passed to the upstream processes/logic 300. The upstream module includes a router 420 and a combiner 500. The combiner 500 operates in reverse of the manner described and discussed above in connection with the parsing unit 402. The router 420 passes the substreams 454-456 to the combiner 500. The output of the combiner is the subscriber datastream(s) 176.

FIG. 5B shows the modules discussed above in connection with FIG. 5A during the reception of multi-base spatial transmissions from the subscriber unit 150 as well as the single-base transmission from subscriber unit 144. BTS 132 and the associated receiver module 330, have their spatial processor configured to generate a single one of the substreams 456 that can be derived from the composite signals 178_M and 180 of subscriber unit 150. The other substream 454 is generated by corresponding modules associated with BTS 120. Additionally, on the same/different channel, BTS 132 with the receiver 330 is configured to generate a single datastream(s) 182 from the composite signal 182 transmitted by the subscriber unit 144. The datastream(s) 182 of the associated decoder of that BTS, i.e. decoder 340A is passed to the router 420. The combiner is configured to combine substreams 454-456 into datastream 176 and to pass datastream(s) 182 along without combining.

Thus, in an embodiment of the invention, the method and apparatus of the current invention may be used to implement SM_MA both on the down/up link. As will be obvious to those skilled in the art, SM may be asymmetrically implemented as well, on either the down/up link selectively, without departing from the scope of this invention.

FIG. 6 shows an antenna array of BTS transmitter 132 and the antenna array of the subscriber unit receiver 138 (see FIG. 3). The antenna array of the final transmissions stage 316 includes antennas 134T –136T. The antenna array of the first receiver stage 382 includes antennas 140R-142R. The first receiver stage passes the composite signals 640-642 to the space/space-time processor 386. The output of the

Exhibit 1002
Page 0398 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

processor is presented to the decoder 388 from which, as output, the substreams 454-456 are generated.

As will be obvious to those skilled in the art, the transmission of data through a wireless medium may involve modulation of an information signal derived from a datastream(s) or substream on a carrier signal. Information may, for example, be contained in the phase and/or amplitude relationship of the signal modulating the carrier. Each specific phase and/or amplitude relationship that is utilized is referred to as a "symbol". The set of all symbols is referred to as the "constellation". The greater the number of symbols in a constellation, the more binary bits of information may be encoded in each symbol in a given constellation. Current communication protocols allow for constellations with over 1024 symbols, each encoding for one of ten bit combinations. Antenna 134T is shown transmitting a symbol 600 within a signal constellation. This corresponds to an associated group of the bits corresponding to the data from a portion of substream 454. Antenna 136T is shown transmitting symbol 606 which corresponds to a different bit sequence derived directly from substream 456. The transmission of substream 454 by antenna 134 results in at least two signals 602-604. The transmission of the symbol 606 by antenna 136 generates at least two signals 608-610. Additional signals are likely in a multi-path environment with numerous scattering objects, such as buildings, etc. For the sake of simplicity, signals 602 and 610 transmitted from respectively antennas 134T-136T are both received by antenna 140R as a single composite signal. The corresponding signals 604 and 608 are received by antenna 142R as a single composite signal. In order for the spatial receiver of the subscriber unit to resolve the composite signals into the estimated subscriber datastream/substreams, the spatial processor 386 must include information about the spatial signatures 620-622 of the transmissions from each of the antennas 134-136. These spatial signatures may be determined using either blind and or non-blind training methods in the manner described and discussed above. By placing the decoder 388 downstream from the space/space-time processor 386, the appropriate symbols may then be derived from the substream and converted into a corresponding binary sequence from which the corresponding portions of the substreams 454-456 may be generated.

As will be obvious to those skilled in the art, any of a number of other modulation techniques may be used to implement the current invention including:

Exhibit 1002
Page 0399 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

continuous phase modulation (CPM), continuous frequency modulation (CFM), phase shift keying (PSK), offset phase shift keying, amplitude shift keying (ASK), pulse position modulation (PPM), pulse width modulation (PWM), etc., without departing from the scope of this invention.

FIGS. 7A-B show an embodiment of the invention in which the spatial processor 386 is configured for both traditional and spatial mode signal reception. Additionally, in the spatial mode, the spatial processor is configurable to generate a variable number of substreams to correspond to the number transmitted. Spatial processor 386 and the decoder 388 are shown. The spatial processor 386 includes: first fabric switch 700, first configurable logic 702, second fabric switch 730, second configurable logic 732, an evaluator 740, and a controller 746.

The spatial processor 386 is coupled via the receive processes 384 to the receiver first stage 380 of the subscriber unit, as discussed above in connection with FIG. 3. Similar design applies to the spatial processor 338 in the BTS (see FIG. 3). The composite signal(s) detected by the first stage receiver is passed to the fabric switch 700 of the spatial processor. Responsive to signals generated by the control unit 746, the first fabric switch passes the composite signal/signals to one or more of the sub-modules within first logic unit 702. In the embodiment shown, a sub-module includes a multiplier 704 and a weight register 712. The multiplier generates an output signal which is a product of the weight stored in weight register 712 multiplied by the incoming composite signal. The weights in this register and the register of other sub-modules may be derived using non-blind or blind training methods as discussed above. In the example shown in FIG. 7A, a composite signal 750 is presented to fabric switch 700. This switch has been configured utilizing in/out of band control signals to process a single composite signal. The output of the multiplier is presented to the second fabric switch 730. This fabric switch also is configurable by means of the control unit 746. The fabric switch 730 presents the signals from the first logic module in variable configurations to one or more of the summers, e.g. summer 734 which is part of the second configurable logic in this embodiment of the invention. Because a single composite signal is being processed in the embodiment shown in FIG. 7A, only one summer is utilized. The input to that summer is the output of the multiplier 704 and the zero input provided by the control unit 746. The output of the summer 734 is passed to the evaluator 740 (optional). The evaluator

Exhibit 1002
Page 0400 of 1285
Ubiquiti Inc. v. XR. Comm.
IPR2024-00148