File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	SB08.pdf	615429 8b74b3daaf5cacae9cc16690f45eddea38dc4e85	no	4
Warnings:					
Information:					
2	Other Reference-Patent/App/Search documents	ISR.pdf	121038 6955c6932bb77464b7e2b6dd89a5223308789dc5	no	4
Warnings:					
Information:					
3	Non Patent Literature	R1-113659.pdf	156883 0e55e3c29f26e19ff83055b96c4f037194ed40fb	no	6
Warnings:					
Information:					
4	Non Patent Literature	R1-114082.pdf	163221 2bf3aa8b3b720f261793a4af9d861c50ebae6f75	no	5
Warnings:					
Information:					
5	Foreign Reference	wo11146766.pdf	1844722 f8fb08ed0c592e33ba0ac2cacc81aa53dcb7e723	no	48
Warnings:					
Information:					
6	Foreign Reference	wo12023895.pdf	2302816 3b1dc02bde1ad3567c5151dc2191d5143252c784	no	42
Warnings:					
Information:					

7	Non Patent Literature	Dahlman_Chapter14.pdf	1915117 c056d2ffdab9d81066ffa5e8952eaf80c6470e14	no	26
Warnings:					
Information:					
8	Fee Worksheet (SB06)	fee-info.pdf	31022 3e6a6e49c042a36361ced7ee2221b5b5c5ea1b4a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	7150248		

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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.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the **PATENT APPLICATION** of:	
	Philip Young
Application No.:	14/372,363
Confirmation No.:	1411
Filed:	July 15, 2014
For:	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER
Group:	2415
Examiner:	Jonathan Wood

Our File:	IPW2-USAP205496
Date:	September 12, 2016

RESPONSE PURSUANT TO 37 C.F.R. § 1.111

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

This Response is being filed in response to the Non-Final Office Action dated March 11, 2016 and is submitted in conjunction with an appropriate petition for extension of time.

Please amend the application without prejudice or disclaimer as follows:

Amendments to the Claims:

This listing of the claims will replace all prior versions of the claims in the application:

1.-39. (CANCELED)

40. (Currently Amended) A ~~network device~~ base station comprising:

~~a network device~~ a processor configured to wirelessly communicate with a first type of terminal device and a second type of terminal device;

~~the network device~~ a transceiver ~~further~~ configured to ~~communicate with~~ transmit a signal to the first type of terminal device ~~with~~ on a host carrier having radio resource segments allocated in a first time period ~~distributed in time~~, wherein each radio resource segment ~~provides~~ uses radio resources across a first frequency band;

the ~~network device~~ transceiver further configured to ~~communicate~~, within a second frequency band, [[with]] transmit another signal to the second type of terminal device using a subordinate carrier ~~comprising~~ with allocated resources that are a subset of the host carrier radio resource segments in the first time period; [[and]]

wherein the second frequency band is narrower than the first frequency band and contained within the first frequency band; and

wherein in a second time period the subset of the host carrier radio resource segments is used to communicate with the first type of terminal device.

41. (Currently Amended) The ~~network device~~ base station of claim 40 further comprising:

the radio resource segments are subframes of radio frames having a plurality of subframes; and

subframes are allocated to the subordinate carrier using a subordinate carrier subframe allocation set, wherein the subordinate carrier subframe allocation set determines which subframes within a repeating group of one or more radio frames are allocated to the subordinate carrier.

42. (Currently Amended) The ~~network device~~ base station of claim 41, wherein the subordinate carrier subframe allocation set is defined by one or more reserved subframe allocation patterns.

43. (Currently Amended) The ~~network device~~ base station of claim 42, wherein the one or more reserved subframe allocation patterns comprise substantially all or a subset of all reserved subframe allocation patterns of the host carrier.

44. (Currently Amended) The ~~network device~~ base station of claim 42 ~~further comprising:~~ wherein acquisition information required for the second type of terminal device to receive the subordinate carrier is allocated to subframes of the subordinate carrier using at least a portion of the subframes in the one or more reserved subframe allocation patterns.

45. (Currently Amended) The ~~network device~~ base station of claim 40, wherein the first type of terminal device is capable of receiving a full bandwidth of the first frequency band, wherein the second type of terminal device is incapable of receiving the full bandwidth of the first frequency band, and wherein the second type of terminal device is capable of receiving the full bandwidth of the second frequency band.

46. (Currently Amended) A method performed by a ~~network device~~ base station, the method comprising:

communicating, wirelessly by a processor of the base station ~~network device~~, with a first type of terminal device and a second type of terminal device;

transmitting ~~communicating~~, by a transceiver of the base station ~~network device~~, ~~with~~ a signal to the first type of terminal device ~~with~~ on a host carrier having radio resource segments allocated in a first time period ~~distributed in time~~,

wherein each radio resource segment ~~provides~~ uses radio resources across a first frequency band;

transmitting ~~communicating~~, by the transceiver of the base station ~~network device~~ within a second frequency band, another signal to [[with]] the second type of terminal device using a subordinate carrier ~~comprising~~ with allocated resources that are a subset of the host carrier radio resource segments in the first time period; [[and]]

wherein the second frequency band is narrower than the first frequency band and contained within the first frequency band; and

wherein in a second time period the subset of the host carrier radio resource segments is used to communicate with the first type of terminal device.

47. (Previously Presented) The method of claim 46 further comprising:

the radio resource segments are subframes of radio frames having a plurality of subframes; and

subframes are allocated to the subordinate carrier using a subordinate carrier subframe allocation set, wherein the subordinate carrier subframe allocation set determines which subframes within a repeating group of one or more radio frames are allocated to the subordinate carrier.

48. (Previously Presented) The method of claim 47, wherein the subordinate carrier subframe allocation set is defined by one or more reserved subframe allocation patterns.

49. (Previously Presented) The method of claim 48, wherein the one or more reserved subframe allocation patterns comprise substantially all or a subset of all reserved subframe allocation patterns of the host carrier.

50. (Currently Amended) The method of claim 48 ~~further comprising:~~ wherein acquisition information required for the second type of terminal device to receive the subordinate carrier is allocated to subframes of the subordinate carrier using at least a portion of the subframes in the one or more reserved subframe allocation patterns.

51. (Previously Presented) The method of claim 46, wherein the first type of terminal device is capable of receiving a full bandwidth of the first frequency band, wherein the second type of terminal device is incapable of receiving the full bandwidth of the first frequency band, and wherein the second type of terminal device is capable of receiving the full bandwidth of the second frequency band.

Amendments to the Specification:

Please replace paragraph [0077] with the following amended paragraph:

[0077] In FIG. 8, example signalling on the host carrier and the subordinate carrier is schematically illustrated. In FIG. 8, eight radio frames 800 are shown, each having a central frequency portion 820 usable by both the host carrier and the subordinate carrier, and outer frequency portions 810 usable only by the host carrier. In each radio frame, a MIB 830 is provided in the central frequency portion 820. The MIB 830 is readable by devices using both the host carrier and the subordinate carrier. Devices seeking to use a subordinate carrier may be able to determine from the MIB 830 whether a subordinate carrier exists based on a flag present in the MIB 830. In an outer frequency portion 810, system information 840 is provided for use by devices served by the host carrier. The system information 840 is shown to be outside of the central frequency portion 820 and is thus not available to the kind of low-capability devices intending to use the subordinate carrier. It will be appreciated that some system information may happen to be transmitted within the central frequency portion 820, but this cannot be guaranteed. The system information 840 is provided in the form of System Information Blocks (SIBs). Unlike the Master Information Block which is broadcast on the Physical Broadcast Channel (PBCH), the SIBs are mapped onto the Physical Downlink Shared Channel (PDSCH). Generally, the Master Information Block 830 provides sufficient information to gain access to the first of the System Information Blocks (SIB1), which in turn provides sufficient information to gain access to SIB2 et seq. SIB2 includes parameters relating to the reservation of MBSFN subframes (as described above). Legacy LTE devices using the host carrier will therefore be informed of the subframes reserved for use by the subordinate carrier (or for other purposes, for example MBMS or relay backhaul) when they decode SIB2. They will therefore know that these subframes cannot be used and to ignore them. Within the

central portion [[810]] 820 of some or all of the radio frames (every other radio frame in this example) is a portion 850 allocated to the subordinate carrier. For the sake of clarity the portion 850 shown in FIG. 8 is contiguous, but it will be appreciated from FIGS. 5A to 5D for example that this may not be the case. The portions 850 are used to transmit data and signalling to low capability devices using the subordinate carrier. Within the allocated portion 850 of the first radio frame is a subordinate carrier MIB (scMIB) 860 carrying various information required for a low capability device to acquire the remainder of the subordinate carrier system information.

REMARKS/ARGUMENTS

After the foregoing Amendment, claims 40-51 are currently pending in this application. Claims 40-46 and 50 are amended. In the specification, paragraph [0077] is amended to correct a reference number.

Objections to the Specification

The Examiner objected to the specification because of informalities. The specification has been amended to change "central portion 810" to "central portion 820" in paragraph [0077]. We thank the Examiner for this recommendation. In view of the amendment, withdrawal of the objection to the specification is respectfully requested.

Claim Rejections - 35 U.S.C. § 101

Claims 40-51 are rejected under 35 U.S.C. § 101 because the claimed invention is directed to a judicial exception (i.e., a law of nature, a natural phenomenon, or an abstract idea) without significantly more. The outstanding Office Action states that claims 40 and 46 recite a framework for dividing frequency and time resources between various terminal devices for use in wireless communication. However, no allocation, assignment or use of the resources is recited.

Without conceding the propriety of the rejection and in an effort to advance prosecution, claims 40 and 46 are amended. Changes to claims 40 and 46 were made based on the Examiner's comments and 2014 Interim Guidance On Patent Subject Matter Eligibility published December 2014 (as Updated July 2015 and May 2016). Applicant believes that the changes made to amended claims 40 and 46 result in claims that give significantly more than an abstract idea. Based on the arguments presented above, withdrawal of the 35 U.S.C. § 101 rejection of claims 40-51 is respectfully requested.

Claim Rejections - 35 U.S.C. § 112

Claims 40-51 are rejected under pre-AIA 35 U.S.C. § 112, sixth paragraph, because it uses a generic placeholder "*configured to*" coupled with functional language without reciting sufficient structure to achieve the function. Without conceding the propriety of the rejection and in an effort to advance prosecution, claims 40 and 46 are amended. Support for a transceiver and processor of a network device is given at least in paragraphs [0006], [0041], and [0043]. Moreover, "processor configured to..." and a "transceiver configure to..." given in amended claim 40 are not functional limitations that may invoke 112 sixth paragraph interpretation.

Based on the arguments presented above, withdrawal of the 35 U.S.C. § 112 rejection of claims 40-51 is respectfully requested.

Claim Rejections - 35 U.S.C. § 112

Claims 40-45 are rejected under pre-AIA 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter regarded as the invention. Without conceding the propriety of the rejection and in an effort to advance prosecution, claim 40 is amended. In particular, in amended claim 40 and throughout, network device is changed to base station. Based on the arguments presented above, withdrawal of the 35 U.S.C. § 112 rejection of claims 40-45 is respectfully requested.

Claim Rejections - 35 U.S.C. § 103(a)

Claims 40 and 46 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Publication No. 2009/0180430 to Fadell (hereinafter "Fadell", in view of U.S. Publication No. 2008/0130486 to Lim et al. (hereinafter "Lim"). Without conceding the propriety of the rejection and in an effort to advance prosecution, claim 40 is amended. Fadell in view of Lim, alone or in combination, at least do not teach or suggest to "...transmit another signal to the second type of terminal device using a subordinate carrier with allocated resources that are a subset of the host carrier radio resource segments in the first time period...wherein the second frequency band is narrower than the first frequency band and contained within the first frequency band...wherein in a second time period the subset of the host carrier

radio resource segments is used to communicate with the first type of terminal device" of amended claim 40.

Lim is introduced to cure the deficiency of Fadell allocating a narrow frequency band within a wider allocated frequency band. However, Lim at least does not teach or suggest the resource allocation and timing of transmitting "another signal to the second type of terminal device using a subordinate carrier with allocated resources that are a subset of the host carrier radio resource segments in the first time period...wherein the second frequency band is narrower than the first frequency band and contained within the first frequency band...wherein in a second time period the subset of the host carrier radio resource segments is used to communicate with the first type of terminal device" of amended claim 40.

Amended claim 46, although different, is allowable for at least the same reasons as amended claim 40. Based on the arguments presented above, withdrawal of the 35 U.S.C. § 103(a) rejection of claims 40 and 46 is respectfully requested.

Claims 41-44 and 47-50 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Fadell, in view of Lim, and further in view of U.S. Publication No. 2012/0263093 to Roessel et al. (hereinafter "Roessel"). Claims 41-44 and 47-50 are allowable for at least the same reasons provided above for claims 40 and 46. Roessel does not cure any of the deficiencies of Fadell in view of Lim. Based on the

arguments presented above, withdrawal of the 35 U.S.C. § 103(a) rejection of claims 41-44 and 47-50 is respectfully requested.

Claims 45 and 51 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Fadell, in view of Lim, and further in view of U.S. Publication No. 2008/0069060 to Das et al. (hereinafter "Das"). Claims 45 and 51 are allowable for at least the same reasons provided above for claims 40 and 46. Das does not cure any of the deficiencies of Fadell in view of Lim. Based on the arguments presented above, withdrawal of the 35 U.S.C. § 103(a) rejection of claims 45 and 51 is respectfully requested.

Conclusion

It should also be noted that although arguments have been presented with respect to certain claims herein, the recited subject matter as well as various other subject matter and/or combinations of subject matter may be patentable for other reasons. Further, the failure to address any statement by the Examiner herein should not be interpreted as acquiescence or agreement with such statement. The Applicant expressly reserves the right to set forth additional and/or alternative reasons for patentability and/or allowance with the present application or in any other future proceeding, and to rebut any statement presented by the Examiner in this or other papers during prosecution of the present application.

If the Examiner believes that any additional minor formal matters need to be addressed in order to place this application in condition for allowance, or that a telephonic interview will help to materially advance the prosecution of this application, the Examiner is invited to contact the undersigned by telephone at the Examiner's convenience.

In view of the foregoing, Applicant respectfully submits that the present application, including claims 40-51, is in condition for allowance and a notice to that effect is respectfully requested.

Respectfully submitted,

Intellectual Ventures Holding 81, LLC

By:____/Harry Vartanian/____
Harry Vartanian
Registration No. 56,787

Volpe and Koenig, P.C.
United Plaza
30 South 17th Street
Philadelphia, PA 19103-4009
Telephone: (215) 568-6400
Facsimile: (215) 568-6499

HV/eam

PTO/AIA/22 (03-13)
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): IPW2-USAP205496

Application Number: 14/372,363

Filed: July 15, 2014

For: WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

Art Unit: 2415

Examiner: Jonathan Wood

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	Micro Entity Fee	
☐ One month (37 CFR 1.17(a)(1))	$200	$100	$50	$
☐ Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$
☑ Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$ 1,400
☐ Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐ Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number _____.

☑ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 56,787.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Harry Vartanian/ — Signature

September 12, 2016 — Date

Harry Vartanian — Typed or printed name

215-568-6400 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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.
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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.

Electronic Patent Application Fee Transmittal

Application Number:	14372363
Filing Date:	15-Jul-2014
Title of Invention:	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER
First Named Inventor/Applicant Name:	Philip Young
Filer:	Harry Vartanian
Attorney Docket Number:	IPW2-USAP205496

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 3 months with $0 paid	1253	1	1400	1400
Miscellaneous:				
			Total in USD ($)	**1400**

Electronic Acknowledgement Receipt

EFS ID:	26903136
Application Number:	14372363
International Application Number:	
Confirmation Number:	1411
Title of Invention:	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER
First Named Inventor/Applicant Name:	Philip Young
Customer Number:	3624
Filer:	Harry Vartanian
Filer Authorized By:	
Attorney Docket Number:	IPW2-USAP205496
Receipt Date:	12-SEP-2016
Filing Date:	15-JUL-2014
Time Stamp:	22:50:50
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1400
RAM confirmation Number	7553
Deposit Account	220493
Authorized User	VARTANIAN, HARRY

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 CFR 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 CFR 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 CFR 1.19 (Document supply fees)

Charge any Additional Fees required under 37 CFR 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 CFR 1.21 (Miscellaneous fees and charges)

Charge any Additional Fees required under 37 CFR 1.492(a) (basic national fee only)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		IPW2-USAP205496-Response_to_non-final-20160912.pdf	105227 a16ce3356aae65af7f78db7e24118148ab6f7fed	yes	14

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Claims	2	6
Specification	7	8
Applicant Arguments/Remarks Made in an Amendment	9	14

Warnings:

Information:

2	Extension of Time	IPW2-USAP205496-Extension_of_Time-20160912.PDF	163506 0df6c3e8a42159ab0279fb10e661408fc184a407	no	2

Warnings:

Information:

3	Fee Worksheet (SB06)	fee-info.pdf	30863 fd3f8da9eb8be1e46a869afbae0fac2989a26248	no	2

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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.

PTO/SB/06 (09-11)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/372,363	Filing Date 07/15/2014	☐ 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 09/12/2016	(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))	* 11	Minus	** 20	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	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.

LIE
MINNIE JACKSON

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/372,363	07/15/2014	Philip Young	IPW2-USAP205496	1411

3624 7590 03/11/2016

VOLPE AND KOENIG, P.C.
UNITED PLAZA
30 SOUTH 17TH STREET, 18th Floor
PHILADELPHIA, PA 19103

EXAMINER
WOOD, JONATHAN

ART UNIT	PAPER NUMBER
2415	

NOTIFICATION DATE	DELIVERY MODE
03/11/2016	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):

eoffice@volpe-koenig.com

Office Action Summary	Application No. 14/372,363	Applicant(s) YOUNG, PHILIP	
	Examiner JONATHAN B. WOOD	Art Unit 2415	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 *07/15/2014*.

☐ 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) *40-51* 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) *40-51* 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 *07/15/2014* 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 *01/22/2015*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

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DETAILED ACTION

1. The present application is being examined under the pre-AIA first to invent provisions.

Specification

2. The disclosure is objected to because of the following informalities.

[0077] line 26: "*central portion 810*" should read "*central portion 820*" to be consistent with FIG 8 and other specification references.

Appropriate correction is required.

Claim Rejections - 35 USC § 101

3. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

4. **Claims 40-51** are rejected under 35 U.S.C. 101 because the claimed invention is directed to a judicial exception (i.e., a law of nature, a natural phenomenon, or an abstract idea) without significantly more. **Claims 40-51** are directed to an abstract idea. The claims do not include additional elements that are sufficient to amount to significantly more than the judicial exception because they recite an idea standing alone that represents an uninstantiated concept or scheme. As such, no actual improvement

of a machine/system is implemented.

5. Regarding **claims 40 and 46**, each recites a framework for dividing frequency and time resources between various terminal devices for use in wireless communication. However, no allocation, assignment or use of the resources is recited. Thus, the claims recite the idea of dividing frequency and time resources for use in wireless communication, but do not provide significantly more than that idea. An example significantly more would be actual allocation and use of the frequency and time resources to perform wireless communication.

6. Dependent **claims 41-45 and 47-51** fail to correct provide significantly more that the idea recited in parent **claims 40 and 46**, and are likewise rejected.

Claim Rejections - 35 USC § 112

7. The following is a quotation of 35 U.S.C. 112(f):

> (f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

> An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

8. Claim limitation "*a network device*" has been interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because it uses a generic placeholder "*configured to*" coupled with functional language without reciting sufficient structure to achieve the function. Furthermore, the generic placeholder is not preceded by a structural modifier.

Since the claim limitation invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, **claims 40-51** have been interpreted to cover the corresponding structure described in the specification that achieves the claimed function, and equivalents thereof. A review of the specification shows that the following appears to be the corresponding structure described in the specification for the 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph limitation: paragraph [0006] discloses a transceiver and a processor in a smartphone, which is a type of network device. However, the specification review fails to find corresponding structure disclosed for other types of network devices.

If applicant wishes to provide further explanation or dispute the examiner's interpretation of the corresponding structure, applicant must identify the corresponding structure with reference to the specification by page and line number, and to the drawing, if any, by reference characters in response to this Office action.

If applicant does not intend to have the claim limitation treated under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112 , sixth paragraph, applicant may amend the claims so that they will clearly not invoke 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, or present a sufficient showing that the claim recites/recite sufficient

structure, material, or acts for performing the claimed function to preclude application of 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

For more information, see MPEP § 2173 *et seq.* and *Supplementary Examination Guidelines for Determining Compliance With 35 U.S.C. 112 and for Treatment of Related Issues in Patent Applications*, 76 FR 7162, 7167 (Feb. 9, 2011).

Claim Rejections - 35 USC § 112

9. 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.

10. **Claims 40-45** 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.

11. Regarding **claim 40**, the claim preamble on line 1 recites "*a network device*", so **claim 40** is drawn to the machine category of statutory subject matter. However, **claim 40** fails to recite any parts or combinations of parts that comprise the network device. To qualify as statutory subject matter, a machine must be a concrete thing consisting or

parts, devices, or a combinations of devices (see MPEP 2016, section I, ii: Machine). Therefore, **claim 40** fails to meet the statutory requirements, and is rejected under 112 second paragraph.

12. Dependent **claims 41-45** fail to correct the deficiencies of parent **claim 40** and are likewise rejected.

13. Regarding **claim 40**, line 2 recites "*a network device configured to*", and lines 4 and 8 recite "*a network device further configured to*", all of which are being interpreted as means-plus-function claims (see above). Such claims must be supported by corresponding structure in the specification. The examiner notes that specification FIG 2 and associated specification paragraph [0034] make clear that the network device recited in **claim 40** is the Base Station (BS) 101. A review of the specification fails to finds corresponding structure for the BS 101 network device. Therefore, claim 40 is rejected for lacking corresponding structure capable of implementing the recited functionality.

14. Dependent **claims 41-45** fail to correct the deficiencies of parent **claim 40** and are likewise rejected.

Claim Rejections - 35 USC § 103

15. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

16. **Claims 40 and 46** are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Fadell USPG-Pub 2009/0180430-A1 (hereinafter Fadell), in view of Lim et al. USPG-Pub 2008/0130486-A1 (hereinafter Lim).

17. Regarding **claims 40 and 46**, and using **claim 40** as the exemplary recitation for the claim group, Fadell suggests *a network device* (AP 304) *comprising: a network device* (AP 304) *configured to wirelessly communicate* (wireless network) *with a first type of terminal device* (PUs 306) *and a second type of terminal device* (NPUs 308) {FIG 3 shows a wireless network 300, including Access Point (AP) 304 wirelessly communicating with a plurality of Premises Users (PUs) 306 and a plurality of Non-Premises Users (NPUs) 308}*; the network device* (AP 304) *further configured to communicate* (wireless communication) *with the first type of terminal device* (PUs 306) *with a host carrier* (802.11 carrier) *having radio resource segments distributed in time* (time/frequency resources)*, wherein each radio resource segment* (time/frequency resource) *provides radio resources across a first frequency band* (first portion of available BW) {FIG 2 and [0026] describes a method for allocating network bandwidth

(BW) between two or more uses, allocating a first portion of available BW to the first use and a second portion of available BW to a second use. [0071] describes support for wireless/cellular communications standards that provide for host carriers divided into time/frequency resource elements, such as TDMA, CDMA, MWBA, OFDM, PCS/DCS, etc. [0101] describes the AP 304 providing communication services according to various 802.11 standards which support allocations and use of time/frequency resources within a defined host carrier frequency range}*; the network device* (AP 304) *further configured to communicate* (wireless communication)*, within a second frequency band* (second portion of available BW)*, with the second type of terminal device* (NPUs 308) *using a subordinate carrier* (portion of available BW) *comprising resources* (time/frequency resources) *that are a subset of the host carrier radio resource segments* (portion of network BW) {FIG 2 and [0026] describes a method for allocating network BW between two or more uses, allocating a first portion of available BW to the first use and a second portion of available BW to a second use}.

Fadell discloses a wireless communication network supporting BW allocations for multiple uses. However, Fadell fails to specifically disclose allocating a narrow frequency band within a wider allocated frequency band. Lim discloses a wireless communication network supporting BW allocations for multiple uses. Further, Lim suggests *wherein the second frequency band is narrower* (NB) *than and contained within the first frequency band* (among the frequency bands used for WB) {[0010] describes Narrow-Band (NB) wireless communication that uses a frequency band that is among the frequency bands used for Wide-Band (WB) wireless communication. Further

described in a BS that allocates resources for both NB and WB communication}. It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the allocation methods of Fadell with the allocation methods of Lim to reduce control information overhead and maintain backward compatibility with narrow-band wireless communication systems {[0087]}.

18. Specifically for **claim 46**, Fadell suggests *a method performed by a network device* {FIG 2 and [0026] describes a method for allocating network BW between two or more uses}.

19. **Claims 41-44 and 47-50** are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Fadell, in view of Lim, and further in view of Roessel et al. USPG-Pub 2012/0263093-A1 (hereinafter Roessel).

20. Regarding **claims 41 and 47**, the combination of Fadell and Lim disclose all the limitations of parent **claims 40 and 46** respectively. Using **claim 41** as the exemplary recitation for the claim group, Fadell suggests *the radio resource segments* (time/frequency resources) *are subframes of radio frames* (portions of network BW) *having a plurality of subframes* (multiple BW portions) {FIG 2 and [0026] describes a method for allocating network BW between two or more uses, allocating a first portion of available BW to the first use and a second portion of available BW to a second use}.

Fadell and Lim both disclose wireless communication networks supporting BW allocations for multiple uses. However, the combination of Fadell and Lim fails to specifically disclose use of subframe allocation sets. Roessel discloses a wireless communication network supporting BW allocations for multiple uses. Further, Roessel suggests *subframes are allocated* (subframe allocation) *to the subordinate carrier* (sub-carrier) *using a subordinate carrier subframe allocation set* (co-channel allocation sets), *wherein the subordinate carrier subframe allocation set* (co-channel allocation sets) *determines which subframes* (time domain subframe) *within a repeating group* (periodically recurring pattern) *of one or more radio frames are allocated to the subordinate carrier* (frequency domain sub-carrier) {[0162] describes channel control that can define co-channels through the use of frequency sub-carrier and time subframe allocation sets. [0082] describes use of periodically recurring patterns of frame/subframe structure}. It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the allocation methods of Fadell and Lim with the allocation methods of Roessel to reduce interference between wide area macro networks and local area networks {[0133]}.

21. Regarding **claims 42 and 48**, the combination of Fadell, Lim and Roessel disclose all the limitations of parent **claims 40, 41 and 46, 47** respectively. **Claim 42** is used as the exemplary recitation for the claim group. Fadell and Lim both disclose wireless communication networks supporting BW allocations for multiple uses. However, the combination of Fadell and Lim fails to specifically disclose use of

subframe allocation sets. Roessel discloses a wireless communication network supporting BW allocations for multiple uses. Further, Roessel suggests *the subordinate carrier subframe allocation set* (co-channel allocation sets) *is defined by one or more reserved subframe allocation patterns* (pre-defined allocation patterns) {[0162] describes channel control that can define co-channels through the use of frequency sub-carrier and time subframe allocation sets. [0191] describes use of pre-defined allocation patterns that attempt to be mutually disjoint in frequency and time}. It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the allocation methods of Fadell and Lim with the allocation methods of Roessel to reduce interference between wide area macro networks and local area networks {[0133]}.

22. Regarding **claims 43 and 49**, the combination of Fadell, Lim and Roessel disclose all the limitations of parent **claims 40, 41, 42 and 46, 47, 48** respectively. **Claim 43** is used as the exemplary recitation for the claim group. Fadell and Lim both disclose wireless communication networks supporting BW allocations for multiple uses. However, the combination of Fadell and Lim fails to specifically disclose use of subframe allocation sets. Roessel discloses a wireless communication network supporting BW allocations for multiple uses. Further, Roessel suggests *the one or more reserved subframe allocation patterns* (pre-defined allocation patterns) *comprise substantially all or a subset of all reserved subframe allocation patterns* (all mini-CCEs) *of the host carrier* (host frequency resources) {[0191] describes pre-defined allocation

patterns are used to form mini-Channel Control Elements (mini-CCEs) or resource element groups. [0195] describes that the macro cell may allocate all mini-CCEs}. It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the allocation methods of Fadell and Lim with the allocation methods of Roessel to reduce interference between wide area macro networks and local area networks {[0133]}.

23. Regarding **claims 44 and 50**, the combination of Fadell, Lim and Roessel disclose all the limitations of parent **claims 40, 41, 42 and 46, 47, 48** respectively. Using **claim 44** is used as the exemplary recitation for the claim group, Fadell suggests *acquisition information* (receives allocation information) *required for the second type of terminal device* (NPUs 308) *to receive the subordinate carrier* (assigned portion of available BW) *is allocated to subframes of the subordinate carrier* (portions of available BW) *using at least a portion of the subframes* (multiple BW portions) *in the one or more reserved subframe allocation patterns* (BW reservations) {FIG 2 and [0026] describes a method for allocating network BW between two or more uses, allocating a first portion of available BW to the first use and a second portion of available BW to a second use. [0015] describes a communication device receiving BW allocation information, and that BW reservations can be provided to communications devices via network policy}.

24. **Claims 45 and 51** are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Fadell, in view of Lim, and further in view of Das et al. USPG-Pub

2008/0069060-A1 (hereinafter Das).

25. Regarding **claims 45 and 51**, the combination of Fadell and Lim disclose all the limitations of parent **claims 40 and 46** respectively. **Claim 45** is used as the exemplary recitation for the claim group. Fadell and Lim both disclose wireless communication networks supporting BW allocations for multiple uses. However, the combination of Fadell and Lim fails to specifically disclose terminals with BW restrictions. Das discloses a wireless communication network supporting BW allocations for multiple uses. Further, Das suggests *the first type of terminal device* (wideband terminal) *is capable of receiving a full bandwidth* (can process all subbands) *of the first frequency band* (full DL BW)*, wherein the second type of terminal device* (narrowband terminal) *is incapable of receiving* (can't process all subbands) *the full bandwidth of the first frequency band* (full DL BD)*, and wherein the second type of terminal device* (narrowband terminal) *is capable of receiving the full bandwidth* (can process 1 subband) *of the second frequency band* (1 DL subband) {[0009] describes a wideband device (terminal) that can receive information over a plurality of subbands and a narrowband device (terminal) that can only receive information over one of the subbands. [0036] describes a wideband terminal that is capable of receiving all subbands in a downlink (DL) BW, and a narrowband terminal that is only capable of receiving only one subband of the set of subbands comprising the DL BW}. It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the device types of Fadell and Lim with the device types of Das to allow support for various types of terminals and improve

performance for the wideband terminals {[0040]}.

Conclusion

26. Any inquiry concerning this communication or earlier communications from the examiner should be directed to JONATHAN B. WOOD whose telephone number is (571)270-0175. The examiner can normally be reached on MON-FRI, 7:30AM-5:00PM EST, Alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, JEFFREY RUTKOWSKI can be reached on 571-270-1215. 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.

/J. B. W./
Examiner, Art Unit 2415

/JEFFREY M RUTKOWSKI/

Supervisory Patent Examiner, Art Unit 2415

Notice of References Cited	Application/Control No. 14/372,363	Applicant(s)/Patent Under Reexamination YOUNG, PHILIP	
	Examiner JONATHAN B. WOOD	Art Unit 2415	Page 1 of 2

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-2007/0258417 A1	11-2007	Harvey; Richard Lee	H04W16/14	370/338
*	B	US-2008/0069060 A1	03-2008	Das; Arnab	H04L5/023	370/337
*	C	US-2008/0130486 A1	06-2008	Lim; Chi-Woo	H04L5/0007	370/210
*	D	US-2008/0232240 A1	09-2008	Baum; Kevin L.	H04L5/0007	370/210
*	E	US-7,499,438 B2	03-2009	Hinman; Brian L.	H04L63/10	370/338
*	F	US-2009/0180430 A1	07-2009	Fadell; Anthony M.	H04L12/5695	370/329
*	G	US-2009/0247171 A1	10-2009	Suga; Junichi	H04W72/046	455/447
*	H	US-2010/0135242 A1	06-2010	Nam; Young-Han	H04L5/0007	370/330
*	I	US-2010/0220607 A1	09-2010	Fujishima; Kenzaburo	H04W16/10	370/252
*	J	US-2010/0323709 A1	12-2010	Nam; Young-Han	H04B7/043	455/450
*	K	US-2010/0317283 A1	12-2010	Wu; Chih-Hsiang	H04W72/005	455/3.06
*	L	US-2011/0274063 A1	11-2011	Li; Ming-Che	H04L5/001	370/329
*	M	US-2012/0044852 A1	02-2012	Zhang; Wenjian	H04B7/15528	370/312

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Notice of References Cited	Application/Control No. 14/372,363	Applicant(s)/Patent Under Reexamination YOUNG, PHILIP	
	Examiner JONATHAN B. WOOD	Art Unit 2415	Page 2 of 2

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-2012/0155361 A1	06-2012	Wei; Hung-Yu	H04W4/06	370/312
*	B	US-8,249,635 B2	08-2012	Fukui; Noriyuki	H04L5/0037	370/328
*	C	US-2012/0213143 A1	08-2012	Zhang; Xiaoxia	H04L5/001	370/312
*	D	US-2012/0250564 A1	10-2012	Marque-Pucheu; Gerard	H04W72/082	370/252
*	E	US-2012/0263093 A1	10-2012	Roessel; Sabine	H04L5/0053	370/312
*	F	US-2013/0088986 A1	04-2013	Xiao; Weimin	H04W72/0426	370/252
*	G	US-2013/0114555 A1	05-2013	Sato; Yoshizo	H04W72/046	370/329
*	H	US-2013/0242821 A1	09-2013	Wei; Na	H04W72/04	370/280
*	I	US-2014/0094183 A1	04-2014	Gao; Chunyan	H04W72/048	455/450
*	J	US-9,094,991 B2	07-2015	Gheorghiu; Valentin Alexandru	H04L1/007	1/1
*	K	US-9,131,503 B2	09-2015	Ishii; Hiroyuki	H04W8/22	1/1
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S2	1	"14372363"	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/02/22 15:27
S3	5	(philip near young).in. & (alton).inci.	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/02/23 09:37
S4	239	(intellectual ventures holding).as. | (intellectual ventures holding).aanm.	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/02/23 09:38
S5	2	S3 & S4	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/02/23 09:39
S6	242	S3 | S4	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/02/23 09:39
S7	1	S6 & ((network (device | node)) with (first near (terminal | device | UE | (user equipment) | mobile)) with (second near (terminal | device | UE | (user equipment) | mobile))).clm.	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/02/23 09:43
S8	2	S6 & ((host carrier) with (resource near (segment | subframe))).clm.	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/02/23 09:45
S9	4	("20090180430" | "20100135242").PN.	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/02/23 09:51
S10	75141	H04W76/022,025,041,045.cpc. | H04W72/00,06.cpc. | H04W72/04$.cpc. \| H04W72/12$.cpc. | H04W88/00,02,18.cpc. | H04W28/00.cpc. | H04W84/02.cpc.	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/02 16:52
S11	10	((network near (device | node | switch | router)) | (base station) | BS! | eNB | eNodeB | e-NodeB | (evolved nodeB)) same ((host near carrier) with (time | TDD))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/02 16:59
S12	16673	((network near (device | node | switch | router)) | (base station) | BS! | eNB | eNodeB | e-NodeB | (evolved nodeB)) same ((host | carrier) with (time | TDD))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/02 17:00
S13	91768	((network near (device | node | switch | router)) | (base station) | BS! | eNB |	US-PGPUB;	ADJ	ON	2016/03/02 17:05

		eNodeB | e-NodeB | (evolved nodeB)) same ((first | primary) with (terminal | device | mobile | UE | WTRU | (user equipment))) same ((second$4 | $2other) with (terminal | device | mobile | UE | WTRU | (user equipment)))	US-PGPUB; USPAT; DERWENT			
S14	1840	((network near (device | node | switch | router)) | (base station) | BS! | eNB | eNodeB | e-NodeB | (evolved nodeB)) same ((first | primary) with (terminal | device | mobile | UE | WTRU | (user equipment))) same ((carrier | frequency) with resource with (time | TDD))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/02 17:08
S15	210	((network near (device | node | switch | router)) | (base station) | BS! | eNB | eNodeB | e-NodeB | (evolved nodeB)) same ((second$4 | $2other) with (terminal | device | mobile | UE | WTRU | (user equipment))) same ((carrier | frequency) with resource with (time | TDD)) same (subset | subordinate | part$4 | segment | slice)	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/02 17:12
S16	192	S13 & S14 & S15	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/02 17:13
S17	95	S13 & S14 & S15 & S10	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/02 17:14
S18	14	(US-20140362831-$ or US-20090180430-$ or US-20100135242-$ or US-20140094183-$ or US-20130242821-$ or US-20130114555-$ or US-20130088986-$ or US-20110274063-$ or US-20100323709-$ or US-20100220607-$ or US-20080232240-$).did. or (US-9094991-$ or US-8619693-$ or US-8249635-$).did.	US-PGPUB; USPAT	ADJ	ON	2016/03/03 12:49
S19	8692	(frequency (band | bandwidth | BW!) with (narrow$4 | small$4 | restrict$4 | parti$6) with (within | contain$4 | inside))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 12:54
S20	9718	((frequency near (band | bandwidth | BW!)) with (narrow$4 | small$4 | restrict$4 | parti$6) with (within | contain$4 | inside))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 12:55
S21	75244	H04W76/022,025,041,045.cpc. | H04W72/00,06.cpc. | H04W72/04$.cpc. \| H04W72/12$.cpc. | H04W88/00,02,18.cpc. | H04W28/00.cpc. | H04W84/02.cpc.	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 12:55
S22	589	S21 & S20	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 12:55
S23	4885	((frequency near (band | bandwidth | BW!)) with (narrow$4 | small$4) with (within | contain$4 | inside))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 12:56
S24	282	S21 & S23	US-	ADJ	ON	2016/03/03

			PGPUB; USPAT; DERWENT			12:56
S25	74	(((second$4 | $2other) near frequency near (band | bandwidth | BW!)) with (narrow$4 | small$4) with (within | contain$4 | inside) with ((first | primary) near frequency near (band | bandwidth | BW!)))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 12:59
S26	16	S21 & S25	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 13:00
S27	90	(((second$4 | $2other) near frequency near (band | bandwidth | BW!)) with (narrow$4 | small$4) with (within | contain$4 | inside | "same") with ((first | primary) near frequency near (band | bandwidth | BW!)))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 13:05
S28	20	S21 & S27	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 13:06
S29	70	S27 not S28	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 13:14
S30	73	(broadband with narrowband with (subset | subcarrier | subfrequency))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 13:30
S31	26788	wlan with bluetooth	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 13:37
S32	2042	S21 & S31	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 13:37
S33	586	(subframe | sub-frame) near (allocat$4 | assign$4) near (set | group)	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 14:42
S34	65	(subframe | sub-frame) near (allocat$4) near (set)	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 14:43
S35	11	((subframe | sub-frame) near (allocat$4 | assign$4) near (set | group)) same $4carrier	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 15:10
S36	25	(US-20140362831-$ or US-20090180430-$ or US-20100135242-$ or US-20140094183-$ or US-20130242821-$ or US-20130114555-$ or US-20130088986-$ or US-20110274063-$ or US-20100323709-$ or US-20100220607-$ or US-20080232240-$ or US-20120250564-$ or US-20090247171-$ or US-20080130486-$ or US-20070258417-$ or	US-PGPUB; USPAT	ADJ	ON	2016/03/03 16:11

		US-20120263093-$ or US-20120155361-$ or US-20120044852-$ or US-20100317283-$ or US-20120213143-$).did. or (US-9094991-$ or US-8619693-$ or US-8249635-$ or US-9131503-$ or US-8879461-$).did.				
S37	143	(((wideband | wide-band | (wide band)) near device) & ((narrowband | narrow-band | (narrow band)) near device))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 16:13
S38	108	(((wideband | wide-band | (wide band)) near device) same ((narrowband | narrow-band | (narrow band)) near device))	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 16:13
S39	6	S21 & S37	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 16:13
S40	2	S21 & S38	US-PGPUB; USPAT; DERWENT	ADJ	ON	2016/03/03 16:14

3/ 3/ 2016 5:34:45 PM
C:\ Users\ jwood2\ Documents\ EAST\ Workspaces\ 14372363.wsp

PTO/SB/429(08-12)
Approved for use through 07/31/2015. OMB 0651-0031
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THIRD-PARTY SUBMISSION UNDER 37 CFR 1.290	Application Number	14372363

U.S. PATENTS

Cite No	Patent Number	Kind Code [1]	Issue Date (YYYY-MM-DD)	First Named Inventor

U.S. PATENT APPLICATION PUBLICATIONS

Cite No	Publication Number	Kind Code [1]	Publication Date (YYYY-MM-DD)	First Named Inventor
1	20090180430		2009-07-16	Fadell; Anthony M.
2	20100135242		2010-06-03	Nam; Young-Han

FOREIGN PATENTS AND PUBLISHED FOREIGN PATENT APPLICATIONS

Cite No	Foreign Document Number [3]	Country Code [2]	Kind Code [1]	Publication Date (YYYY-MM-DD)	Applicant, Patentee or First Named Inventor	T [5]
						☐

NON-PATENT PUBLICATIONS (e.g., journal article, Office action)

Cite No	Author (if any), title of the publication, page(s) being submitted, publication date, publisher (where available), place of publication (where available).	T [5]	E [6]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.W./

Receipt date: 01/22/2015 THIRD-PARTY SUBMISSION UNDER 37 CFR 1.290	Application Number	14372363 - GAU: 2415 14372363

		☐	☐

STATEMENTS

The party making the submission is not an individual who has a duty to disclose information with respect to the above-identified application under 37 CFR 1.56.

This submission complies with the requirements of 35 U.S.C. 122(e) and 37 CFR 1.290.

☐ The fee set forth in 37 CFR 1.290(f) has been submitted herewith.

☒ The fee set forth in 37 CFR 1.290(f) is not required because this submission lists three or fewer total items and, to the knowledge of the person signing the statement after making reasonable inquiry, this submission is the first and the only submission under 35 U.S.C 122(e) filed in the above-identified application by the party making the submission or by a party in privity with the party.

☐ No fee is required because this submission is a resubmission after a finding of non-compliance, and the proper fee set forth in 37 CFR 1.290(f) was submitted with the non-compliant submission or was not required to be submitted because the non-complaint submission was accompanied by the statement set forth in 37 CFR 1.290(g).

Signature	/Candace Guzman/		
Name/Print	Candace Guzman	Registration Number (if applicable)	

Examiner Signature	/Jonathan Wood/	Date Considered	02/22/2016

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14372363	YOUNG, PHILIP
	Examiner	Art Unit
	JONATHAN B WOOD	2415

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor & assignee searches (double patenting) and IDS search	2/23/2016	JBW
H04W76/02,025,041,045; H04W72/00,04$,06,12$; (network device with terminals and multiple frequency BWs)	3/2/2016	JBW
H04W88/00,02,18; (wideband & narrowband, subframe allocation set)	3/3/2016	JBW

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14372363	YOUNG, PHILIP
	Examiner	Art Unit
	JONATHAN B WOOD	2415

✓	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	03/03/2016								
	1	-								
	2	-								
	3	-								
	4	-								
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	25	-								
	26	-								
	27	-								
	28	-								
	29	-								
	30	✓								
	31	✓								
	32	✓								
	33	✓								
	34	✓								
	35	✓								
	36	✓								

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14372363	YOUNG, PHILIP
	Examiner	**Art Unit**
	JONATHAN B WOOD	2415

✓	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	03/03/2016								
	37	✓								
	38	✓								
	39	✓								
	40	✓								
	41	✓								

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BIB DATA SHEET

CONFIRMATION NO. 1411

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
14/372,363	07/15/2014	370	2415	IPW2-USAP205496

APPLICANTS
Intellectual Ventures Holding 81 LLC, Las Vegas, NV;

INVENTORS
Philip Young, Alton, UNITED KINGDOM;

**** CONTINUING DATA ***************************
This application is a 371 of PCT/GB2013/050126 01/21/2013

**** FOREIGN APPLICATIONS ***************************
UNITED KINGDOM 1201000.5 01/20/2012

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
09/15/2014

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	/JONATHAN WOOD/ Examiner's Signature	☐ Initials	UNITED KINGDOM	8	12	2

ADDRESS

VOLPE AND KOENIG, P.C.
UNITED PLAZA
30 SOUTH 17TH STREET, 18th Floor
PHILADELPHIA, PA 19103
UNITED STATES

TITLE

WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

FILING FEE RECEIVED		
1620	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

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Application	Document	Mailroom Date	Attorney Docket No.
14372363	CTNF	03/11/2016	IPW2-USAP205496
	892	03/11/2016	IPW2-USAP205496
	1449	03/11/2016	IPW2-USAP205496

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Application	Document	Mailroom Date	Attorney Docket No.
14372363	M327	02/04/2015	IPW2-USAP205496

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/372,363	07/15/2014	Philip Young	IPW2-USAP205496	1411

3624 7590 02/04/2015

VOLPE AND KOENIG, P.C.
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

EXAMINER
NGO, RICKY QUOC

ART UNIT	PAPER NUMBER
2464	

NOTIFICATION DATE	DELIVERY MODE
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APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
14/372,363	15 July, 2014	YOUNG, PHILIP	IPW2-USAP205496

VOLPE AND KOENIG, P.C.
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

EXAMINER	
JUSTIN RIDER	
ART UNIT	PAPER
2400	20150203

DATE MAILED:

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A third-party submission under 37 CFR 1.290 was filed on January 22nd, and is being entered in the above-identified application. Please allow a few days for the submission to be visible in the Patent Application Information Retrieval (PAIR) system. Note that the submission will be identified using the "Information Disclosure Statement Filed" Document Description. This Document Description is being used for the internal purposes only. The Office does not consider the submission to be an Information Disclosure Statement under 37 CFR 1.97 and 1.98.

Any questions regarding this communication should be directed to Justin W. Rider at (571) 270-1068. A secondary contact is Christopher Grant (571) 272-7294

/JUSTIN RIDER/
Supervisory Patent Examiner, Art Unit 2400

PTO-90C (Rev.04-03)

THIRD-PARTY SUBMISSION UNDER 37 CFR 1.290
CONCISE DESCRIPTION OF RELEVANCE

Application Number	14372363

U.S. PATENTS

Cite No	Patent Number	Concise Description of Relevance

U.S. PATENT APPLICATION PUBLICATION

Cite No	Publication Number	Concise Description of Relevance
1	20100135242	See Attached

2	20090180430	See Attached

FOREIGN PATENT DOCUMENTS		
CiteNo	**Foreign Document Number**	**Concise Description of Relevance**

NON-PATENT PUBLICATIONS		
Cite No	**Reference**	**Concise Description of Relevance**

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THIRD-PARTY SUBMISSION UNDER 37 CFR 1.290	Application Number	14372363

U.S. PATENTS				
Cite No	Patent Number	Kind Code [1]	Issue Date (YYYY-MM-DD)	First Named Inventor

U.S. PATENT APPLICATION PUBLICATIONS				
Cite No	Publication Number	Kind Code [1]	Publication Date (YYYY-MM-DD)	First Named Inventor
1	20090180430		2009-07-16	Fadell; Anthony M.
2	20100135242		2010-06-03	Nam; Young-Han

FOREIGN PATENTS AND PUBLISHED FOREIGN PATENT APPLICATIONS						
Cite No	Foreign Document Number [3]	Country Code [2]	Kind Code [1]	Publication Date (YYYY-MM-DD)	Applicant, Patentee or First Named Inventor	T [5]
						☐

NON-PATENT PUBLICATIONS (e.g., journal article, Office action)			
Cite No	Author (if any), title of the publication, page(s) being submitted, publication date, publisher (where available), place of publication (where available).	T [5]	E [6]

THIRD-PARTY SUBMISSION UNDER 37 CFR 1.290	Application Number	14372363

		☐	☐

STATEMENTS

The party making the submission is not an individual who has a duty to disclose information with respect to the above-identified application under 37 CFR 1.56.

This submission complies with the requirements of 35 U.S.C. 122(e) and 37 CFR 1.290.

☐ The fee set forth in 37 CFR 1.290(f) has been submitted herewith.

☒ The fee set forth in 37 CFR 1.290(f) is not required because this submission lists three or fewer total items and, to the knowledge of the person signing the statement after making reasonable inquiry, this submission is the first and the only submission under 35 U.S.C 122(e) filed in the above-identified application by the party making the submission or by a party in privity with the party.

☐ No fee is required because this submission is a resubmission after a finding of non-compliance, and the proper fee set forth in 37 CFR 1.290(f) was submitted with the non-compliant submission or was not required to be submitted because the non-complaint submission was accompanied by the statement set forth in 37 CFR 1.290(g).

Signature	/Candace Guzman/		
Name/Print	Candace Guzman	Registration Number (if applicable)	

Examiner Signature		Date Considered	

*EXAMINER: Signature indicates all documents listed above have been considered,except for citations through which a line is drawn. Draw line through citation if not considered. Include a copy of this form with next communication to applicant. 1. If known, enter kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16. See MPEP 901.04(a). 2. Enter the country or patent office that issued the document, by two-letter code under WIPO standard ST.3. See MPEP 1851. 3. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 4. If known, enter the kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 . See MPEP 901.04(a). 5. Check mark indicates translation attached. 6. Check mark indicates evidence of publication attached.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT:	Philip Young
SERIAL NO:	14/372,363
PUBLICATION NO:	20140376509
FILING DATE:	July 15, 2014
TITLE:	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER
EXAMINER:	Ricky Quoc Ngo
GROUP ART UNIT:	2464
CONFIRMATION NO:	1411

CONCISE DESCRIPTION OF ASSERTED REVELENCE ACCOMPANYING THIRD PARTY SUBMISSION PURSUANT TO 35 USC §122(e) AND 37 CFR §1.290

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

Dear Sir,

This concise description of asserted relevance is being submitted pursuant to 35 USC §122(e) and 37 CFR §1.290.

The above identified application has yet to receive a first office action and was published on December 25, 2014. Since this submission is being made within the later of the mailing of the first office action rejecting a claim and six months of the application's publications, it is timely under 37 CFR §1.29(b)(2)(i).

US 20100135242 – Young-Han Nam et al.

US 20100135242 ("'242 prior art") was filed on and has a priority date of October 28, 2009 prior to the filing and priority date of the patent application by Philip Young. ("Young"). The below claim chart identifies the particular passages of the '242 prior art that are equivalent to the Young claims.

CONCISE EXPLANATION OF RELEVANCY

Reference #1 Nam et al. - (US Pat. Pub. No. US2010/0135242 A1)

US 20140376509 **Claims: 40-44 and 46-50** **Priority Date: Jan. 20, 2012**	**US20100135242 A1** **Nam Disclosure** **Priority Date: Oct. 28, 2009**
40. A network device comprising:	For use in a wireless **network** *(network)* comprising a plurality of base stations for communicating With subscriber stations using orthogonal frequency division multiplexing (OFDM), a **first base station** *(a network device)* is provided. (Par. [0004])
a network device configured to wirelessly communicate with a first type of terminal device and a second type of terminal device;	**Base station 102** *(a network device)* provides **wireless broadband access** *(configured to wirelessly communicate)* to Internet 130 to a first plurality of subscriber stations within coverage area 120 of base station 102. The first plurality of subscriber stations includes **subscriber station** *(a first type of terminal device)* 111, which may be located in a small business (SB), subscriber station 112, which may be located in an enterprise (E), subscriber station 113, which may be located in a WiFi hotspot (HS), subscriber station 114, which may be located in a first residence (R), subscriber station 115, which may be located in a second residence (R), and subscriber station 116, which may be a **mobile device (M)**, *(a second type of terminal device)* such as a cell phone, a wireless laptop, a wireless PDA, or the like. (Par. [0035])
the network device further configured to communicate with the first type of terminal device with a host carrier having radio resource segments distributed in time,	For use in a wireless network comprising a **plurality of base stations for communicating with** *(the network device further configured to communicate with)* **subscriber stations** *(the first type of terminal device)* using orthogonal frequency division multiplexing (OFDM), a first base station is provided. The first

	base station comprises a downlink transmit path comprising circuitry configured to **transmit a plurality of dedicated reference (DR) signals in even-numbered time slots and odd-numbered time slots**. *(having radio resource segments distributed in time)* Each of the even-numbered and odd-numbered time slots comprising S OFDM symbols. (Par. [0004]) Within these subframes, the new sets of CRSs are transmitted by the eNodeB either in all the **resource blocks (RBs) over the entire bandwidth**, *(host carrier having radio resource segments)* or only in a subset of the RBs. (Par. [0111])
wherein each radio resource segment provides radio resources across a first frequency band;	The transmitted signal in each slot of a resource block is described by a resource grid of NrbdlNscrb subcarriers and NsymbDL OFDM symbols. The quantity NRBDL depends on the downlink transmission bandwidth configured in the cell and fulfills NRB min.DL<NRBDL<NRB max.DL, where N **RB min.DL and N RB max.DL** *(wherein each radio resource segment provides radio resources)* are the **smallest** *(across a first frequency band)* … (Par. [0048])
the network device further configured to communicate, within a second frequency band,	Each of **base stations** *(the network device)* 101-103 may **implement a transmit path** *(further configured to communicate)* that is analogous to transmitting in the downlink to subscriber stations 111-116 and may implement a receive path that is analogous to receiving in the uplink from subscriber stations 111-116. (Par. [0046]) … and **largest downlink bandwidth**, *(within a second frequency band)* respectively, supported. In some

	embodiments, subcarriers are considered the smallest elements that are capable of being modulated. (Par. [0048])
with the second type of terminal device using a subordinate carrier comprising resources that are a subset of the host carrier radio resource segments; and	Subscriber station 116 may be any of a number of **mobile devices**, *(the second type of terminal device)* including a wireless enabled laptop computer, personal data assistant, notebook, handheld device, or other wireless-enabled device. (Par. [0038]) Within these **subframes**, the new sets of CRSs are transmitted by the eNodeB either in all the **resource blocks (RBs)** *(the host carrier radio resource segments)* over the entire bandwidth, or **only in a subset of the RBs**. *(using a subordinate carrier comprising resources that are a subset)* (Par. [0111])
wherein the second frequency band is narrower than and contained within the first frequency band.	The quantity NRBDL depends on the downlink transmission bandwidth configured in the cell and fulfills NRB min.DL<NRBDL<NRB max.DL, where N RB min.DL and N RB max.DL are the **smallest** and **largest downlink bandwidth**, *(the second frequency band is narrower than and contained within the first frequency band)* respectively, supported. In some embodiments, subcarriers are considered the smallest elements that are capable of being modulated. (Par. [0048])
41. The network device of claim 40 further comprising: the radio resource segments are subframes of radio frames having a plurality of subframes; and subframes are allocated to the subordinate carrier using a subordinate carrier subframe allocation set, wherein the subordinate carrier subframe allocation set determines which subframes within a repeating group of one or more	No Art Found.

radio frames are allocated to the subordinate carrier.	
42. The network device of claim 41, wherein the subordinate carrier subframe allocation set is defined by one or more reserved subframe allocation patterns.	When cell-specific frequency shifting is applied, the **subcarrier indices** *(the subordinate carrier)* at RS REs in a resource block in a **subframe circularly shift** *(one or more reserved subframe allocation patterns)* by an integer number. (Par. [0055]) Conversely, DRSs are transmitted by the eNodeB only within certain resource blocks such that only a subset of DEs in the cell are **allocated to receive the packet**. *(the subordinate carrier subframe allocation set)* Accordingly, the packets are accessed only by the subset of DEs. (Par. [0054])
43. The network device of claim 42, wherein the one or more reserved subframe allocation patterns comprise substantially all or a subset of all reserved subframe allocation patterns of the host carrier.	When cell-specific frequency shifting is applied, the subcarrier indices at RS REs in a resource block in a **subframe** *(one or more reserved subframe)* circularly shift by an integer number. (Par. [0055]) Conversely, DRSs are transmitted by the eNodeB only within certain resource blocks such that only a subset of DEs in the cell are **allocated to receive the packet**. *(allocation patterns comprise substantially all or a subset of all reserved subframe allocation patterns of the host carrier)* Accordingly, the packets are accessed only by the subset of DEs. (Par. [0054]) The new sets of CRSs are transmitted by an eNodeB in LTE-A subframes. Within these sub frames, the new sets of CRSs are **transmitted** by the eNodeB **either in all the resource blocks (RBs) over the entire bandwidth, or only in a subset of the RBs**. *(all or a subset of all reserved subframe allocation patterns of the host carrier)* (Par. [0111])

44. The network device of claim 42 further comprising: acquisition information required for the second type of terminal device to receive the subordinate carrier is allocated to subframes of the subordinate carrier using at least a portion of the subframes in the one or more reserved subframe allocation patterns.	When cell-specific frequency shifting is applied, the **subcarrier indices** *(the subordinate carrier)* at RS REs in a resource block in a **subframe** *(subframe allocation set)* circularly shift by an integer number. (Par. [0055]) Conversely, DRSs are transmitted by the eNodeB only within certain resource blocks such that only a subset of DEs in the cell are **allocated to receive the packet**. *(defined by one or more reserved subframe allocation patterns)* Accordingly, the packets are accessed only by the subset of DEs. (Par. [0054])
45. The network device of claim 40, wherein the first type of terminal device is capable of receiving a full bandwidth of the first frequency band, wherein the second type of terminal device is incapable of receiving the full bandwidth of the first frequency band, and wherein the second type of terminal device is capable of receiving the full bandwidth of the second frequency band.	See ref. #2.
46. A method performed by a network device, the method comprising: communicating, wirelessly by the network device, with a first type of terminal device	**METHOD** *(method)* AND SYSTEM FOR REFERENCE SIGNAL PATTERN DESIGN (Title) For use in a wireless **network** *(network)* comprising a plurality of base stations for communicating With subscriber stations using orthogonal frequency division multiplexing (OFDM), a **first base station** *(a network device)* is provided. (Par. [0004]) **Base station 102** *(the network device)* provides **wireless broadband access**

and a second type of terminal device;	*(communicating, wirelessly)* to Internet 130 to a first plurality of subscriber stations within coverage area 120 of base station 102. The first plurality of subscriber stations includes **subscriber station** *(a first type of terminal device)* 111, which may be located in a small business (SB), subscriber station 112, which may be located in an enterprise (E), subscriber station 113, which may be located in a WiFi hotspot (HS), subscriber station 114, which may be located in a first residence (R), subscriber station 115, which may be located in a second residence (R), and subscriber station 116, which may be a **mobile device (M)**, *(a second type of terminal device)* such as a cell phone, a wireless laptop, a wireless PDA, or the like. (Par. [0035])
communicating, by the network device, with the first type of terminal device with a host carrier having radio resource segments distributed in time,	For use in a wireless network comprising a **plurality of base stations for communicating with** *(communicating, by the network device)* **subscriber stations** *(with the first type of terminal device)* using orthogonal frequency division multiplexing (OFDM), a first base station is provided. The first base station comprises a downlink transmit path comprising circuitry configured to **transmit a plurality of dedicated reference (DR) signals in even-numbered time slots and odd-numbered time slots**. *(with a host carrier having radio resource segments distributed in time)* Each of the even-numbered and odd-numbered time slots comprising S OFDM symbols. (Par. [0004]) Within these subframes, the new sets of CRSs are transmitted by the eNodeB either in all the **resource blocks (RBs) over the entire bandwidth**, *(with a host carrier having radio resource segments distributed in time)* or only in a subset of the RBs. (Par. [0111])

wherein each radio resource segment provides radio resources across a first frequency band;	The transmitted signal in each slot of a resource block is described by a resource grid of NrbdlNscrb subcarriers and NsymbDL OFDM symbols. The quantity NRBDL depends on the downlink transmission bandwidth configured in the cell and fulfills NRB min.DL<NRBDL<NRB max.DL, where N **RB min.DL and N RB max.DL** *(wherein each radio resource segment provides radio resources)* are the **smallest** *(across a first frequency band)* … (Par. [0048])
communicating, by the network device within a second frequency band, with the second type of terminal device using a subordinate carrier comprising resources that are a subset of the host carrier radio resource segments; and	Subscriber station 116 may be any of a number of **mobile devices**, *(the second type of terminal device)* including a wireless enabled laptop computer, personal data assistant, notebook, handheld device, or other wireless-enabled device. (Par. [0038]) Within these **subframes**, the new sets of CRSs are **transmitted** *(communicating, by the network device)* by the eNodeB either in all the **resource blocks (RBs)** *(the host carrier radio resource segments)* over the entire bandwidth, or **only in a subset of the RBs**. *(subordinate carrier comprising resources that are a subset of the host carrier radio resource segments)* (Par. [0111])
wherein the second frequency band is narrower than and contained within the first frequency band.	The quantity NRBDL depends on the downlink transmission bandwidth configured in the cell and fulfills NRB min.DL<NRBDL<NRB max.DL, where N RB min.DL and N RB max.DL are the **smallest** and **largest downlink bandwidth**, *(the second frequency band is narrower than and contained within the first frequency band)* respectively, supported. In some embodiments, subcarriers are considered the smallest elements that are capable of being

	modulated. (Par. [0048])
47. The method of claim 46 further comprising: the radio resource segments are subframes of radio frames having a plurality of subframes; and subframes are allocated to the subordinate carrier using a subordinate carrier subframe allocation set, wherein the subordinate carrier subframe allocation set determines which subframes within a repeating group of one or more radio frames are allocated to the subordinate carrier.	No Art Found
48. The method of claim 47, wherein the subordinate carrier subframe allocation set is defined by one or more reserved subframe allocation patterns.	When cell-specific frequency shifting is applied, the **subcarrier indices** *(the subordinate carrier)* at RS REs in a resource block in a **subframe circularly shift** *(one or more reserved subframe allocation patterns)* by an integer number. (Par. [0055]) Conversely, DRSs are transmitted by the eNodeB only within certain resource blocks such that only a subset of DEs in the cell are **allocated to receive the packet**. *(the subordinate carrier subframe allocation set)* Accordingly, the packets are accessed only by the subset of DEs. (Par. [0054])
49. The method of claim 48, wherein the one or more reserved subframe allocation patterns comprise substantially all or a subset of all reserved subframe allocation patterns of the host carrier.	When cell-specific frequency shifting is applied, the subcarrier indices at RS REs in a resource block in a **subframe** *(one or more reserved subframe)* circularly shift by an integer number. (Par. [0055]) Conversely, DRSs are transmitted by the eNodeB only within certain resource blocks such that only a subset of DEs in the cell are **allocated to receive the packet**. *(allocation patterns comprise substantially all or a subset of all reserved subframe allocation patterns of the host carrier)* Accordingly, the packets are accessed only by the subset of DEs.

	(Par. [0054]) The new sets of CRSs are transmitted by an eNodeB in LTE-A subframes. Within these sub frames, the new sets of CRSs are **transmitted** by the eNodeB **either in all the resource blocks (RBs) over the entire bandwidth, or only in a subset of the RBs**. *(all or a subset of all reserved subframe allocation patterns of the host carrier)* (Par. [0111])
50. The method of claim 48 further comprising: acquisition information required for the second type of terminal device to receive the subordinate carrier is allocated to subframes of the subordinate carrier using at least a portion of the subframes in the one or more reserved subframe allocation patterns.	When cell-specific frequency shifting is applied, the **subcarrier indices** *(the subordinate carrier)* at RS REs in a resource block in a **subframe** *(subframe allocation set)* circularly shift by an integer number. (Par. [0055]) Conversely, DRSs are transmitted by the eNodeB only within certain resource blocks such that only a subset of DEs in the cell are **allocated to receive the packet**. *(defined by one or more reserved subframe allocation patterns)* Accordingly, the packets are accessed only by the subset of DEs. (Par. [0054])

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT:	Philip Young
SERIAL NO:	14/372,363
PUBLICATION NO:	20140376509
FILING DATE:	July 15, 2014
TITLE:	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER
EXAMINER:	Ricky Quoc Ngo
GROUP ART UNIT:	2464
CONFIRMATION NO:	1411

CONCISE DESCRIPTION OF ASSERTED REVELENCE ACCOMPANYING THIRD PARTY SUBMISSION PURSUANT TO 35 USC §122(e) AND 37 CFR §1.290

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

Dear Sir,

This concise description of asserted relevance is being submitted pursuant to 35 USC §122(e) and 37 CFR §1.290.

The above identified application has yet to receive a first office action and was published on December 25, 2014. Since this submission is being made within the later of the mailing of the first office action rejecting a claim and six months of the application's publications, it is timely under 37 CFR §1.29(b)(2)(i).

US 20090180430 – Anthony Fadell

US 20090180430 ("'430 prior art") was filed on and has a priority date of January 1, 2008 prior to the filing and priority date of the patent application by Philip Young. ("Young"). The below claim chart identifies the particular passages of the '430 prior art that are equivalent to the Young claims.

CONCISE EXPLANATION OF RELEVANCY

Reference #2 Fadell - (US Pat. Pub. No. US2009/0180430 A1)

US 20140376509 **Claim: 45** **Priority Date: Jan. 20, 2012**	**US20090180430 A1** **Fadell Disclosure** **Priority Date: Jan. 10, 2008**
45. The network device of claim 40, wherein the first type of terminal device is capable of receiving a full bandwidth of the first frequency band, wherein the second type of terminal device is incapable of receiving the full bandwidth of the first frequency band, and wherein the second type of terminal device is capable of receiving the full bandwidth of the second frequency band.	The aforementioned VoiP application might be classified by the resource management client program as "**low bandwidth**", *(wherein the second type of terminal device is incapable of receiving the full bandwidth of the first frequency band, and wherein the second type of terminal device is capable of receiving the full bandwidth of the second frequency band)* and the streaming video application (e.g., Windows Media, Real Player, etc.), as "**high bandwidth**", *(the first type of terminal device is capable of receiving a full bandwidth of the first frequency band)* thereby in combination making the client's resource requirements "high bandwidth" for purposes of allocation. (Par. [0091])

Electronic Acknowledgement Receipt

EFS ID:	21285370
Application Number:	14372363
International Application Number:	
Confirmation Number:	1411
Title of Invention:	
First Named Inventor/Applicant Name:	
Correspondence Address:	- - - - - - - - - -
Filer:	Candace Guzman
Filer Authorized By:	
Attorney Docket Number:	
Receipt Date:	22-JAN-2015
Filing Date:	
Time Stamp:	19:08:11
Application Type:	

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	Concise Description of Relevance	Concise-description-generated.pdf	28621 8c33df21a3c1029c8b88eb63cef2b7a4d2da608c	no	3
Warnings:					
Information:					
2	Third-Party Submission Under 37 CFR 1.290	Third-party-preissuance-submission.pdf	41908 0f2fc76de3c2c71656a29b96d34ad853b374db1f	no	2
Warnings:					
Information:					
3	Request for Notification of Non-compliant Third-Party Submission	Third-party-notification-request.pdf	19635 e1ec0b01aca117c5068f38fd25f60e4164c904e1	no	1
Warnings:					
Information:					
4	Concise Description of Relevance	Reference1Nam_USPatPubNo_US20100135242_123.pdf	69882 427a33cb3511abe5f7b586bc1843c6449f3f8ab2	no	10
Warnings:					
Information:					
5	Concise Description of Relevance	Reference2Fadel_USPatPubNo_US20090180430_123.pdf	48487 9dfaf52ebeb69d96e34cda14fcac415c5654d356	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	208533		

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

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/372,363	07/15/2014	Philip Young	IPW2-USAP205496

CONFIRMATION NO. 1411

3624
VOLPE AND KOENIG, P.C.
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

PUBLICATION NOTICE

OC00000072574115

Title:WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

Publication No.US-2014-0376509-A1
Publication Date:12/25/2014

NOTICE OF PUBLICATION OF APPLICATION

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

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

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

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

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

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To: eoffice@volpe-koenig.com,,
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 3624

Dec 29, 2014 05:29:17 AM

Dear PAIR Customer:

VOLPE AND KOENIG, P.C.
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103
UNITED STATES

The following USPTO patent application(s) associated with your Customer Number, 3624 , have new outgoing correspondence. This correspondence is now available for viewing in Private PAIR.

The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

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Application	Document	Mailroom Date	Attorney Docket No.
14372363	NTC.PUB	12/29/2014	IPW2-USAP205496

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Thank you for prompt attention to this notice,

UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

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U.S. APPLICATION NUMBER NO.	FIRST NAMED INVENTOR	ATTY. DOCKET NO.
14/372,363	Philip Young	IPW2-USAP205496

3624
VOLPE AND KOENIG, P.C.
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

INTERNATIONAL APPLICATION NO.	
PCT/GB2013/050126	
I.A. FILING DATE	PRIORITY DATE
01/21/2013	01/20/2012

CONFIRMATION NO. 1411
371 ACCEPTANCE LETTER

OC000000070769860

Date Mailed: 09/18/2014

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office, in its capacity as a Designated / Elected Office (37 CFR 1.495), has ACCEPTED the above identified international application for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above. A Filing Receipt will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE or 371(c) DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1) and (c)(2) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN BELOW.** The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363)

07/15/2014
DATE OF RECEIPT OF 35 U.S.C.
371(c)(1) and (c)(2) REQUIREMENTS

The following items have been received:

- Copy of the International Application filed on 07/15/2014
- Copy of the International Search Report filed on 07/15/2014
- Preliminary Amendments filed on 07/15/2014
- Request for Immediate Examination filed on 07/15/2014
- U.S. Basic National Fees filed on 07/15/2014
- Priority Documents filed on 07/15/2014
- Application Data Sheet (37 CFR 1.76) filed on 07/15/2014

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 1.495(c).

- Properly executed inventor's oath or declaration for the following inventor(s) has not been submitted: **Philip Young**

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

FREDERICK SMITH

Telephone: (571) 272-8679

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
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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
14/372,363	07/15/2014		1620	IPW2-USAP205496	12	2

CONFIRMATION NO. 1411

3624
VOLPE AND KOENIG, P.C.
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

FILING RECEIPT

OC000000070769859

Date Mailed: 09/18/2014

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)
Philip Young, Alton, UNITED KINGDOM;

Applicant(s)
Intellectual Ventures Holding 81 LLC, Las Vegas, NV

Assignment For Published Patent Application
INTELLECTUAL VENTURES HOLDING 81 LLC, Las Vegas, NV

Power of Attorney: The patent practitioners associated with Customer Number 03624

Domestic Priority data as claimed by applicant
This application is a 371 of PCT/GB2013/050126 01/21/2013

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
UNITED KINGDOM 1201000.5 01/20/2012 No Access Code Provided

If Required, Foreign Filing License Granted: 09/15/2014

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/372,363**

Projected Publication Date: 12/25/2014

Non-Publication Request: No

Early Publication Request: No

Title

WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

Preliminary Class

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

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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

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

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

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

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific 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.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/372,363

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	480
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	12 minus 20 =	*			OR	x 80 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*				x 420 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1480

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($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

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

MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET

Substitute for Form PTO-1360
(For use with Form PTO/SB/06)

Application Number	Filing Date
14372363	

Applicant(s) Philip YOUNG

* May be used for additional claims or amendments

CLAIMS	AS FILED		AFTER FIRST AMENDMENT		AFTER SECOND AMENDMENT	
	Indep	Depend	Indep	Depend	Indep	Depend
1	1		---	---		
2		1	---	---		
3		1	---	---		
4		1	---	---		
5		2	---	---		
6		(1)	---	---		
7		(1)	---	---		
8		(1)	---	---		
9		(1)	---	---		
10		(1)	---	---		
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47				1		
48				1		
49				1		
50				1		
Total Indep	5		2		0	
Total Depend	35	↵	10	↵	0	↵
Total Claims	40		12		0	

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	Indep	Depend	Indep	Depend	Indep	Depend
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To: eoffice@volpe-koenig.com,,
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 3624

Sep 18, 2014 05:31:02 AM

Dear PAIR Customer:

VOLPE AND KOENIG, P.C.
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103
UNITED STATES

The following USPTO patent application(s) associated with your Customer Number, 3624 , have new outgoing correspondence. This correspondence is now available for viewing in Private PAIR.

The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

Disclaimer:
The list of documents shown below is provided as a courtesy and is not part of the official file wrapper. The content of the images shown in PAIR is the official record.

Application	Document	Mailroom Date	Attorney Docket No.
14372363	M903	09/18/2014	IPW2-USAP205496
	APP.FILE.REC	09/18/2014	IPW2-USAP205496

To view your correspondence online or update your email addresses, please visit us anytime at https://sportal.uspto.gov/secure/myportal/privatepair.

If you have any questions, please email the Electronic Business Center (EBC) at EBC@uspto.gov with 'e-Office Action' on the subject line or call 1-866-217-9197 during the following hours:

Monday - Friday 6:00 a.m. to 12:00 a.m.

Thank you for prompt attention to this notice,

UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

PTO-1390 (06-13)
Approved for use through 6/30/2013. OMB 0651-0021
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.

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

Attorney Docket No.	U.S. Application No. (if known, see 37 CFR 1.5)
IPW2-USAP205496	

International Application No.	International Filing Date	Priority Date Claimed
PCT/GB2013/050126	21 January 2013	20 January 2012

Title of Invention
WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

First Named Inventor
Philip YOUNG

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☑ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.
2. ☑ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).
3. An English language translation of the International Application (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
   a. ☐ is attached.
   b. ☐ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).
6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).
7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
10. ☑ A preliminary amendment.
11. ☑ An Application Data Sheet under 37 CFR 1.76.
12. ☑ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).
13. ☐ A power of attorney and/or change of address letter.
14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825.
15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee: _____
16. ☐ 37 CFR 3.73(c) Statement *(when there is an Assignee)*.

This collection of information is required by 37 CFR 1.414 and 1.491-1.492. 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 15 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

U.S. APPLN. No. (if known – see 37 CFR 1.5)	INTERNATIONAL APPLICATION No.	ATTORNEY DOCKET No.
	PCT/GB2013/050126	IPW2-USAP205496

17. ☑ Other items or information:

PCT Request Form for PCT/GB2013/050126
WO 2013/108048 Publication
Notification of Submission, Obtention or Transmittal of Priority Document (PCT/IB/304)
International Search Report and Written Opinion

The following fees have been submitted.	CALCULATIONS	PTO USE ONLY
18. ☑ Basic national fee (37 CFR 1.492(a)) **$280**	$ 280	
19. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$720**	$ 720	
20. ☑ Search fee (37 CFR 1.492(b)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .....**$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .....**$480** All other situations **$600**	$ 480	
TOTAL OF 18, 19, and 20 =	$ 1480	

☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)).
Fee for each additional 50 sheets of paper or fraction thereof **$400**

Total Sheets	Extra Sheets	Number of each addition 50 or fraction thereof (round **up** to a whole number)	RATE	
40 - 100 =	/ 50 =		x **$400**	$

Surcharge of **$140.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$ 140	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	12 - 20 =		x **$80**	$	
Independent claims	2 - 3 =		x **$420**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			**+ $780**	$	

Processing fee of **$140.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). **+**	$	
TOTAL OF ABOVE CALCULATIONS =	$ 1620	
☐ **Applicant asserts small entity status.** See 37 CFR 1.27. Fees above are reduced by ½.		
☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Fees above are reduced by ¾. Applicant must attach form PTO/SB/15A or B or equivalent.		
TOTAL NATIONAL FEE =	$ 1620	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property. **+**	$	
TOTAL FEES ENCLOSED =	$ 1620	
	Amount to be refunded:	$
	Amount to be charged:	$

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

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees.

c. ☑ The Director is hereby authorized to charge additional fees which may be required, or credit any overpayment, to Deposit Account No. 220493 as follows:

i. ☑ any required fee.

ii. ☐ any required fee except for excess claims fees required under 37 CFR 1.492(d) and (e) and multiple dependent claim fee required under 37 CFR 1.492(f).

d. ☑ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended to pay fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

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 1: 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**.

NOTE 2: A U.S. national stage application may not claim priority to the international application of which it is the national phase. The filing date of a U.S. national stage application is the international filing date. See 35 U.S.C. 363.

Correspondence Address

☑ The address associated with Customer Number: 03624 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone			
Email					

Signature	/Harry Vartanian/	Date	July 15, 2014
Name (Print/Type)	Harry Vartanian	Registration No. (Attorney/Agent)	56,787

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.

PTO/AIA/14 (12-13)
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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	IPW2-USAP205496
	Application Number	
Title of Invention	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER	

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Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Philip		YOUNG	

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

City	Alton	Country of Residence i	GB

Mailing Address of Inventor:

Address 1	Sweet Briar, Hussell Lane		
Address 2	Medstead		
City	Alton, Hampshire	**State/Province**	
Postal Code	GU34 5PF	**Country** i	GB

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Application Information:

Title of the Invention	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER		
Attorney Docket Number	IPW2-USAP205496	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	8	**Suggested Figure for Publication (if any)**	3

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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).

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Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	a 371 of international	PCT/GB2013/050126	2013-01-21

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	IPW2-USAP205496
	Application Number	
Title of Invention	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER	

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Application Number	Country [i]	Filing Date (YYYY-MM-DD)	Access Code [i] (if applicable)
1201000.5	GB	2012-01-20	

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☐ 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.
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Authorization to Permit Access:

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◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
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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	Intellectual Ventures Holding 81 LLC

Mailing Address Information:

Address 1	7251 West Lake Mead Boulevard		
Address 2	Suite 300		
City	Las Vegas	**State/Province**	NV
Country [i]	US	Postal Code	89128
Phone Number		Fax Number	

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Organization Name	Intellectual Ventures Holding 81 LLC

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	7251 West Lake Mead Boulevard		
Address 2			
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Country i	US	Postal Code	89128
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Signature	/Harry Vartanian/			Date (YYYY-MM-DD)	2014-07-15
First Name	Harry	Last Name	Vartanian	Registration Number	56787

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	IPW2-USAP205496
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Title of Invention	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER	

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SUBSTITUTE SPECIFICATION - MARKED UP

WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

FIELD OF THE INVENTION

[0001] The present invention relates to wireless communications systems and methods, and in particular to a system, method, base station and terminal device for communicating using a subordinate carrier of a host carrier.

BACKGROUND OF THE INVENTION

[0002] Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

[0003] Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architectures, are able to support a more sophisticated range of services than simple voice and messaging services offered by previous generations of mobile telecommunication systems.

[0004] For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications

such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and the coverage area of these networks, i.e. geographic locations where access to the networks is possible, is expected to increase rapidly.

[0005] The anticipated widespread deployment of third and fourth generation networks has led to the parallel development of a class of devices and applications which, rather than taking advantage of the high data rates available, instead take advantage of the robust radio interface and increasing ubiquity of the coverage area. Examples include so-called machine type communication (MTC) applications, also known as machine-to-machine (M2M) communications, some of which are in some respects typified by semi-autonomous or autonomous wireless communication devices (i.e. MTC devices) communicating small amounts of data on a relatively infrequent basis. Examples include so-called smart meters which, for example, are located in a customer's home and periodically transmit data back to a central MTC server relating to the customer's consumption of a utility such as gas, water, electricity and so on.

[0006] Whilst it can be convenient for a terminal such as an MTC-type terminal to take advantage of the wide coverage area provided by a third or fourth generation mobile telecommunication network there are at present disadvantages. Unlike a conventional third or fourth generation mobile terminal such as a smartphone, a primary driver for MTC-type terminals will be a desire for such terminals to be relatively simple and inexpensive. The type of functions typically performed by a MTC-type terminal (e.g. simple collection and reporting of relatively small amounts of data) do not require particularly complex processing to perform, for example, compared to a smartphone supporting video streaming. However, third and fourth generation mobile telecommunication networks typically employ advanced data modulation techniques and support wide bandwidth usage on the

radio interface which can require more complex and expensive radio transceivers to implement. It is usually justified to include such complex transceivers in a smartphone as a smartphone will typically require a powerful processor to perform typical smartphone type functions. However, as indicated above, there is now a desire to use relatively inexpensive and less complex devices to communicate using LTE type networks.

SUMMARY OF THE INVENTION

[0007] According to a first aspect of the invention there is provided a wireless communications system, comprising a base station, one or more terminal devices of a first type and one or more terminal devices of a second type. The base station is operable to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0008] In this way, an efficient and flexible mechanism for specifying and controlling an amount and location of radio resources to be dedicated to a subordinate earner for use by a particular (e.g. reduced capability) type of device can be provided.

[0009] One way of achieving this differentiated access between the terminal devices of the first type and second type is to allocate a part of the carrier resource that is dedicated to the second type of device (e.g. MTC traffic) using normal eNB (base station) scheduling. The eNB differentiates between MTC and non-MTC (example of the first type of device) UEs and only schedules MTC UEs within the reserved part of the earner resource and only schedules non-MTC UEs outside of

the reserved part of the carrier resource. While this solution is viable, the simple scheduling approach places some restrictions on the MTC subordinate carrier that can be realised. For instance, it would be necessary to use the same carrier characteristics and/or reference signals. If it were advantageous to use different carrier characteristics or to use additional or modified reference signals then this may not be possible in an MTC subordinate carrier implemented purely by eNB scheduling.

[0010] The radio resource segments may be sub-frames of radio frames, each radio frame comprising a plurality of sub-frames. In this case, the sub-frames may be allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set, the subordinate carrier sub-frame allocation set determining which sub frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The subordinate carrier sub-frame allocation set may be defined by one or more reserved sub-frame allocation patterns. The one or more reserved sub-frame allocation patterns may comprise all or a sub-set of all reserved sub-frame allocation patterns defined for the host carrier.

[0011] In one example, the subframes selected for the subordinate carrier are so-called MBSFN (Multimedia Broadcast/multicast service over a Single Frequency Network) subframes. This embodiment relies on the fact that such subframes do not have to be used exclusively for MBSFN. The LTE Rel. 8/9/10 specifications define a means (in the standard LTE SystemInformationBlockType2 - SIB2) by which certain subframes can be excluded from normal allocation to the Physical Downlink Shared Channel (PDSCH). Furthermore, the specifications define signalling within the standard system information which allows some or all of these excluded subframes to be used for other defined purposes, such as MBMS (in SystemInformationBlockType13 - SIB 13), relay and positioning reference signal transmission. However, reading of this system information may require reception across the whole carrier bandwidth.

[0012] Acquisition information required for a terminal device of the second type to receive the subordinate carrier may be allocated for inclusion in sub-frames of the subordinate carrier using at least a portion of the subframes in one or more of the reserved sub-frame allocation patterns defining the subordinate carrier.

[0013] The base station may be operable to transmit an indication of the radio resources of all reserved sub-frames to terminal devices of the first type. In this way, the first type of device is informed of subframes which are reserved for the subordinate carrier, another subordinate carrier, and for other purposes such as relay backhaul. A particular device of the first type is not required to know why a particular sub-frame is reserved, merely that it is not available to that device. This indication may be presented to the terminal devices of the first type as a reserved subframe allocation within a system information block transmitted using frequency resources not necessarily limited to the second frequency band of the subordinate carrier. In this way, it is possible to exclude non-MTC devices from a resource reserved for the subordinate carrier.

[0014] The base station may be operable to transmit, using radio resources within the second frequency band, subordinate carrier information indicating that a subordinate carrier is available within the host carrier. A terminal device of the second type may be responsive to subordinate carrier information indicating that a subordinate carrier is not available within the host carrier to terminate a camp-on procedure for camping on to the network.

[0015] The subordinate carrier information may be provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the system information of the host carrier. The first acquisition information may be a master information block transmitted on a physical broadcast channel within radio resources of the host earner. In this way it is possible to signal via the first acquisition information, to terminal devices of the second type,

the presence of an MTC subordinate carrier existing within the reserved resource and using only a restricted bandwidth. If the subordinate carrier information is not present then the camp-on process by a terminal device may be terminated early, thereby reducing time and power wastage at the terminal device.

[0016] The first type of terminal device may be capable of receiving the full bandwidth of the first frequency band, and the second type of terminal device may not be capable of receiving the full bandwidth of the first frequency band but be capable of receiving the full bandwidth of the second frequency band. The bandwidth of the subordinate carrier may be predetermined and be known in advance to terminal devices of the second type. Alternatively, the base station may be operable to transmit, using radio resources within the second frequency band, an indication of the bandwidth of the subordinate carrier. In this case the bandwidth need not necessarily be predetermined. The indication of the bandwidth of the subordinate carrier may be provided within first acquisition information transmitted on radio resources within the second frequency band, the acquisition information being provided to permit a terminal device of the first type to receive the host carrier downlink and camp on to the host carrier. Alternatively, the base station may be operable to transmit, using radio resources of the subordinate carrier, an indication of the bandwidth of the subordinate carrier.

[0017] The base station may be operable to transmit, using radio resources of the subordinate carrier, second acquisition information required for a terminal device of the second type to receive the subordinate carrier downlink and camp on to the subordinate carrier. The second acquisition information may be transmitted on predetermined radio resources which are known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the bandwidth of the subordinate carrier. In this way, it is possible to signal system information defining the characteristics of the MTC subordinate carrier using only resources within the MTC subordinate carrier.

[0018] The radio resource segments may be sub-frames of radio frames in the time direction, each radio frame comprising a plurality of sub-frames. The second acquisition information may be transmitted in at least some of the sub-frames allocated to the subordinate carrier. A terminal device of the second type may be operable to determine whether a sub-frame contains second acquisition information from a current radio frame number and a first sub-frame allocation set for allocating the second acquisition information to sub-frames within the subordinate carrier, said first sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames contain the second acquisition information.

[0019] The current radio frame number may be determined from first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the host carrier downlink and camp on to the network. The first sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the current radio frame number. Accordingly, once the second acquisition information is available to a mobile terminal, it may from that point on obtain the current radio frame number from the second acquisition information rather than having to refer back to the first acquisition information.

[0020] A terminal device of the second type may be operable to determine whether a sub-frame is allocated to the subordinate carrier from a current radio frame number and a second sub-frame allocation set for the subordinate carrier, said second sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The current radio frame number may be determined from the second acquisition information. Alternatively, the current radio frame number may be determined from the first acquisition information and updated by counting radio frames.

[0021] The second sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. Alternatively, the second sub-frame allocation set may be specified in the second acquisition information. It will be appreciated that the second sub-frame allocation set may be different to the first sub-frame allocation set, but will include all of the sub-frames of the first sub-frame allocation set (and probably additional sub-frames as well).

[0022] The first type of terminal device may be an LTE device and the second type of device may be a low data rate device. The first type of terminal device may be an LTE device and the second type of device may be a low data rate device for providing machine-to-machine (M2M) communication.

[0023] It will be appreciated that different radio resource segments of the same or a different frequency band may be used to support a further subordinate carrier.

[0024] At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host earner allocated to the subordinate carrier may be allocated to another subordinate carrier. In other words, a different frequency band of the same resource segments (in time) may support another carrier.

[0025] At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier may be used for communicating with terminal devices of the first type. In other words, a different frequency band of the same resource segments (in time) may support the host carrier.

[0026] Viewed from another aspect, there is provided a base station for communicating with terminal devices. The base station is operable to communicate with terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to

communicate with terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0027] Viewed from another aspect, there is provided a terminal device for communicating with a base station which supports a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The terminal device is operable to communicate with the base station using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0028] Viewed from another aspect, there is provided a method of communicating between a base station and terminal devices of a first type and a second type. The method comprises communicating between the base station and terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and communicating between the base station and terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0029] Viewed from another aspect, there is provided a method of communicating with a base station from a terminal device, comprising communicating with the base station using a subordinate carrier of a host carrier comprising radio resource segments distributed in time, each radio resource segment of the host carrier providing radio resources across a first frequency band, the subordinate carrier comprising radio resources within a second frequency band

of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0030] It will be appreciated that features of the above-described aspects and embodiments of the invention may be combined with features of other aspects and embodiments of the invention as appropriate and in combinations other than those explicitly set out. For example, optional features of the first aspect of the invention may equally optionally be incorporated in embodiments according to other aspects of the invention, for example where the different aspects have corresponding features.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Example embodiments of the present invention will now be described with reference to the accompanying drawings in which like parts have the same designated references and in which:

[0032] Figure 1 is a schematic block diagram of a radio network and a plurality of user equipments forming a wireless communication system which operates in accordance with the 3GPP Long Term Evolution (LTE) standard;

[0033] Figure 2 schematically represents elements of a mobile telecommunications system for implementing embodiments of the invention;

[0034] Figure 3 schematically represents a time and frequency resource allocation between a host carrier and a subordinate carrier;

[0035] Figure 4 schematically illustrates a radio frame and resource grid structure of time and frequency resources;

[0036] Figures 5A to 5D schematically illustrate example allocations of resources to the subordinate carrier;

[0037] Figure 6 is a schematic flow diagram of a first part of a camp-on procedure for connecting to the subordinate carrier;

[0038] Figure 7 is a schematic flow diagram of a second part of the camp-on procedure for connecting to the subordinate carrier; and

[0039] Figure 8 schematically illustrates a signalling configuration according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

Network Structure

[0040] Embodiments of the present invention are described herein with particular reference to an example implementation in a wireless communication system having carriers based around the 3GPP Long Term Evolution (LTE) standard.

[0041] Figure 1 schematically shows an example architecture of an LTE system. The LTE system is provided by a telecommunications network operator to allow parties to communicate. As shown in Figure 1, mobile communications devices designated as user equipment (UE) 105 are arranged to communicate data to and from base stations (transceiver stations) 101 which are frequently referred to in LTE as E-UTRAN NodeBs (e-nodeB). Each of the base stations 101 comprises a transceiver unit 103 enabling communication of data to and from a plurality of mobile communication devices via a radio interface. The e-nodeBs 101 are connected to a serving gateway S-GW 104 and to a mobility management entity (MME) 107. The S-GW 104 is arranged to perform routing and management of mobile communications services to the communications devices 105 in the mobile radio network. In order to maintain mobility management and connectivity, the mobility management entity (MME) 107 manages evolved packet system (EPS) connections with the communications devices 105 using subscriber information stored in a home subscriber server (HSS) 108. Other core network components include a packet data network gateway (P-GW) 106 which connects to an internet network 109 and finally to an external server (not shown). In the context of MTC

communications a UE supporting MTC communications may, for example, be conveniently referred to as an MTC terminal or MTC UE, and a server with which the MTC terminal(s) communicate data may, for example, be conveniently referred to as an MTC server. More generally, devices in the system capable of supporting MTC communications may be referred to as MTC entities. The various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [1]. These conventional aspects of LTE networks are not described further in the interest of brevity.

[0042] Two classes of device are considered herein. A first class of device is configured to communicate via a host carrier, and a second class of device is configured to communicate via a subordinate carrier. In some of the particular examples considered here, the first class of device and the host carrier are compliant with particular standards, for example, LTE Rel. 8/9/10 standards, and the second class of device and the subordinate carrier are compliant with modified versions of these particular standards, for example, based on versions of the standards modified to support lower-capability devices. Accordingly, and purely for the sake of reference and to aid explanation, the first class of device and the host carrier may be referred to here in some examples as legacy devices and legacy carrier, while the second class of device and the subordinate carrier may be referred to in some examples as MTC devices and MTC carrier (or in alternative DMN (Dedicated Messaging Network) devices and DMN carrier). However, it will be appreciated that these terms are simply used as labels for ease of explanation of particular implementations of embodiments of the invention for distinguishing the two classes of device and carrier. Thus, the term "legacy" should not be considered as indicating any form of obsolescence, and indeed the devices and carrier(s) referred to here as legacy devices and carrier(s) may equally correspond with

devices and carrier(s) that comply with future releases of the LTE standards, for examples Rel. 11 and beyond. Equally, and as already noted above, DMN should not be taken to refer to a network which exclusively supports only basic messaging services. Furthermore, the second class of device and subordinate carrier that are described here as not being fully compliant with the operating standards of the first class of device and first carrier (for example because of reduced capability) may nonetheless be compliant with their own standards. Furthermore, the functionality described herein as regards both the first and second classes of device and carriers might comply with different aspects of a future standard, for example a future release of the LTE standards.

[0043] Referring now to Figure 2, a base station 101' is shown communicatively connected to an LTE device 105a via a transceiver unit 103' and a first (host) earner 110a, and communicatively connected to an MTC device 105b via the transceiver unit 103' and a second (subordinate) carrier 110b. The base station 101' is responsible for a coverage area in which both the LTE device 105a and the MTC device 105b are located. The single base station 101' is able to communicate on both the first carrier 110a and the second carrier 110b. The first carrier 110a is a host carrier having a broad bandwidth, while the second carrier 110b is a subordinate carrier having a narrower bandwidth located within the frequency band of the host earner. As will be explained in more detail below, the time and frequency resources of the first (host) carrier and the second (subordinate) carrier are logically separate for the purposes of data transmission and most control signalling, but some time and frequency resources are accessible to and used by devices connected to both the first and second carriers.

Host Carrier and Subordinate Carrier Overview

[0044] Referring to Figure 3, the time and frequency resources constituting the host carrier and the subordinate carrier are schematically illustrated. The horizontal axis of Figure 3 is time, with a time period from t_1 to t_2 being shown in

Figure 3. The vertical axis of Figure 3 is frequency, the frequency increasing from a frequency f_1 to a frequency f_4. The host carrier has a frequency band F_1, extending from the frequency f_1 to the frequency f_4. The subordinate earner has a frequency band F_2, extending from a frequency f_2 to a frequency f_3. The subordinate carrier is intended primarily for use by terminal devices which do not have the capability to receive or transmit between the frequencies f_1 and f_2, and between the frequencies f_3 and f_4. The subordinate carrier does not occupy all of the time and frequency resources within the frequency band F_2. Instead, certain time periods 305 of the frequency band F_2 are allocated to the subordinate carrier (and potentially to other subordinate carriers), with the unallocated time periods within the frequency band F_2 forming part of the host carrier resources. The shaded portions 310 of Figure 3 indicates those time and frequency resources allocated to the subordinate carrier. When a time period 305 is allocated to the subordinate carrier, the time and frequency resources 315 falling outside of the frequency band F_2 (but within the frequency band F_1) are not allocated to the subordinate carrier. In some implementations these time and frequency resources may be available to the host carrier (or to another subordinate earner having a different (and non-overlapping) frequency band). In other implementations these time and frequency resources may be "lost" and unusable by either the first type of device or the second type of device. It is envisaged that the central frequency and bandwidth of the frequency bands F_1 and F_2 would be fixed for a given host carrier/subordinate carrier, although implementations in which they are not fixed may be possible. The particular time periods allocated to the subordinate carrier may be fixed, or may be dynamically variable, for example to increase or decrease the amount of radio resources allocated to the subordinate carrier to adapt to traffic conditions of the subordinate carrier (and/or possibly of the host carrier).

Radio Frame and Resource Grid Structure

[0045] Referring now to Figure 4, a radio frame and resource grid structure for an LTE type network ~~are~~ is schematically illustrated. At the top of Figure 4, a radio frame 410 is shown. This occupies the full width of the frequency band of the host carrier, and has a duration of 10ms. The radio frame 410 is one of a sequence of radio frames which are used to communicate data between a base station and a terminal device. The radio frame 410 comprises 10 sub-frames 420, which again occupy the fully width of the frequency band of the host carrier. Each of these sub-frames 420 has a duration of 1ms. Each of the sub-frames 420 comprises two slots 430, each slot occupying the full width of the frequency band of the host carrier and having a duration of 0.5ms. Each slot comprises a plurality of resource blocks 440 in the frequency direction, and only a single resource block 440 in the time direction. In other words each resource block 440 has a duration of 0.5ms (the same as the duration of the slot 430), but occupies only a portion of the bandwidth of the host carrier. Each resource block 440 comprises a two-dimensional array of resource elements 450 distributed in both the time direction and the frequency direction. Each resource element 450 has a length (duration) of one modulation symbol, and a frequency range of one subcarrier (e.g. 15kHz). In the present case the resource block 440 has a dimension of 12 resource elements 450 in the frequency dimension and 7 resource elements 450 in the time dimension, resulting in an overall bandwidth of 12 subcarriers and a duration of 7 symbols.

[0046] In operation, data transmissions between a base station and a terminal device may be scheduled to use particular resource blocks. This scheduling is usually carried out by the base station or a related network entity. Certain resource blocks may be permanently allocated to carry predetermined signalling information.

[0047] 3GPP LTE Releases 8, 9 and 10 (Rel. 8/9/10) define 6 downlink transmission bandwidth configurations from 1.4 MHz to 20 MHz representing the use of 6, 15, 25, 50, 75 or 100 resource blocks. As noted above, all Rel. 8/9/10

terminal devices are required to support the maximum single carrier bandwidth of 20 MHz for compliance with the Rel. 8/9/10 standards. Nevertheless, for all bandwidth configurations Rel. 8/9/10 has specified that basic physical layer synchronisation signals (Primary Synchronisation Signals - PSS, and Secondary Synchronisation Signals - SSS), and the most fundamental system information (Master Information Block - MIB) is transmitted using only the central 6 resource blocks which are receivable with a 1.4 MHz transceiver. However, in order to receive the remainder of the carrier system information the terminal device is required to be able to receive the full bandwidth of the carrier.

[0048] However, and as also noted above, for some applications, for example in situations relating to machine type communications (MTC) and/or dedicated messaging networks (DMN), there is a drive to build low cost and hence low capability devices. Ideally, device simplification should permit a reduction in required bandwidth of operation as well as reduction of features and throughput. Terminal devices with a lower bandwidth capability than that specified for Rel. 8/9/10 may mean that such devices are unable to operate properly on Rel. 8/9/10 compliant networks which specify higher bandwidth capabilities. For example, terminal devices with a lower bandwidth capability may not even be able to receive any more system information than that contained in the MIB of a Rel. 8/9/10 compliant network.

[0049] Low capability devices will ideally be able to find and camp-on the carrier associated with their target dedicated messaging network(s) even in the presence of Rel. 8/9/10 higher bandwidth carriers. Furthermore, there is a desire that DMN carriers are not swamped by Rel. 8/9/10 capable devices camping-on the DMN, even though the Rel. 8/9/10 capable devices are in the coverage area of a higher bandwidth Rel. 8/9/10 carrier which they could otherwise use.

Subordinate Carrier Definition

[0050] As described in relation to Figure 3, the subordinate carrier resources (for use by MTC devices) may be defined by a certain bandwidth in the frequency domain (frequency band F_2 in Figure 3 for example) and a certain pattern of time periods in the time domain. The certain pattern of time periods may be a sequence of subframes as described above with reference to Figure 4. The sequence of subframes may be a sequence of MBSFN subframes as defined by signalling within SystemInformationBlockType2 (SIB2) of the legacy LTE host carrier. However, it will be recognised that the subordinate carrier may be delineated by other means, for example by scheduling by a base station. The pattern of subframes may be a subset (or all) of those subframes reserved by the information element mbsfh-SubframeConfigList in the host carrier SIB2.

[0051] Conveniently, non-MTC UEs will read SIB2 of the legacy LTE host carrier and determine that a configured pattern of subframes are reserved for other purposes (such as MBMS, relay or as in the present case MTC subordinate carrier operation). The non-MTC UEs will therefore ignore the subframes allocated to the subordinate carrier. The configured pattern of reserved subframes is defined in a flexible manner by the information element mbsfn-SubframeConfigList.

[0052] In particular, mbsfn-SubframeConfigList comprises a set of 1 or more subframe allocations each of which is defined by the following fragment of ASN.1 from TS 36.331:

```
MBSFN-SubframeConfig ::=     SEQUENCE {
        radioframeAllocationPeriod      ENUMERATED {n1 , n2, n4, n8, n16, n32},
        radioframeAllocationOffset      INTEGER (0..7),
        subframeAllocation                      CHOICE {
                oneFrame                                BIT STRING (SIZE(6)),
                fourFrames                              BIT STRING (SIZE(24))
        }
}
```

[0053] For a given allocation, the "radioframeAllocationPeriod" indicates the periodicity, in radio frames, with which MBSFN subframes are included in the allocation, "n1" indicates that MBSFN subframes are present in every radio frame, while "n2" indicates that MBSFN subframes are present in every other radio frame. A radioframeAllocationPeriod of "n32" indicates that one in every 32 radio frames includes one or more MBSFN subframes. Radio-frames that contain MBSFN subframes occur when equation SystemFrameNumber mod radioFrameAllocationPeriod = radioFrameAllocationOffset is satisfied. In other words, the radioframeAllocationOffset parameter sets an offset for a start position of the repeating pattern of radio frames. The subframeAllocation parameter defines the subframes that are allocated for MBSFN within the radio frame allocation period defined by the radioFrameAllocationPeriod and the radioFrameAllocationOffset parameters. The subframe allocation can either be specified for a single radio frame within the radio frame allocation period (oneFrame) or for four consecutive radio frames within the radio frame allocation period (four Frames). The subFrameAllocation parameter is a 6 bit (oneFrame) or 24 bit (fourFrame) mask, indicating whether each of 6 (oneFrame) or 24 (fourFrame) predetermined subframes are to be reserved. The LTE specification places restrictions on which subframes may be reserved for other purposes by this method, in order that there is no conflict with the requirement to receive system information and paging. In an FDD LTE system one or more of subframes 1, 2, 3, 6, 7 and 8 may be reserved for other purposes. In a TDD LTE system the subframes that may be reserved are 3, 4, 7, 8 and 9. The system frame number can be derived from the MIB of the host carrier.

[0054] Figures 5A to 5D are example subframe patterns. Each of Figures 5 A to 5D shows a portion of a repeating pattern which could be specified by mbsfn-SubframeConfigList or by a similar pattern specifying function. Four radio frames having ten subframes each are shown in Figures 5A to 5D. The subframes are

labelled from 0 (zero) to 9 (nine). The shaded subframes are those allocated to the subordinate carrier, with the unshaded subframes being retained for use on the host carrier. Figure 5A schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 111111 (thereby selecting each of subframes 1, 2, 3, 6, 7 and 8). It will be appreciated that this subframe allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

[0055] Figure 5B schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 11111x (thereby selecting each of subframes 3, 4, 7, 8 and 9). It should be noted that the last bit of the mask is not used for TDD. The difference between Figures 5A and 5B results from the different subframes mapped to the bit mask in the FDD and TDD schemes.

[0056] Figure 5C schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n1 (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 101010 (thereby selecting each of subframes 1, 3 and 7). It will be appreciated that this subframe 615 allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

[0057] Figure 5D schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to nl (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 10101x (thereby selecting each of

subframes 3, 7 and 9). It should be noted that the last bit of the mask is not used for TDD. Again, the difference between Figures 5C and 5D results from the different subframes mapped to the bit mask in the FDD and TDD schemes. All of the patterns shown in Figures 5A to 5D will repeat until the mbsfn-SubframeConfigList is altered. The set of allocation patterns specified in mbsfn-SubframeConfigList , which is signalled in SIB2, defines the "reserved set". A sub-set of the allocation patterns could be used to define the subordinate earner. Also, two mutually exclusive sub-sets could be used to define two separate subordinate carriers delimited in the time domain.

[0058] It will be appreciated that this mechanism provides a great deal of flexibility in how much carrier resource is to be allocated to the subordinate carrier, and also how that resource is distributed with respect to time. The minimum (non-zero) amount of resources (in the time domain) which can be allocated is 1 in 320 subframes (when radioframeAllocationPeriod is set to n32 and only one bit is set in the subframeAllocation bit mask). The maximum amount of resources (in the time domain) which can be allocated is 192 in 320 subframes (when radioframeAllocationPeriod is set to n1 and all six bits are set in the subframeAllocation bit mask). In some implementations the allocation might be static to provide a fixed resource subordinate carrier. The fixed resources could in this case be known to a terminal device in advance. In other implementations the allocation might be dynamic, resulting in a subordinate carrier having a resource allocation which can be increased or decreased to for example meet traffic loading conditions on the subordinate carrier and/or on the host carrier. These increases or decreases could be based on requests from terminal devices for additional resource, or based on decisions made at the base station or a related entity. An increase in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined above, or by adding a new subframe allocation according to the principles set out

above. A decrease in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined above, or by removing an existing subframe allocation.

[0059] In other words, it is possible to use multiple subframe allocations to achieve allocation patterns which would not be possible with a single subframe allocation, and to provide a simple way of increasing (or decreasing, if one of multiple subframe allocations is removed) the amount of resources allocated to the subordinate carrier. In one implementation, a first subframe allocation with a relatively low allocation period and subframe allocation could be used to maintain a low resource subordinate carrier which can be camped onto by a low capability terminal device, and then further subframe allocations could be added to service the communication needs of the low capability terminal device when it has successfully camped on. In this way, the resources available to the host carrier are retained at a high level to serve LTE traffic when the subordinate carrier is not in use.

Signalling the presence of the Subordinate Carrier

[0060] Certain resource blocks may be used to carry control signalling including synchronisation signals and system information. As explained above, a problem can therefore arise if essential control signalling from the base station is transmitted outside of the frequency range which can be received by a low-capability device. Fortunately, as described above, the synchronisation signals and the Master Information Block (MIB) of the system information are present within a frequency range which is likely to be receivable by a low-capability device. However, further system information, carried in System Information Blocks (SIBs), and the associated control signalling may be transmitted at a frequency which cannot be received by the low-capability device. This would cause problems, potentially preventing the low-capability device from being able to camp on to the network. It will be appreciated that not all host carriers will necessary support a subordinate carrier. If a low-capability device attempts to camp-on to a network

which does not support a subordinate carrier then the camp-on procedure will ultimately fail. This is a waste of time and power for the low-capability device.

[0061] It would therefore be desirable to signal to an MTC UE which has restricted reception bandwidth the presence of an MTC subordinate carrier within a larger bandwidth LTE carrier accessible to legacy UEs (LTE Rel. 8/9/10 UEs). It was discussed above that for all LTE bandwidths (Rel. 8/9/10) the basic physical layer synchronisation signals and the most important system information (Master Information Block) is transmitted using only the central 6 resource blocks (72 subcarriers). The Master Information Block (MIB) is transmitted in the Physical Broadcast Channel (PBCH) which is allocated to the central 72 subcarriers and to just the first 4 OFDMA symbols of the second slot of every 10ms radio frame. Thus, assuming that the low bandwidth MT UE is able to receive at least 6 resource blocks in the frequency domain, then the PBCH (for example the MIB) may be used to signal the presence of an MTC subordinate carrier.

[0062] In Figure 6, a schematic flow diagram of a first part of a camp-on procedure is shown. At a step A1, an MTC device seeking to camp-on to a subordinate carrier, for example following power-up, seeks to identify and decode PSS (Primary Synchronisation Signals) and SSS (Secondary Synchronisation Signals) signalling being broadcast in its location. Once the MTC device synchronises to a carrier using the PSS and SSS, the MTC device determines the frame timing and proceeds to decode the PBCH to determine the MIB for the carrier. At a step A2, the MTC device determines whether or not a subordinate carrier indicator flag is present in the MIB. The MTC subordinate carrier indicator flag may be signalled in one (or more) of the MIB bits that are spare in LTE Release 8 / 9 / 10 (10 bits are currently spare). If the MTC device determines that the MIB contains a subordinate carrier indicator flag then the camp-on process continues at a step A3. If on the other hand the MTC subordinate carrier indicator flag was found not to be present, then the camp-on procedure to this carrier would be

terminated. This would allow the device to decide upon proceeding with camp-on (or not) simply based upon decoding of the legacy LTE MIB, and to discontinue with camp-on immediately after the decoding of the legacy LTE MIB should the subordinate carrier indicator flag not be present. As an alternative to using the MIB to signal the presence of a subordinate carrier, a subordinate carrier indicator signal could be provided at a known time / frequency somewhere other than in the MIB. The particular time / frequency may be defined referentially with respect to the MIB (for example). The subordinate carrier indicator signal may be relative to the host carrier PBCH and/or the System Frame Number conveyed in the host carrier PBCH / MIB. In this case the MTC device would, following synchronisation (at the step A1), search for the subordinate carrier indicator signal at the expected time / frequency (at the step A2). If it is found, then the MTC device knows that one (or more) subordinate carriers are present and continues its discovery of the MTC subordinate carrier and the subsequent camp-on process.

[0063] In either implementation, it will be appreciated that the presence of the subordinate carrier indicator is derivable by the MTC device without being required to decode any system information block (SIB) of the host carrier since the MTC device may be unable to receive the host carrier SIBs which are signalled across the full host carrier frequency band F1.

[0064] If the MTC device does not find a subordinate carrier associated with the host carrier, then it may search for and seek to camp-on to another carrier by returning to the step A1 to seek to synchronise with and decode PBCH for a different carrier.

Signalling the bandwidth of the subordinate carrier(s

[0065] Having detected the presence of an MTC subordinate carrier the UE needs to determine the bandwidth of the subordinate carrier in order to be able to read the further system information which will contain the other characteristics of

the subordinate carrier. There are a number of alternative ways in which the subordinate carrier bandwidth may be signalled to the MTC UE:

(1) The simplest method is to fix the bandwidth of the subordinate carrier in the 3GPP specifications. Having detected the presence of a subordinate carrier in the manner described above, the MTC UE would know by definition the MTC subordinate carrier bandwidth (e.g. 1,4MHz, 3MHz or 5 MHZ).

(2) The downlink bandwidth of the MTC subordinate carrier may be signalled in the legacy LTE MIB. For example if the subordinate carrier indicator flag were signalled in the PBCH by using a 2 bit field, 4 states could be signalled (absence of a subordinate earner and three different subordinate carrier bandwidths, e.g. 1.4MHz, 3MHz and 5 MHZ).

(3) The downlink bandwidth (and possibly other characteristics) of the MTC subordinate carrier could be signalled in a Subordinate Carrier Master Information Block (scMIB). The scMIB would be signalled in fixed time / frequency resources, known in advance to the mobile terminal and preferably defined in the 3GPP specifications. The possibilities for signalling the scMIB are described in the following section.

Signalling the Subordinate Carrier Master Information Block (scMIB)

[0066] In the above section three methods of determining the downlink bandwidth of an MTC subordinate carrier by an MTC UE have been described. The first two of these methods involve a priori knowledge of when decoding of the subordinate carrier begins. The last of the described methods involves signalling the downlink bandwidth in a Master Information Block of the subordinate carrier itself.

[0067] A Master Information Block may be regarded as collection of parameters giving values to configurable characteristics of the carrier and other information to achieve/maintain radio frame synchronisation. A Master

Information Block is required to be supplied in fixed time/frequency resources and must be received and decoded before a more flexible scheme of downlink message exchange may be employed. According to the above description, at the point at which the UE tries to decode the scMIB, the UE will know:

- That an MTC subordinate carrier is present (from the indicator flag / signal).
- The subordinate carrier centre frequency (it may generally be assumed that this will be the same as the centre frequency of the host legacy LTE carrier).

[0068] In addition the UE may know the MTC subordinate carrier bandwidth, if this has been fixed in the specifications, conveyed in the host carrier MIB or conveyed by some other a priori means. In order to receive and decode the scMIB the UE must be able to determine in which resource elements it is carried. The number of resource elements used for the scMIB could be related to the subordinate carrier bandwidth or it could be fixed (as is the case for the legacy LTE MIB). If the number of resource elements were defined to be dependent upon the subordinate carrier bandwidth, this would require the value of the subordinate carrier bandwidth to be known a priori. There are a limited number of spare bits available in the legacy host carrier LTE MIB, and so it may be considered that there are not sufficient available to use 1 or more of these to carry subordinate carrier bandwidth information. In this case, the UE will not have a priori knowledge of the subordinate carrier bandwidth so the UE will be unable to derive the scMIB resource elements from the bandwidth. Accordingly, for the purposes of the following description it is assumed that the scMIB is always signalled in a fixed set of resource elements defined within the 3GPP specifications. Nonetheless, it should be understood that the present invention is not limited to this, and that in certain implementations the set of resource elements used to convey the scMIB may not be fixed.

[0069] The fixed set of resource elements is contained within a subset (or all) of those subframes reserved by one (or more) of the subframe allocations configured

in the information element mbsfn-SubframeConfigList broadcast in the host carrier SIB2. The fixed subframe allocation to convey the scMIB should:

- Be frequent enough to occasion an acceptable latency for acquisition of the scMIB by MTC UEs.
- Not be too frequent that excessive resources are consumed from the host carrier and subordinate carrier.

[0070] It should be noted that it is common for MTC devices to exhibit low mobility and be able to tolerate comparatively high latencies in message transmission. However, this may not be the case with all possible MTC traffic and it is therefore preferable that the frequency of MIB transmission be fixed within the 3GPP specification and thus cannot be configured dependent upon the expected MTC traffic characteristics.

[0071] Various fixed characteristics of the scMIB transmission scheme, including the following, should preferably be defined within the 3GPP specifications:

- The number, periodicity and relationship to host carrier System Frame Number of the subframes used for scMIB.
- The level of repetition encoding employed.
- Within the subframes used, the number and location of resource elements used to convey the scMIB (that is, exactly which slot(s), subcarriers and symbols are to be used).

[0072] The number of resource elements used for the scMIB will be a function of the number of bits of information that must be conveyed by this method, which will be influenced by the further details of the subordinate carrier design, but the number will also be constrained by the overhead that this imposes. The System Frame Number, necessary for the UE to maintain radio frame synchronisation, upon which many LTE higher layer processes are dependent, may be read from the host carrier MIB. However, for efficiency reasons it is likely that once the UE

synchronises to the subordinate carrier, it would be undesirable for the UE to have to keep re-reading the host carrier MIB to maintain this information. Thus, System Frame Number is likely to be carried by the scMIB, although the UE might depend upon the host carrier MIB for this information.

[0073] Any combination of parameters conforming to and fully resolving the definition of MBSFN-SubframeConfig may be chosen to define which subframes convey the scMIB. However, use of a single subframe allocation pattern will provide a solution involving least complexity. For example a single pattern comprising a single subframe allocation once per radio frame allocation period of 32 frames and with an offset value of zero may be considered adequate to convey the scMIB dependent upon other details of the subordinate carrier design. Alternatively, if more MIB bits are required then a shorter allocation period of, for example, 16 or 8 radio frames could be used and/or more subframes per allocation period. Note that while the subframes used to convey the scMIB may be defined by such a subframe allocation pattern or patterns, not all slots or resource elements in the subframes defined by the pattern(s) are necessarily used to convey the scMIB. Use of a shorter allocation period but sparse use of the resource elements for the scMIB may offer the best compromise in relation to scMIB acquisition time and resource overhead.

[0074] The subframe allocation pattern or patterns chosen to define the subframes used for the scMIB will be included in the mbsfn-SubframeConfigList of SIB2 of the host carrier in order to reserve these subframes for special use within the context of the host carrier. However, low bandwidth MTC UEs searching for a suitable subordinate carrier will not be required to read SIB2 of the host carrier to gain this information, since the subframe allocation pattern(s) for the scMIB will be fixed and defined in the 3GPP specifications.

Camp-on procedure

[0075] Referring to Figure 7, the camp-on procedure following the initial steps shown in Figure 6 is schematically illustrated. At a step B1 the location of the scMIB is determined. As discussed above, the location of the scMIB is likely to be fixed in the 3GPP standards, and so the MTC UE will be able to frame synchronise with the scMIB broadcast by comparing the location of the scMIB (radio frame and sub-frame known from the 3GPP specifications) with the current System Frame Number (which the MTC UE can derive from the host carrier MIB). At a step B2 the scMIB is received and decoded, whereby the system information specified therein can be acquired and used. At a step B3 the bandwidth and central frequency of the subordinate carrier is determined. The bandwidth of the subordinate carrier may be determined by one of the methods described above in the section "Signalling the Bandwidth of the Subordinate Carrier(s)". The central frequency may be assumed to be the same as that of the host carrier, but in some implementations may have a different central frequency which would need to be signalled to the MTC UE. The central frequency and bandwidth together identify the frequency band forming the subordinate carrier. Note that if the bandwidth is not determined from the scMIB then the step B3 can be performed before (or in parallel with) the steps B1 and B2.

[0076] At a step B4, the allocation of subordinate carrier subframes is determined. An indication of those subframes allocated to the subordinate carrier may be specified in the scMIB. As described above, sub-frames are allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set which determines which sub frames within a repeating group of radio frames are allocated to the subordinate carrier. At a step B5, further system information (System Information Blocks) relating to the subordinate carrier is obtained from subframes allocated to the subordinate carrier. This further system information can be used to complete the camp on procedure of the MTC UE to the subordinate carrier at a step B6. The further system information may be at a fixed location within the radio

resources of the subordinate carrier, or at a location within the radio resources of the subordinate carrier which has been scheduled by the base station, or a combination of both.

[0077] In Figure 8, example signalling on the host carrier and the subordinate carrier is schematically illustrated. In Figure 8, eight radio frames 800 are shown, each having a central frequency portion 820 usable by both the host carrier and the subordinate carrier, and outer frequency portions 810 usable only by the host carrier. In each radio frame, a MIB 830 is provided in the central frequency portion 820. The MIB 830 is readable by devices using both the host carrier and the subordinate carrier. Devices seeking to use a subordinate carrier may be able to determine from the MIB 830 whether a subordinate carrier exists based on a flag present in the MIB 830. In an outer frequency portion 810, system information 840 is provided for use by devices served by the host carrier. The system information 840 is shown to be outside of the central frequency portion 820 and is thus not available to the kind of low-capability devices intending to use the subordinate carrier. It will be appreciated that some system information may happen to be transmitted within the central frequency portion 820, but this cannot be guaranteed. The system information 840 is provided in the form of System Information Blocks (SIBs). Unlike the Master Information Block which is broadcast on the Physical Broadcast Channel (PBCH), the SIBs are mapped onto the Physical Downlink Shared Channel (PDSCH). Generally, the Master Information Block 830 provides sufficient information to gain access to the first of the System Information Blocks (SIB1), which in turn provides sufficient information to gain access to SIB2 et seq. SIB2 includes parameters relating to the reservation of MBSFN subframes (as described above). Legacy LTE devices using the host carrier will therefore be informed of the subframes reserved for use by the subordinate carrier (or for other purposes, for example MBMS or relay backhaul) when they decode SIB2. They will therefore know that these subframes cannot be used and to ignore them. Within

the central portion 810 of some or all of the radio frames (every other radio frame in this example) is a portion 850 allocated to the subordinate carrier. For the sake of clarity the portion 850 shown in Figure 8 is contiguous, but it will be appreciated from Figures 5A to 5D for example that this may not be the case. The portions 850 are used to transmit data and signalling to low capability devices using the subordinate carrier. Within the allocated portion 850 of the first radio frame is a subordinate carrier MIB (scMIB) 860 carrying various information required for a low capability device to acquire the remainder of the subordinate carrier system information.

[0078] Within the allocated, portion 850 of the second radio frame is system information 870 relating to the subordinate carrier. This system information 870 provides information required for a terminal device to camp on to the subordinate carrier. It will be appreciated that the locations of the scMIB 860 and the system information 870 is purely exemplary. The important point is that the scMIB 860 and the system information 870 are conveyed in the allocated portions 850. As described in detail above, the location and periodicity of the scMIB would probably be fixed (predetermined). The system information 870, which could be conveyed in the form of System Information Blocks in a similar manner to with the host carrier, may be predetermined, or dynamically allocated (scheduled), depending on implementation.

[0079] In the host carrier, the MIB and any associated SIBs together provide the parameters necessary for system access using the host carrier. Similarly, in the subordinate carrier, the scMIB and any associated SIBs carried in subframes allocated to the subordinate carrier provide the parameters necessary for system access using the subordinate carrier. In both cases, the UE (legacy or MTC) requires the MIB to decode the shared channel (and thus access SIBs). The MIB contains downlink system bandwidth of the host carrier and the system frame number.

[0080] The above embodiment describe a method of conveying a subordinate carrier for low bandwidth devices within a portion of a larger host carrier using for example MBSFN subframe allocation pattern(s) to reserve subframes for the subordinate carrier. This permits a flexible and efficient definition of a subordinate carrier within a host carrier. An indication of the presence of the MTC subordinate carrier is provided using a flag in the host carrier MIB. This may require the 3GPP standard to be updated, but will not require any change to legacy LTE devices because the flag is set in current spare bits which can and will be ignored by a legacy device. Various methods of signalling subordinate carrier downlink bandwidth have been described, including fixing the MTC subordinate carrier bandwidth in 3GPP specifications, signalling the subordinate carrier downlink bandwidth via a field in host carrier MIB, or signalling using a bit field within the subordinate carrier MIB (scMIB). A method of defining the subframes used for the subordinate carrier Master Information Block by using fixed (defined in 3GPP specifications) subframe allocation pattern(s) in relation to the System Frame Number of the host carrier has also been described above. A subordinate carrier has been described (in one example) to be specified using a repeating pattern of sub-frames. A mechanism to specify this already exists in LTE, originally for the purpose of specifying sub-frames for use in MBSFN.

[0081] It will be appreciated that various modifications can be made to the embodiments described above without departing from the scope of the present invention as defined in the appended claims. In particular although embodiments of the invention have been described with reference to an LTE mobile radio network, it will be appreciated that the present invention can be applied to other forms of network such as GSM, 3G / UMTS, CDMA2000, etc. The term MTC terminal as used herein can be replaced with user equipment (UE), mobile communications device, mobile terminal etc. Furthermore, although the term base

station has been used interchangeably with e-nodeB it should be understood that there is no difference in functionality between these network entities.

[0082] Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

REFERENCES

[1] Holma H. and Toskala A. "*LTE for UMTS OFDMA and SC-FDMA based radio access*", John Wiley and Sons, 2009.

* * *

SUBSTITUTE SPECIFICATION

WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

FIELD OF THE INVENTION

[0001] The present invention relates to wireless communications systems and methods, and in particular to a system, method, base station and terminal device for communicating using a subordinate carrier of a host carrier.

BACKGROUND OF THE INVENTION

[0002] Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

[0003] Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architectures, are able to support a more sophisticated range of services than simple voice and messaging services offered by previous generations of mobile telecommunication systems.

[0004] For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications

such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and the coverage area of these networks, i.e. geographic locations where access to the networks is possible, is expected to increase rapidly.

[0005] The anticipated widespread deployment of third and fourth generation networks has led to the parallel development of a class of devices and applications which, rather than taking advantage of the high data rates available, instead take advantage of the robust radio interface and increasing ubiquity of the coverage area. Examples include so-called machine type communication (MTC) applications, also known as machine-to-machine (M2M) communications, some of which are in some respects typified by semi-autonomous or autonomous wireless communication devices (i.e. MTC devices) communicating small amounts of data on a relatively infrequent basis. Examples include so-called smart meters which, for example, are located in a customer's home and periodically transmit data back to a central MTC server relating to the customer's consumption of a utility such as gas, water, electricity and so on.

[0006] Whilst it can be convenient for a terminal such as an MTC-type terminal to take advantage of the wide coverage area provided by a third or fourth generation mobile telecommunication network there are at present disadvantages. Unlike a conventional third or fourth generation mobile terminal such as a smartphone, a primary driver for MTC-type terminals will be a desire for such terminals to be relatively simple and inexpensive. The type of functions typically performed by a MTC-type terminal (e.g. simple collection and reporting of relatively small amounts of data) do not require particularly complex processing to perform, for example, compared to a smartphone supporting video streaming. However, third and fourth generation mobile telecommunication networks typically employ advanced data modulation techniques and support wide bandwidth usage on the

radio interface which can require more complex and expensive radio transceivers to implement. It is usually justified to include such complex transceivers in a smartphone as a smartphone will typically require a powerful processor to perform typical smartphone type functions. However, as indicated above, there is now a desire to use relatively inexpensive and less complex devices to communicate using LTE type networks.

SUMMARY OF THE INVENTION

[0007] According to a first aspect of the invention there is provided a wireless communications system, comprising a base station, one or more terminal devices of a first type and one or more terminal devices of a second type. The base station is operable to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0008] In this way, an efficient and flexible mechanism for specifying and controlling an amount and location of radio resources to be dedicated to a subordinate earner for use by a particular (e.g. reduced capability) type of device can be provided.

[0009] One way of achieving this differentiated access between the terminal devices of the first type and second type is to allocate a part of the carrier resource that is dedicated to the second type of device (e.g. MTC traffic) using normal eNB (base station) scheduling. The eNB differentiates between MTC and non-MTC (example of the first type of device) UEs and only schedules MTC UEs within the reserved part of the earner resource and only schedules non-MTC UEs outside of

the reserved part of the carrier resource. While this solution is viable, the simple scheduling approach places some restrictions on the MTC subordinate carrier that can be realised. For instance, it would be necessary to use the same carrier characteristics and/or reference signals. If it were advantageous to use different carrier characteristics or to use additional or modified reference signals then this may not be possible in an MTC subordinate carrier implemented purely by eNB scheduling.

[0010] The radio resource segments may be sub-frames of radio frames, each radio frame comprising a plurality of sub-frames. In this case, the sub-frames may be allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set, the subordinate carrier sub-frame allocation set determining which sub frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The subordinate carrier sub-frame allocation set may be defined by one or more reserved sub-frame allocation patterns. The one or more reserved sub-frame allocation patterns may comprise all or a sub-set of all reserved sub-frame allocation patterns defined for the host carrier.

[0011] In one example, the subframes selected for the subordinate carrier are so-called MBSFN (Multimedia Broadcast/multicast service over a Single Frequency Network) subframes. This embodiment relies on the fact that such subframes do not have to be used exclusively for MBSFN. The LTE Rel. 8/9/10 specifications define a means (in the standard LTE SystemInformationBlockType2 - SIB2) by which certain subframes can be excluded from normal allocation to the Physical Downlink Shared Channel (PDSCH). Furthermore, the specifications define signalling within the standard system information which allows some or all of these excluded subframes to be used for other defined purposes, such as MBMS (in SystemInformationBlockType13 - SIB 13), relay and positioning reference signal transmission. However, reading of this system information may require reception across the whole carrier bandwidth.

[0012] Acquisition information required for a terminal device of the second type to receive the subordinate carrier may be allocated for inclusion in sub-frames of the subordinate carrier using at least a portion of the subframes in one or more of the reserved sub-frame allocation patterns defining the subordinate carrier.

[0013] The base station may be operable to transmit an indication of the radio resources of all reserved sub-frames to terminal devices of the first type. In this way, the first type of device is informed of subframes which are reserved for the subordinate carrier, another subordinate carrier, and for other purposes such as relay backhaul. A particular device of the first type is not required to know why a particular sub-frame is reserved, merely that it is not available to that device. This indication may be presented to the terminal devices of the first type as a reserved subframe allocation within a system information block transmitted using frequency resources not necessarily limited to the second frequency band of the subordinate carrier. In this way, it is possible to exclude non-MTC devices from a resource reserved for the subordinate carrier.

[0014] The base station may be operable to transmit, using radio resources within the second frequency band, subordinate carrier information indicating that a subordinate carrier is available within the host carrier. A terminal device of the second type may be responsive to subordinate carrier information indicating that a subordinate carrier is not available within the host carrier to terminate a camp-on procedure for camping on to the network.

[0015] The subordinate carrier information may be provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the system information of the host carrier. The first acquisition information may be a master information block transmitted on a physical broadcast channel within radio resources of the host earner. In this way it is possible to signal via the first acquisition information, to terminal devices of the second type,

the presence of an MTC subordinate carrier existing within the reserved resource and using only a restricted bandwidth. If the subordinate carrier information is not present then the camp-on process by a terminal device may be terminated early, thereby reducing time and power wastage at the terminal device.

[0016] The first type of terminal device may be capable of receiving the full bandwidth of the first frequency band, and the second type of terminal device may not be capable of receiving the full bandwidth of the first frequency band but be capable of receiving the full bandwidth of the second frequency band. The bandwidth of the subordinate carrier may be predetermined and be known in advance to terminal devices of the second type. Alternatively, the base station may be operable to transmit, using radio resources within the second frequency band, an indication of the bandwidth of the subordinate carrier. In this case the bandwidth need not necessarily be predetermined. The indication of the bandwidth of the subordinate carrier may be provided within first acquisition information transmitted on radio resources within the second frequency band, the acquisition information being provided to permit a terminal device of the first type to receive the host carrier downlink and camp on to the host carrier. Alternatively, the base station may be operable to transmit, using radio resources of the subordinate carrier, an indication of the bandwidth of the subordinate carrier.

[0017] The base station may be operable to transmit, using radio resources of the subordinate carrier, second acquisition information required for a terminal device of the second type to receive the subordinate carrier downlink and camp on to the subordinate carrier. The second acquisition information may be transmitted on predetermined radio resources which are known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the bandwidth of the subordinate carrier. In this way, it is possible to signal system information defining the characteristics of the MTC subordinate carrier using only resources within the MTC subordinate carrier.

[0018] The radio resource segments may be sub-frames of radio frames in the time direction, each radio frame comprising a plurality of sub-frames. The second acquisition information may be transmitted in at least some of the sub-frames allocated to the subordinate carrier. A terminal device of the second type may be operable to determine whether a sub-frame contains second acquisition information from a current radio frame number and a first sub-frame allocation set for allocating the second acquisition information to sub-frames within the subordinate carrier, said first sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames contain the second acquisition information.

[0019] The current radio frame number may be determined from first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the host carrier downlink and camp on to the network. The first sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the current radio frame number. Accordingly, once the second acquisition information is available to a mobile terminal, it may from that point on obtain the current radio frame number from the second acquisition information rather than having to refer back to the first acquisition information.

[0020] A terminal device of the second type may be operable to determine whether a sub-frame is allocated to the subordinate carrier from a current radio frame number and a second sub-frame allocation set for the subordinate carrier, said second sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The current radio frame number may be determined from the second acquisition information. Alternatively, the current radio frame number may be determined from the first acquisition information and updated by counting radio frames.

[0021] The second sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. Alternatively, the second sub-frame allocation set may be specified in the second acquisition information. It will be appreciated that the second sub-frame allocation set may be different to the first sub-frame allocation set, but will include all of the sub-frames of the first sub-frame allocation set (and probably additional sub-frames as well).

[0022] The first type of terminal device may be an LTE device and the second type of device may be a low data rate device. The first type of terminal device may be an LTE device and the second type of device may be a low data rate device for providing machine-to-machine (M2M) communication.

[0023] It will be appreciated that different radio resource segments of the same or a different frequency band may be used to support a further subordinate carrier.

[0024] At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host earner allocated to the subordinate carrier may be allocated to another subordinate carrier. In other words, a different frequency band of the same resource segments (in time) may support another carrier.

[0025] At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier may be used for communicating with terminal devices of the first type. In other words, a different frequency band of the same resource segments (in time) may support the host carrier.

[0026] Viewed from another aspect, there is provided a base station for communicating with terminal devices. The base station is operable to communicate with terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to

communicate with terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0027] Viewed from another aspect, there is provided a terminal device for communicating with a base station which supports a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The terminal device is operable to communicate with the base station using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0028] Viewed from another aspect, there is provided a method of communicating between a base station and terminal devices of a first type and a second type. The method comprises communicating between the base station and terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and communicating between the base station and terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0029] Viewed from another aspect, there is provided a method of communicating with a base station from a terminal device, comprising communicating with the base station using a subordinate carrier of a host carrier comprising radio resource segments distributed in time, each radio resource segment of the host carrier providing radio resources across a first frequency band, the subordinate carrier comprising radio resources within a second frequency band

of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

[0030] It will be appreciated that features of the above-described aspects and embodiments of the invention may be combined with features of other aspects and embodiments of the invention as appropriate and in combinations other than those explicitly set out. For example, optional features of the first aspect of the invention may equally optionally be incorporated in embodiments according to other aspects of the invention, for example where the different aspects have corresponding features.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Example embodiments of the present invention will now be described with reference to the accompanying drawings in which like parts have the same designated references and in which:

[0032] Figure 1 is a schematic block diagram of a radio network and a plurality of user equipments forming a wireless communication system which operates in accordance with the 3GPP Long Term Evolution (LTE) standard;

[0033] Figure 2 schematically represents elements of a mobile telecommunications system for implementing embodiments of the invention;

[0034] Figure 3 schematically represents a time and frequency resource allocation between a host carrier and a subordinate carrier;

[0035] Figure 4 schematically illustrates a radio frame and resource grid structure of time and frequency resources;

[0036] Figures 5A to 5D schematically illustrate example allocations of resources to the subordinate carrier;

[0037] Figure 6 is a schematic flow diagram of a first part of a camp-on procedure for connecting to the subordinate carrier;

[0038] Figure 7 is a schematic flow diagram of a second part of the camp-on procedure for connecting to the subordinate carrier; and

[0039] Figure 8 schematically illustrates a signalling configuration according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

Network Structure

[0040] Embodiments of the present invention are described herein with particular reference to an example implementation in a wireless communication system having carriers based around the 3GPP Long Term Evolution (LTE) standard.

[0041] Figure 1 schematically shows an example architecture of an LTE system. The LTE system is provided by a telecommunications network operator to allow parties to communicate. As shown in Figure 1, mobile communications devices designated as user equipment (UE) 105 are arranged to communicate data to and from base stations (transceiver stations) 101 which are frequently referred to in LTE as E-UTRAN NodeBs (e-nodeB). Each of the base stations 101 comprises a transceiver unit 103 enabling communication of data to and from a plurality of mobile communication devices via a radio interface. The e-nodeBs 101 are connected to a serving gateway S-GW 104 and to a mobility management entity (MME) 107. The S-GW 104 is arranged to perform routing and management of mobile communications services to the communications devices 105 in the mobile radio network. In order to maintain mobility management and connectivity, the mobility management entity (MME) 107 manages evolved packet system (EPS) connections with the communications devices 105 using subscriber information stored in a home subscriber server (HSS) 108. Other core network components include a packet data network gateway (P-GW) 106 which connects to an internet network 109 and finally to an external server (not shown). In the context of MTC

communications a UE supporting MTC communications may, for example, be conveniently referred to as an MTC terminal or MTC UE, and a server with which the MTC terminal(s) communicate data may, for example, be conveniently referred to as an MTC server. More generally, devices in the system capable of supporting MTC communications may be referred to as MTC entities. The various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [1]. These conventional aspects of LTE networks are not described further in the interest of brevity.

[0042] Two classes of device are considered herein. A first class of device is configured to communicate via a host carrier, and a second class of device is configured to communicate via a subordinate carrier. In some of the particular examples considered here, the first class of device and the host carrier are compliant with particular standards, for example, LTE Rel. 8/9/10 standards, and the second class of device and the subordinate carrier are compliant with modified versions of these particular standards, for example, based on versions of the standards modified to support lower-capability devices. Accordingly, and purely for the sake of reference and to aid explanation, the first class of device and the host carrier may be referred to here in some examples as legacy devices and legacy carrier, while the second class of device and the subordinate carrier may be referred to in some examples as MTC devices and MTC carrier (or in alternative DMN (Dedicated Messaging Network) devices and DMN carrier). However, it will be appreciated that these terms are simply used as labels for ease of explanation of particular implementations of embodiments of the invention for distinguishing the two classes of device and carrier. Thus, the term "legacy" should not be considered as indicating any form of obsolescence, and indeed the devices and carrier(s) referred to here as legacy devices and carrier(s) may equally correspond with

devices and carrier(s) that comply with future releases of the LTE standards, for examples Rel. 11 and beyond. Equally, and as already noted above, DMN should not be taken to refer to a network which exclusively supports only basic messaging services. Furthermore, the second class of device and subordinate carrier that are described here as not being fully compliant with the operating standards of the first class of device and first carrier (for example because of reduced capability) may nonetheless be compliant with their own standards. Furthermore, the functionality described herein as regards both the first and second classes of device and carriers might comply with different aspects of a future standard, for example a future release of the LTE standards.

[0043] Referring now to Figure 2, a base station 101' is shown communicatively connected to an LTE device 105a via a transceiver unit 103' and a first (host) earner 110a, and communicatively connected to an MTC device 105b via the transceiver unit 103' and a second (subordinate) carrier 110b. The base station 101' is responsible for a coverage area in which both the LTE device 105a and the MTC device 105b are located. The single base station 101' is able to communicate on both the first carrier 110a and the second carrier 110b. The first carrier 110a is a host carrier having a broad bandwidth, while the second carrier 110b is a subordinate carrier having a narrower bandwidth located within the frequency band of the host earner. As will be explained in more detail below, the time and frequency resources of the first (host) carrier and the second (subordinate) carrier are logically separate for the purposes of data transmission and most control signalling, but some time and frequency resources are accessible to and used by devices connected to both the first and second carriers.

Host Carrier and Subordinate Carrier Overview

[0044] Referring to Figure 3, the time and frequency resources constituting the host carrier and the subordinate carrier are schematically illustrated. The horizontal axis of Figure 3 is time, with a time period from t_1 to t_2 being shown in

Figure 3. The vertical axis of Figure 3 is frequency, the frequency increasing from a frequency f_1 to a frequency f_4. The host carrier has a frequency band F_1, extending from the frequency f_1 to the frequency f_4. The subordinate earner has a frequency band F_2, extending from a frequency f_2 to a frequency f_3. The subordinate carrier is intended primarily for use by terminal devices which do not have the capability to receive or transmit between the frequencies f_1 and f_2, and between the frequencies f_3 and f_4. The subordinate carrier does not occupy all of the time and frequency resources within the frequency band F_2. Instead, certain time periods 305 of the frequency band F_2 are allocated to the subordinate carrier (and potentially to other subordinate carriers), with the unallocated time periods within the frequency band F_2 forming part of the host carrier resources. The shaded portions 310 of Figure 3 indicates those time and frequency resources allocated to the subordinate carrier. When a time period 305 is allocated to the subordinate carrier, the time and frequency resources 315 falling outside of the frequency band F_2 (but within the frequency band F_1) are not allocated to the subordinate carrier. In some implementations these time and frequency resources may be available to the host carrier (or to another subordinate earner having a different (and non-overlapping) frequency band). In other implementations these time and frequency resources may be "lost" and unusable by either the first type of device or the second type of device. It is envisaged that the central frequency and bandwidth of the frequency bands F_1 and F_2 would be fixed for a given host carrier/subordinate carrier, although implementations in which they are not fixed may be possible. The particular time periods allocated to the subordinate carrier may be fixed, or may be dynamically variable, for example to increase or decrease the amount of radio resources allocated to the subordinate carrier to adapt to traffic conditions of the subordinate carrier (and/or possibly of the host carrier).

Radio Frame and Resource Grid Structure

[0045] Referring now to Figure 4, a radio frame and resource grid structure for an LTE type network is schematically illustrated. At the top of Figure 4, a radio frame 410 is shown. This occupies the full width of the frequency band of the host carrier, and has a duration of 10ms. The radio frame 410 is one of a sequence of radio frames which are used to communicate data between a base station and a terminal device. The radio frame 410 comprises 10 sub-frames 420, which again occupy the fully width of the frequency band of the host carrier. Each of these sub-frames 420 has a duration of 1ms. Each of the sub-frames 420 comprises two slots 430, each slot occupying the full width of the frequency band of the host carrier and having a duration of 0.5ms. Each slot comprises a plurality of resource blocks 440 in the frequency direction, and only a single resource block 440 in the time direction. In other words each resource block 440 has a duration of 0.5ms (the same as the duration of the slot 430), but occupies only a portion of the bandwidth of the host carrier. Each resource block 440 comprises a two-dimensional array of resource elements 450 distributed in both the time direction and the frequency direction. Each resource element 450 has a length (duration) of one modulation symbol, and a frequency range of one subcarrier (e.g. 15kHz). In the present case the resource block 440 has a dimension of 12 resource elements 450 in the frequency dimension and 7 resource elements 450 in the time dimension, resulting in an overall bandwidth of 12 subcarriers and a duration of 7 symbols.

[0046] In operation, data transmissions between a base station and a terminal device may be scheduled to use particular resource blocks. This scheduling is usually carried out by the base station or a related network entity. Certain resource blocks may be permanently allocated to carry predetermined signalling information.

[0047] 3GPP LTE Releases 8, 9 and 10 (Rel. 8/9/10) define 6 downlink transmission bandwidth configurations from 1.4 MHz to 20 MHz representing the

use of 6, 15, 25, 50, 75 or 100 resource blocks. As noted above, all Rel. 8/9/10 terminal devices are required to support the maximum single carrier bandwidth of 20 MHz for compliance with the Rel. 8/9/10 standards. Nevertheless, for all bandwidth configurations Rel. 8/9/10 has specified that basic physical layer synchronisation signals (Primary Synchronisation Signals - PSS, and Secondary Synchronisation Signals - SSS), and the most fundamental system information (Master Information Block - MIB) is transmitted using only the central 6 resource blocks which are receivable with a 1.4 MHz transceiver. However, in order to receive the remainder of the carrier system information the terminal device is required to be able to receive the full bandwidth of the carrier.

[0048] However, and as also noted above, for some applications, for example in situations relating to machine type communications (MTC) and/or dedicated messaging networks (DMN), there is a drive to build low cost and hence low capability devices. Ideally, device simplification should permit a reduction in required bandwidth of operation as well as reduction of features and throughput. Terminal devices with a lower bandwidth capability than that specified for Rel. 8/9/10 may mean that such devices are unable to operate properly on Rel. 8/9/10 compliant networks which specify higher bandwidth capabilities. For example, terminal devices with a lower bandwidth capability may not even be able to receive any more system information than that contained in the MIB of a Rel. 8/9/10 compliant network.

[0049] Low capability devices will ideally be able to find and camp-on the carrier associated with their target dedicated messaging network(s) even in the presence of Rel. 8/9/10 higher bandwidth carriers. Furthermore, there is a desire that DMN carriers are not swamped by Rel. 8/9/10 capable devices camping-on the DMN, even though the Rel. 8/9/10 capable devices are in the coverage area of a higher bandwidth Rel. 8/9/10 carrier which they could otherwise use.

Subordinate Carrier Definition

[0050] As described in relation to Figure 3, the subordinate carrier resources (for use by MTC devices) may be defined by a certain bandwidth in the frequency domain (frequency band F_2 in Figure 3 for example) and a certain pattern of time periods in the time domain. The certain pattern of time periods may be a sequence of subframes as described above with reference to Figure 4. The sequence of subframes may be a sequence of MBSFN subframes as defined by signalling within SystemInformationBlockType2 (SIB2) of the legacy LTE host carrier. However, it will be recognised that the subordinate carrier may be delineated by other means, for example by scheduling by a base station. The pattern of subframes may be a subset (or all) of those subframes reserved by the information element mbsfh-SubframeConfigList in the host carrier SIB2.

[0051] Conveniently, non-MTC UEs will read SIB2 of the legacy LTE host carrier and determine that a configured pattern of subframes are reserved for other purposes (such as MBMS, relay or as in the present case MTC subordinate carrier operation). The non-MTC UEs will therefore ignore the subframes allocated to the subordinate carrier. The configured pattern of reserved subframes is defined in a flexible manner by the information element mbsfn-SubframeConfigList.

[0052] In particular, mbsfn-SubframeConfigList comprises a set of 1 or more subframe allocations each of which is defined by the following fragment of ASN.1 from TS 36.331:

```
MBSFN-SubframeConfig ::=     SEQUENCE {
        radioframeAllocationPeriod      ENUMERATED {n1 , n2, n4, n8, n16, n32},
        radioframeAllocationOffset      INTEGER (0..7),
        subframeAllocation                      CHOICE {
                oneFrame                                BIT STRING (SIZE(6)),
                fourFrames                              BIT STRING (SIZE(24))
        }
```

}

[0053] For a given allocation, the "radioframeAllocationPeriod" indicates the periodicity, in radio frames, with which MBSFN subframes are included in the allocation, "n1" indicates that MBSFN subframes are present in every radio frame, while "n2" indicates that MBSFN subframes are present in every other radio frame. A radioframeAllocationPeriod of "n32" indicates that one in every 32 radio frames includes one or more MBSFN subframes. Radio-frames that contain MBSFN subframes occur when equation SystemFrameNumber mod radioFrameAllocationPeriod = radioFrameAllocationOffset is satisfied. In other words, the radioframeAllocationOffset parameter sets an offset for a start position of the repeating pattern of radio frames. The subframeAllocation parameter defines the subframes that are allocated for MBSFN within the radio frame allocation period defined by the radioFrameAllocationPeriod and the radioFrameAllocationOffset parameters. The subframe allocation can either be specified for a single radio frame within the radio frame allocation period (oneFrame) or for four consecutive radio frames within the radio frame allocation period (four Frames). The subFrameAllocation parameter is a 6 bit (oneFrame) or 24 bit (fourFrame) mask, indicating whether each of 6 (oneFrame) or 24 (fourFrame) predetermined subframes are to be reserved. The LTE specification places restrictions on which subframes may be reserved for other purposes by this method, in order that there is no conflict with the requirement to receive system information and paging. In an FDD LTE system one or more of subframes 1, 2, 3, 6, 7 and 8 may be reserved for other purposes. In a TDD LTE system the subframes that may be reserved are 3, 4, 7, 8 and 9. The system frame number can be derived from the MIB of the host carrier.

[0054] Figures 5A to 5D are example subframe patterns. Each of Figures 5 A to 5D shows a portion of a repeating pattern which could be specified by mbsfn-SubframeConfigList or by a similar pattern specifying function. Four radio frames

having ten subframes each are shown in Figures 5A to 5D. The subframes are labelled from 0 (zero) to 9 (nine). The shaded subframes are those allocated to the subordinate carrier, with the unshaded subframes being retained for use on the host carrier. Figure 5A schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 111111 (thereby selecting each of subframes 1, 2, 3, 6, 7 and 8). It will be appreciated that this subframe allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

[0055] Figure 5B schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 11111x (thereby selecting each of subframes 3, 4, 7, 8 and 9). It should be noted that the last bit of the mask is not used for TDD. The difference between Figures 5A and 5B results from the different subframes mapped to the bit mask in the FDD and TDD schemes.

[0056] Figure 5C schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n1 (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 101010 (thereby selecting each of subframes 1, 3 and 7). It will be appreciated that this subframe 615 allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

[0057] Figure 5D schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to nl (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset

is 0 (zero) and the subframeAllocation mask is 10101x (thereby selecting each of subframes 3, 7 and 9). It should be noted that the last bit of the mask is not used for TDD. Again, the difference between Figures 5C and 5D results from the different subframes mapped to the bit mask in the FDD and TDD schemes. All of the patterns shown in Figures 5A to 5D will repeat until the mbsfn-SubframeConfigList is altered. The set of allocation patterns specified in mbsfn-SubframeConfigList , which is signalled in SIB2, defines the "reserved set". A sub-set of the allocation patterns could be used to define the subordinate earner. Also, two mutually exclusive sub-sets could be used to define two separate subordinate carriers delimited in the time domain.

[0058] It will be appreciated that this mechanism provides a great deal of flexibility in how much carrier resource is to be allocated to the subordinate carrier, and also how that resource is distributed with respect to time. The minimum (non-zero) amount of resources (in the time domain) which can be allocated is 1 in 320 subframes (when radioframeAllocationPeriod is set to n32 and only one bit is set in the subframeAllocation bit mask). The maximum amount of resources (in the time domain) which can be allocated is 192 in 320 subframes (when radioframeAllocationPeriod is set to n1 and all six bits are set in the subframeAllocation bit mask). In some implementations the allocation might be static to provide a fixed resource subordinate carrier. The fixed resources could in this case be known to a terminal device in advance. In other implementations the allocation might be dynamic, resulting in a subordinate carrier having a resource allocation which can be increased or decreased to for example meet traffic loading conditions on the subordinate carrier and/or on the host carrier. These increases or decreases could be based on requests from terminal devices for additional resource, or based on decisions made at the base station or a related entity. An increase in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined

above, or by adding a new subframe allocation according to the principles set out above. A decrease in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined above, or by removing an existing subframe allocation.

[0059] In other words, it is possible to use multiple subframe allocations to achieve allocation patterns which would not be possible with a single subframe allocation, and to provide a simple way of increasing (or decreasing, if one of multiple subframe allocations is removed) the amount of resources allocated to the subordinate carrier. In one implementation, a first subframe allocation with a relatively low allocation period and subframe allocation could be used to maintain a low resource subordinate carrier which can be camped onto by a low capability terminal device, and then further subframe allocations could be added to service the communication needs of the low capability terminal device when it has successfully camped on. In this way, the resources available to the host carrier are retained at a high level to serve LTE traffic when the subordinate carrier is not in use.

Signalling the presence of the Subordinate Carrier

[0060] Certain resource blocks may be used to carry control signalling including synchronisation signals and system information. As explained above, a problem can therefore arise if essential control signalling from the base station is transmitted outside of the frequency range which can be received by a low-capability device. Fortunately, as described above, the synchronisation signals and the Master Information Block (MIB) of the system information are present within a frequency range which is likely to be receivable by a low-capability device. However, further system information, carried in System Information Blocks (SIBs), and the associated control signalling may be transmitted at a frequency which cannot be received by the low-capability device. This would cause problems, potentially preventing the low-capability device from being able to camp on to the network. It will be appreciated that not all host carriers will necessary support a

subordinate carrier. If a low-capability device attempts to camp-on to a network which does not support a subordinate carrier then the camp-on procedure will ultimately fail. This is a waste of time and power for the low-capability device.

[0061] It would therefore be desirable to signal to an MTC UE which has restricted reception bandwidth the presence of an MTC subordinate carrier within a larger bandwidth LTE carrier accessible to legacy UEs (LTE Rel. 8/9/10 UEs). It was discussed above that for all LTE bandwidths (Rel. 8/9/10) the basic physical layer synchronisation signals and the most important system information (Master Information Block) is transmitted using only the central 6 resource blocks (72 subcarriers). The Master Information Block (MIB) is transmitted in the Physical Broadcast Channel (PBCH) which is allocated to the central 72 subcarriers and to just the first 4 OFDMA symbols of the second slot of every 10ms radio frame. Thus, assuming that the low bandwidth MT UE is able to receive at least 6 resource blocks in the frequency domain, then the PBCH (for example the MIB) may be used to signal the presence of an MTC subordinate carrier.

[0062] In Figure 6, a schematic flow diagram of a first part of a camp-on procedure is shown. At a step A1, an MTC device seeking to camp-on to a subordinate carrier, for example following power-up, seeks to identify and decode PSS (Primary Synchronisation Signals) and SSS (Secondary Synchronisation Signals) signalling being broadcast in its location. Once the MTC device synchronises to a carrier using the PSS and SSS, the MTC device determines the frame timing and proceeds to decode the PBCH to determine the MIB for the carrier. At a step A2, the MTC device determines whether or not a subordinate carrier indicator flag is present in the MIB. The MTC subordinate carrier indicator flag may be signalled in one (or more) of the MIB bits that are spare in LTE Release 8 / 9 / 10 (10 bits are currently spare). If the MTC device determines that the MIB contains a subordinate carrier indicator flag then the camp-on process continues at a step A3. If on the other hand the MTC subordinate carrier indicator flag was

found not to be present, then the camp-on procedure to this carrier would be terminated. This would allow the device to decide upon proceeding with camp-on (or not) simply based upon decoding of the legacy LTE MIB, and to discontinue with camp-on immediately after the decoding of the legacy LTE MIB should the subordinate carrier indicator flag not be present. As an alternative to using the MIB to signal the presence of a subordinate carrier, a subordinate carrier indicator signal could be provided at a known time / frequency somewhere other than in the MIB. The particular time / frequency may be defined referentially with respect to the MIB (for example). The subordinate carrier indicator signal may be relative to the host carrier PBCH and/or the System Frame Number conveyed in the host carrier PBCH / MIB. In this case the MTC device would, following synchronisation (at the step A1), search for the subordinate carrier indicator signal at the expected time / frequency (at the step A2). If it is found, then the MTC device knows that one (or more) subordinate carriers are present and continues its discovery of the MTC subordinate carrier and the subsequent camp-on process.

[0063] In either implementation, it will be appreciated that the presence of the subordinate carrier indicator is derivable by the MTC device without being required to decode any system information block (SIB) of the host carrier since the MTC device may be unable to receive the host carrier SIBs which are signalled across the full host carrier frequency band F1.

[0064] If the MTC device does not find a subordinate carrier associated with the host carrier, then it may search for and seek to camp-on to another carrier by returning to the step A1 to seek to synchronise with and decode PBCH for a different carrier.

Signalling the bandwidth of the subordinate carrier(s

[0065] Having detected the presence of an MTC subordinate carrier the UE needs to determine the bandwidth of the subordinate carrier in order to be able to read the further system information which will contain the other characteristics of

the subordinate carrier. There are a number of alternative ways in which the subordinate carrier bandwidth may be signalled to the MTC UE:

(1) The simplest method is to fix the bandwidth of the subordinate carrier in the 3GPP specifications. Having detected the presence of a subordinate carrier in the manner described above, the MTC UE would know by definition the MTC subordinate carrier bandwidth (e.g. 1,4MHz, 3MHz or 5 MHZ).

(2) The downlink bandwidth of the MTC subordinate carrier may be signalled in the legacy LTE MIB. For example if the subordinate carrier indicator flag were signalled in the PBCH by using a 2 bit field, 4 states could be signalled (absence of a subordinate earner and three different subordinate carrier bandwidths, e.g. 1.4MHz, 3MHz and 5 MHZ).

(3) The downlink bandwidth (and possibly other characteristics) of the MTC subordinate carrier could be signalled in a Subordinate Carrier Master Information Block (scMIB). The scMIB would be signalled in fixed time / frequency resources, known in advance to the mobile terminal and preferably defined in the 3GPP specifications. The possibilities for signalling the scMIB are described in the following section.

Signalling the Subordinate Carrier Master Information Block (scMIB)

[0066] In the above section three methods of determining the downlink bandwidth of an MTC subordinate carrier by an MTC UE have been described. The first two of these methods involve a priori knowledge of when decoding of the subordinate carrier begins. The last of the described methods involves signalling the downlink bandwidth in a Master Information Block of the subordinate carrier itself.

[0067] A Master Information Block may be regarded as collection of parameters giving values to configurable characteristics of the carrier and other information to achieve/maintain radio frame synchronisation. A Master

Information Block is required to be supplied in fixed time/frequency resources and must be received and decoded before a more flexible scheme of downlink message exchange may be employed. According to the above description, at the point at which the UE tries to decode the scMIB, the UE will know:

- That an MTC subordinate carrier is present (from the indicator flag / signal).
- The subordinate carrier centre frequency (it may generally be assumed that this will be the same as the centre frequency of the host legacy LTE carrier).

[0068] In addition the UE may know the MTC subordinate carrier bandwidth, if this has been fixed in the specifications, conveyed in the host carrier MIB or conveyed by some other a priori means. In order to receive and decode the scMIB the UE must be able to determine in which resource elements it is carried. The number of resource elements used for the scMIB could be related to the subordinate carrier bandwidth or it could be fixed (as is the case for the legacy LTE MIB). If the number of resource elements were defined to be dependent upon the subordinate carrier bandwidth, this would require the value of the subordinate carrier bandwidth to be known a priori. There are a limited number of spare bits available in the legacy host carrier LTE MIB, and so it may be considered that there are not sufficient available to use 1 or more of these to carry subordinate carrier bandwidth information. In this case, the UE will not have a priori knowledge of the subordinate carrier bandwidth so the UE will be unable to derive the scMIB resource elements from the bandwidth. Accordingly, for the purposes of the following description it is assumed that the scMIB is always signalled in a fixed set of resource elements defined within the 3GPP specifications. Nonetheless, it should be understood that the present invention is not limited to this, and that in certain implementations the set of resource elements used to convey the scMIB may not be fixed.

[0069] The fixed set of resource elements is contained within a subset (or all) of those subframes reserved by one (or more) of the subframe allocations configured

in the information element mbsfn-SubframeConfigList broadcast in the host carrier SIB2. The fixed subframe allocation to convey the scMIB should:

- Be frequent enough to occasion an acceptable latency for acquisition of the scMIB by MTC UEs.
- Not be too frequent that excessive resources are consumed from the host carrier and subordinate carrier.

[0070] It should be noted that it is common for MTC devices to exhibit low mobility and be able to tolerate comparatively high latencies in message transmission. However, this may not be the case with all possible MTC traffic and it is therefore preferable that the frequency of MIB transmission be fixed within the 3GPP specification and thus cannot be configured dependent upon the expected MTC traffic characteristics.

[0071] Various fixed characteristics of the scMIB transmission scheme, including the following, should preferably be defined within the 3GPP specifications:

- The number, periodicity and relationship to host carrier System Frame Number of the subframes used for scMIB.
- The level of repetition encoding employed.
- Within the subframes used, the number and location of resource elements used to convey the scMIB (that is, exactly which slot(s), subcarriers and symbols are to be used).

[0072] The number of resource elements used for the scMIB will be a function of the number of bits of information that must be conveyed by this method, which will be influenced by the further details of the subordinate carrier design, but the number will also be constrained by the overhead that this imposes. The System Frame Number, necessary for the UE to maintain radio frame synchronisation, upon which many LTE higher layer processes are dependent, may be read from the host carrier MIB. However, for efficiency reasons it is likely that once the UE

synchronises to the subordinate carrier, it would be undesirable for the UE to have to keep re-reading the host carrier MIB to maintain this information. Thus, System Frame Number is likely to be carried by the scMIB, although the UE might depend upon the host carrier MIB for this information.

[0073] Any combination of parameters conforming to and fully resolving the definition of MBSFN-SubframeConfig may be chosen to define which subframes convey the scMIB. However, use of a single subframe allocation pattern will provide a solution involving least complexity. For example a single pattern comprising a single subframe allocation once per radio frame allocation period of 32 frames and with an offset value of zero may be considered adequate to convey the scMIB dependent upon other details of the subordinate carrier design. Alternatively, if more MIB bits are required then a shorter allocation period of, for example, 16 or 8 radio frames could be used and/or more subframes per allocation period. Note that while the subframes used to convey the scMIB may be defined by such a subframe allocation pattern or patterns, not all slots or resource elements in the subframes defined by the pattern(s) are necessarily used to convey the scMIB. Use of a shorter allocation period but sparse use of the resource elements for the scMIB may offer the best compromise in relation to scMIB acquisition time and resource overhead.

[0074] The subframe allocation pattern or patterns chosen to define the subframes used for the scMIB will be included in the mbsfn-SubframeConfigList of SIB2 of the host carrier in order to reserve these subframes for special use within the context of the host carrier. However, low bandwidth MTC UEs searching for a suitable subordinate carrier will not be required to read SIB2 of the host carrier to gain this information, since the subframe allocation pattern(s) for the scMIB will be fixed and defined in the 3GPP specifications.

Camp-on procedure

[0075] Referring to Figure 7, the camp-on procedure following the initial steps shown in Figure 6 is schematically illustrated. At a step B1 the location of the scMIB is determined. As discussed above, the location of the scMIB is likely to be fixed in the 3GPP standards, and so the MTC UE will be able to frame synchronise with the scMIB broadcast by comparing the location of the scMIB (radio frame and sub-frame known from the 3GPP specifications) with the current System Frame Number (which the MTC UE can derive from the host carrier MIB). At a step B2 the scMIB is received and decoded, whereby the system information specified therein can be acquired and used. At a step B3 the bandwidth and central frequency of the subordinate carrier is determined. The bandwidth of the subordinate carrier may be determined by one of the methods described above in the section "Signalling the Bandwidth of the Subordinate Carrier(s)". The central frequency may be assumed to be the same as that of the host carrier, but in some implementations may have a different central frequency which would need to be signalled to the MTC UE. The central frequency and bandwidth together identify the frequency band forming the subordinate carrier. Note that if the bandwidth is not determined from the scMIB then the step B3 can be performed before (or in parallel with) the steps B1 and B2.

[0076] At a step B4, the allocation of subordinate carrier subframes is determined. An indication of those subframes allocated to the subordinate carrier may be specified in the scMIB. As described above, sub-frames are allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set which determines which sub frames within a repeating group of radio frames are allocated to the subordinate carrier. At a step B5, further system information (System Information Blocks) relating to the subordinate carrier is obtained from subframes allocated to the subordinate carrier. This further system information can be used to complete the camp on procedure of the MTC UE to the subordinate carrier at a step

B6. The further system information may be at a fixed location within the radio resources of the subordinate carrier, or at a location within the radio resources of the subordinate carrier which has been scheduled by the base station, or a combination of both.

[0077] In Figure 8, example signalling on the host carrier and the subordinate carrier is schematically illustrated. In Figure 8, eight radio frames 800 are shown, each having a central frequency portion 820 usable by both the host carrier and the subordinate carrier, and outer frequency portions 810 usable only by the host carrier. In each radio frame, a MIB 830 is provided in the central frequency portion 820. The MIB 830 is readable by devices using both the host carrier and the subordinate carrier. Devices seeking to use a subordinate carrier may be able to determine from the MIB 830 whether a subordinate carrier exists based on a flag present in the MIB 830. In an outer frequency portion 810, system information 840 is provided for use by devices served by the host carrier. The system information 840 is shown to be outside of the central frequency portion 820 and is thus not available to the kind of low-capability devices intending to use the subordinate carrier. It will be appreciated that some system information may happen to be transmitted within the central frequency portion 820, but this cannot be guaranteed. The system information 840 is provided in the form of System Information Blocks (SIBs). Unlike the Master Information Block which is broadcast on the Physical Broadcast Channel (PBCH), the SIBs are mapped onto the Physical Downlink Shared Channel (PDSCH). Generally, the Master Information Block 830 provides sufficient information to gain access to the first of the System Information Blocks (SIB1), which in turn provides sufficient information to gain access to SIB2 et seq. SIB2 includes parameters relating to the reservation of MBSFN subframes (as described above). Legacy LTE devices using the host carrier will therefore be informed of the subframes reserved for use by the subordinate carrier (or for other purposes, for example MBMS or relay backhaul) when they decode SIB2. They will

therefore know that these subframes cannot be used and to ignore them. Within the central portion 810 of some or all of the radio frames (every other radio frame in this example) is a portion 850 allocated to the subordinate carrier. For the sake of clarity the portion 850 shown in Figure 8 is contiguous, but it will be appreciated from Figures 5A to 5D for example that this may not be the case. The portions 850 are used to transmit data and signalling to low capability devices using the subordinate carrier. Within the allocated portion 850 of the first radio frame is a subordinate carrier MIB (scMIB) 860 carrying various information required for a low capability device to acquire the remainder of the subordinate carrier system information.

[0078] Within the allocated, portion 850 of the second radio frame is system information 870 relating to the subordinate carrier. This system information 870 provides information required for a terminal device to camp on to the subordinate carrier. It will be appreciated that the locations of the scMIB 860 and the system information 870 is purely exemplary. The important point is that the scMIB 860 and the system information 870 are conveyed in the allocated portions 850. As described in detail above, the location and periodicity of the scMIB would probably be fixed (predetermined). The system information 870, which could be conveyed in the form of System Information Blocks in a similar manner to with the host carrier, may be predetermined, or dynamically allocated (scheduled), depending on implementation.

[0079] In the host carrier, the MIB and any associated SIBs together provide the parameters necessary for system access using the host carrier. Similarly, in the subordinate carrier, the scMIB and any associated SIBs carried in subframes allocated to the subordinate carrier provide the parameters necessary for system access using the subordinate carrier. In both cases, the UE (legacy or MTC) requires the MIB to decode the shared channel (and thus access SIBs). The MIB

contains downlink system bandwidth of the host carrier and the system frame number.

[0080] The above embodiment describe a method of conveying a subordinate carrier for low bandwidth devices within a portion of a larger host carrier using for example MBSFN subframe allocation pattern(s) to reserve subframes for the subordinate carrier. This permits a flexible and efficient definition of a subordinate carrier within a host carrier. An indication of the presence of the MTC subordinate carrier is provided using a flag in the host carrier MIB. This may require the 3GPP standard to be updated, but will not require any change to legacy LTE devices because the flag is set in current spare bits which can and will be ignored by a legacy device. Various methods of signalling subordinate carrier downlink bandwidth have been described, including fixing the MTC subordinate carrier bandwidth in 3GPP specifications, signalling the subordinate carrier downlink bandwidth via a field in host carrier MIB, or signalling using a bit field within the subordinate carrier MIB (scMIB). A method of defining the subframes used for the subordinate carrier Master Information Block by using fixed (defined in 3GPP specifications) subframe allocation pattern(s) in relation to the System Frame Number of the host carrier has also been described above. A subordinate carrier has been described (in one example) to be specified using a repeating pattern of sub-frames. A mechanism to specify this already exists in LTE, originally for the purpose of specifying sub-frames for use in MBSFN.

[0081] It will be appreciated that various modifications can be made to the embodiments described above without departing from the scope of the present invention as defined in the appended claims. In particular although embodiments of the invention have been described with reference to an LTE mobile radio network, it will be appreciated that the present invention can be applied to other forms of network such as GSM, 3G / UMTS, CDMA2000, etc. The term MTC terminal as used herein can be replaced with user equipment (UE), mobile

communications device, mobile terminal etc. Furthermore, although the term base station has been used interchangeably with e-nodeB it should be understood that there is no difference in functionality between these network entities.

[0082] Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

REFERENCES

[1] Holma H. and Toskala A. "*LTE for UMTS OFDMA and SC-FDMA based radio access*", John Wiley and Sons, 2009.

* * *

FIG. 1

1/8

FIG. 2

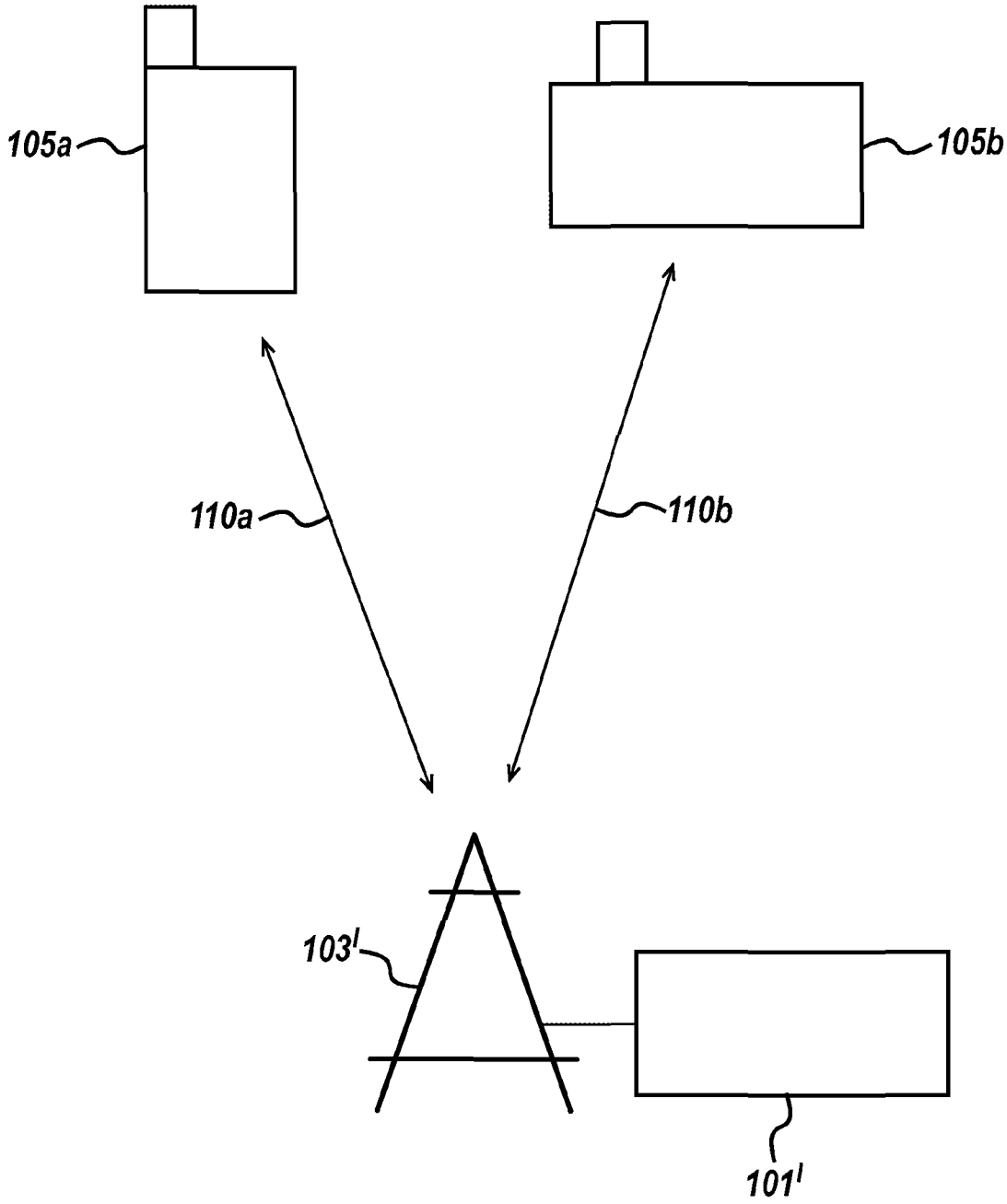
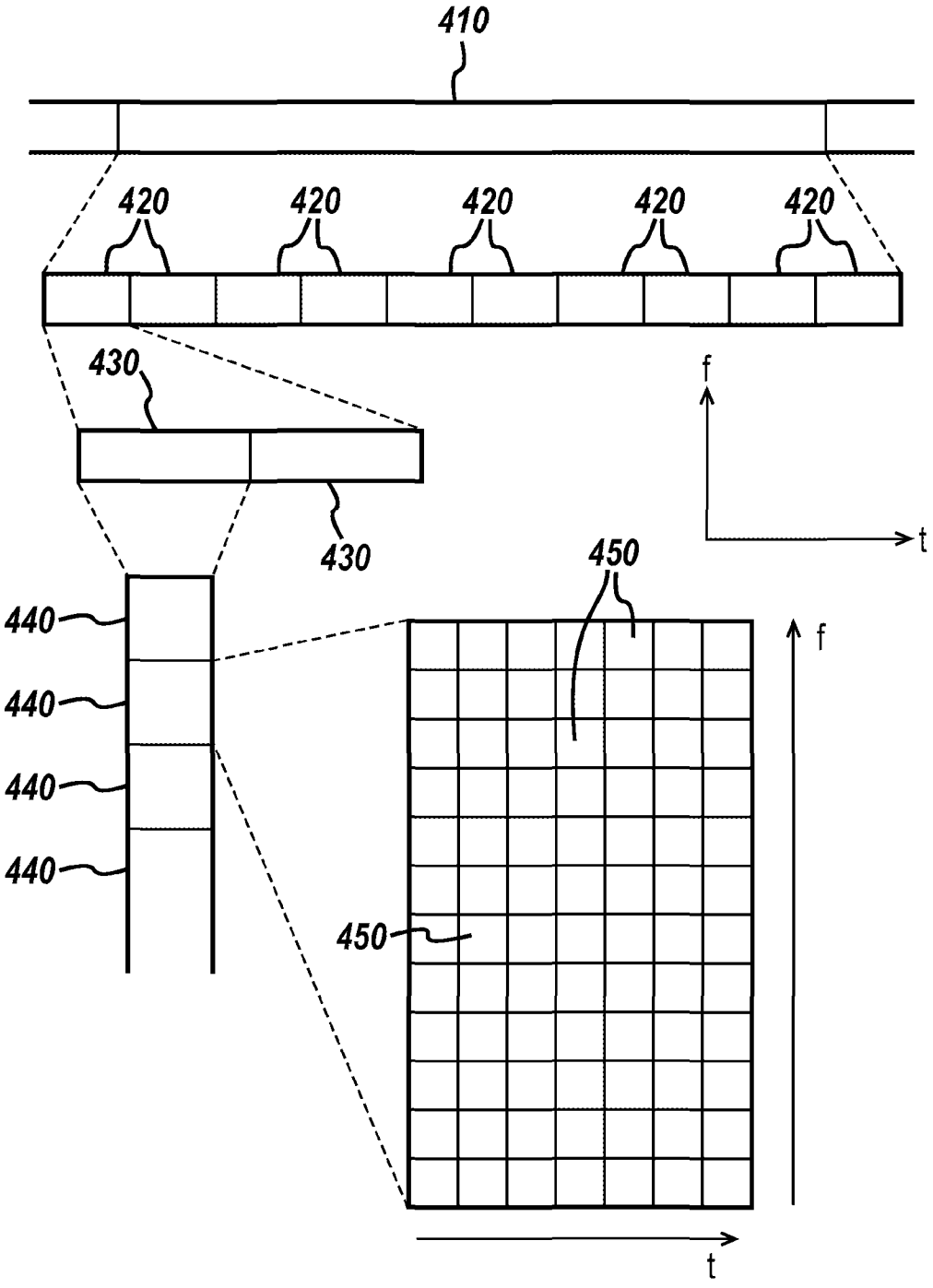


FIG. 3

FIG. 4



0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9

FIG. 5A

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9

FIG. 5B

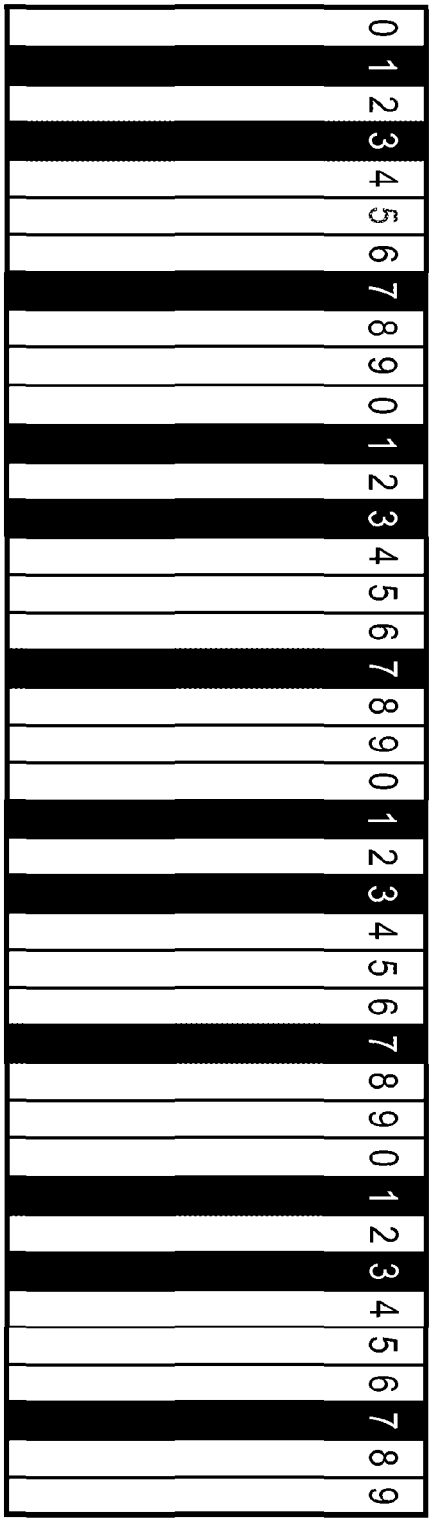

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9

FIG. 5C

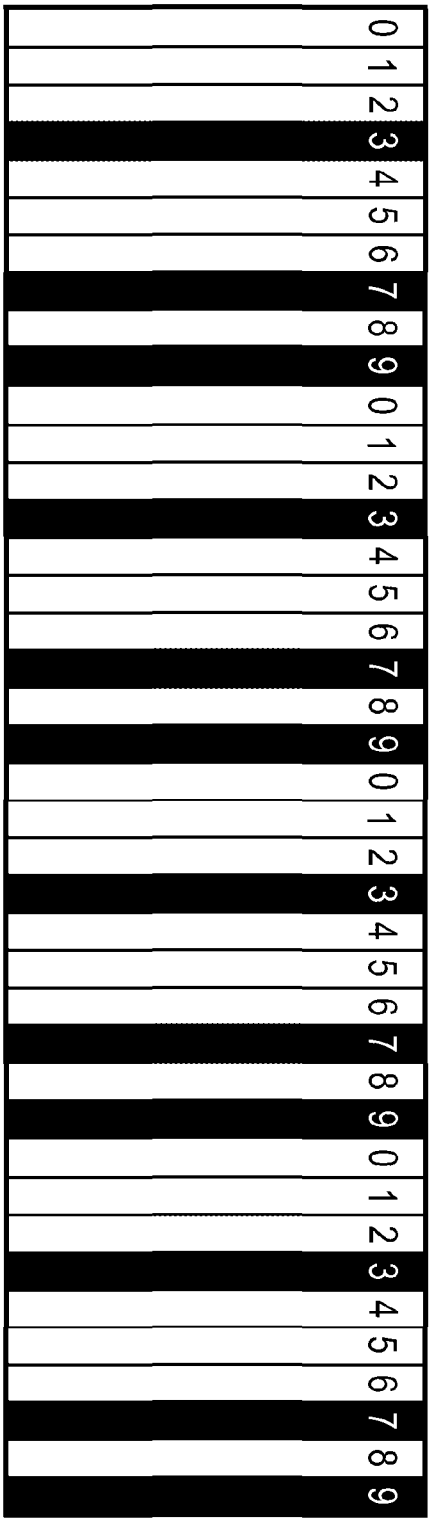

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9

FIG. 5D

FIG. 6

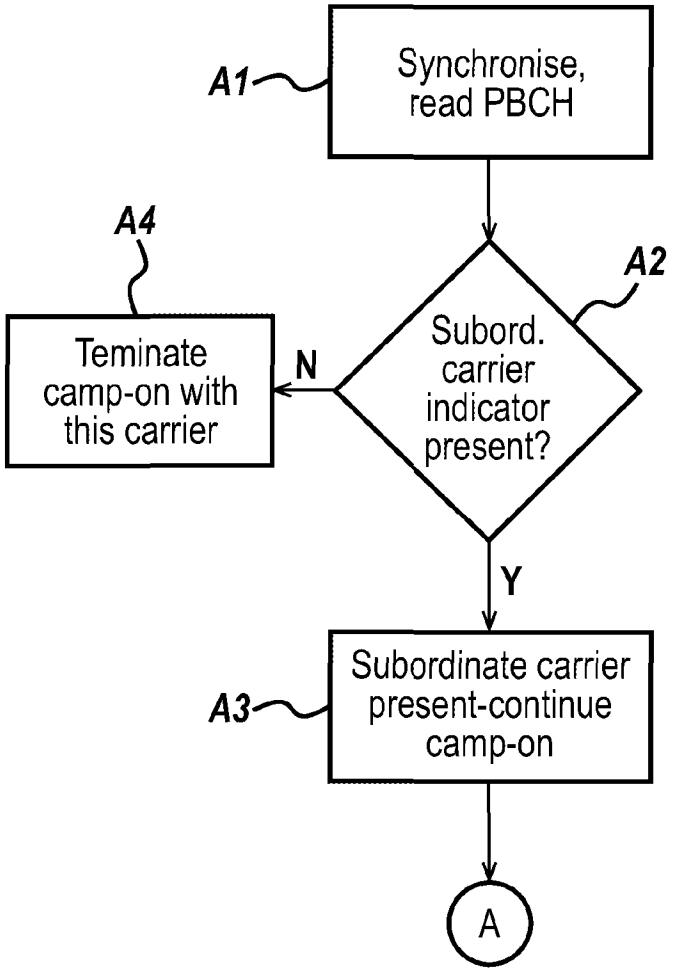
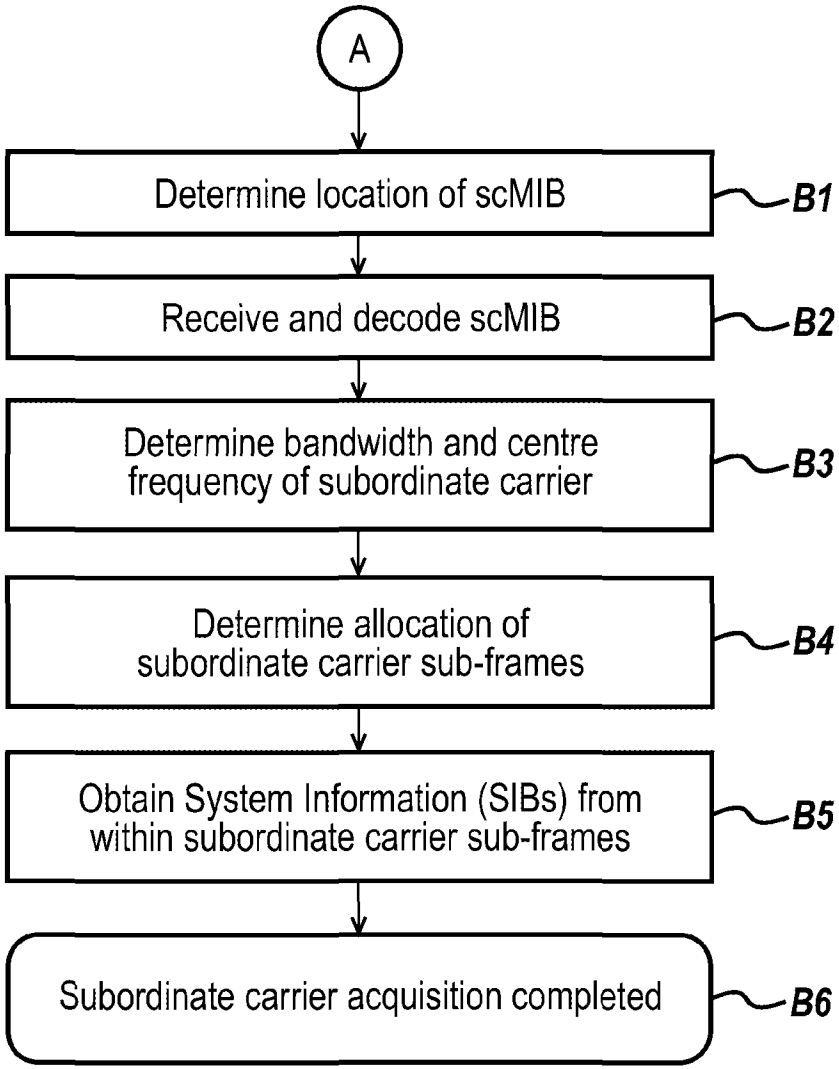


FIG. 7



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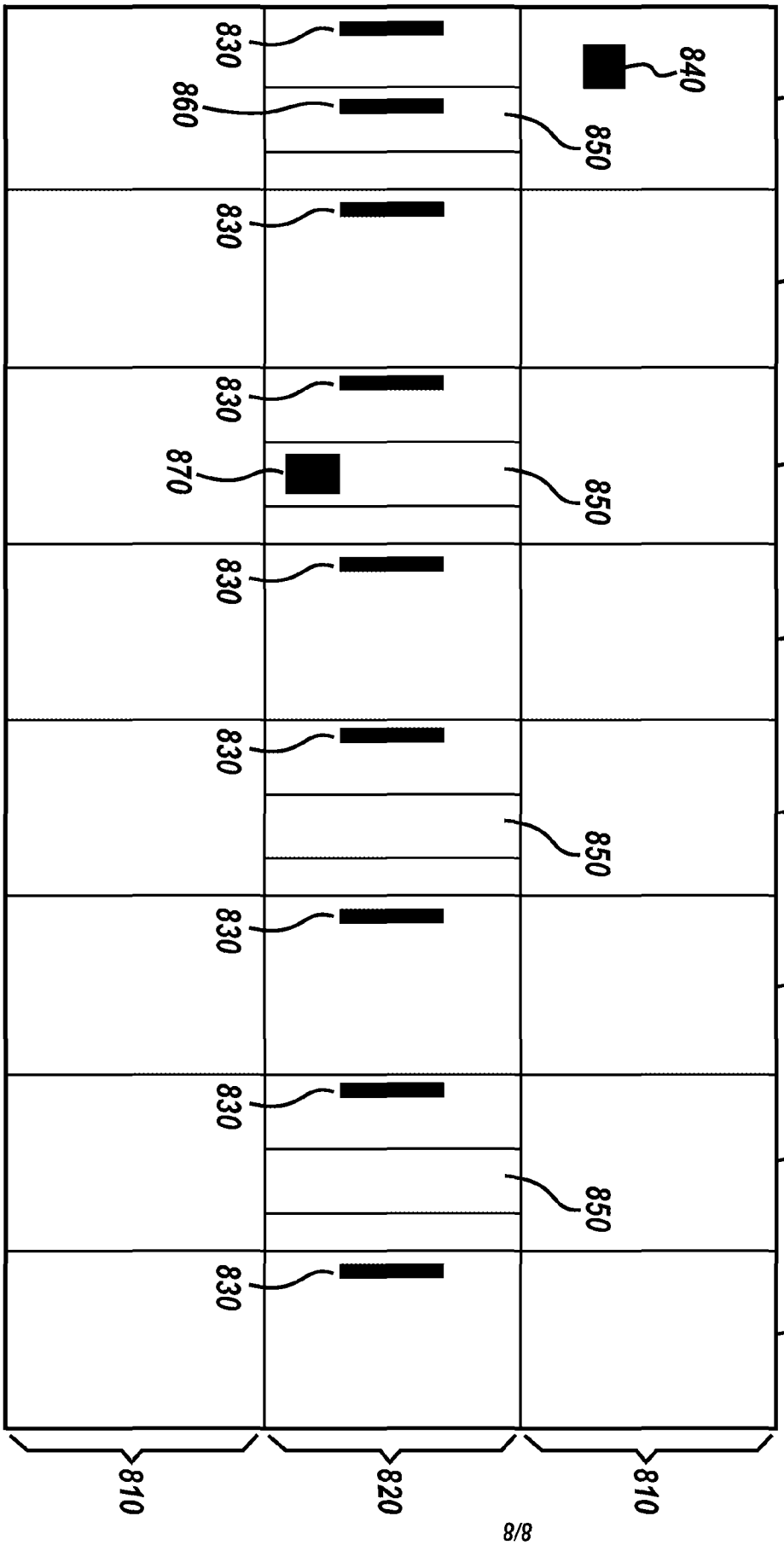


FIG. 8

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the **PATENT APPLICATION** of:	
Intellectual Ventures Holding 81 LLC	
Application No.: Not Yet Known	
Filed: Herewith	
For: WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER	
Group: Not Yet Known	
Examiner: Not Yet Known	

Our File: IPW2-USAP205496

Date: July 15, 2014

PRELIMINARY AMENDMENT

Mail Stop PCT (Via EFS)
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Prior to examination, and the calculation of fees, please amend the application without prejudice or disclaimer as follows:

IN THE SPECIFICATION

Please replace the Specification with the enclosed Substitute Specification in accordance with 37 C.F.R. 1.121(b)(3). The Substitute Specification merely serves to comply with U.S. practice by inserting paragraph numbering. The Substitute Specification also has some other minor corrections. No new matter has been introduced by the Substitute Specification. A marked-up copy of the Substitute Specification indicating changes is also enclosed.

IN THE CLAIMS

1. – 39. (CANCELED)

40. (NEW) A network device comprising:

a network device configured to wirelessly communicate with a first type of terminal device and a second type of terminal device;

the network device further configured to communicate with the first type of terminal device with a host carrier having radio resource segments distributed in time, wherein each radio resource segment provides radio resources across a first frequency band;

the network device further configured to communicate, within a second frequency band, with the second type of terminal device using a subordinate carrier comprising resources that are a subset of the host carrier radio resource segments; and

wherein the second frequency band is narrower than and contained within the first frequency band.

41. (NEW) The network device of claim 40 further comprising:

the radio resource segments are subframes of radio frames having a plurality of subframes; and

subframes are allocated to the subordinate carrier using a subordinate carrier subframe allocation set, wherein the subordinate carrier subframe allocation

set determines which subframes within a repeating group of one or more radio frames are allocated to the subordinate carrier.

42. (NEW) The network device of claim 41, wherein the subordinate carrier subframe allocation set is defined by one or more reserved subframe allocation patterns.

43. (NEW) The network device of claim 42, wherein the one or more reserved subframe allocation patterns comprise substantially all or a subset of all reserved subframe allocation patterns of the host carrier.

44. (NEW) The network device of claim 42 further comprising:

acquisition information required for the second type of terminal device to receive the subordinate carrier is allocated to subframes of the subordinate carrier using at least a portion of the subframes in the one or more reserved subframe allocation patterns.

45. (NEW) The network device of claim 40, wherein the first type of terminal device is capable of receiving a full bandwidth of the first frequency band, wherein the second type of terminal device is incapable of receiving the full

bandwidth of the first frequency band, and wherein the second type of terminal device is capable of receiving the full bandwidth of the second frequency band.

46. (NEW) A method performed by a network device, the method comprising:

communicating, wirelessly by the network device, with a first type of terminal device and a second type of terminal device;

communicating, by the network device, with the first type of terminal device with a host carrier having radio resource segments distributed in time, wherein each radio resource segment provides radio resources across a first frequency band;

communicating, by the network device within a second frequency band, with the second type of terminal device using a subordinate carrier comprising resources that are a subset of the host carrier radio resource segments; and

wherein the second frequency band is narrower than and contained within the first frequency band.

47. (NEW) The method of claim 46 further comprising:

the radio resource segments are subframes of radio frames having a plurality of subframes; and

subframes are allocated to the subordinate carrier using a subordinate carrier subframe allocation set, wherein the subordinate carrier subframe allocation

set determines which subframes within a repeating group of one or more radio frames are allocated to the subordinate carrier.

48. (NEW) The method of claim 47, wherein the subordinate carrier subframe allocation set is defined by one or more reserved subframe allocation patterns.

49. (NEW) The method of claim 48, wherein the one or more reserved subframe allocation patterns comprise substantially all or a subset of all reserved subframe allocation patterns of the host carrier.

50. (NEW) The method of claim 48 further comprising:

acquisition information required for the second type of terminal device to receive the subordinate carrier is allocated to subframes of the subordinate carrier using at least a portion of the subframes in the one or more reserved subframe allocation patterns.

51. (NEW) The method of claim 46, wherein the first type of terminal device is capable of receiving a full bandwidth of the first frequency band, wherein the second type of terminal device is incapable of receiving the full bandwidth of the

first frequency band, and wherein the second type of terminal device is capable of receiving the full bandwidth of the second frequency band.

IN THE ABSTRACT

Please substitute the Abstract submitted herewith on a separate sheet for the Abstract appearing on the face sheet of the International Application as published.

ABSTRACT

Wirelessly communicating with a first type of terminal device and a second type of terminal device is disclosed. The first type of terminal device may have a host carrier having radio resource segments distributed in time. Each radio resource segment may provide radio resources across a first frequency band. A second type of terminal device may also communicate, within a second frequency band, using a subordinate carrier comprising resources that are a subset of the host carrier radio resource segments. The second frequency band may be narrower than and contained within the first frequency band.

REMARKS

Examination is requested based upon the amendments made via this Preliminary Amendment. No new matter is added by this Preliminary Amendment.

Respectfully submitted,

Intellectual Ventures Holding 81 LLC

By: /Harry Vartanian/
Harry Vartanian
Registration No.: 56,787
(215) 568-6400

Volpe and Koenig, P.C.
United Plaza, Suite 1800
30 South 17th Street
Philadelphia, PA 19103

HV/lcg
Enclosure

AA 19 Due: 6.7.13
AA 34 & Demand Due: 20.11.13

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:
Small, Gary James
Carpmaels & Ransford
One Southampton Row
London
WC1B 5HA
ROYAUME UNI

Page by Page Check Done by Records
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- 7 MAY 2013
CARPMAELS & RANSFORD
ACTIONED

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference P059858WO	Date of mailing *(day/month/year)* 6 May 2013 (06-05-2013) **FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/GB2013/050126	International filing date *(day/month/year)* 21 January 2013 (21-01-2013)

Applicant

WIRELESS TECHNOLOGY SOLUTIONS LLC

1. [X] The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the International Search Report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Fascimile No.: (41-22) 338.82.70

   For more detailed instructions, see *PCT Applicant's Guide,* International Phase, paragraphs 9.004 - 9.011.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. [ ] **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   [ ] the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.

   [ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

   Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

   In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

   For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040 Fax: (+31-70) 340-3016	EMERY, Carole Tel: +31 (0)70 340-2848

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
P059858WO		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB2013/050126	21/01/2013	20/01/2012
Applicant		
WIRELESS TECHNOLOGY SOLUTIONS LLC		

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

This international search report consists of a total of 4 sheets.

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

1. **Basis of the report**
   a. With regard to the **language,** the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. [ ] **Certain claims were found unsearchable** (See Box No. II)

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

4. With regard to the **title,**
   [ ] the text is approved as submitted by the applicant
   [X] the text has been established by this Authority to read as follows:

   WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

5. With regard to the **abstract,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 3
      [X] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [ ] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050126

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00
ADD.

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)
H04L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/085457 A1 (CHEN WANSHI [US] ET AL) 14 April 2011 (2011-04-14) figure 4A figure 2 figure 5 figure 7a figure 7A paragraph [0007] paragraph [0044] - paragraph [0045] paragraph [0055] paragraph [0060] paragraph [0051] paragraph [0068] paragraph [0075] - paragraph [0076] paragraph [0065] paragraph [0158] ----- -/--	1-39

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2013	06/05/2013

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, Fax: (+31-70) 340-3016	Hanus, Pavol

2

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HUAWEI ET AL: "Considerations on the bandwidth reduction for low cost MTC UE", 3GPP DRAFT; R1-113659, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. San Francisco, USA; 20111114 - 20111118, 8 November 2011 (2011-11-08), XP050561799, title, section 3.1	1-39
A	Erik Dahlman ET AL: "Access Procedures (Chapter 14)" In: "4G LTE/LTE-Advanced for Mobile Broadband", 29 March 2011 (2011-03-29), Academic Press in Elsevier, XP055061127, pages 301-321, section 14.2	1-39
A	NTT DOCOMO: "Issues Regarding LTE Network for Low Cost MTC", 3GPP DRAFT; R1-114082 LOW COST MTC, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. San Francisco, USA; 20111114 - 20111118, 8 November 2011 (2011-11-08), XP050562063, section 3.2	1-39

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2013/050126

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011085457 A1	14-04-2011	CN 102388665 A	21-03-2012
		EP 2417814 A1	15-02-2012
		JP 2012523772 A	04-10-2012
		TW 201136241 A	16-10-2011
		US 2011085457 A1	14-04-2011
		WO 2010118382 A1	14-10-2010

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY
(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB2013/050126	21.01.2013	20.01.2012

International Patent Classification (IPC) or both national classification and IPC
INV. H04L5/00

Applicant
WIRELESS TECHNOLOGY SOLUTIONS LLC

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Fax: +31 70 340 - 3016	see form PCT/ISA/210	Hanus, Pavol Telephone No. +31 70 340-2622

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

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

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

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

   ☐ on paper

   ☐ in electronic form

   b. (time)

   ☐ in the international application as filed

   ☐ together with the international application in electronic form

   ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	4, 7, 9, 13, 18, 19, 21-29, 31, 32
	No:	Claims	1-3, 5, 6, 8, 10-12, 14-17, 20, 30, 33-39
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-39
Industrial applicability (IA)	Yes:	Claims	1-39
	No:	Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Reference is made to the following documents:

D1 US 2011/085457 A1 (CHEN WANSHI [US] ET AL) 14 April 2011 (2011-04-14)

D2 HUAWEI ET AL: "Considerations on the bandwidth reduction for low cost MTC UE", 3GPP DRAFT; R1-113659, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. San Francisco, USA; 20111114 - 20111118, 8 November 2011 (2011-11-08), XP050561799,

D3 Erik Dahlman ET AL: "Access Procedures (Chapter 14)" In: "4G LTE/LTE-Advanced for Mobile Broadband", 29 March 2011 (2011-03-29), Academic Press in Elsevier, XP055061127, pages 301-321,

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 **Novelty (claims 1 to 3, 5, 6, 8, 10 to 12, 14 to 17, 20, 30, 33, 36 and 37)**
The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 1 to 3, 5, 6, 8, 10 to 12, 14 to 17, 20, 30, 33, 36 and 37 is not new in the sense of Article 33(2) PCT.

1.1 Independent claim 1: The subject-matter of claim 1 is not new since D1 discloses a wireless communications system, comprising: a base station (D1: paragraph [0007]), one or more terminal devices of a first type (D1: paragraph [0044], new/second UEs); and one or more terminal devices of a second type (D1: paragraph [0044], legacy/first UEs); wherein the base station is operable to

- communicate with the terminal devices of the first type using a host carrier (D1: figure 4A, paragraph [0007], paragraph [0044], second system bandwidth ´NewBW´ for new/second UEs)
- comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band (D1: figure 2, subframes),

- and to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band (D1: figure 4A, paragraph [0044], first system bandwidth ´R8BW´ for legacy/first UEs)
- of a subset of the radio resource segments of the host carrier (D1: figure 5, R8 subframes, paragraph [0055], paragraph [0060], legacy and new UEs multiplexed in different subframes),
- the second frequency band being narrower than and contained within the first frequency band (D1: figure 4A, paragraph [0051]).

1.2 Claim 2: The subject-matter of claim 2 is not new since D1 further discloses that the radio resource segments are sub-frames of radio frames, each radio frame comprising a plurality of sub-frames (D1: figure 2, subframes), and sub-frames are allocated to the subordinate carrier using a subordinate carrier sub- frame allocation set, the subordinate carrier sub-frame allocation set determining which sub frames within a repeating group of one or more radio frames are allocated to the subordinate carrier (D1: figure 5, R8 subframes, paragraph [0055], paragraph [0060], legacy and new UEs multiplexed in different subframes).

1.3 Claim 3: The subject-matter of claim 3 is not new since D1 further discloses that the subordinate carrier sub-frame allocation set is defined by one or more reserved sub-frame allocation patterns (D1: paragraph [0068], MBSFN subframes are used to define the reserved sub-frame allocation patterns).

1.4 Claim 5: The subject-matter of claim 5 is not new since D1 further discloses that acquisition information required for a terminal device of the second type to receive the subordinate carrier is allocated to sub-frames of the subordinate carrier using at least a portion of the subframes in one or more of the reserved sub-frame allocation patterns defining the subordinate carrier (D1: figure 7a, R8BW Control region).

1.5 Claim 6: The subject-matter of claim 6 is not new since D1 further discloses that said base station is operable to transmit an indication of the radio resources of all reserved sub- frames to terminal devices of the first type (D1: paragraph [0068], MBSFN subframes pattern indicates to new/second UEs the reserved sub-frames).

1.6 Claim 8: The subject-matter of claim 8 is not new since D1 further discloses that the base station is operable to transmit, using radio resources within the second frequency band, subordinate carrier information indicating that a subordinate carrier is available within the host carrier (D1: implicit from

paragraph [0045], since R8BW and NewBW are conveyed in MIB to all UEs and from paragraph [0068] since all UEs are also conveyed the MBSFN subframes pattern).

1.7 Claim 10: The subject-matter of claim 10 is not new since D1 further discloses that the subordinate carrier information is provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the system information of the host carrier (D1: paragraph [0045], R8BW and NewBW conveyed in MIB).

1.8 Claim 11: The subject-matter of claim 11 is not new since D1 further discloses that the first acquisition information is a master information block transmitted on a physical broadcast channel within radio resources of the host carrier (D1: paragraph [0045], R8BW and NewBW conveyed in MIB).

1.9 Claim 12: The subject-matter of claim 12 is not new since D1 further discloses that the first type of terminal devices are capable of receiving the full bandwidth of the first frequency band, and the second type of terminal devices are not capable of receiving the full bandwidth of the first frequency band but are capable of receiving the full bandwidth of the second frequency band (D1: paragraph [0075]).

1.10 Claim 14: The subject-matter of claim 14 is not new since D1 further discloses that the base station is operable to transmit, using radio resources within the second frequency band, an indication of the bandwidth of the subordinate carrier (D1: paragraph [0045], R8BW and NewBW conveyed in MIB).

1.11 Claim 15: The subject-matter of claim 15 is not new since D1 further discloses that the indication of the bandwidth of the subordinate carrier is provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being provided to permit a terminal device of the first type to receive the host carrier downlink and camp on to the host carrier (D1: paragraph [0045], R8BW and NewBW conveyed in MIB).

1.12 Claim 16: The subject-matter of claim 16 is not new since D1 further discloses that the base station is operable to transmit, using radio resources of the subordinate carrier, an indication of the bandwidth of the subordinate carrier (D1: paragraph [0045], R8BW and NewBW conveyed in MIB).

1.13 Claim 17: The subject-matter of claim 17 is not new since D1 further discloses that the base station is operable to transmit, using radio resources of the subordinate carrier, second acquisition information required for a terminal device of the second type to receive the subordinate carrier downlink and camp on to the subordinate carrier (D1: implicit from paragraph [0044], since legacy UE is LTE rel 8 UE, apart from MIB it is also send the SIB required to receive the downlink and perform camp-on).

1.14 Claim 20: The subject-matter of claim 20 is not new since D1 further discloses that the second acquisition information is transmitted in at least some of the sub-frames allocated to the subordinate carrier (D1: implicit from paragraph [0044], since legacy UE is LTE rel 8 UE, the SIB is partially transmitted to it on DL-SCH of the subordinate carrier sub-frames).

1.15 Claim 30: The subject-matter of claim 30 is not new since D1 further discloses that the first type of terminal device is an LTE device and the second type of device is a low data rate device (D1: paragraph [0076], R8BW can be very small in order to support low-cost UEs).

1.16 Claim 33: The subject-matter of claim 33 is not new since D1 further discloses that at least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier are used for communicating with terminal devices of the first type (D1: figure 7A, paragraph [0065]).

1.17 Claim 36: The subject-matter of claim 36 is not new since D1 further discloses that a computer program, which when executed on a computer will cause the computer to perform a method according to claim 35 (D1: paragraph [0158]).

1.18 Claim 37: The subject-matter of claim 37 is not new since D1 further discloses that a recording medium storing the computer program of claim 36 (D1: paragraph [0158]).

1.19 Furthermore, it is noted that the document D2 also comprises all the essential features of claims 1 to 3, 5, 6, 8, 10 to 12, 14 to 17, 20, 30, 33, 36 and 37, see citations provided in the search report.

2 **Inventive Step (claims 4, 7, 9, 13, 18, 19, 21 to 29, 31 and 32)**

The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 4, 7, 9, 13, 18, 19, 21 to 29, 31 and 32 does not involve an inventive step in the sense of Article 33(3) PCT.

2.1 Claims 4, 7, 9, 13, 18, 19, 21 to 29, 31 and 32: *The features of these claims are merely implementation details that would be regarded by the skilled person as a normal design option, see also D3 (D3: section 14.2)*

3 **Corresponding claims 34, 35, 38 and 39**

It is noted that the subject-matter of claims 34(1), 35(1), 38(1), 39(1) has been found to correspond respectively to the subject-matter of those listed in parentheses. Therefore, no specific argumentation is provided for claims 34, 35, 38 and 39 and the argumentation provided for the corresponding claim 1 applies mutatis-mutandis.

Re Item VII
Certain defects in the international application

1 Contrary to the requirements of Rule 5.1(a) (ii) PCT, the disclosure of relevant background art in D1, D2 is not mentioned in the description.

2 The independent claims are not in the two-part form in accordance with Rule 6.3(b) PCT.

3 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

Re Item VIII
Certain observations on the international application

1 **Claims 35, 38 and 39**

Although claims 35, 38 and 39 have been drafted as separate independent claims, they appear to relate effectively to the same subject-matter and to differ from each other only with regard to the definition of the subject-matter for which protection is sought and/or in respect of the terminology used for the features of that subject-matter. The aforementioned claims therefore lack conciseness and as such do not meet the requirements of Article 6 PCT. Furthermore, it is clear from the description that the features of claim 35, are essential for the definition of the invention and must therefore be contained in the independent claims 38 and 39.

2 **Clarity (claim 1)**

The present application does not meet the requirements of Article 6 PCT, because the subject-matter of claim1 for which protection is sought is not clearly defined. The following arguments apply mutatis-mutandis to the respective corresponding claims.

2.1 The term "subordinate carrier" used in claims 1 is vague and unclear and leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear. In particular, the term carrier typically refers to a certain part of the frequency spectrum.
However, in the description on page 12 it is defined "by a certain bandwidth in the frequency domain and a certain pattern of time periods in the time domain". This definition is considered essential for the definition of the invention and must therefore be contained in the independent claim 1.

PCT REQUEST

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0	**For receiving Office use only**	
0-1	International Application No.	PCT/GB2013/050126
0-2	International Filing Date	21 January 2013 (21.01.2013)
0-3	Name of receiving Office and "PCT International Application"	RO/GB

0-4	**Form PCT/RO/101 PCT Request**	
0-4-1	Prepared Using	PCT Online Filing Version 3.5.000.232 MT/FOP 20020701/0.20.5.20
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	UK Intellectual Property Office (RO/GB)
0-7	**Applicant's or agent's file reference**	P059858WO
I	**Title of Invention**	WIRELESS COMMUNICATIONS SYSTEM AND METHOD
II	**Applicant**	
II-1	This person is	Applicant only
II-2	Applicant for	AP: (BW GH GM KE LR LS MW MZ NA RW SD SL SZ TZ UG ZM ZW); EA: (AM AZ BY KG KZ RU TJ TM); EP: (AL AT BE BG CH&LI CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR); OA: (BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG); AE AG AL AM AO AT AU AZ BA BB BG BH BN BR BW BY BZ CA CH&LI CL CN CO CR CU CZ DE DK DM DO DZ EC EE EG ES FI GB GD GE GH GM GT HN HR HU ID IL IN IS JP KE KG KM KN KP KR KZ LA LC LK LR LS LT LU LY MA MD ME MG MK MN MW MX MY MZ NA NG NI NO NZ OM PA PE PG PH PL PT QA RO RS RU RW SC SD SE SG SK SL SM ST SV SY TH TJ TM TN TR TT TZ UA UG UZ VC VN ZA ZM ZW
II-4	Name	Wireless Technology Solutions LLC
II-5	Address	550 Madison Avenue New York 10022 United States of America
II-6	State of nationality	US
II-7	State of residence	US

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III-1	**Applicant and/or inventor**	
III-1-1	This person is	Applicant and inventor
III-1-2	Applicant for	US
III-1-4	Name (LAST, First)	YOUNG, Philip
III-1-5	Address	Sweet Briar Hussell Lane Medstead Alton Hampshire GU34 5PF United Kingdom
III-1-6	State of nationality	GB
III-1-7	State of residence	GB
IV-1	**Agent or common representative; or address for correspondence**	
	The person identified below is hereby/ has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	Agent
IV-1-1	Name (LAST, First)	SMALL, Gary James
IV-1-2	Address	Carpmaels & Ransford One Southampton Row London WC1B 5HA United Kingdom
IV-1-3	Telephone No.	00442072428692
IV-1-4	Facsimile No.	00442074054166
IV-2	**Additional agent(s)**	additional agent(s) with same address as first named agent
IV-2-1	Name(s)	HOWICK, Nicholas Keith; HALLYBONE, Huw George; JACKSON, Richard Eric; HOWARD, Paul Nicholas; JAMES, Anthony Christopher W.P.; COCKERTON, Bruce Roger; MARSHALL, Cameron John; GOODFELLOW, Hugh Robin; TUNSTALL, Christopher Stephen; KIRSCH, Susan Edith; WARNER, James Alexander; BULLETT, Rachel Margaret; BRUNNER, John Michael Owen; CHAPMAN, Desmond Mark; WISE, Daniel Joseph
V	**DESIGNATIONS**	
V-1	**The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.**	

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VI-1	**Priority claim of earlier national application**		
VI-1-1	Filing date	20 January 2012 (20.01.2012)	
VI-1-2	Number	1201000.5	
VI-1-3	Country	GB	
VI-2	**Priority document request** The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1	
VI-3	**Incorporation by reference :** where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.		
VII-1	**International Searching Authority Chosen**	European Patent Office (EPO) (ISA/EP)	
VIII	**Declarations**	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	-	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	-	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	-	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	-	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	-	
IX	**Check list**	Number of sheets	Electronic file(s) attached
IX-1	Request (including declaration sheets)	4	✓
IX-2	Description	25	✓
IX-3	Claims	6	✓
IX-4	Abstract	1	✓
IX-5	Drawings	8	✓
IX-7	TOTAL	44	

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	Accompanying Items	Paper document(s) attached	Electronic file(s) attached
IX-8	Fee calculation sheet	–	✓
IX-18	PCT-SAFE physical media	–	–
IX-20	**Figure of the drawings which should accompany the abstract**	3	
IX-21	**Language of filing of the international application**	English	
X-1	**Signature of applicant, agent or common representative**	/SMALL, Gary James/	
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X-1-3	Capacity (if such capacity is not obvious from reading the request)	(Representative)	

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10-2	**Drawings:**	
10-2-1	Received	
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10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/EP
10-6	**Transmittal of search copy delayed until search fee is paid**	

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(71) Applicant *(for all designated States except US)*: **WIRELESS TECHNOLOGY SOLUTIONS LLC** [US/US]; 550 Madison Avenue, New York 10022 (US).

(72) Inventor; and
(71) Applicant *(for US only)*: **YOUNG, Philip** [GB/GB]; Sweet Briar, Hussell Lane, Medstead, Alton, Hampshire GU34 5PF (GB).

(74) Agents: **SMALL, Gary James** et al.; Carpmaels & Ransford, One Southampton Row, London WC1B 5HA (GB).

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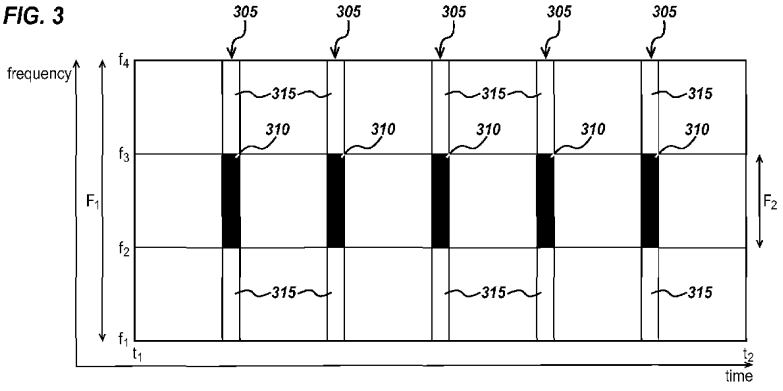
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(54) **Title**: WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

FIG. 3



(57) **Abstract**: A wireless communications system is described which comprises a base station, one or more terminal devices of a first type, and one or more terminal devices of a second type. The base station is operable to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band. In this way, an efficient and flexible mechanism for specifying and controlling an amount and location of radio resources to be dedicated to a subordinate carrier for use by a particular (e.g. reduced capability) type of device can be provided.

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WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

Field of the Invention

The present invention relates to wireless communications systems and methods, and in particular to a system, method, base station and terminal device for communicating using a subordinate carrier of a host carrier.

Background of the Invention

Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architectures, are able to support a more sophisticated range of services than simple voice and messaging services offered by previous generations of mobile telecommunication systems.

For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and the coverage area of these networks, i.e. geographic locations where access to the networks is possible, is expected to increase rapidly.

The anticipated widespread deployment of third and fourth generation networks has led to the parallel development of a class of devices and applications which, rather than taking advantage of the high data rates available, instead take advantage of the robust radio interface and increasing ubiquity of the coverage area. Examples include so-called machine type communication (MTC) applications, also known as machine-to-machine (M2M) communications, some of which are in some respects typified by semi-autonomous or autonomous wireless communication devices (i.e. MTC devices) communicating small amounts of data on a relatively infrequent basis. Examples include so-called smart meters

which, for example, are located in a customer's home and periodically transmit data back to a central MTC server relating to the customer's consumption of a utility such as gas, water, electricity and so on.

Whilst it can be convenient for a terminal such as an MTC-type terminal to take advantage of the wide coverage area provided by a third or fourth generation mobile telecommunication network there are at present disadvantages. Unlike a conventional third or fourth generation mobile terminal such as a smartphone, a primary driver for MTC-type terminals will be a desire for such terminals to be relatively simple and inexpensive. The type of functions typically performed by a MTC-type terminal (e.g. simple collection and reporting of relatively small amounts of data) do not require particularly complex processing to perform, for example, compared to a smartphone supporting video streaming. However, third and fourth generation mobile telecommunication networks typically employ advanced data modulation techniques and support wide bandwidth usage on the radio interface which can require more complex and expensive radio transceivers to implement. It is usually justified to include such complex transceivers in a smartphone as a smartphone will typically require a powerful processor to perform typical smartphone type functions. However, as indicated above, there is now a desire to use relatively inexpensive and less complex devices to communicate using LTE type networks.

Summary of the Invention

According to a first aspect of the invention there is provided a wireless communications system, comprising a base station, one or more terminal devices of a first type and one or more terminal devices of a second type. The base station is operable to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

In this way, an efficient and flexible mechanism for specifying and controlling an amount and location of radio resources to be dedicated to a subordinate carrier for use by a particular (e.g. reduced capability) type of device can be provided.

One way of achieving this differentiated access between the terminal devices of the first type and second type is to allocate a part of the carrier resource that is dedicated to the

second type of device (e.g. MTC traffic) using normal eNB (base station) scheduling. The eNB differentiates between MTC and non-MTC (example of the first type of device) UEs and only schedules MTC UEs within the reserved part of the carrier resource and only schedules non-MTC UEs outside of the reserved part of the carrier resource. While this solution is viable, the simple scheduling approach places some restrictions on the MTC subordinate carrier that can be realised. For instance, it would be necessary to use the same carrier characteristics and/or reference signals. If it were advantageous to use different carrier characteristics or to use additional or modified reference signals then this may not be possible in an MTC subordinate carrier implemented purely by eNB scheduling.

The radio resource segments may be sub-frames of radio frames, each radio frame comprising a plurality of sub-frames. In this case, the sub-frames may be allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set, the subordinate carrier sub-frame allocation set determining which sub frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The subordinate carrier sub-frame allocation set may be defined by one or more reserved sub-frame allocation patterns. The one or more reserved sub-frame allocation patterns may comprise all or a sub-set of all reserved sub-frame allocation patterns defined for the host carrier.

In one example, the subframes selected for the subordinate carrier are so-called MBSFN (Multimedia Broadcast/multicast service over a Single Frequency Network) subframes. This embodiment relies on the fact that such subframes do not have to be used exclusively for MBSFN. The LTE Rel8/9/10 specifications define a means (in the standard LTE SystemInformationBlockType2 – SIB2) by which certain subframes can be excluded from normal allocation to the Physical Downlink Shared Channel (PDSCH). Furthermore, the specifications define signalling within the standard system information which allows some or all of these excluded subframes to be used for other defined purposes, such as MBMS (in SystemInformationBlockType13 – SIB13), relay and positioning reference signal transmission. However, reading of this system information may require reception across the whole carrier bandwidth.

Acquisition information required for a terminal device of the second type to receive the subordinate carrier may be allocated for inclusion in sub-frames of the subordinate carrier using at least a portion of the subframes in one or more of the reserved sub-frame allocation patterns defining the subordinate carrier.

The base station may be operable to transmit an indication of the radio resources of all reserved sub-frames to terminal devices of the first type. In this way, the first type of device is informed of subframes which are reserved for the subordinate carrier, another subordinate carrier, and for other purposes such as relay backhaul. A particular device of the first type is not required to know why a particular sub-frame is reserved, merely that it is not available to that device. This indication may be presented to the terminal devices of the first type as a reserved subframe allocation within a system information block transmitted using frequency resources not necessarily limited to the second frequency band of the subordinate carrier. In this way, it is possible to exclude non-MTC devices from a resource reserved for the subordinate carrier.

The base station may be operable to transmit, using radio resources within the second frequency band, subordinate carrier information indicating that a subordinate carrier is available within the host carrier. A terminal device of the second type may be responsive to subordinate carrier information indicating that a subordinate carrier is not available within the host carrier to terminate a camp-on procedure for camping on to the network.

The subordinate carrier information may be provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the system information of the host carrier. The first acquisition information may be a master information block transmitted on a physical broadcast channel within radio resources of the host carrier. In this way it is possible to signal via the first acquisition information, to terminal devices of the second type, the presence of an MTC subordinate carrier existing within the reserved resource and using only a restricted bandwidth. If the subordinate carrier information is not present then the camp-on process by a terminal device may be terminated early, thereby reducing time and power wastage at the terminal device.

The first type of terminal device may be capable of receiving the full bandwidth of the first frequency band, and the second type of terminal device may not be capable of receiving the full bandwidth of the first frequency band but be capable of receiving the full bandwidth of the second frequency band. The bandwidth of the subordinate carrier may be predetermined and be known in advance to terminal devices of the second type. Alternatively, the base station may be operable to transmit, using radio resources within the second frequency band, an indication of the bandwidth of the subordinate carrier. In this case the bandwidth need not necessarily be predetermined. The indication of the bandwidth of the

subordinate carrier may be provided within first acquisition information transmitted on radio resources within the second frequency band, the acquisition information being provided to permit a terminal device of the first type to receive the host carrier downlink and camp on to the host carrier. Alternatively, the base station may be operable to transmit, using radio resources of the subordinate carrier, an indication of the bandwidth of the subordinate carrier.

The base station may be operable to transmit, using radio resources of the subordinate carrier, second acquisition information required for a terminal device of the second type to receive the subordinate carrier downlink and camp on to the subordinate carrier. The second acquisition information may be transmitted on predetermined radio resources which are known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the bandwidth of the subordinate carrier. In this way, it is possible to signal system information defining the characteristics of the MTC subordinate carrier using only resources within the MTC subordinate carrier.

The radio resource segments may be sub-frames of radio frames in the time direction, each radio frame comprising a plurality of sub-frames. The second acquisition information may be transmitted in at least some of the sub-frames allocated to the subordinate carrier. A terminal device of the second type may be operable to determine whether a sub-frame contains second acquisition information from a current radio frame number and a first sub-frame allocation set for allocating the second acquisition information to sub-frames within the subordinate carrier, said first sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames contain the second acquisition information.

The current radio frame number may be determined from first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the host carrier downlink and camp on to the network. The first sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the current radio frame number. Accordingly, once the second acquisition information is available to a mobile terminal, it may from that point on obtain the current radio frame number from the second acquisition information rather than having to refer back to the first acquisition information.

A terminal device of the second type may be operable to determine whether a sub-frame is allocated to the subordinate carrier from a current radio frame number and a second sub-frame allocation set for the subordinate carrier, said second sub-frame allocation set

identifying which sub-frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The current radio frame number may be determined from the second acquisition information. Alternatively, the current radio frame number may be determined from the first acquisition information and updated by counting radio frames.

The second sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. Alternatively, the second sub-frame allocation set may be specified in the second acquisition information. It will be appreciated that the second sub-frame allocation set may be different to the first sub-frame allocation set, but will include all of the sub-frames of the first sub-frame allocation set (and probably additional sub-frames as well).

The first type of terminal device may be an LTE device and the second type of device may be a low data rate device. The first type of terminal device may be an LTE device and the second type of device may be a low data rate device for providing machine-to-machine (M2M) communication.

It will be appreciated that different radio resource segments of the same or a different frequency band may be used to support a further subordinate carrier.

At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier may be allocated to another subordinate carrier. In other words, a different frequency band of the same resource segments (in time) may support another carrier.

At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier may be used for communicating with terminal devices of the first type. In other words, a different frequency band of the same resource segments (in time) may support the host carrier.

Viewed from another aspect, there is provided a base station for communicating with terminal devices. The base station is operable to communicate with terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

Viewed from another aspect, there is provided a terminal device for communicating with a base station which supports a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The terminal device is operable to communicate with the base station using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

Viewed from another aspect, there is provided a method of communicating between a base station and terminal devices of a first type and a second type. The method comprises communicating between the base station and terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and communicating between the base station and terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

Viewed from another aspect, there is provided a method of communicating with a base station from a terminal device, comprising communicating with the base station using a subordinate carrier of a host carrier comprising radio resource segments distributed in time, each radio resource segment of the host carrier providing radio resources across a first frequency band, the subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

It will be appreciated that features of the above-described aspects and embodiments of the invention may be combined with features of other aspects and embodiments of the invention as appropriate and in combinations other than those explicitly set out. For example, optional features of the first aspect of the invention may equally optionally be incorporated in embodiments according to other aspects of the invention, for example where the different aspects have corresponding features.

Brief Description of the Drawings

Example embodiments of the present invention will now be described with reference to the accompanying drawings in which like parts have the same designated references and in which:

Figure 1 is a schematic block diagram of a radio network and a plurality of user equipments forming a wireless communication system which operates in accordance with the 3GPP Long Term Evolution (LTE) standard;

Figure 2 schematically represents elements of a mobile telecommunications system for implementing embodiments of the invention;

Figure 3 schematically represents a time and frequency resource allocation between a host carrier and a subordinate carrier;

Figure 4 schematically illustrates a radio frame and resource grid structure of time and frequency resources;

Figures 5A to 5D schematically illustrate example allocations of resources to the subordinate carrier;

Figure 6 is a schematic flow diagram of a first part of a camp-on procedure for connecting to the subordinate carrier;

Figure 7 is a schematic flow diagram of a second part of the camp-on procedure for connecting to the subordinate carrier; and

Figure 8 schematically illustrates a signalling configuration according to an embodiment of the invention.

Detailed Description of the Example Embodiments

Network Structure

Embodiments of the present invention are described herein with particular reference to an example implementation in a wireless communication system having carriers based around the 3GPP Long Term Evolution (LTE) standard.

Figure 1 schematically shows an example architecture of an LTE system. The LTE system is provided by a telecommunications network operator to allow parties to communicate. As shown in Figure 1, mobile communications devices designated as user equipment (UE) 105 are arranged to communicate data to and from base stations (transceiver stations) 101 which are frequently referred to in LTE as E-UTRAN NodeBs (e-nodeB). Each of the base stations 101 comprises a transceiver unit 103 enabling communication of data to and from a plurality of mobile communication devices via a radio interface. The e-nodeBs 101 are connected to a serving gateway S-GW 104 and to a mobility management entity (MME) 107. The S-GW 104 is arranged to perform routing and management of mobile communications services to the communications devices 105 in the mobile radio network. In order to maintain mobility management and connectivity, the mobility management entity

(MME) 107 manages evolved packet system (EPS) connections with the communications devices 105 using subscriber information stored in a home subscriber server (HSS) 108. Other core network components include a packet data network gateway (P-GW) 106 which connects to an internet network 109 and finally to an external server (not shown). In the context of MTC communications a UE supporting MTC communications may, for example, be conveniently referred to as an MTC terminal or MTC UE, and a server with which the MTC terminal(s) communicate data may, for example, be conveniently referred to as an MTC server. More generally, devices in the system capable of supporting MTC communications may be referred to as MTC entities. The various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [1]. These conventional aspects of LTE networks are not described further in the interest of brevity.

Two classes of device are considered herein. A first class of device is configured to communicate via a host carrier, and a second class of device is configured to communicate via a subordinate carrier. In some of the particular examples considered here, the first class of device and the host carrier are compliant with particular standards, for example, LTE Rel8/9/10 standards, and the second class of device and the subordinate carrier are compliant with modified versions of these particular standards, for example, based on versions of the standards modified to support lower-capability devices. Accordingly, and purely for the sake of reference and to aid explanation, the first class of device and the host carrier may be referred to here in some examples as legacy devices and legacy carrier, while the second class of device and the subordinate carrier may be referred to in some examples as MTC devices and MTC carrier (or in alternative DMN (Dedicated Messaging Network) devices and DMN carrier). However, it will be appreciated that these terms are simply used as labels for ease of explanation of particular implementations of embodiments of the invention for distinguishing the two classes of device and carrier. Thus, the term "legacy" should not be considered as indicating any form of obsolescence, and indeed the devices and carrier(s) referred to here as legacy devices and carrier(s) may equally correspond with devices and carrier(s) that comply with future releases of the LTE standards, for examples Rel11 and beyond. Equally, and as already noted above, DMN should not be taken to refer to a network which exclusively supports only basic messaging services. Furthermore, the second class of device and subordinate carrier that are described here as not being fully compliant with the operating

standards of the first class of device and first carrier (for example because of reduced capability) may nonetheless be compliant with their own standards. Furthermore, the functionality described herein as regards both the first and second classes of device and carriers might comply with different aspects of a future standard, for example a future release of the LTE standards.

Referring now to Figure 2, a base station 101' is shown communicatively connected to an LTE device 105a via a transceiver unit 103' and a first (host) carrier 110a, and communicatively connected to an MTC device 105b via the transceiver unit 103' and a second (subordinate) carrier 110b. The base station 101' is responsible for a coverage area in which both the LTE device 105a and the MTC device 105b are located. The single base station 101' is able to communicate on both the first carrier 110a and the second carrier 110b. The first carrier 110a is a host carrier having a broad bandwidth, while the second carrier 110b is a subordinate carrier having a narrower bandwidth located within the frequency band of the host carrier. As will be explained in more detail below, the time and frequency resources of the first (host) carrier and the second (subordinate) carrier are logically separate for the purposes of data transmission and most control signalling, but some time and frequency resources are accessible to and used by devices connected to both the first and second carriers.

Host Carrier and Subordinate Carrier Overview

Referring to Figure 3, the time and frequency resources constituting the host carrier and the subordinate carrier are schematically illustrated. The horizontal axis of Figure 3 is time, with a time period from t_1 to t_2 being shown in Figure 3. The vertical axis of Figure 3 is frequency, the frequency increasing from a frequency f_1 to a frequency f_4. The host carrier has a frequency band F_1, extending from the frequency f_1 to the frequency f_4. The subordinate carrier has a frequency band F_2, extending from a frequency f_2 to a frequency f_3. The subordinate carrier is intended primarily for use by terminal devices which do not have the capability to receive or transmit between the frequencies f_1 and f_2, and between the frequencies f_3 and f_4. The subordinate carrier does not occupy all of the time and frequency resources within the frequency band F_2. Instead, certain time periods 305 of the frequency band F_2 are allocated to the subordinate carrier (and potentially to other subordinate carriers), with the unallocated time periods within the frequency band F_2 forming part of the host carrier resources. The shaded portions 310 of Figure 3 indicates those time and frequency resources allocated to the subordinate carrier. When a time period 305 is allocated to the subordinate

carrier, the time and frequency resources 315 falling outside of the frequency band F_2 (but within the frequency band F_1) are not allocated to the subordinate carrier. In some implementations these time and frequency resources may be available to the host carrier (or to another subordinate carrier having a different (and non-overlapping) frequency band). In other implementations these time and frequency resources may be "lost" and unusable by either the first type of device or the second type of device. It is envisaged that the central frequency and bandwidth of the frequency bands F_1 and F_2 would be fixed for a given host carrier/subordinate carrier, although implementations in which they are not fixed may be possible. The particular time periods allocated to the subordinate carrier may be fixed, or may be dynamically variable, for example to increase or decrease the amount of radio resources allocated to the subordinate carrier to adapt to traffic conditions of the subordinate carrier (and/or possibly of the host carrier).

Radio Frame and Resource Grid Structure

Referring now to Figure 4, a radio frame and resource grid structure for an LTE type network are schematically illustrated. At the top of Figure 4, a radio frame 410 is shown. This occupies the full width of the frequency band of the host carrier, and has a duration of 10ms. The radio frame 410 is one of a sequence of radio frames which are used to communicate data between a base station and a terminal device. The radio frame 410 comprises 10 sub-frames 420, which again occupy the fully width of the frequency band of the host carrier. Each of these sub-frames 420 has a duration of 1ms. Each of the sub-frames 420 comprises two slots 430, each slot occupying the full width of the frequency band of the host carrier and having a duration of 0.5ms. Each slot comprises a plurality of resource blocks 440 in the frequency direction, and only a single resource block 440 in the time direction. In other words each resource block 440 has a duration of 0.5ms (the same as the duration of the slot 430), but occupies only a portion of the bandwidth of the host carrier. Each resource block 440 comprises a two-dimensional array of resource elements 450 distributed in both the time direction and the frequency direction. Each resource element 450 has a length (duration) of one modulation symbol, and a frequency range of one subcarrier (e.g. 15kHz). In the present case the resource block 440 has a dimension of 12 resource elements 450 in the frequency dimension and 7 resource elements 450 in the time dimension, resulting in an overall bandwidth of 12 subcarriers and a duration of 7 symbols.

In operation, data transmissions between a base station and a terminal device may be scheduled to use particular resource blocks. This scheduling is usually carried out by the base

station or a related network entity. Certain resource blocks may be permanently allocated to carry predetermined signalling information.

3GPP LTE Releases 8, 9 and 10 (Rel8/9/10) define 6 downlink transmission bandwidth configurations from 1.4 MHz to 20 MHz representing the use of 6, 15, 25, 50, 75 or 100 resource blocks. As noted above, all Rel8/9/10 terminal devices are required to support the maximum single carrier bandwidth of 20 MHz for compliance with the Rel8/9/10 standards. Nevertheless, for all bandwidth configurations Rel8/9/10 has specified that basic physical layer synchronisation signals (Primary Synchronisation Signals - PSS, and Secondary Synchronisation Signals - SSS), and the most fundamental system information (Master Information Block - MIB) is transmitted using only the central 6 resource blocks which are receivable with a 1.4 MHz transceiver. However, in order to receive the remainder of the carrier system information the terminal device is required to be able to receive the full bandwidth of the carrier.

However, and as also noted above, for some applications, for example in situations relating to machine type communications (MTC) and/or dedicated messaging networks (DMN), there is a drive to build low cost and hence low capability devices. Ideally, device simplification should permit a reduction in required bandwidth of operation as well as reduction of features and throughput. Terminal devices with a lower bandwidth capability than that specified for Rel8/9/10 may mean that such devices are unable to operate properly on Rel8/9/10 compliant networks which specify higher bandwidth capabilities. For example, terminal devices with a lower bandwidth capability may not even be able to receive any more system information than that contained in the MIB of a Rel8/9/10 compliant network.

Low capability devices will ideally be able to find and camp-on the carrier associated with their target dedicated messaging network(s) even in the presence of Rel8/9/10 higher bandwidth carriers. Furthermore, there is a desire that DMN carriers are not swamped by Rel8/9/10 capable devices camping-on the DMN, even though the Rel8/9/10 capable devices are in the coverage area of a higher bandwidth Rel8/9/10 carrier which they could otherwise use.

Subordinate Carrier Definition

As described in relation to Figure 3, the subordinate carrier resources (for use by MTC devices) may be defined by a certain bandwidth in the frequency domain (frequency band F_2 in Figure 3 for example) and a certain pattern of time periods in the time domain. The certain pattern of time periods may be a sequence of subframes as described above with reference to

Figure 4. The sequence of subframes may be a sequence of MBSFN subframes as defined by signalling within SystemInformationBlockType2 (SIB2) of the legacy LTE host carrier. However, it will be recognised that the subordinate carrier may be delineated by other means, for example by scheduling by a base station. The pattern of subframes may be a subset (or all) of those subframes reserved by the information element mbsfn-SubframeConfigList in the host carrier SIB2.

Conveniently, non-MTC UEs will read SIB2 of the legacy LTE host carrier and determine that a configured pattern of subframes are reserved for other purposes (such as MBMS, relay or as in the present case MTC subordinate carrier operation). The non-MTC UEs will therefore ignore the subframes allocated to the subordinate carrier. The configured pattern of reserved subframes is defined in a flexible manner by the information element mbsfn-SubframeConfigList.

In particular, mbsfn-SubframeConfigList comprises a set of 1 or more subframe allocations each of which is defined by the following fragment of ASN.1 from TS 36.331:

```
MBSFN-SubframeConfig ::=          SEQUENCE {
    radioframeAllocationPeriod          ENUMERATED {n1, n2, n4, n8, n16, n32},
    radioframeAllocationOffset          INTEGER (0..7),
    subframeAllocation                      CHOICE {
        oneFrame                                BIT STRING (SIZE(6)),
        fourFrames                              BIT STRING (SIZE(24))
    }
}
```

For a given allocation, the "radioframeAllocationPeriod" indicates the periodicity, in radio frames, with which MBSFN subframes are included in the allocation. "n1" indicates that MBSFN subframes are present in every radio frame, while "n2" indicates that MBSFN subframes are present in every other radio frame. A radioframeAllocationPeriod of "n32" indicates that one in every 32 radio frames includes one or more MBSFN subframes. Radio-frames that contain MBSFN subframes occur when equation SystemFrameNumber mod radioFrameAllocationPeriod = radioFrameAllocationOffset is satisfied. In other words, the radioframeAllocationOffset parameter sets an offset for a start position of the repeating pattern of radio frames. The subframeAllocation parameter defines the subframes that are allocated for MBSFN within the radio frame allocation period defined by the radioFrameAllocationPeriod and the radioFrameAllocationOffset parameters. The subframe

allocation can either be specified for a single radio frame within the radio frame allocation period (oneFrame) or for four consecutive radio frames within the radio frame allocation period (fourFrames). The subFrameAllocation parameter is a 6 bit (oneFrame) or 24 bit (fourFrame) mask, indicating whether each of 6 (oneFrame) or 24 (fourFrame) predetermined subframes are to be reserved. The LTE specification places restrictions on which subframes may be reserved for other purposes by this method, in order that there is no conflict with the requirement to receive system information and paging. In an FDD LTE system one or more of subframes 1, 2, 3, 6, 7 and 8 may be reserved for other purposes. In a TDD LTE system the subframes that may be reserved are 3, 4, 7, 8 and 9. The system frame number can be derived from the MIB of the host carrier.

Figures 5A to 5D are example subframe patterns. Each of Figures 5A to 5D shows a portion of a repeating pattern which could be specified by mbsfn-SubframeConfigList or by a similar pattern specifying function. Four radio frames having ten subframes each are shown in Figures 5A to 5D. The subframes are labelled from 0 (zero) to 9 (nine). The shaded subframes are those allocated to the subordinate carrier, with the unshaded subframes being retained for use on the host carrier. Figure 5A schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 111111 (thereby selecting each of subframes 1, 2, 3, 6, 7 and 8). It will be appreciated that this subframe allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

Figure 5B schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 11111x (thereby selecting each of subframes 3, 4, 7, 8 and 9). It should be noted that the last bit of the mask is not used for TDD. The difference between Figures 5A and 5B results from the different subframes mapped to the bit mask in the FDD and TDD schemes.

Figure 5C schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n1 (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 101010 (thereby selecting each of subframes 1, 3 and 7). It will be appreciated that this subframe

allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

Figure 5D schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to n1 (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 10101x (thereby selecting each of subframes 3, 7 and 9). It should be noted that the last bit of the mask is not used for TDD. Again, the difference between Figures 5C and 5D results from the different subframes mapped to the bit mask in the FDD and TDD schemes. All of the patterns shown in Figures 5A to 5D will repeat until the mbsfn-SubframeConfigList is altered. The set of allocation patterns specified in mbsfn-SubframeConfigList , which is signalled in SIB2, defines the "reserved set". A sub-set of the allocation patterns could be used to define the subordinate carrier. Also, two mutually exclusive sub-sets could be used to define two separate subordinate carriers delimited in the time domain.

It will be appreciated that this mechanism provides a great deal of flexibility in how much carrier resource is to be allocated to the subordinate carrier, and also how that resource is distributed with respect to time. The minimum (non-zero) amount of resources (in the time domain) which can be allocated is 1 in 320 subframes (when radioframeAllocationPeriod is set to n32 and only one bit is set in the subframeAllocation bit mask). The maximum amount of resources (in the time domain) which can be allocated is 192 in 320 subframes (when radioframeAllocationPeriod is set to n1 and all six bits are set in the subframeAllocation bit mask). In some implementations the allocation might be static to provide a fixed resource subordinate carrier. The fixed resources could in this case be known to a terminal device in advance. In other implementations the allocation might be dynamic, resulting in a subordinate carrier having a resource allocation which can be increased or decreased to for example meet traffic loading conditions on the subordinate carrier and/or on the host carrier. These increases or decreases could be based on requests from terminal devices for additional resource, or based on decisions made at the base station or a related entity. An increase in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined above, or by adding a new subframe allocation according to the principles set out above. A decrease in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined above, or by removing an existing subframe allocation.

In other words, it is possible to use multiple subframe allocations to achieve allocation patterns which would not be possible with a single subframe allocation, and to provide a simple way of increasing (or decreasing, if one of multiple subframe allocations is removed) the amount of resources allocated to the subordinate carrier. In one implementation, a first subframe allocation with a relatively low allocation period and subframe allocation could be used to maintain a low resource subordinate carrier which can be camped onto by a low capability terminal device, and then further subframe allocations could be added to service the communication needs of the low capability terminal device when it has successfully camped on. In this way, the resources available to the host carrier are retained at a high level to serve LTE traffic when the subordinate carrier is not in use.

Signalling the presence of the Subordinate Carrier

Certain resource blocks may be used to carry control signalling including synchronisation signals and system information. As explained above, a problem can therefore arise if essential control signalling from the base station is transmitted outside of the frequency range which can be received by a low-capability device. Fortunately, as described above, the synchronisation signals and the Master Information Block (MIB) of the system information are present within a frequency range which is likely to be receivable by a low-capability device. However, further system information, carried in System Information Blocks (SIBs), and the associated control signalling may be transmitted at a frequency which cannot be received by the low-capability device. This would cause problems, potentially preventing the low-capability device from being able to camp on to the network. It will be appreciated that not all host carriers will necessary support a subordinate carrier. If a low-capability device attempts to camp-on to a network which does not support a subordinate carrier then the camp-on procedure will ultimately fail. This is a waste of time and power for the low-capability device.

It would therefore be desirable to signal to an MTC UE which has restricted reception bandwidth the presence of an MTC subordinate carrier within a larger bandwidth LTE carrier accessible to legacy UEs (LTE Rel 8/9/10 UEs). It was discussed above that for all LTE bandwidths (Rel8/9/10) the basic physical layer synchronisation signals and the most important system information (Master Information Block) is transmitted using only the central 6 resource blocks (72 subcarriers). The Master Information Block (MIB) is transmitted in the Physical Broadcast Channel (PBCH) which is allocated to the central 72 subcarriers and to just the first 4 OFDMA symbols of the second slot of every 10ms radio frame. Thus,

assuming that the low bandwidth MT UE is able to receive at least 6 resource blocks in the frequency domain, then the PBCH (for example the MIB) may be used to signal the presence of an MTC subordinate carrier.

In Figure 6, a schematic flow diagram of a first part of a camp-on procedure is shown. At a step A1, an MTC device seeking to camp-on to a subordinate carrier, for example following power-up, seeks to identify and decode PSS (Primary Synchronisation Signals) and SSS (Secondary Synchronisation Signals) signalling being broadcast in its location. Once the MTC device synchronises to a carrier using the PSS and SSS, the MTC device determines the frame timing and proceeds to decode the PBCH to determine the MIB for the carrier. At a step A2, the MTC device determines whether or not a subordinate carrier indicator flag is present in the MIB. The MTC subordinate carrier indicator flag may be signalled in one (or more) of the MIB bits that are spare in LTE Release 8 / 9 / 10 (10 bits are currently spare). If the MTC device determines that the MIB contains a subordinate carrier indicator flag then the camp-on process continues at a step A3. If on the other hand the MTC subordinate carrier indicator flag was found not to be present, then the camp-on procedure to this carrier would be terminated. This would allow the device to decide upon proceeding with camp-on (or not) simply based upon decoding of the legacy LTE MIB, and to discontinue with camp-on immediately after the decoding of the legacy LTE MIB should the subordinate carrier indicator flag not be present. As an alternative to using the MIB to signal the presence of a subordinate carrier, a subordinate carrier indicator signal could be provided at a known time / frequency somewhere other than in the MIB. The particular time / frequency may be defined referentially with respect to the MIB (for example). The subordinate carrier indicator signal may be relative to the host carrier PBCH and/or the System Frame Number conveyed in the host carrier PBCH / MIB. In this case the MTC device would, following synchronisation (at the step A1), search for the subordinate carrier indicator signal at the expected time / frequency (at the step A2). If it is found, then the MTC device knows that one (or more) subordinate carriers are present and continues its discovery of the MTC subordinate carrier and the subsequent camp-on process.

In either implementation, it will be appreciated that the presence of the subordinate carrier indicator is derivable by the MTC device without being required to decode any system information block (SIB) of the host carrier since the MTC device may be unable to receive the host carrier SIBs which are signalled across the full host carrier frequency band F1.

If the MTC device does not find a subordinate carrier associated with the host carrier, then it may search for and seek to camp-on to another carrier by returning to the step A1 to seek to synchronise with and decode PBCH for a different carrier.

Signalling the bandwidth of the subordinate carrier(s)

Having detected the presence of an MTC subordinate carrier the UE needs to determine the bandwidth of the subordinate carrier in order to be able to read the further system information which will contain the other characteristics of the subordinate carrier. There are a number of alternative ways in which the subordinate carrier bandwidth may be signalled to the MTC UE:

(1) The simplest method is to fix the bandwidth of the subordinate carrier in the 3GPP specifications. Having detected the presence of a subordinate carrier in the manner described above, the MTC UE would know by definition the MTC subordinate carrier bandwidth (e.g. 1.4MHz, 3MHz or 5 MHZ).

(2) The downlink bandwidth of the MTC subordinate carrier may be signalled in the legacy LTE MIB. For example if the subordinate carrier indicator flag were signalled in the PBCH by using a 2 bit field, 4 states could be signalled (absence of a subordinate carrier and three different subordinate carrier bandwidths, e.g. 1.4MHz, 3MHz and 5 MHZ).

(3) The downlink bandwidth (and possibly other characteristics) of the MTC subordinate carrier could be signalled in a Subordinate Carrier Master Information Block (scMIB). The scMIB would be signalled in fixed time / frequency resources, known in advance to the mobile terminal and preferably defined in the 3GPP specifications. The possibilities for signalling the scMIB are described in the following section.

Signalling the Subordinate Carrier Master Information Block (scMIB)

In the above section three methods of determining the downlink bandwidth of an MTC subordinate carrier by an MTC UE have been described. The first two of these methods involve a priori knowledge of when decoding of the subordinate carrier begins. The last of the described methods involves signalling the downlink bandwidth in a Master Information Block of the subordinate carrier itself.

A Master Information Block may be regarded as collection of parameters giving values to configurable characteristics of the carrier and other information to achieve/maintain radio frame synchronisation. A Master Information Block is required to be supplied in fixed time/frequency resources and must be received and decoded before a more flexible scheme of

downlink message exchange may be employed. According to the above description, at the point at which the UE tries to decode the scMIB, the UE will know:

- That an MTC subordinate carrier is present (from the indicator flag / signal).
- The subordinate carrier centre frequency (it may generally be assumed that this will be the same as the centre frequency of the host legacy LTE carrier).

In addition the UE may know the MTC subordinate carrier bandwidth, if this has been fixed in the specifications, conveyed in the host carrier MIB or conveyed by some other a priori means. In order to receive and decode the scMIB the UE must be able to determine in which resource elements it is carried. The number of resource elements used for the scMIB could be related to the subordinate carrier bandwidth or it could be fixed (as is the case for the legacy LTE MIB). If the number of resource elements were defined to be dependent upon the subordinate carrier bandwidth, this would require the value of the subordinate carrier bandwidth to be known a priori. There are a limited number of spare bits available in the legacy host carrier LTE MIB, and so it may be considered that there are not sufficient available to use 1 or more of these to carry subordinate carrier bandwidth information. In this case, the UE will not have a priori knowledge of the subordinate carrier bandwidth so the UE will be unable to derive the scMIB resource elements from the bandwidth.. Accordingly, for the purposes of the following description it is assumed that the scMIB is always signalled in a fixed set of resource elements defined within the 3GPP specifications. Nonetheless, it should be understood that the present invention is not limited to this, and that in certain implementations the set of resource elements used to convey the scMIB may not be fixed.

The fixed set of resource elements is contained within a subset (or all) of those subframes reserved by one (or more) of the subframe allocations configured in the information element mbsfn-SubframeConfigList broadcast in the host carrier SIB2. The fixed subframe allocation to convey the scMIB should:

- Be frequent enough to occasion an acceptable latency for acquisition of the scMIB by MTC UEs.
- Not be too frequent that excessive resources are consumed from the host carrier and subordinate carrier.

It should be noted that it is common for MTC devices to exhibit low mobility and be able to tolerate comparatively high latencies in message transmission. However, this may not be the case with all possible MTC traffic and it is therefore preferable that the frequency of

MIB transmission be fixed within the 3GPP specification and thus cannot be configured dependent upon the expected MTC traffic characteristics.

Various fixed characteristics of the scMIB transmission scheme, including the following, should preferably be defined within the 3GPP specifications:

- The number, periodicity and relationship to host carrier System Frame Number of the subframes used for scMIB.
- The level of repetition encoding employed.
- Within the subframes used, the number and location of resource elements used to convey the scMIB (that is, exactly which slot(s), subcarriers and symbols are to be used).

The number of resource elements used for the scMIB will be a function of the number of bits of information that must be conveyed by this method, which will be influenced by the further details of the subordinate carrier design, but the number will also be constrained by the overhead that this imposes. The System Frame Number, necessary for the UE to maintain radio frame synchronisation, upon which many LTE higher layer processes are dependent, may be read from the host carrier MIB. However, for efficiency reasons it is likely that once the UE synchronises to the subordinate carrier, it would be undesirable for the UE to have to keep re-reading the host carrier MIB to maintain this information. Thus, System Frame Number is likely to be carried by the scMIB, although the UE might depend upon the host carrier MIB for this information.

Any combination of parameters conforming to and fully resolving the definition of MBSFN-SubframeConfig may be chosen to define which subframes convey the scMIB. However, use of a single subframe allocation pattern will provide a solution involving least complexity. For example a single pattern comprising a single subframe allocation once per radio frame allocation period of 32 frames and with an offset value of zero may be considered adequate to convey the scMIB dependent upon other details of the subordinate carrier design. Alternatively, if more MIB bits are required then a shorter allocation period of, for example, 16 or 8 radio frames could be used and/or more subframes per allocation period. Note that while the subframes used to convey the scMIB may be defined by such a subframe allocation pattern or patterns, not all slots or resource elements in the subframes defined by the pattern(s) are necessarily used to convey the scMIB. Use of a shorter allocation period but sparse use of the resource elements for the scMIB may offer the best compromise in relation to scMIB acquisition time and resource overhead.

The subframe allocation pattern or patterns chosen to define the subframes used for the scMIB will be included in the mbsfn-SubframeConfigList of SIB2 of the host carrier in order to reserve these subframes for special use within the context of the host carrier. However, low bandwidth MTC UEs searching for a suitable subordinate carrier will not be required to read SIB2 of the host carrier to gain this information, since the subframe allocation pattern(s) for the scMIB will be fixed and defined in the 3GPP specifications.

Camp-on procedure

Referring to Figure 7, the camp-on procedure following the initial steps shown in Figure 6 is schematically illustrated. At a step B1 the location of the scMIB is determined. As discussed above, the location of the scMIB is likely to be fixed in the 3GPP standards, and so the MTC UE will be able to frame synchronise with the scMIB broadcast by comparing the location of the scMIB (radio frame and sub-frame known from the 3GPP specifications) with the current System Frame Number (which the MTC UE can derive from the host carrier MIB). At a step B2 the scMIB is received and decoded, whereby the system information specified therein can be acquired and used. At a step B3 the bandwidth and central frequency of the subordinate carrier is determined. The bandwidth of the subordinate carrier may be determined by one of the methods described above in the section "Signalling the Bandwidth of the Subordinate Carrier(s)". The central frequency may be assumed to be the same as that of the host carrier, but in some implementations may have a different central frequency which would need to be signalled to the MTC UE. The central frequency and bandwidth together identify the frequency band forming the subordinate carrier. Note that if the bandwidth is not determined from the scMIB then the step B3 can be performed before (or in parallel with) the steps B1 and B2.

At a step B4, the allocation of subordinate carrier subframes is determined. An indication of those subframes allocated to the subordinate carrier may be specified in the scMIB. As described above, sub-frames are allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set which determines which sub frames within a repeating group of radio frames are allocated to the subordinate carrier. At a step B5, further system information (System Information Blocks) relating to the subordinate carrier is obtained from subframes allocated to the subordinate carrier. This further system information can be used to complete the camp on procedure of the MTC UE to the subordinate carrier at a step B6. The further system information may be at a fixed location within the radio resources

of the subordinate carrier, or at a location within the radio resources of the subordinate carrier which has been scheduled by the base station, or a combination of both.

In Figure 8, example signalling on the host carrier and the subordinate carrier is schematically illustrated. In Figure 8, eight radio frames 800 are shown, each having a central frequency portion 820 usable by both the host carrier and the subordinate carrier, and outer frequency portions 810 usable only by the host carrier. In each radio frame, a MIB 830 is provided in the central frequency portion 820. The MIB 830 is readable by devices using both the host carrier and the subordinate carrier. Devices seeking to use a subordinate carrier may be able to determine from the MIB 830 whether a subordinate carrier exists based on a flag present in the MIB 830. In an outer frequency portion 810, system information 840 is provided for use by devices served by the host carrier. The system information 840 is shown to be outside of the central frequency portion 820 and is thus not available to the kind of low-capability devices intending to use the subordinate carrier. It will be appreciated that some system information may happen to be transmitted within the central frequency portion 820, but this cannot be guaranteed. The system information 840 is provided in the form of System Information Blocks (SIBs). Unlike the Master Information Block which is broadcast on the Physical Broadcast Channel (PBCH), the SIBs are mapped onto the Physical Downlink Shared Channel (PDSCH). Generally, the Master Information Block 830 provides sufficient information to gain access to the first of the System Information Blocks (SIB1), which in turn provides sufficient information to gain access to SIB2 et seq. SIB2 includes parameters relating to the reservation of MBSFN subframes (as described above). Legacy LTE devices using the host carrier will therefore be informed of the subframes reserved for use by the subordinate carrier (or for other purposes, for example MBMS or relay backhaul) when they decode SIB2. They will therefore know that these subframes cannot be used and to ignore them. Within the central portion 810 of some or all of the radio frames (every other radio frame in this example) is a portion 850 allocated to the subordinate carrier. For the sake of clarity the portion 850 shown in Figure 8 is contiguous, but it will be appreciated from Figures 5A to 5D for example that this may not be the case. The portions 850 are used to transmit data and signalling to low capability devices using the subordinate carrier. Within the allocated portion 850 of the first radio frame is a subordinate carrier MIB (scMIB) 860 carrying various information required for a low capability device to acquire the remainder of the subordinate carrier system information.

Within the allocated portion 850 of the second radio frame is system information 870 relating to the subordinate carrier. This system information 870 provides information required for a terminal device to camp on to the subordinate carrier. It will be appreciated that the locations of the scMIB 860 and the system information 870 is purely exemplary. The important point is that the scMIB 860 and the system information 870 are conveyed in the allocated portions 850. As described in detail above, the location and periodicity of the scMIB would probably be fixed (predetermined). The system information 870, which could be conveyed in the form of System Information Blocks in a similar manner to with the host carrier, may be predetermined, or dynamically allocated (scheduled), depending on implementation.

In the host carrier, the MIB and any associated SIBs together provide the parameters necessary for system access using the host carrier. Similarly, in the subordinate carrier, the scMIB and any associated SIBs carried in subframes allocated to the subordinate carrier provide the parameters necessary for system access using the subordinate carrier. In both cases, the UE (legacy or MTC) requires the MIB to decode the shared channel (and thus access SIBs). The MIB contains downlink system bandwidth of the host carrier and the system frame number.

The above embodiment describe a method of conveying a subordinate carrier for low bandwidth devices within a portion of a larger host carrier using for example MBSFN subframe allocation pattern(s) to reserve subframes for the subordinate carrier. This permits a flexible and efficient definition of a subordinate carrier within a host carrier. An indication of the presence of the MTC subordinate carrier is provided using a flag in the host carrier MIB. This may require the 3GPP standard to be updated, but will not require any change to legacy LTE devices because the flag is set in current spare bits which can and will be ignored by a legacy device. Various methods of signalling subordinate carrier downlink bandwidth have been described, including fixing the MTC subordinate carrier bandwidth in 3GPP specifications, signalling the subordinate carrier downlink bandwidth via a field in host carrier MIB, or signalling using a bit field within the subordinate carrier MIB (scMIB). A method of defining the subframes used for the subordinate carrier Master Information Block by using fixed (defined in 3GPP specifications) subframe allocation pattern(s) in relation to the System Frame Number of the host carrier has also been described above. A subordinate carrier has been described (in one example) to be specified using a repeating pattern of sub-frames. A

mechanism to specify this already exists in LTE, originally for the purpose of specifying sub-frames for use in MBSFN.

It will be appreciated that various modifications can be made to the embodiments described above without departing from the scope of the present invention as defined in the appended claims. In particular although embodiments of the invention have been described with reference to an LTE mobile radio network, it will be appreciated that the present invention can be applied to other forms of network such as GSM, 3G / UMTS, CDMA2000, etc. The term MTC terminal as used herein can be replaced with user equipment (UE), mobile communications device, mobile terminal etc. Furthermore, although the term base station has been used interchangeably with e-nodeB it should be understood that there is no difference in functionality between these network entities.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

REFERENCES

[1] Holma H. and Toskala A, "*LTE for UMTS OFDMA and SC-FDMA based radio access*", John Wiley and Sons, 2009.

CLAIMS

1. A wireless communications system, comprising:

a base station,

one or more terminal devices of a first type; and

one or more terminal devices of a second type; wherein

the base station is operable

to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and

to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

2. A wireless communications system according to claim 1, wherein

the radio resource segments are sub-frames of radio frames, each radio frame comprising a plurality of sub-frames, and

sub-frames are allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set, the subordinate carrier sub-frame allocation set determining which sub frames within a repeating group of one or more radio frames are allocated to the subordinate carrier.

3. A wireless communications system according to claim 2, wherein the subordinate carrier sub-frame allocation set is defined by one or more reserved sub-frame allocation patterns.

4. A wireless communications system according to claim 3, wherein the one or more reserved sub-frame allocation patterns comprise all or a sub-set of all reserved sub-frame allocation patterns defined for the host carrier.

5. A wireless communications system according to claim 3 or 4, wherein

acquisition information required for a terminal device of the second type to receive the subordinate carrier is allocated to sub-frames of the subordinate carrier using at least a portion of the subframes in one or more of the reserved sub-frame allocation patterns defining the subordinate carrier.

6. A wireless communications system according to one of claims 2 to 5, wherein said base station is operable to transmit an indication of the radio resources of all reserved sub-frames to terminal devices of the first type.

7. A wireless communications system according to claim 6, wherein the indication of the radio resources of the reserved sub-frames are presented to the terminal devices of the first type as a reserved subframe allocation within a system information block outside of the second frequency band of the subordinate carrier.

8. A wireless communications system according to any preceding claim, wherein the base station is operable

to transmit, using radio resources within the second frequency band, subordinate carrier information indicating that a subordinate carrier is available within the host carrier.

9. A wireless communications system according to claim 8, wherein a terminal device of the second type is responsive to subordinate carrier information indicating that a subordinate carrier is not available within the host carrier to terminate a camp-on procedure for camping on to the network.

10. A wireless communications system according to claim 8 or claim 9, wherein the subordinate carrier information is provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the system information of the host carrier.

11. A wireless communications system according to claim 10, wherein the first acquisition information is a master information block transmitted on a physical broadcast channel within radio resources of the host carrier.

12. A wireless communications system according to any preceding claim, wherein the first type of terminal devices are capable of receiving the full bandwidth of the first frequency band, and the second type of terminal devices are not capable of receiving the full bandwidth of the first frequency band but are capable of receiving the full bandwidth of the second frequency band.

13. A wireless communications system according to any preceding claim, wherein the bandwidth of the subordinate carrier is predetermined and is known in advance to terminal devices of the second type.

14. A wireless communications system according to any one of claims 1 to 12, wherein the base station is operable to transmit, using radio resources within the second frequency band, an indication of the bandwidth of the subordinate carrier.

15. A wireless communications system according to claim 14, wherein the indication of the bandwidth of the subordinate carrier is provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being provided to permit a terminal device of the first type to receive the host carrier downlink and camp on to the host carrier.

16. A wireless communications system according to any one of claims 1 to 14, wherein the base station is operable to transmit, using radio resources of the subordinate carrier, an indication of the bandwidth of the subordinate carrier.

17. A wireless communications system according to any preceding claim, wherein the base station is operable to transmit, using radio resources of the subordinate carrier, second acquisition information required for a terminal device of the second type to receive the subordinate carrier downlink and camp on to the subordinate carrier.

18. A wireless communications system according to claim 17, wherein the second acquisition information is transmitted on predetermined radio resources which are known in advance to terminal devices of the second type.

19. A wireless communications system according to claim 17, wherein the second acquisition information comprises an indication of the bandwidth of the subordinate carrier.

20. A wireless communications system according to claim 17, wherein the radio resource segments are sub-frames of radio frames in the time direction, each radio frame comprising a plurality of sub-frames, and wherein the second acquisition information is transmitted in at least some of the sub-frames allocated to the subordinate carrier.

21. A wireless communications system according to claim 20, wherein a terminal device of the second type is operable to determine whether a sub-frame contains second acquisition information from a current radio frame number and a first sub-frame allocation set for allocating the second acquisition information to sub-frames within the subordinate carrier, said first sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames contain the second acquisition information.

22. A wireless communications system according to claim 21, wherein the current radio frame number is determined from first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the host carrier downlink and camp on to the network.

23. A wireless communications system according to claim 21 or claim 22, wherein the first sub-frame allocation set is predetermined and known in advance to terminal devices of the second type.

24. A wireless communications system according to claim 17, wherein the second acquisition information comprises an indication of the current radio frame number.

25. A wireless communications system according to claim 20, wherein a terminal device of the second type is operable to determine whether a sub-frame is allocated to the subordinate carrier from a current radio frame number and a second sub-frame allocation set

for the subordinate carrier, said second sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames are allocated to the subordinate carrier.

26. A wireless communications system according to claim 25, wherein the current radio frame number is determined from the second acquisition information.

27. A wireless communications system according to claim 25, wherein the current radio frame number is determined from the first acquisition information and updated by counting radio frames.

28. A wireless communications system according to claim 25, wherein the second sub-frame allocation set is predetermined and known in advance to terminal devices of the second type.

29. A wireless communications system according to claim 25, wherein the second sub-frame allocation set is specified in the second acquisition information.

30. A wireless communications system according to any preceding claim, wherein the first type of terminal device is an LTE device and the second type of device is a low data rate device.

31. A wireless communications system according to any preceding claim, wherein the first type of terminal device is an LTE device and the second type of device is a low data rate device for providing machine-to-machine (M2M) communication.

32. A wireless communications system according to any preceding claim, wherein at least a portion of the radio resources, comprising a third frequency band, of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier and which are outside of the second frequency band are allocated to another subordinate carrier.

33. A wireless communications system according to any preceding claim, wherein at least a portion of the radio resources outside of the second frequency band of the subset of the radio

resource segments of the host carrier allocated to the subordinate carrier are used for communicating with terminal devices of the first type.

34. A base station for communicating with terminal devices, said base station being operable

to communicate with terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and

to communicate with terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

35. A method of communicating between a base station and terminal devices of a first type and a second type, comprising:

communicating between the base station and terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and

communicating between the base station and terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

36. A computer program, which when executed on a computer will cause the computer to perform a method according to claim 35.

37. A recording medium storing the computer program of claim 36.

38. A wireless communications method substantially as hereinbefore described with reference to the accompanying drawings.

39. A method of communicating substantially as hereinbefore described with reference to the accompanying drawings.

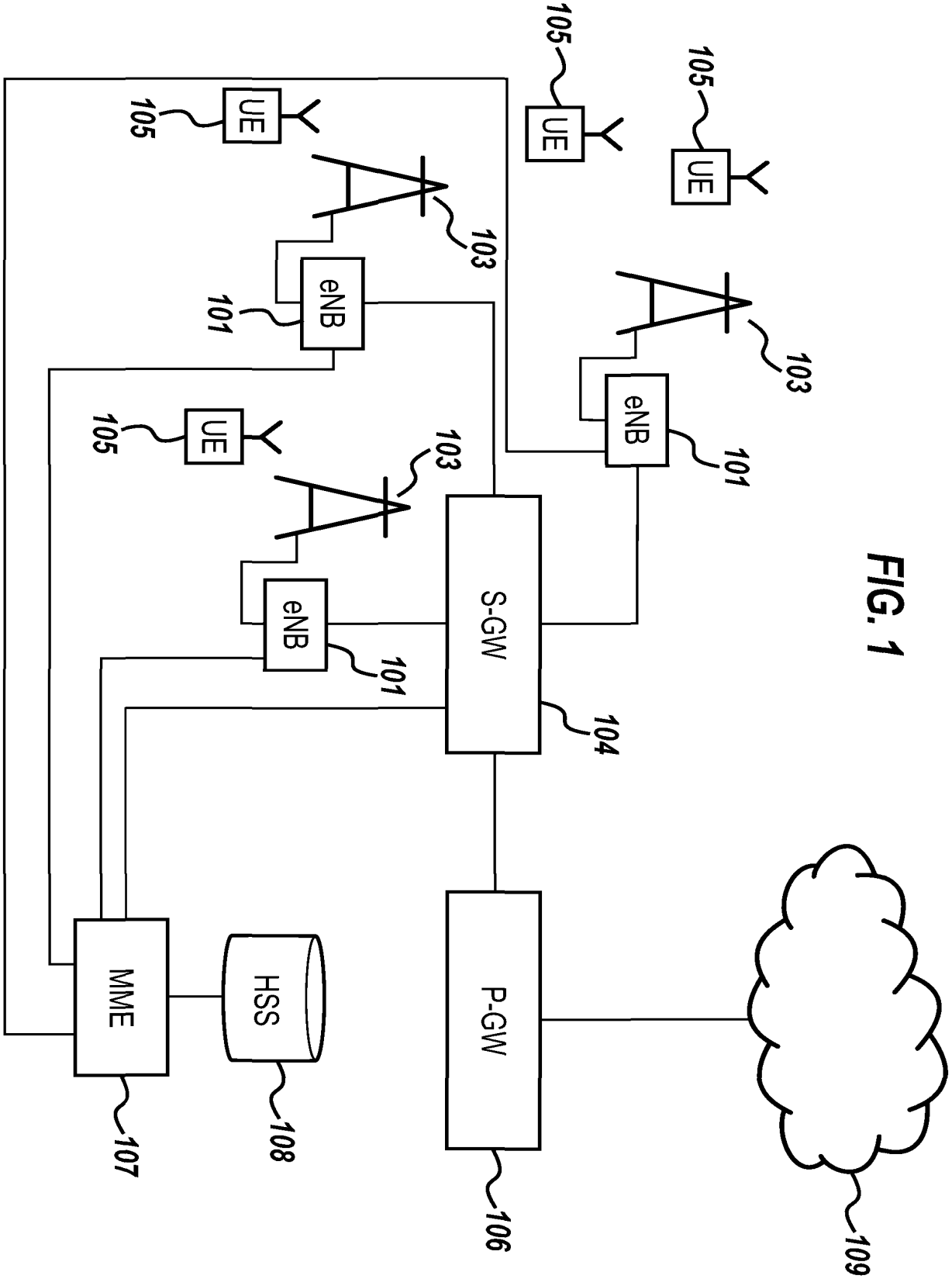
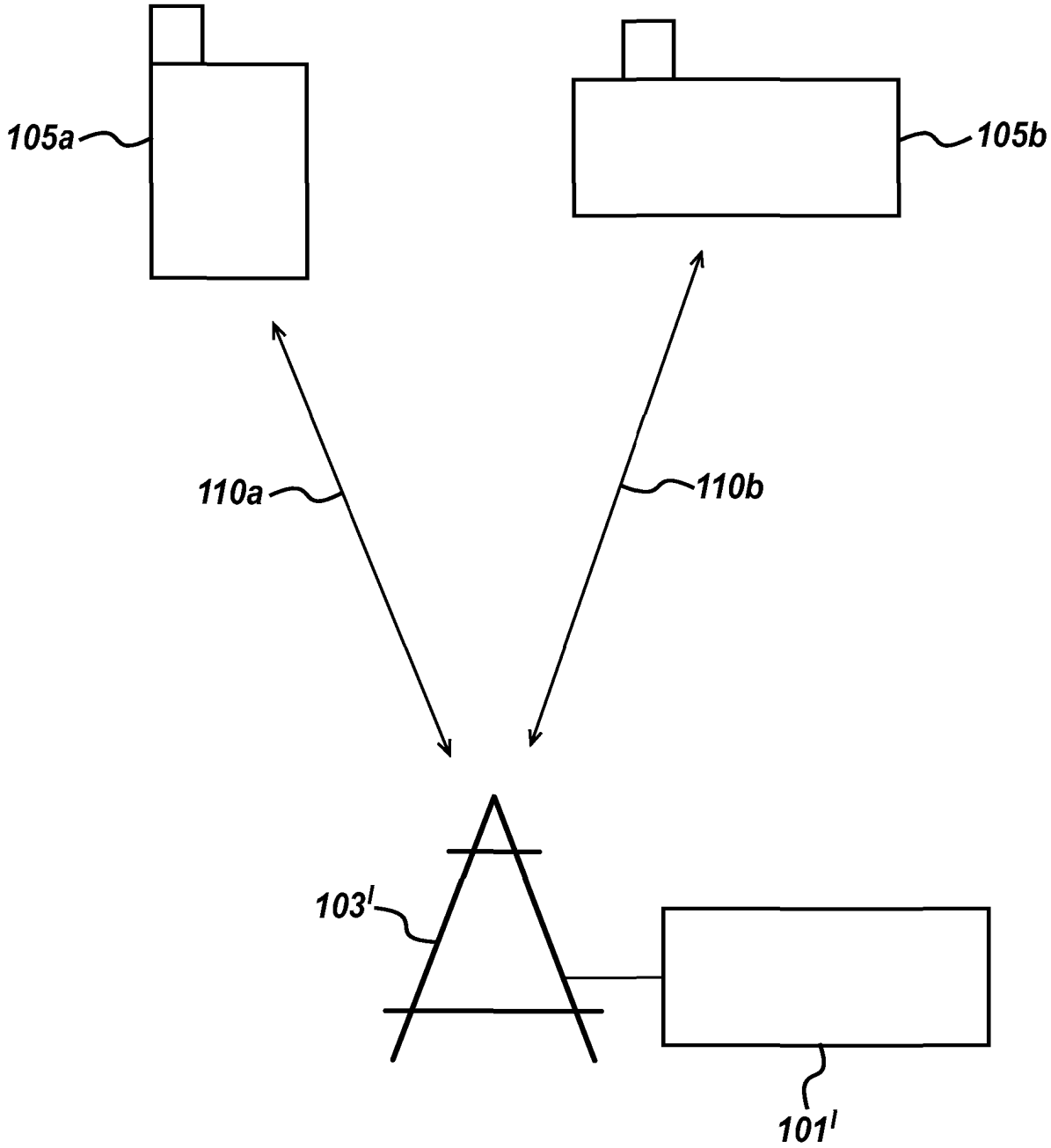


FIG. 1

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FIG. 2



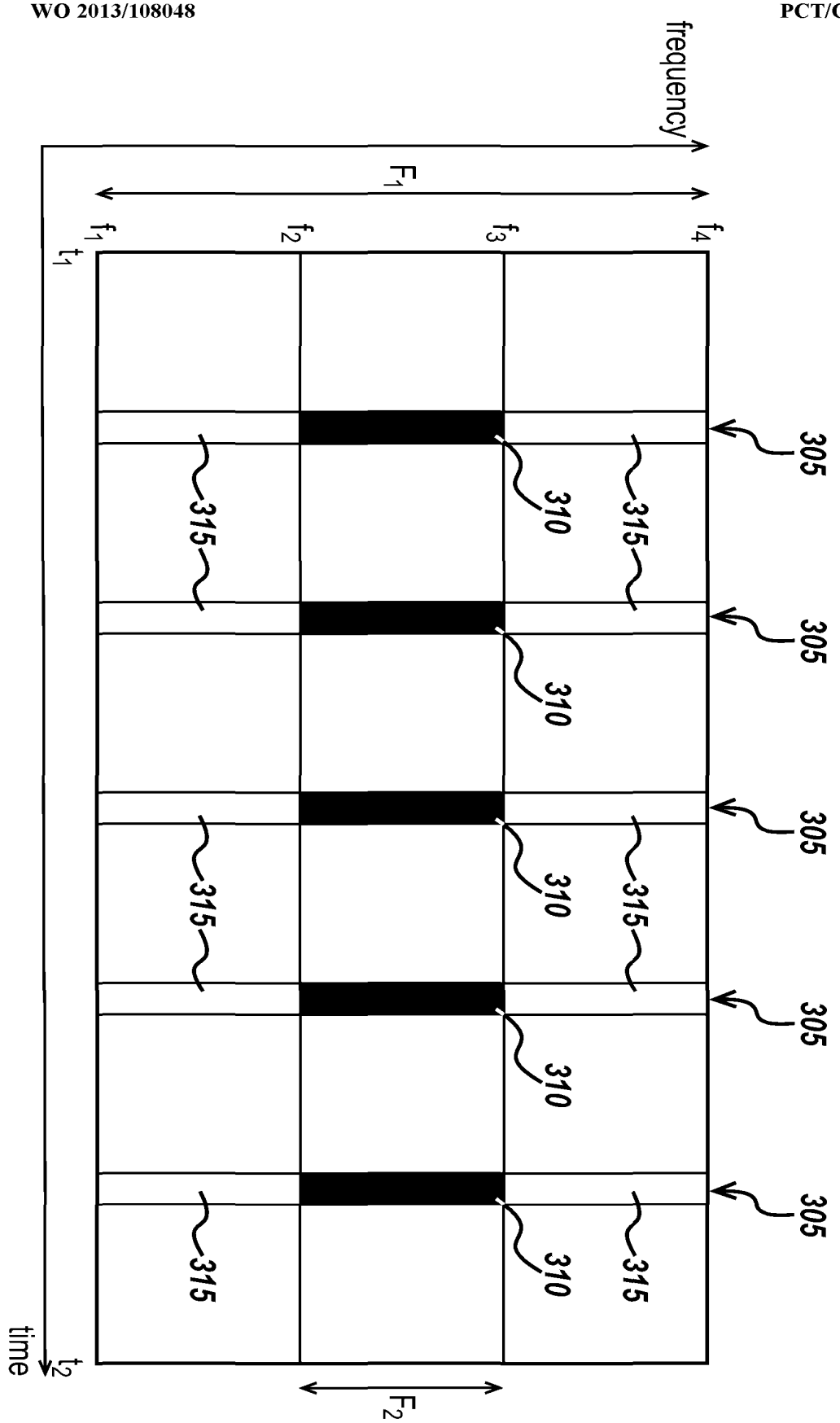
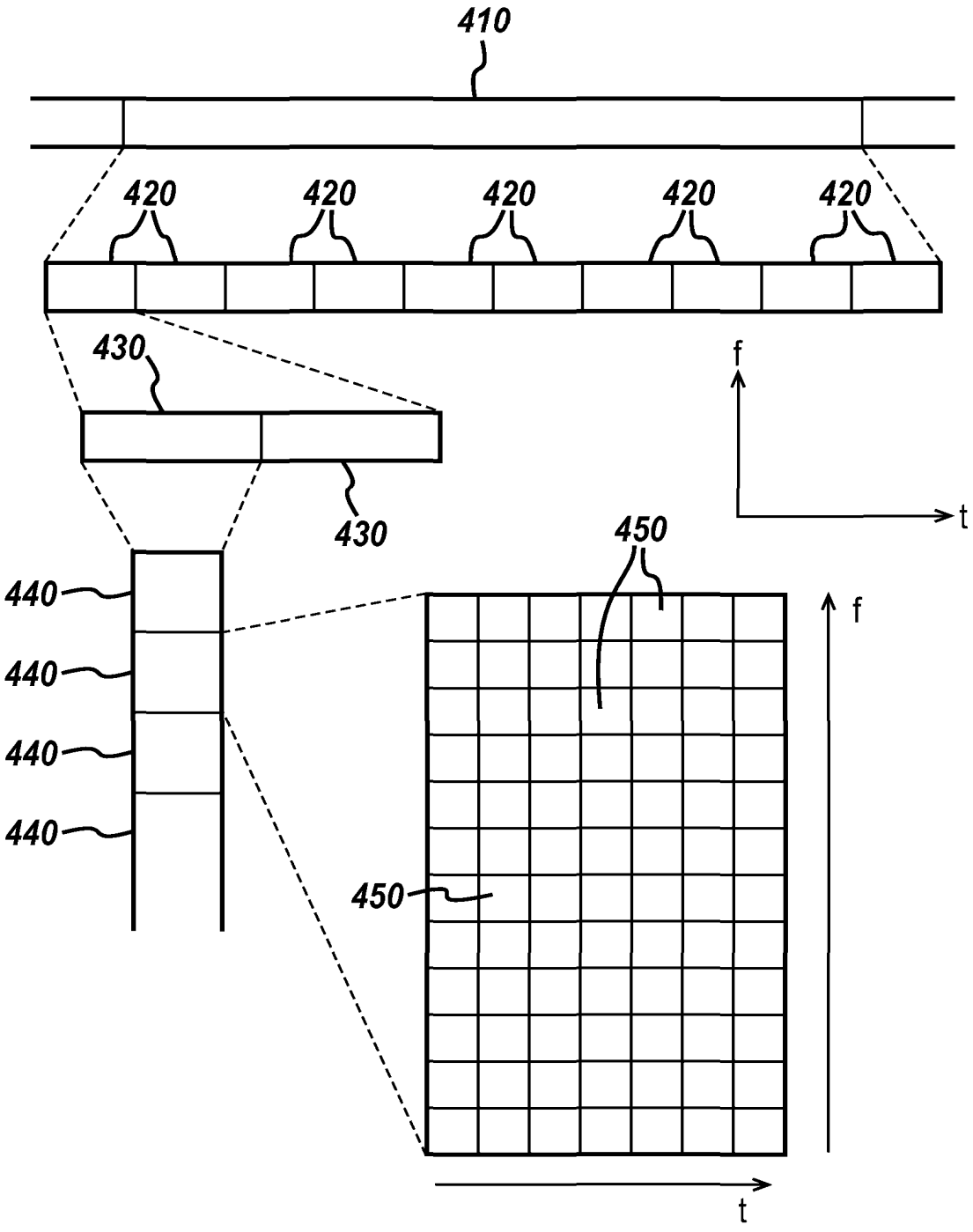


FIG. 3

SUBSTITUTE SHEET (RULE 26)

FIG. 4



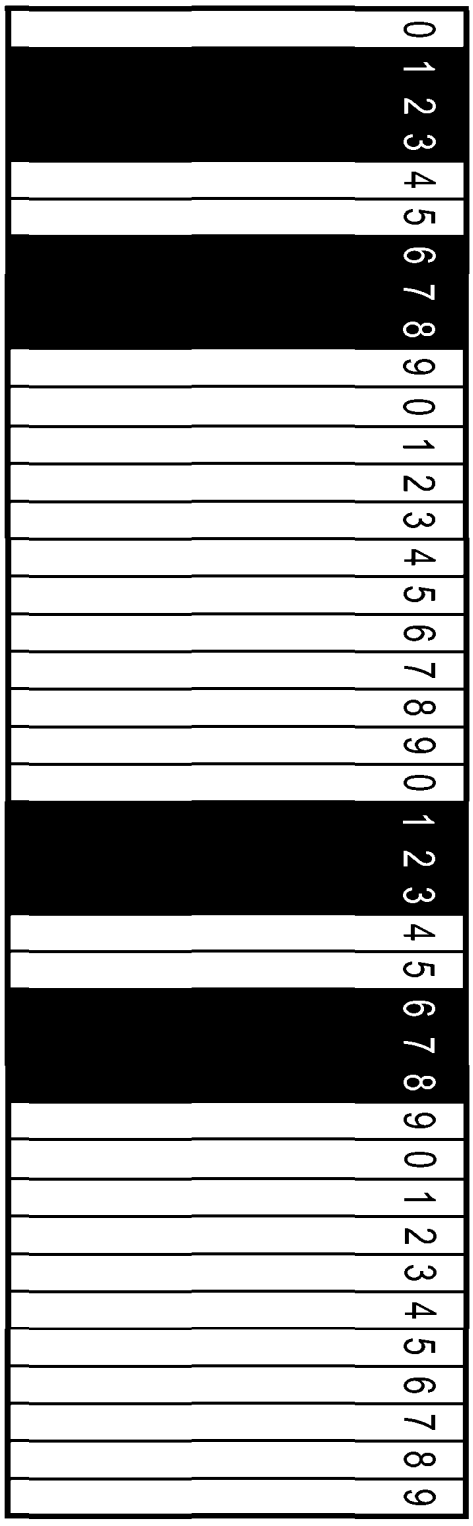


FIG. 5A

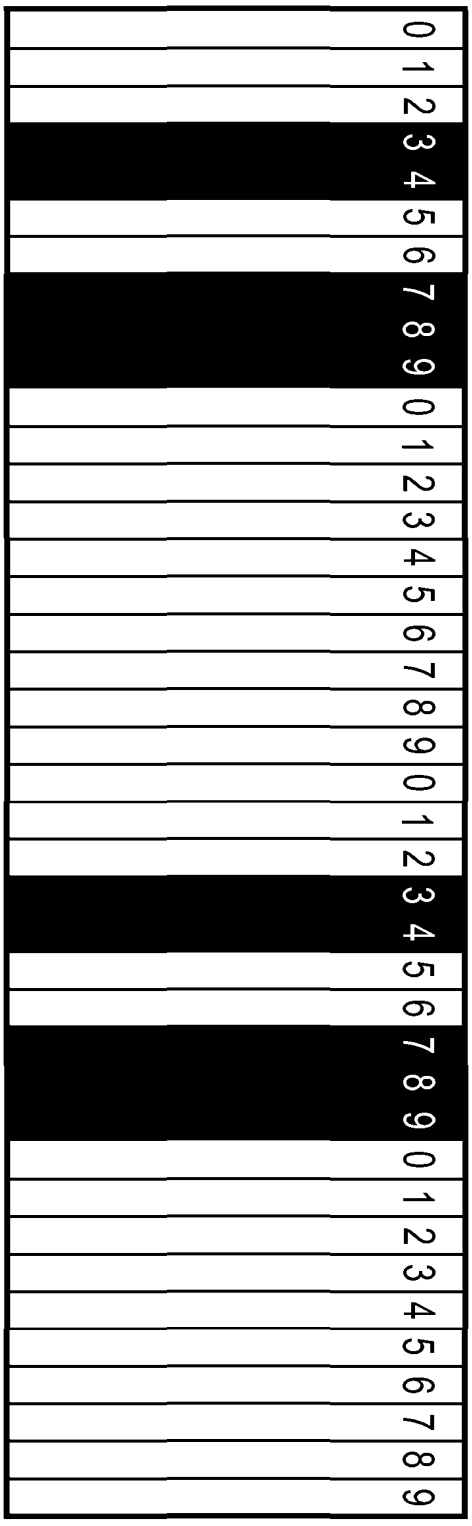


FIG. 5B

SUBSTITUTE SHEET (RULE 26)

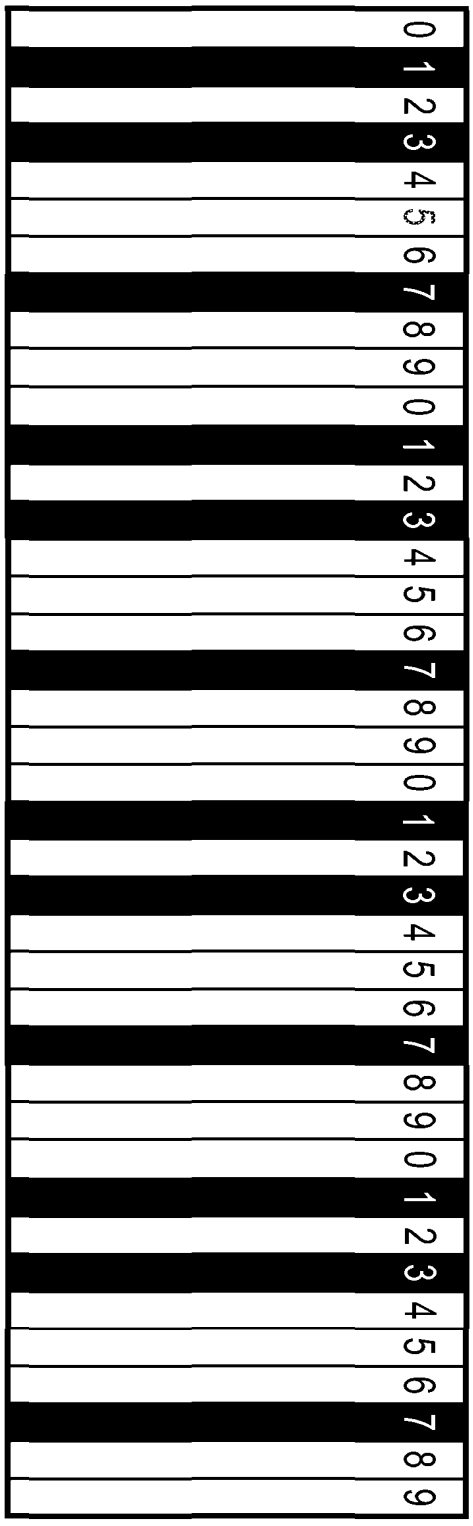


FIG. 5C

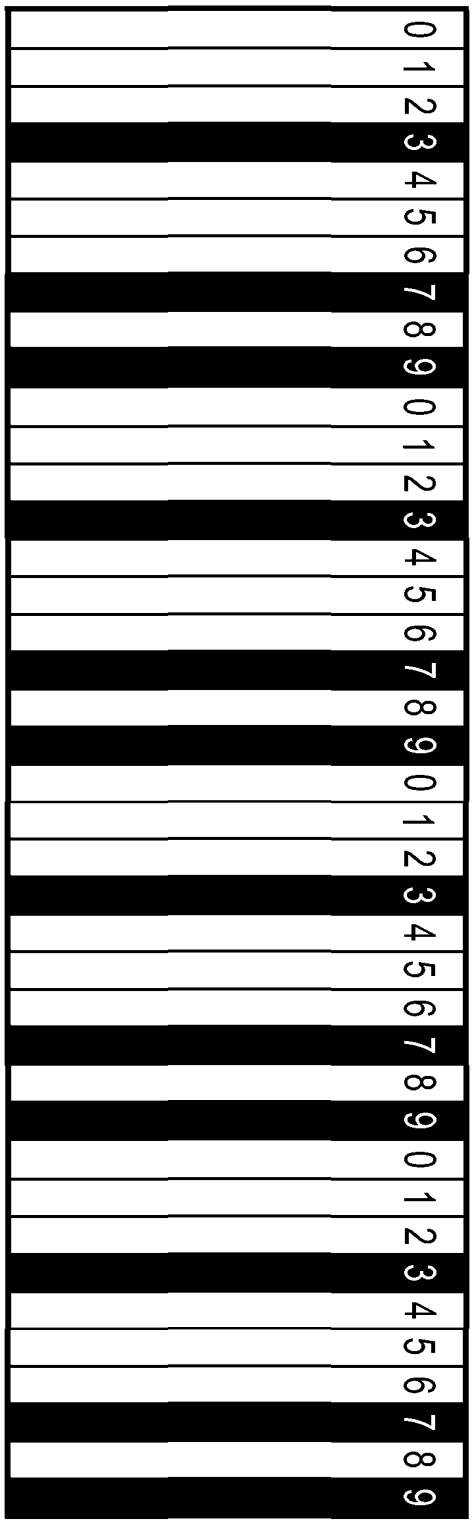


FIG. 5D

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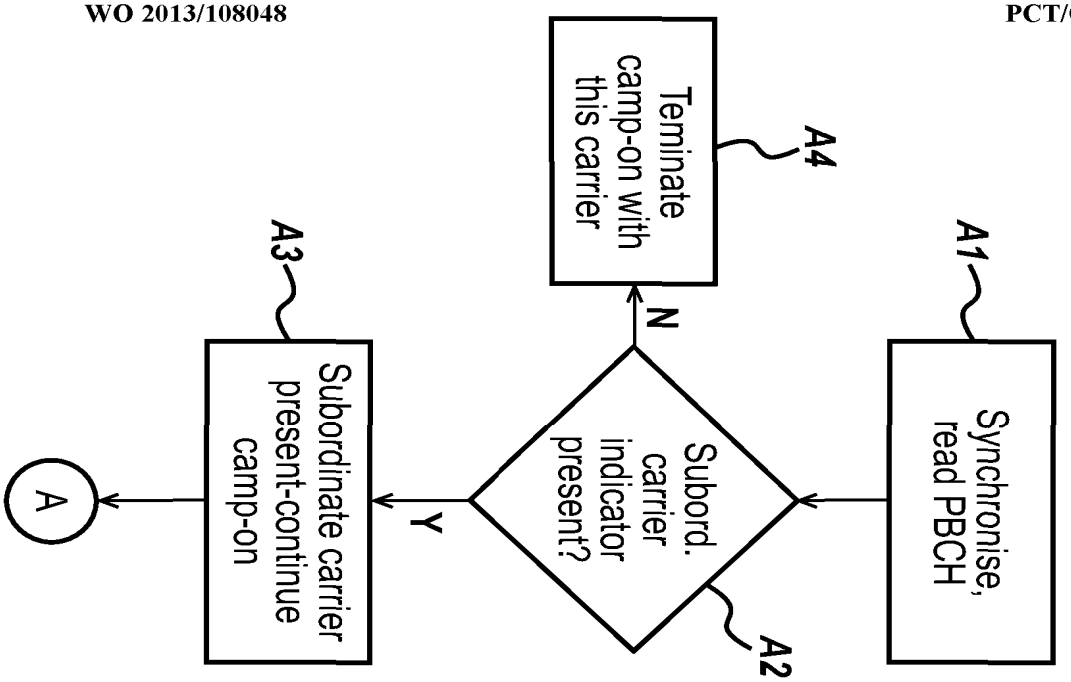


FIG. 6

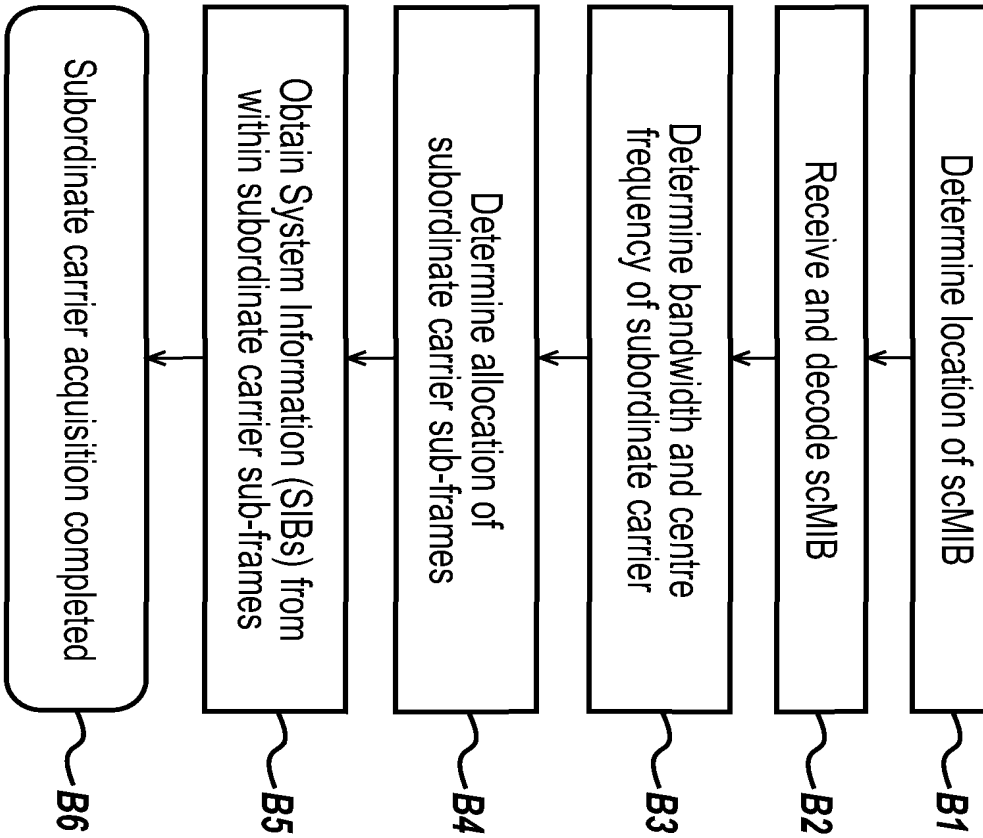


FIG. 7

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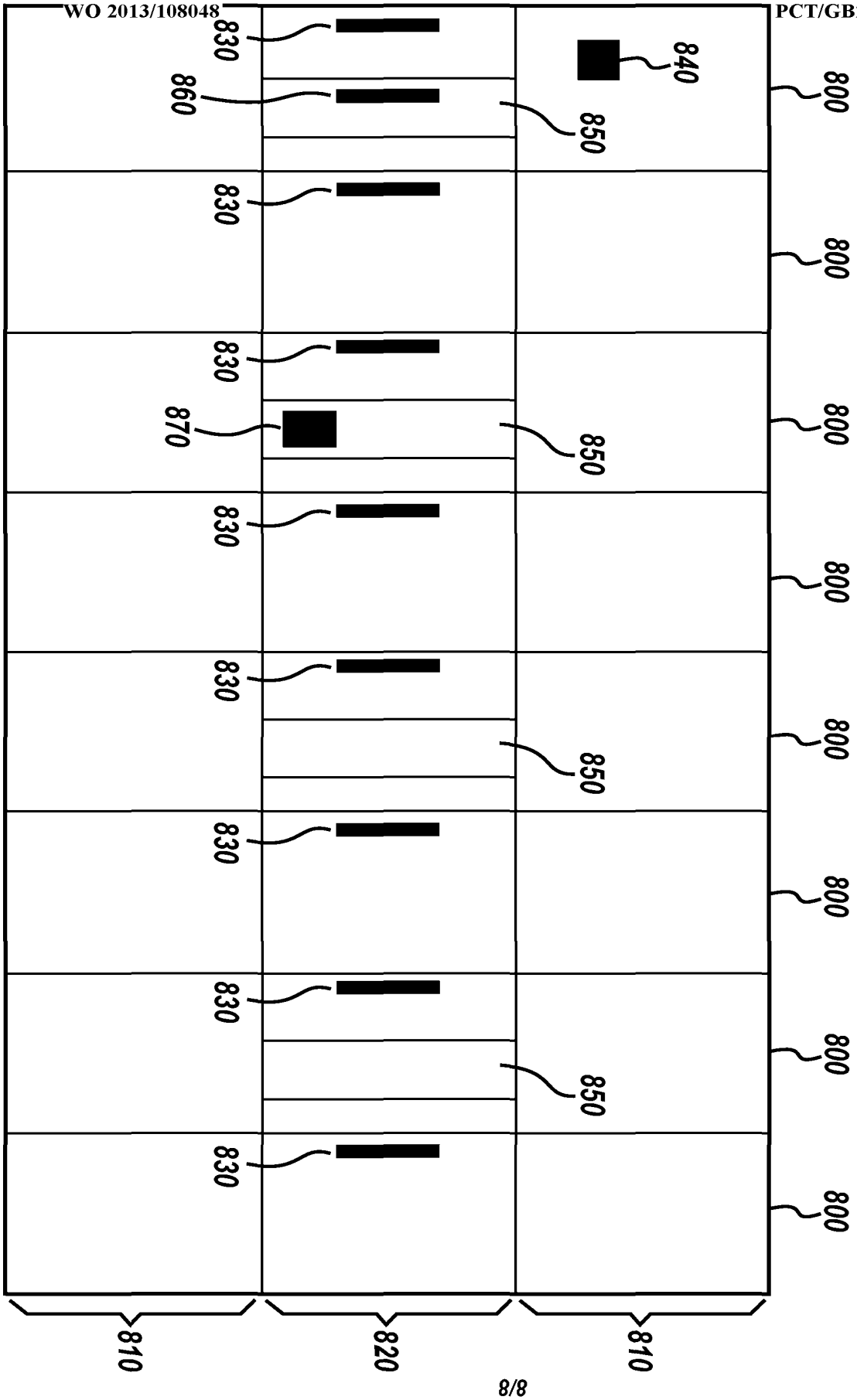


FIG. 8

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From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION, OBTENTION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

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London WC1B 5HA
ROYAUME-UNI

Date of mailing *(day/month/year)* 21 February 2013 (21.02.2013)	
Applicant's or agent's file reference P059858WO	**IMPORTANT NOTIFICATION**
International application No. PCT/GB2013/050126	International filing date *(day/month/year)* 21 January 2013 (21.01.2013)
International publication date *(day/month/year)* **Not yet published**	Priority date *(day/month/year)* 20 January 2012 (20.01.2012)
Applicant WIRELESS TECHNOLOGY SOLUTIONS LLC et al	

The applicant is hereby notified of the date of receipt (or of obtaining by the International Bureau) of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to the date of receipt, **the priority document concerned was submitted or transmitted to or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*)**. This Form replaces any previously issued notification concerning submission, transmittal or obtaining of priority documents.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
20 January 2012 (20.01.2012)	1201000.5	GB	25 January 2013 (25.01.2013)

The letters "NR" denote a priority document which, on the date of mailing of this Form, had not yet been received or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*). Where the applicant has failed to either submit, request to prepare and transmit, or to request the International Bureau to obtain the priority document within the applicable time limit under that Rule, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

An asterisk "*" next to a date of receipt, denotes a priority document submitted or transmitted to or obtained by the International Bureau but not in compliance with Rule 17.1(a), (b) or (b-*bis*) (the priority document was received after the time limit prescribed in Rule 17.1(a); the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b) or the request to the International Bureau to obtain the priority document was made after the applicable time limit under Rule 17.1(b-*bis*)). Even though the priority document was not furnished in compliance with Rule 17.1(a), (b) or (b-*bis*), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as the priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

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34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 89 95

Authorized officer
Athina Nickitas-Etienne
e-mail pt04.pct@wipo.int
Telephone No. +41 22 338 74 04

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER
First Named Inventor/Applicant Name:	Philip YOUNG
Filer:	Harry Vartanian/Lorraine Givigliano
Attorney Docket Number:	IPW2-USAP205496

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
National Stage Fee	1631	1	280	280
Natl Stage Search Fee - Report provided	1642	1	480	480
National Stage Exam - all other cases	1633	1	720	720
Pages:				
Claims:				
Miscellaneous-Filing:				
Oath/Decl > 30 Mos From 371 commencement	1617	1	140	140
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1620**

Electronic Acknowledgement Receipt

EFS ID:	19584982
Application Number:	14372363
International Application Number:	PCT/GB2013/050126
Confirmation Number:	1411
Title of Invention:	WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER
First Named Inventor/Applicant Name:	Philip YOUNG
Customer Number:	3624
Filer:	Harry Vartanian/Lorraine Givigliano
Filer Authorized By:	Harry Vartanian
Attorney Docket Number:	IPW2-USAP205496
Receipt Date:	15-JUL-2014
Filing Date:	
Time Stamp:	15:46:19
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$1620
RAM confirmation Number	2006
Deposit Account	220493
Authorized User	VARTANIAN, HARRY

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)					
File Listing:					
Document Number	**Document Description**	**File Name**	**File Size(Bytes)/ Message Digest**	**Multi Part /.zip**	**Pages (if appl.)**
1	Transmittal of New Application	1_IPW2_USAP205496_371_Transmittal_Letter_EFS.pdf	220557 567273105bad1df39b906f99d36f5f54bda37ce5	no	4
Warnings:					
Information:					
2	Application Data Sheet	2_IPW2_USAP205496_ADS_EFS.pdf	1561387 4b0a7774f6cc4af87d7b1d7aef0d34c7174b4df9	no	7
Warnings:					
Information:					
3	Specification	3_IPW2_USAP205496_Substitute_Specification_Marked_Up_EFS.pdf	124856 8cf60d7354d1d68eeaa0b9fa299bb4b37b3f15c0	no	32
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4	Specification	4_IPW2_USAP205496_Substitute_Specification_EFS.pdf	123699 c0dd05f5473bdd48499c8f4f0c7e42eadccc3edb	no	32
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5	Drawings-only black and white line drawings	5_IPW2_USAP205496_Drawings_EFS.pdf	423525 b04e95000ddd7b406d47edd242c2e3f9fa457a2d	no	8
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6		6_IPW2_USAP205496_Preliminary_Amendment_EFS.pdf	85160 76bea331a0db624c65c38fbc0f1cd4833d36b54e	yes	10

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Preliminary Amendment	1	1
Specification	2	2
Claims	3	7
Abstract	8	9

	Applicant Arguments/Remarks Made in an Amendment		10	10	
Warnings:					
Information:					
7	Documents submitted with 371 Applications	7_IPW2_USAP205496_ISR_and_Written_Opinion_EFS.pdf	710887 9ab9667c44ec35c1d4048b2177a47cffadcee7ee	no	14
Warnings:					
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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.

PTO-1390 (06-13)
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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

Attorney Docket No.	U.S. Application No. (if known, see 37 CFR 1.5)
IPW2-USAP205496	

International Application No.	International Filing Date	Priority Date Claimed
PCT/GB2013/050126	21 January 2013	20 January 2012

Title of Invention
WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

First Named Inventor
Philip YOUNG

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☑ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.
2. ☑ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).
3. An English language translation of the International Application (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
   a. ☐ is attached.
   b. ☐ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).
6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).
7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
10. ☑ A preliminary amendment.
11. ☑ An Application Data Sheet under 37 CFR 1.76.
12. ☑ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).
13. ☐ A power of attorney and/or change of address letter.
14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825.
15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee: _____
16. ☐ 37 CFR 3.73(c) Statement *(when there is an Assignee)*.

This collection of information is required by 37 CFR 1.414 and 1.491-1.492. 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 15 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

U.S. APPLN. No. (if known – see 37 CFR 1.5)	INTERNATIONAL APPLICATION No.	ATTORNEY DOCKET No.
	PCT/GB2013/050126	IPW2-USAP205496

17. ☑ Other items or information:

PCT Request Form for PCT/GB2013/050126
WO 2013/108048 Publication
Notification of Submission, Obtention or Transmittal of Priority Document (PCT/IB/304)
International Search Report and Written Opinion

The following fees have been submitted.	CALCULATIONS	PTO USE ONLY
18. ☑ Basic national fee (37 CFR 1.492(a)) **$280**	$ 280	
19. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$720**	$ 720	
20. ☑ Search fee (37 CFR 1.492(b)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .....**$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .....**$480** All other situations **$600**	$ 480	
TOTAL OF 18, 19, and 20 =	$ 1480	

☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)).
Fee for each additional 50 sheets of paper or fraction thereof **$400**

Total Sheets	Extra Sheets	Number of each addition 50 or fraction thereof (round **up** to a whole number)	RATE	
40 - 100 =	/ 50 =		x **$400**	$

Surcharge of **$140.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$ 140	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	12 - 20 =		x **$80**	$	
Independent claims	2 - 3 =		x **$420**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			**+ $780**	$	
Processing fee of **$140.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). **+**				$	
TOTAL OF ABOVE CALCULATIONS =				$ 1620	
☐ **Applicant asserts small entity status.** See 37 CFR 1.27. Fees above are reduced by ½.					
☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Fees above are reduced by ¾. Applicant must attach form PTO/SB/15A or B or equivalent.					
TOTAL NATIONAL FEE =				$ 1620	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property. **+**				$	
TOTAL FEES ENCLOSED =				$ 1620	
				Amount to be refunded:	$
				Amount to be charged:	$

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

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees.

c. ☑ The Director is hereby authorized to charge additional fees which may be required, or credit any overpayment, to Deposit Account No. 220493 as follows:

i. ☑ any required fee.

ii. ☐ any required fee except for excess claims fees required under 37 CFR 1.492(d) and (e) and multiple dependent claim fee required under 37 CFR 1.492(f).

d. ☑ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended to pay fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

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 1: 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**.

NOTE 2: A U.S. national stage application may not claim priority to the international application of which it is the national phase. The filing date of a U.S. national stage application is the international filing date. See 35 U.S.C. 363.

Correspondence Address

☑ The address associated with Customer Number: 03624 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone			
Email					

Signature	/Harry Vartanian/	Date	July 15, 2014
Name (Print/Type)	Harry Vartanian	Registration No. (Attorney/Agent)	56,787

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.

PCT REQUEST

Print Out (Original in Electronic Form)

0	**For receiving Office use only**	
0-1	International Application No.	PCT/GB2013/050126
0-2	International Filing Date	21 January 2013 (21.01.2013)
0-3	Name of receiving Office and "PCT International Application"	RO/GB

0-4	**Form PCT/RO/101 PCT Request**	
0-4-1	Prepared Using	PCT Online Filing Version 3.5.000.232 MT/FOP 20020701/0.20.5.20
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	UK Intellectual Property Office (RO/GB)
0-7	**Applicant's or agent's file reference**	P059858WO
I	**Title of Invention**	WIRELESS COMMUNICATIONS SYSTEM AND METHOD
II	**Applicant**	
II-1	This person is	Applicant only
II-2	Applicant for	AP: (BW GH GM KE LR LS MW MZ NA RW SD SL SZ TZ UG ZM ZW); EA: (AM AZ BY KG KZ RU TJ TM); EP: (AL AT BE BG CH&LI CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR); OA: (BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG); AE AG AL AM AO AT AU AZ BA BB BG BH BN BR BW BY BZ CA CH&LI CL CN CO CR CU CZ DE DK DM DO DZ EC EE EG ES FI GB GD GE GH GM GT HN HR HU ID IL IN IS JP KE KG KM KN KP KR KZ LA LC LK LR LS LT LU LY MA MD ME MG MK MN MW MX MY MZ NA NG NI NO NZ OM PA PE PG PH PL PT QA RO RS RU RW SC SD SE SG SK SL SM ST SV SY TH TJ TM TN TR TT TZ UA UG UZ VC VN ZA ZM ZW
II-4	Name	Wireless Technology Solutions LLC
II-5	Address	550 Madison Avenue New York 10022 United States of America
II-6	State of nationality	US
II-7	State of residence	US

PCT REQUEST

Print Out (Original in Electronic Form)

III-1	**Applicant and/or inventor**	
III-1-1	This person is	Applicant and inventor
III-1-2	Applicant for	US
III-1-4	Name (LAST, First)	YOUNG, Philip
III-1-5	Address	Sweet Briar Hussell Lane Medstead Alton Hampshire GU34 5PF United Kingdom
III-1-6	State of nationality	GB
III-1-7	State of residence	GB
IV-1	**Agent or common representative; or address for correspondence**	
	The person identified below is hereby/ has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	Agent
IV-1-1	Name (LAST, First)	SMALL, Gary James
IV-1-2	Address	Carpmaels & Ransford One Southampton Row London WC1B 5HA United Kingdom
IV-1-3	Telephone No.	00442072428692
IV-1-4	Facsimile No.	00442074054166
IV-2	**Additional agent(s)**	additional agent(s) with same address as first named agent
IV-2-1	Name(s)	HOWICK, Nicholas Keith; HALLYBONE, Huw George; JACKSON, Richard Eric; HOWARD, Paul Nicholas; JAMES, Anthony Christopher W.P.; COCKERTON, Bruce Roger; MARSHALL, Cameron John; GOODFELLOW, Hugh Robin; TUNSTALL, Christopher Stephen; KIRSCH, Susan Edith; WARNER, James Alexander; BULLETT, Rachel Margaret; BRUNNER, John Michael Owen; CHAPMAN, Desmond Mark; WISE, Daniel Joseph
V	**DESIGNATIONS**	
V-1	**The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.**	

PCT REQUEST

Print Out (Original in Electronic Form)

VI-1	**Priority claim of earlier national application**		
VI-1-1	Filing date	20 January 2012 (20.01.2012)	
VI-1-2	Number	1201000.5	
VI-1-3	Country	GB	
VI-2	**Priority document request** The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1	
VI-3	**Incorporation by reference :** where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.		
VII-1	**International Searching Authority Chosen**	European Patent Office (EPO) (ISA/EP)	
VIII	**Declarations**	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	-	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	-	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	-	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	-	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	-	
IX	**Check list**	Number of sheets	Electronic file(s) attached
IX-1	Request (including declaration sheets)	4	✓
IX-2	Description	25	✓
IX-3	Claims	6	✓
IX-4	Abstract	1	✓
IX-5	Drawings	8	✓
IX-7	TOTAL	44	

PCT REQUEST

Print Out (Original in Electronic Form)

	Accompanying Items	Paper document(s) attached	Electronic file(s) attached
IX-8	Fee calculation sheet	–	✓
IX-18	PCT-SAFE physical media	–	–
IX-20	**Figure of the drawings which should accompany the abstract**	3	
IX-21	**Language of filing of the international application**	English	
X-1	**Signature of applicant, agent or common representative**	/SMALL, Gary James/	
X-1-1	Name (LAST, First)	SMALL, Gary James	
X-1-2	Name of signatory	SMALL, Gary James	
X-1-3	Capacity (if such capacity is not obvious from reading the request)	(Representative)	

FOR RECEIVING OFFICE USE ONLY

10-1	**Date of actual receipt of the purported international application**	21 January 2013 (21.01.2013)
10-2	**Drawings:**	
10-2-1	Received	
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/EP
10-6	**Transmittal of search copy delayed until search fee is paid**	

FOR INTERNATIONAL BUREAU USE ONLY

11-1	**Date of receipt of the record copy by the International Bureau**	

Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as stored electronically on the Patents Electronic Case file System in connection with patent application GB1201000.5 filed on 20th Jan 2012

The Patents Electronic Case-file System is compliant with British Standard BS10008 - *Evidential weight and legal admissibility of information stored electronically* and ISO15801 - Electronic imaging – information stored electronically, recommendations for trustworthiness and reliability.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed 

Dated 23rd January 2013

UK Intellectual Property Office is an operating name of the Patent Office

INTELLECTUAL PROPERTY OFFICE

1200032678
K732364 D02246
20/01/2012 165.00 ACCOUNT CHARGE

Patents Form 1
Patents Act 1977 *(Rule 12)*

Request for grant of a patent

Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

Application number GB 1201000.5

1.	Your reference	**P046021GB GCS**
2.	Full name, address and postcode of the applicant or of each applicant Patents ADP number *(if you know it)*	**Wireless Technology Solutions LLC** **550 Madison Avenue** **10022** **New York** **United States of America**
3.	Title of the invention	**Wireless Communications System and Method**
4.	Name of your agent *(if you have one)* "Address for service" to which all correspondence should be sent. This may be in the European Economic area or Channel Islands (see warning note below) *(including the postcode)* Patents ADP number *(if you know it)*	**D Young & Co LLP** **D Young & Co LLP** **120 Holborn** **London EC1N 2DY** **United Kingdom** **10206274001**

5. Priority declaration: Are you claiming priority from one or more earlier-filed patent applications? If so, please give details of the application(s)

Country	Application number	Date of filing	Date available on PDAS

6. Divisionals etc: Is this application a divisional application, or being made following resolution of an entitlement dispute about an earlier application. If so, please give the application number and filing date of the earlier application

Number of earlier UK application	Date of filing *(day / month / year)*

7. Inventorship: (Inventors must be individuals not companies)

   Are all the applicants named above also inventors? **No**

8. Are you paying the application fee with this form? **Yes**

9. Accompanying documents: please enter the number of pages of each item accompanying this form.

   Continuation sheets of this form

   Description: **25**

   Claim*(s)*: **6**

   Abstract: **1**

   Drawing*(s)*: **8**

   If you are not filing a description, please give details of the previous application you are going to rely upon

Country	Application number	Date of filing	Date available on PDAS

10. If you are also filing any of the following, state how many against each item.

Priority documents:	**0**
Statement of inventorship and right to grant of a patent (Patents Form 7):	**1**
Request for search (Patents Form 9A):	**1**
Request for a substantive examination (Patents Form 10):	**0**
Any other documents (please specify):	

11. I/We request the grant of a patent on the basis of this application.

Signature: **Subject: GB, D. Young & Co., G. Scaddan 1427; Issuer: European Patent Office, European Patent Office CA** Date: **20 Jan 2012**

12. Name, e-mail address, telephone, fax and/or mobile number, if any, of a contact point for the applicant

Scaddan, Mr. Gareth Casey
Telephone: +44 (0) 23 8071 9500
Fax: +44 (0) 23 8071 9800

Warning
After an application for a patent has been filed, the Comptroller will consider whether publication or communication of the invention should be prohibited or restricted under section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you are resident in the United Kingdom and your application contains information which relates to military technology, or would be prejudicial to national security or the safety of the public, section 23 of the Patents Act 1977 prohibits you from applying for a patent abroad without first getting written permission from the Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked. Until such time or until the revocation of any direction, for any such application the address for service referred to at part 4 above must be in the United Kingdom.

Although you may have an address for service in the Channel Islands, any agent instructed to act for you must reside or have a place of business in the European Economic Area or Isle of Man.

WIRELESS COMMUNICATIONS SYSTEM AND METHOD

Field of the Invention

The present invention relates to wireless communications systems and methods, and in particular to a system, method, base station and terminal device for communicating using a subordinate carrier of a host carrier.

Background of the Invention

Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architectures, are able to support a more sophisticated range of services than simple voice and messaging services offered by previous generations of mobile telecommunication systems.

For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and the coverage area of these networks, i.e. geographic locations where access to the networks is possible, is expected to increase rapidly.

The anticipated widespread deployment of third and fourth generation networks has led to the parallel development of a class of devices and applications which, rather than taking advantage of the high data rates available, instead take advantage of the robust radio interface and increasing ubiquity of the coverage area. Examples include so-called machine type communication (MTC) applications, also known as machine-to-machine (M2M) communications, some of which are in some respects typified by semi-autonomous or autonomous wireless communication devices (i.e. MTC devices) communicating small amounts of data on a relatively infrequent basis. Examples include so-called smart meters

which, for example, are located in a customer's home and periodically transmit data back to a central MTC server relating to the customer's consumption of a utility such as gas, water, electricity and so on.

Whilst it can be convenient for a terminal such as an MTC-type terminal to take advantage of the wide coverage area provided by a third or fourth generation mobile telecommunication network there are at present disadvantages. Unlike a conventional third or fourth generation mobile terminal such as a smartphone, a primary driver for MTC-type terminals will be a desire for such terminals to be relatively simple and inexpensive. The type of functions typically performed by a MTC-type terminal (e.g. simple collection and reporting of relatively small amounts of data) do not require particularly complex processing to perform, for example, compared to a smartphone supporting video streaming. However, third and fourth generation mobile telecommunication networks typically employ advanced data modulation techniques and support wide bandwidth usage on the radio interface which can require more complex and expensive radio transceivers to implement. It is usually justified to include such complex transceivers in a smartphone as a smartphone will typically require a powerful processor to perform typical smartphone type functions. However, as indicated above, there is now a desire to use relatively inexpensive and less complex devices to communicate using LTE type networks.

Summary of the Invention

According to a first aspect of the invention there is provided a wireless communications system, comprising a base station, one or more terminal devices of a first type and one or more terminal devices of a second type. The base station is operable to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

In this way, an efficient and flexible mechanism for specifying and controlling an amount and location of radio resources to be dedicated to a subordinate carrier for use by a particular (e.g. reduced capability) type of device can be provided.

One way of achieving this differentiated access between the terminal devices of the first type and second type is to allocate a part of the carrier resource that is dedicated to the

second type of device (e.g. MTC traffic) using normal eNB (base station) scheduling. The eNB differentiates between MTC and non-MTC (example of the first type of device) UEs and only schedules MTC UEs within the reserved part of the carrier resource and only schedules non-MTC UEs outside of the reserved part of the carrier resource. While this solution is viable, the simple scheduling approach places some restrictions on the MTC subordinate carrier that can be realised. For instance, it would be necessary to use the same carrier characteristics and/or reference signals. If it were advantageous to use different carrier characteristics or to use additional or modified reference signals then this may not be possible in an MTC subordinate carrier implemented purely by eNB scheduling.

The radio resource segments may be sub-frames of radio frames, each radio frame comprising a plurality of sub-frames. In this case, the sub-frames may be allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set, the subordinate carrier sub-frame allocation set determining which sub frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The subordinate carrier sub-frame allocation set may be defined by one or more reserved sub-frame allocation patterns. The one or more reserved sub-frame allocation patterns may comprise all or a sub-set of all reserved sub-frame allocation patterns defined for the host carrier.

In one example, the subframes selected for the subordinate carrier are so-called MBSFN (Multimedia Broadcast/multicast service over a Single Frequency Network) subframes. This embodiment relies on the fact that such subframes do not have to be used exclusively for MBSFN. The LTE Rel8/9/10 specifications define a means (in the standard LTE SystemInformationBlockType2 – SIB2) by which certain subframes can be excluded from normal allocation to the Physical Downlink Shared Channel (PDSCH). Furthermore, the specifications define signalling within the standard system information which allows some or all of these excluded subframes to be used for other defined purposes, such as MBMS (in SystemInformationBlockType13 – SIB13), relay and positioning reference signal transmission. However, reading of this system information may require reception across the whole carrier bandwidth.

Acquisition information required for a terminal device of the second type to receive the subordinate carrier may be allocated for inclusion in sub-frames of the subordinate carrier using at least a portion of the subframes in one or more of the reserved sub-frame allocation patterns defining the subordinate carrier.

The base station may be operable to transmit an indication of the radio resources of all reserved sub-frames to terminal devices of the first type. In this way, the first type of device is informed of subframes which are reserved for the subordinate carrier, another subordinate carrier, and for other purposes such as relay backhaul. A particular device of the first type is not required to know why a particular sub-frame is reserved, merely that it is not available to that device. This indication may be presented to the terminal devices of the first type as a reserved subframe allocation within a system information block transmitted using frequency resources not necessarily limited to the second frequency band of the subordinate carrier. In this way, it is possible to exclude non-MTC devices from a resource reserved for the subordinate carrier.

The base station may be operable to transmit, using radio resources within the second frequency band, subordinate carrier information indicating that a subordinate carrier is available within the host carrier. A terminal device of the second type may be responsive to subordinate carrier information indicating that a subordinate carrier is not available within the host carrier to terminate a camp-on procedure for camping on to the network.

The subordinate carrier information may be provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the system information of the host carrier. The first acquisition information may be a master information block transmitted on a physical broadcast channel within radio resources of the host carrier. In this way it is possible to signal via the first acquisition information, to terminal devices of the second type, the presence of an MTC subordinate carrier existing within the reserved resource and using only a restricted bandwidth. If the subordinate carrier information is not present then the camp-on process by a terminal device may be terminated early, thereby reducing time and power wastage at the terminal device.

The first type of terminal device may be capable of receiving the full bandwidth of the first frequency band, and the second type of terminal device may not be capable of receiving the full bandwidth of the first frequency band but be capable of receiving the full bandwidth of the second frequency band. The bandwidth of the subordinate carrier may be predetermined and be known in advance to terminal devices of the second type. Alternatively, the base station may be operable to transmit, using radio resources within the second frequency band, an indication of the bandwidth of the subordinate carrier. In this case the bandwidth need not necessarily be predetermined. The indication of the bandwidth of the

subordinate carrier may be provided within first acquisition information transmitted on radio resources within the second frequency band, the acquisition information being provided to permit a terminal device of the first type to receive the host carrier downlink and camp on to the host carrier. Alternatively, the base station may be operable to transmit, using radio resources of the subordinate carrier, an indication of the bandwidth of the subordinate carrier.

The base station may be operable to transmit, using radio resources of the subordinate carrier, second acquisition information required for a terminal device of the second type to receive the subordinate carrier downlink and camp on to the subordinate carrier. The second acquisition information may be transmitted on predetermined radio resources which are known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the bandwidth of the subordinate carrier. In this way, it is possible to signal system information defining the characteristics of the MTC subordinate carrier using only resources within the MTC subordinate carrier.

The radio resource segments may be sub-frames of radio frames in the time direction, each radio frame comprising a plurality of sub-frames. The second acquisition information may be transmitted in at least some of the sub-frames allocated to the subordinate carrier. A terminal device of the second type may be operable to determine whether a sub-frame contains second acquisition information from a current radio frame number and a first sub-frame allocation set for allocating the second acquisition information to sub-frames within the subordinate carrier, said first sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames contain the second acquisition information.

The current radio frame number may be determined from first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the host carrier downlink and camp on to the network. The first sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the current radio frame number. Accordingly, once the second acquisition information is available to a mobile terminal, it may from that point on obtain the current radio frame number from the second acquisition information rather than having to refer back to the first acquisition information.

A terminal device of the second type may be operable to determine whether a sub-frame is allocated to the subordinate carrier from a current radio frame number and a second sub-frame allocation set for the subordinate carrier, said second sub-frame allocation set

identifying which sub-frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The current radio frame number may be determined from the second acquisition information. Alternatively, the current radio frame number may be determined from the first acquisition information and updated by counting radio frames.

The second sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. Alternatively, the second sub-frame allocation set may be specified in the second acquisition information. It will be appreciated that the second sub-frame allocation set may be different to the first sub-frame allocation set, but will include all of the sub-frames of the first sub-frame allocation set (and probably additional sub-frames as well).

The first type of terminal device may be an LTE device and the second type of device may be a low data rate device. The first type of terminal device may be an LTE device and the second type of device may be a low data rate device for providing machine-to-machine (M2M) communication.

It will be appreciated that different radio resource segments of the same or a different frequency band may be used to support a further subordinate carrier.

At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier may be allocated to another subordinate carrier. In other words, a different frequency band of the same resource segments (in time) may support another carrier.

At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier may be used for communicating with terminal devices of the first type. In other words, a different frequency band of the same resource segments (in time) may support the host carrier.

Viewed from another aspect, there is provided a base station for communicating with terminal devices. The base station is operable to communicate with terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

Viewed from another aspect, there is provided a terminal device for communicating with a base station which supports a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The terminal device is operable to communicate with the base station using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

Viewed from another aspect, there is provided a method of communicating between a base station and terminal devices of a first type and a second type. The method comprises communicating between the base station and terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and communicating between the base station and terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

Viewed from another aspect, there is provided a method of communicating with a base station from a terminal device, comprising communicating with the base station using a subordinate carrier of a host carrier comprising radio resource segments distributed in time, each radio resource segment of the host carrier providing radio resources across a first frequency band, the subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

It will be appreciated that features of the above-described aspects and embodiments of the invention may be combined with features of other aspects and embodiments of the invention as appropriate and in combinations other than those explicitly set out. For example, optional features of the first aspect of the invention may equally optionally be incorporated in embodiments according to other aspects of the invention, for example where the different aspects have corresponding features.

Brief Description of the Drawings

Example embodiments of the present invention will now be described with reference to the accompanying drawings in which like parts have the same designated references and in which:

Figure 1 is a schematic block diagram of a radio network and a plurality of user equipments forming a wireless communication system which operates in accordance with the 3GPP Long Term Evolution (LTE) standard;

Figure 2 schematically represents elements of a mobile telecommunications system for implementing embodiments of the invention;

Figure 3 schematically represents a time and frequency resource allocation between a host carrier and a subordinate carrier;

Figure 4 schematically illustrates a radio frame and resource grid structure of time and frequency resources;

Figures 5A to 5D schematically illustrate example allocations of resources to the subordinate carrier;

Figure 6 is a schematic flow diagram of a first part of a camp-on procedure for connecting to the subordinate carrier;

Figure 7 is a schematic flow diagram of a second part of the camp-on procedure for connecting to the subordinate carrier; and

Figure 8 schematically illustrates a signalling configuration according to an embodiment of the invention.

Detailed Description of the Example Embodiments

Network Structure

Embodiments of the present invention are described herein with particular reference to an example implementation in a wireless communication system having carriers based around the 3GPP Long Term Evolution (LTE) standard.

Figure 1 schematically shows an example architecture of an LTE system. The LTE system is provided by a telecommunications network operator to allow parties to communicate. As shown in Figure 1, mobile communications devices designated as user equipment (UE) 105 are arranged to communicate data to and from base stations (transceiver stations) 101 which are frequently referred to in LTE as E-UTRAN NodeBs (e-nodeB). Each of the base stations 101 comprises a transceiver unit 103 enabling communication of data to and from a plurality of mobile communication devices via a radio interface. The e-nodeBs 101 are connected to a serving gateway S-GW 104 and to a mobility management entity (MME) 107. The S-GW 104 is arranged to perform routing and management of mobile communications services to the communications devices 105 in the mobile radio network. In order to maintain mobility management and connectivity, the mobility management entity

(MME) 107 manages evolved packet system (EPS) connections with the communications devices 105 using subscriber information stored in a home subscriber server (HSS) 108. Other core network components include a packet data network gateway (P-GW) 106 which connects to an internet network 109 and finally to an external server (not shown). In the context of MTC communications a UE supporting MTC communications may, for example, be conveniently referred to as an MTC terminal or MTC UE, and a server with which the MTC terminal(s) communicate data may, for example, be conveniently referred to as an MTC server. More generally, devices in the system capable of supporting MTC communications may be referred to as MTC entities. The various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [1]. These conventional aspects of LTE networks are not described further in the interest of brevity.

Two classes of device are considered herein. A first class of device is configured to communicate via a host carrier, and a second class of device is configured to communicate via a subordinate carrier. In some of the particular examples considered here, the first class of device and the host carrier are compliant with particular standards, for example, LTE Rel8/9/10 standards, and the second class of device and the subordinate carrier are compliant with modified versions of these particular standards, for example, based on versions of the standards modified to support lower-capability devices. Accordingly, and purely for the sake of reference and to aid explanation, the first class of device and the host carrier may be referred to here in some examples as legacy devices and legacy carrier, while the second class of device and the subordinate carrier may be referred to in some examples as MTC devices and MTC carrier (or in alternative DMN (Dedicated Messaging Network) devices and DMN carrier). However, it will be appreciated that these terms are simply used as labels for ease of explanation of particular implementations of embodiments of the invention for distinguishing the two classes of device and carrier. Thus, the term "legacy" should not be considered as indicating any form of obsolescence, and indeed the devices and carrier(s) referred to here as legacy devices and carrier(s) may equally correspond with devices and carrier(s) that comply with future releases of the LTE standards, for examples Rel11 and beyond. Equally, and as already noted above, DMN should not be taken to refer to a network which exclusively supports only basic messaging services. Furthermore, the second class of device and subordinate carrier that are described here as not being fully compliant with the operating

standards of the first class of device and first carrier (for example because of reduced capability) may nonetheless be compliant with their own standards. Furthermore, the functionality described herein as regards both the first and second classes of device and carriers might comply with different aspects of a future standard, for example a future release of the LTE standards.

Referring now to Figure 2, a base station 101' is shown communicatively connected to an LTE device 105a via a transceiver unit 103' and a first (host) carrier 110a, and communicatively connected to an MTC device 105b via the transceiver unit 103' and a second (subordinate) carrier 110b. The base station 101' is responsible for a coverage area in which both the LTE device 105a and the MTC device 105b are located. The single base station 101' is able to communicate on both the first carrier 110a and the second carrier 110b. The first carrier 110a is a host carrier having a broad bandwidth, while the second carrier 110b is a subordinate carrier having a narrower bandwidth located within the frequency band of the host carrier. As will be explained in more detail below, the time and frequency resources of the first (host) carrier and the second (subordinate) carrier are logically separate for the purposes of data transmission and most control signalling, but some time and frequency resources are accessible to and used by devices connected to both the first and second carriers.

Host Carrier and Subordinate Carrier Overview

Referring to Figure 3, the time and frequency resources constituting the host carrier and the subordinate carrier are schematically illustrated. The horizontal axis of Figure 3 is time, with a time period from t_1 to t_2 being shown in Figure 3. The vertical axis of Figure 3 is frequency, the frequency increasing from a frequency f_1 to a frequency f_4. The host carrier has a frequency band F_1, extending from the frequency f_1 to the frequency f_4. The subordinate carrier has a frequency band F_2, extending from a frequency f_2 to a frequency f_3. The subordinate carrier is intended primarily for use by terminal devices which do not have the capability to receive or transmit between the frequencies f_1 and f_2, and between the frequencies f_3 and f_4. The subordinate carrier does not occupy all of the time and frequency resources within the frequency band F_2. Instead, certain time periods 305 of the frequency band F_2 are allocated to the subordinate carrier (and potentially to other subordinate carriers), with the unallocated time periods within the frequency band F_2 forming part of the host carrier resources. The shaded portions 310 of Figure 3 indicates those time and frequency resources allocated to the subordinate carrier. When a time period 305 is allocated to the subordinate

carrier, the time and frequency resources 315 falling outside of the frequency band F_2 (but within the frequency band F_1) are not allocated to the subordinate carrier. In some implementations these time and frequency resources may be available to the host carrier (or to another subordinate carrier having a different (and non-overlapping) frequency band). In other implementations these time and frequency resources may be "lost" and unusable by either the first type of device or the second type of device. It is envisaged that the central frequency and bandwidth of the frequency bands F_1 and F_2 would be fixed for a given host carrier/subordinate carrier, although implementations in which they are not fixed may be possible. The particular time periods allocated to the subordinate carrier may be fixed, or may be dynamically variable, for example to increase or decrease the amount of radio resources allocated to the subordinate carrier to adapt to traffic conditions of the subordinate carrier (and/or possibly of the host carrier).

Radio Frame and Resource Grid Structure

Referring now to Figure 4, a radio frame and resource grid structure for an LTE type network are schematically illustrated. At the top of Figure 4, a radio frame 410 is shown. This occupies the full width of the frequency band of the host carrier, and has a duration of 10ms. The radio frame 410 is one of a sequence of radio frames which are used to communicate data between a base station and a terminal device. The radio frame 410 comprises 10 sub-frames 420, which again occupy the fully width of the frequency band of the host carrier. Each of these sub-frames 420 has a duration of 1ms. Each of the sub-frames 420 comprises two slots 430, each slot occupying the full width of the frequency band of the host carrier and having a duration of 0.5ms. Each slot comprises a plurality of resource blocks 440 in the frequency direction, and only a single resource block 440 in the time direction. In other words each resource block 440 has a duration of 0.5ms (the same as the duration of the slot 430), but occupies only a portion of the bandwidth of the host carrier. Each resource block 440 comprises a two-dimensional array of resource elements 450 distributed in both the time direction and the frequency direction. Each resource element 450 has a length (duration) of one modulation symbol, and a frequency range of one subcarrier (e.g. 15kHz). In the present case the resource block 440 has a dimension of 12 resource elements 450 in the frequency dimension and 7 resource elements 450 in the time dimension, resulting in an overall bandwidth of 12 subcarriers and a duration of 7 symbols.

In operation, data transmissions between a base station and a terminal device may be scheduled to use particular resource blocks. This scheduling is usually carried out by the base

station or a related network entity. Certain resource blocks may be permanently allocated to carry predetermined signalling information.

3GPP LTE Releases 8, 9 and 10 (Rel8/9/10) define 6 downlink transmission bandwidth configurations from 1.4 MHz to 20 MHz representing the use of 6, 15, 25, 50, 75 or 100 resource blocks. As noted above, all Rel8/9/10 terminal devices are required to support the maximum single carrier bandwidth of 20 MHz for compliance with the Rel8/9/10 standards. Nevertheless, for all bandwidth configurations Rel8/9/10 has specified that basic physical layer synchronisation signals (Primary Synchronisation Signals - PSS, and Secondary Synchronisation Signals - SSS), and the most fundamental system information (Master Information Block - MIB) is transmitted using only the central 6 resource blocks which are receivable with a 1.4 MHz transceiver. However, in order to receive the remainder of the carrier system information the terminal device is required to be able to receive the full bandwidth of the carrier.

However, and as also noted above, for some applications, for example in situations relating to machine type communications (MTC) and/or dedicated messaging networks (DMN), there is a drive to build low cost and hence low capability devices. Ideally, device simplification should permit a reduction in required bandwidth of operation as well as reduction of features and throughput. Terminal devices with a lower bandwidth capability than that specified for Rel8/9/10 may mean that such devices are unable to operate properly on Rel8/9/10 compliant networks which specify higher bandwidth capabilities. For example, terminal devices with a lower bandwidth capability may not even be able to receive any more system information than that contained in the MIB of a Rel8/9/10 compliant network.

Low capability devices will ideally be able to find and camp-on the carrier associated with their target dedicated messaging network(s) even in the presence of Rel8/9/10 higher bandwidth carriers. Furthermore, there is a desire that DMN carriers are not swamped by Rel8/9/10 capable devices camping-on the DMN, even though the Rel8/9/10 capable devices are in the coverage area of a higher bandwidth Rel8/9/10 carrier which they could otherwise use.

Subordinate Carrier Definition

As described in relation to Figure 3, the subordinate carrier resources (for use by MTC devices) may be defined by a certain bandwidth in the frequency domain (frequency band F_2 in Figure 3 for example) and a certain pattern of time periods in the time domain. The certain pattern of time periods may be a sequence of subframes as described above with reference to

Figure 4. The sequence of subframes may be a sequence of MBSFN subframes as defined by signalling within SystemInformationBlockType2 (SIB2) of the legacy LTE host carrier. However, it will be recognised that the subordinate carrier may be delineated by other means, for example by scheduling by a base station. The pattern of subframes may be a subset (or all) of those subframes reserved by the information element mbsfn-SubframeConfigList in the host carrier SIB2.

Conveniently, non-MTC UEs will read SIB2 of the legacy LTE host carrier and determine that a configured pattern of subframes are reserved for other purposes (such as MBMS, relay or as in the present case MTC subordinate carrier operation). The non-MTC UEs will therefore ignore the subframes allocated to the subordinate carrier. The configured pattern of reserved subframes is defined in a flexible manner by the information element mbsfn-SubframeConfigList.

In particular, mbsfn-SubframeConfigList comprises a set of 1 or more subframe allocations each of which is defined by the following fragment of ASN.1 from TS 36.331:

```
MBSFN-SubframeConfig ::=          SEQUENCE {
    radioframeAllocationPeriod        ENUMERATED {n1, n2, n4, n8, n16, n32},
    radioframeAllocationOffset        INTEGER (0..7),
    subframeAllocation                    CHOICE {
        oneFrame                              BIT STRING (SIZE(6)),
        fourFrames                            BIT STRING (SIZE(24))
    }
}
```

For a given allocation, the "radioframeAllocationPeriod" indicates the periodicity, in radio frames, with which MBSFN subframes are included in the allocation. "n1" indicates that MBSFN subframes are present in every radio frame, while "n2" indicates that MBSFN subframes are present in every other radio frame. A radioframeAllocationPeriod of "n32" indicates that one in every 32 radio frames includes one or more MBSFN subframes. Radio-frames that contain MBSFN subframes occur when equation SystemFrameNumber mod radioFrameAllocationPeriod = radioFrameAllocationOffset is satisfied. In other words, the radioframeAllocationOffset parameter sets an offset for a start position of the repeating pattern of radio frames. The subframeAllocation parameter defines the subframes that are allocated for MBSFN within the radio frame allocation period defined by the radioFrameAllocationPeriod and the radioFrameAllocationOffset parameters. The subframe

allocation can either be specified for a single radio frame within the radio frame allocation period (oneFrame) or for four consecutive radio frames within the radio frame allocation period (fourFrames). The subFrameAllocation parameter is a 6 bit (oneFrame) or 24 bit (fourFrame) mask, indicating whether each of 6 (oneFrame) or 24 (fourFrame) predetermined subframes are to be reserved. The LTE specification places restrictions on which subframes may be reserved for other purposes by this method, in order that there is no conflict with the requirement to receive system information and paging. In an FDD LTE system one or more of subframes 1, 2, 3, 6, 7 and 8 may be reserved for other purposes. In a TDD LTE system the subframes that may be reserved are 3, 4, 7, 8 and 9. The system frame number can be derived from the MIB of the host carrier.

Figures 5A to 5D are example subframe patterns. Each of Figures 5A to 5D shows a portion of a repeating pattern which could be specified by mbsfn-SubframeConfigList or by a similar pattern specifying function. Four radio frames having ten subframes each are shown in Figures 5A to 5D. The subframes are labelled from 0 (zero) to 9 (nine). The shaded subframes are those allocated to the subordinate carrier, with the unshaded subframes being retained for use on the host carrier. Figure 5A schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 111111 (thereby selecting each of subframes 1, 2, 3, 6, 7 and 8). It will be appreciated that this subframe allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

Figure 5B schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 11111x (thereby selecting each of subframes 3, 4, 7, 8 and 9). It should be noted that the last bit of the mask is not used for TDD. The difference between Figures 5A and 5B results from the different subframes mapped to the bit mask in the FDD and TDD schemes.

Figure 5C schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n1 (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 101010 (thereby selecting each of subframes 1, 3 and 7). It will be appreciated that this subframe

allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

Figure 5D schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to n1 (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 10101x (thereby selecting each of subframes 3, 7 and 9). It should be noted that the last bit of the mask is not used for TDD. Again, the difference between Figures 5C and 5D results from the different subframes mapped to the bit mask in the FDD and TDD schemes. All of the patterns shown in Figures 5A to 5D will repeat until the mbsfn-SubframeConfigList is altered. The set of allocation patterns specified in mbsfn-SubframeConfigList , which is signalled in SIB2, defines the "reserved set". A sub-set of the allocation patterns could be used to define the subordinate carrier. Also, two mutually exclusive sub-sets could be used to define two separate subordinate carriers delimited in the time domain.

It will be appreciated that this mechanism provides a great deal of flexibility in how much carrier resource is to be allocated to the subordinate carrier, and also how that resource is distributed with respect to time. The minimum (non-zero) amount of resources (in the time domain) which can be allocated is 1 in 320 subframes (when radioframeAllocationPeriod is set to n32 and only one bit is set in the subframeAllocation bit mask). The maximum amount of resources (in the time domain) which can be allocated is 192 in 320 subframes (when radioframeAllocationPeriod is set to n1 and all six bits are set in the subframeAllocation bit mask). In some implementations the allocation might be static to provide a fixed resource subordinate carrier. The fixed resources could in this case be known to a terminal device in advance. In other implementations the allocation might be dynamic, resulting in a subordinate carrier having a resource allocation which can be increased or decreased to for example meet traffic loading conditions on the subordinate carrier and/or on the host carrier. These increases or decreases could be based on requests from terminal devices for additional resource, or based on decisions made at the base station or a related entity. An increase in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined above, or by adding a new subframe allocation according to the principles set out above. A decrease in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined above, or by removing an existing subframe allocation.

In other words, it is possible to use multiple subframe allocations to achieve allocation patterns which would not be possible with a single subframe allocation, and to provide a simple way of increasing (or decreasing, if one of multiple subframe allocations is removed) the amount of resources allocated to the subordinate carrier. In one implementation, a first subframe allocation with a relatively low allocation period and subframe allocation could be used to maintain a low resource subordinate carrier which can be camped onto by a low capability terminal device, and then further subframe allocations could be added to service the communication needs of the low capability terminal device when it has successfully camped on. In this way, the resources available to the host carrier are retained at a high level to serve LTE traffic when the subordinate carrier is not in use.

Signalling the presence of the Subordinate Carrier

Certain resource blocks may be used to carry control signalling including synchronisation signals and system information. As explained above, a problem can therefore arise if essential control signalling from the base station is transmitted outside of the frequency range which can be received by a low-capability device. Fortunately, as described above, the synchronisation signals and the Master Information Block (MIB) of the system information are present within a frequency range which is likely to be receivable by a low-capability device. However, further system information, carried in System Information Blocks (SIBs), and the associated control signalling may be transmitted at a frequency which cannot be received by the low-capability device. This would cause problems, potentially preventing the low-capability device from being able to camp on to the network. It will be appreciated that not all host carriers will necessary support a subordinate carrier. If a low-capability device attempts to camp-on to a network which does not support a subordinate carrier then the camp-on procedure will ultimately fail. This is a waste of time and power for the low-capability device.

It would therefore be desirable to signal to an MTC UE which has restricted reception bandwidth the presence of an MTC subordinate carrier within a larger bandwidth LTE carrier accessible to legacy UEs (LTE Rel 8/9/10 UEs). It was discussed above that for all LTE bandwidths (Rel8/9/10) the basic physical layer synchronisation signals and the most important system information (Master Information Block) is transmitted using only the central 6 resource blocks (72 subcarriers). The Master Information Block (MIB) is transmitted in the Physical Broadcast Channel (PBCH) which is allocated to the central 72 subcarriers and to just the first 4 OFDMA symbols of the second slot of every 10ms radio frame. Thus,

assuming that the low bandwidth MT UE is able to receive at least 6 resource blocks in the frequency domain, then the PBCH (for example the MIB) may be used to signal the presence of an MTC subordinate carrier.

In Figure 6, a schematic flow diagram of a first part of a camp-on procedure is shown. At a step A1, an MTC device seeking to camp-on to a subordinate carrier, for example following power-up, seeks to identify and decode PSS (Primary Synchronisation Signals) and SSS (Secondary Synchronisation Signals) signalling being broadcast in its location. Once the MTC device synchronises to a carrier using the PSS and SSS, the MTC device determines the frame timing and proceeds to decode the PBCH to determine the MIB for the carrier. At a step A2, the MTC device determines whether or not a subordinate carrier indicator flag is present in the MIB. The MTC subordinate carrier indicator flag may be signalled in one (or more) of the MIB bits that are spare in LTE Release 8 / 9 / 10 (10 bits are currently spare). If the MTC device determines that the MIB contains a subordinate carrier indicator flag then the camp-on process continues at a step A3. If on the other hand the MTC subordinate carrier indicator flag was found not to be present, then the camp-on procedure to this carrier would be terminated. This would allow the device to decide upon proceeding with camp-on (or not) simply based upon decoding of the legacy LTE MIB, and to discontinue with camp-on immediately after the decoding of the legacy LTE MIB should the subordinate carrier indicator flag not be present. As an alternative to using the MIB to signal the presence of a subordinate carrier, a subordinate carrier indicator signal could be provided at a known time / frequency somewhere other than in the MIB. The particular time / frequency may be defined referentially with respect to the MIB (for example). The subordinate carrier indicator signal may be relative to the host carrier PBCH and/or the System Frame Number conveyed in the host carrier PBCH / MIB. In this case the MTC device would, following synchronisation (at the step A1), search for the subordinate carrier indicator signal at the expected time / frequency (at the step A2). If it is found, then the MTC device knows that one (or more) subordinate carriers are present and continues its discovery of the MTC subordinate carrier and the subsequent camp-on process.

In either implementation, it will be appreciated that the presence of the subordinate carrier indicator is derivable by the MTC device without being required to decode any system information block (SIB) of the host carrier since the MTC device may be unable to receive the host carrier SIBs which are signalled across the full host carrier frequency band F1.

If the MTC device does not find a subordinate carrier associated with the host carrier, then it may search for and seek to camp-on to another carrier by returning to the step A1 to seek to synchronise with and decode PBCH for a different carrier.

Signalling the bandwidth of the subordinate carrier(s)

Having detected the presence of an MTC subordinate carrier the UE needs to determine the bandwidth of the subordinate carrier in order to be able to read the further system information which will contain the other characteristics of the subordinate carrier. There are a number of alternative ways in which the subordinate carrier bandwidth may be signalled to the MTC UE:

(1) The simplest method is to fix the bandwidth of the subordinate carrier in the 3GPP specifications. Having detected the presence of a subordinate carrier in the manner described above, the MTC UE would know by definition the MTC subordinate carrier bandwidth (e.g. 1.4MHz, 3MHz or 5 MHZ).

(2) The downlink bandwidth of the MTC subordinate carrier may be signalled in the legacy LTE MIB. For example if the subordinate carrier indicator flag were signalled in the PBCH by using a 2 bit field, 4 states could be signalled (absence of a subordinate carrier and three different subordinate carrier bandwidths, e.g. 1.4MHz, 3MHz and 5 MHZ).

(3) The downlink bandwidth (and possibly other characteristics) of the MTC subordinate carrier could be signalled in a Subordinate Carrier Master Information Block (scMIB). The scMIB would be signalled in fixed time / frequency resources, known in advance to the mobile terminal and preferably defined in the 3GPP specifications. The possibilities for signalling the scMIB are described in the following section.

Signalling the Subordinate Carrier Master Information Block (scMIB)

In the above section three methods of determining the downlink bandwidth of an MTC subordinate carrier by an MTC UE have been described. The first two of these methods involve a priori knowledge of when decoding of the subordinate carrier begins. The last of the described methods involves signalling the downlink bandwidth in a Master Information Block of the subordinate carrier itself.

A Master Information Block may be regarded as collection of parameters giving values to configurable characteristics of the carrier and other information to achieve/maintain radio frame synchronisation. A Master Information Block is required to be supplied in fixed time/frequency resources and must be received and decoded before a more flexible scheme of

downlink message exchange may be employed. According to the above description, at the point at which the UE tries to decode the scMIB, the UE will know:

- That an MTC subordinate carrier is present (from the indicator flag / signal).
- The subordinate carrier centre frequency (it may generally be assumed that this will be the same as the centre frequency of the host legacy LTE carrier).

In addition the UE may know the MTC subordinate carrier bandwidth, if this has been fixed in the specifications, conveyed in the host carrier MIB or conveyed by some other a priori means. In order to receive and decode the scMIB the UE must be able to determine in which resource elements it is carried. The number of resource elements used for the scMIB could be related to the subordinate carrier bandwidth or it could be fixed (as is the case for the legacy LTE MIB). If the number of resource elements were defined to be dependent upon the subordinate carrier bandwidth, this would require the value of the subordinate carrier bandwidth to be known a priori. There are a limited number of spare bits available in the legacy host carrier LTE MIB, and so it may be considered that there are not sufficient available to use 1 or more of these to carry subordinate carrier bandwidth information. In this case, the UE will not have a priori knowledge of the subordinate carrier bandwidth so the UE will be unable to derive the scMIB resource elements from the bandwidth.. Accordingly, for the purposes of the following description it is assumed that the scMIB is always signalled in a fixed set of resource elements defined within the 3GPP specifications. Nonetheless, it should be understood that the present invention is not limited to this, and that in certain implementations the set of resource elements used to convey the scMIB may not be fixed.

The fixed set of resource elements is contained within a subset (or all) of those subframes reserved by one (or more) of the subframe allocations configured in the information element mbsfn-SubframeConfigList broadcast in the host carrier SIB2. The fixed subframe allocation to convey the scMIB should:

- Be frequent enough to occasion an acceptable latency for acquisition of the scMIB by MTC UEs.
- Not be too frequent that excessive resources are consumed from the host carrier and subordinate carrier.

It should be noted that it is common for MTC devices to exhibit low mobility and be able to tolerate comparatively high latencies in message transmission. However, this may not be the case with all possible MTC traffic and it is therefore preferable that the frequency of

MIB transmission be fixed within the 3GPP specification and thus cannot be configured dependent upon the expected MTC traffic characteristics.

Various fixed characteristics of the scMIB transmission scheme, including the following, should preferably be defined within the 3GPP specifications:

- The number, periodicity and relationship to host carrier System Frame Number of the subframes used for scMIB.
- The level of repetition encoding employed.
- Within the subframes used, the number and location of resource elements used to convey the scMIB (that is, exactly which slot(s), subcarriers and symbols are to be used).

The number of resource elements used for the scMIB will be a function of the number of bits of information that must be conveyed by this method, which will be influenced by the further details of the subordinate carrier design, but the number will also be constrained by the overhead that this imposes. The System Frame Number, necessary for the UE to maintain radio frame synchronisation, upon which many LTE higher layer processes are dependent, may be read from the host carrier MIB. However, for efficiency reasons it is likely that once the UE synchronises to the subordinate carrier, it would be undesirable for the UE to have to keep re-reading the host carrier MIB to maintain this information. Thus, System Frame Number is likely to be carried by the scMIB, although the UE might depend upon the host carrier MIB for this information.

Any combination of parameters conforming to and fully resolving the definition of MBSFN-SubframeConfig may be chosen to define which subframes convey the scMIB. However, use of a single subframe allocation pattern will provide a solution involving least complexity. For example a single pattern comprising a single subframe allocation once per radio frame allocation period of 32 frames and with an offset value of zero may be considered adequate to convey the scMIB dependent upon other details of the subordinate carrier design. Alternatively, if more MIB bits are required then a shorter allocation period of, for example, 16 or 8 radio frames could be used and/or more subframes per allocation period. Note that while the subframes used to convey the scMIB may be defined by such a subframe allocation pattern or patterns, not all slots or resource elements in the subframes defined by the pattern(s) are necessarily used to convey the scMIB. Use of a shorter allocation period but sparse use of the resource elements for the scMIB may offer the best compromise in relation to scMIB acquisition time and resource overhead.

The subframe allocation pattern or patterns chosen to define the subframes used for the scMIB will be included in the mbsfn-SubframeConfigList of SIB2 of the host carrier in order to reserve these subframes for special use within the context of the host carrier. However, low bandwidth MTC UEs searching for a suitable subordinate carrier will not be required to read SIB2 of the host carrier to gain this information, since the subframe allocation pattern(s) for the scMIB will be fixed and defined in the 3GPP specifications.

Camp-on procedure

Referring to Figure 7, the camp-on procedure following the initial steps shown in Figure 6 is schematically illustrated. At a step B1 the location of the scMIB is determined. As discussed above, the location of the scMIB is likely to be fixed in the 3GPP standards, and so the MTC UE will be able to frame synchronise with the scMIB broadcast by comparing the location of the scMIB (radio frame and sub-frame known from the 3GPP specifications) with the current System Frame Number (which the MTC UE can derive from the host carrier MIB). At a step B2 the scMIB is received and decoded, whereby the system information specified therein can be acquired and used. At a step B3 the bandwidth and central frequency of the subordinate carrier is determined. The bandwidth of the subordinate carrier may be determined by one of the methods described above in the section "Signalling the Bandwidth of the Subordinate Carrier(s)". The central frequency may be assumed to be the same as that of the host carrier, but in some implementations may have a different central frequency which would need to be signalled to the MTC UE. The central frequency and bandwidth together identify the frequency band forming the subordinate carrier. Note that if the bandwidth is not determined from the scMIB then the step B3 can be performed before (or in parallel with) the steps B1 and B2.

At a step B4, the allocation of subordinate carrier subframes is determined. An indication of those subframes allocated to the subordinate carrier may be specified in the scMIB. As described above, sub-frames are allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set which determines which sub frames within a repeating group of radio frames are allocated to the subordinate carrier. At a step B5, further system information (System Information Blocks) relating to the subordinate carrier is obtained from subframes allocated to the subordinate carrier. This further system information can be used to complete the camp on procedure of the MTC UE to the subordinate carrier at a step B6. The further system information may be at a fixed location within the radio resources

of the subordinate carrier, or at a location within the radio resources of the subordinate carrier which has been scheduled by the base station, or a combination of both.

In Figure 8, example signalling on the host carrier and the subordinate carrier is schematically illustrated. In Figure 8, eight radio frames 800 are shown, each having a central frequency portion 820 usable by both the host carrier and the subordinate carrier, and outer frequency portions 810 usable only by the host carrier. In each radio frame, a MIB 830 is provided in the central frequency portion 820. The MIB 830 is readable by devices using both the host carrier and the subordinate carrier. Devices seeking to use a subordinate carrier may be able to determine from the MIB 830 whether a subordinate carrier exists based on a flag present in the MIB 830. In an outer frequency portion 810, system information 840 is provided for use by devices served by the host carrier. The system information 840 is shown to be outside of the central frequency portion 820 and is thus not available to the kind of low-capability devices intending to use the subordinate carrier. It will be appreciated that some system information may happen to be transmitted within the central frequency portion 820, but this cannot be guaranteed. The system information 840 is provided in the form of System Information Blocks (SIBs). Unlike the Master Information Block which is broadcast on the Physical Broadcast Channel (PBCH), the SIBs are mapped onto the Physical Downlink Shared Channel (PDSCH). Generally, the Master Information Block 830 provides sufficient information to gain access to the first of the System Information Blocks (SIB1), which in turn provides sufficient information to gain access to SIB2 et seq. SIB2 includes parameters relating to the reservation of MBSFN subframes (as described above). Legacy LTE devices using the host carrier will therefore be informed of the subframes reserved for use by the subordinate carrier (or for other purposes, for example MBMS or relay backhaul) when they decode SIB2. They will therefore know that these subframes cannot be used and to ignore them. Within the central portion 810 of some or all of the radio frames (every other radio frame in this example) is a portion 850 allocated to the subordinate carrier. For the sake of clarity the portion 850 shown in Figure 8 is contiguous, but it will be appreciated from Figures 5A to 5D for example that this may not be the case. The portions 850 are used to transmit data and signalling to low capability devices using the subordinate carrier. Within the allocated portion 850 of the first radio frame is a subordinate carrier MIB (scMIB) 860 carrying various information required for a low capability device to acquire the remainder of the subordinate carrier system information.

Within the allocated portion 850 of the second radio frame is system information 870 relating to the subordinate carrier. This system information 870 provides information required for a terminal device to camp on to the subordinate carrier. It will be appreciated that the locations of the scMIB 860 and the system information 870 is purely exemplary. The important point is that the scMIB 860 and the system information 870 are conveyed in the allocated portions 850. As described in detail above, the location and periodicity of the scMIB would probably be fixed (predetermined). The system information 870, which could be conveyed in the form of System Information Blocks in a similar manner to with the host carrier, may be predetermined, or dynamically allocated (scheduled), depending on implementation.

In the host carrier, the MIB and any associated SIBs together provide the parameters necessary for system access using the host carrier. Similarly, in the subordinate carrier, the scMIB and any associated SIBs carried in subframes allocated to the subordinate carrier provide the parameters necessary for system access using the subordinate carrier. In both cases, the UE (legacy or MTC) requires the MIB to decode the shared channel (and thus access SIBs). The MIB contains downlink system bandwidth of the host carrier and the system frame number.

The above embodiment describe a method of conveying a subordinate carrier for low bandwidth devices within a portion of a larger host carrier using for example MBSFN subframe allocation pattern(s) to reserve subframes for the subordinate carrier. This permits a flexible and efficient definition of a subordinate carrier within a host carrier. An indication of the presence of the MTC subordinate carrier is provided using a flag in the host carrier MIB. This may require the 3GPP standard to be updated, but will not require any change to legacy LTE devices because the flag is set in current spare bits which can and will be ignored by a legacy device. Various methods of signalling subordinate carrier downlink bandwidth have been described, including fixing the MTC subordinate carrier bandwidth in 3GPP specifications, signalling the subordinate carrier downlink bandwidth via a field in host carrier MIB, or signalling using a bit field within the subordinate carrier MIB (scMIB). A method of defining the subframes used for the subordinate carrier Master Information Block by using fixed (defined in 3GPP specifications) subframe allocation pattern(s) in relation to the System Frame Number of the host carrier has also been described above. A subordinate carrier has been described (in one example) to be specified using a repeating pattern of sub-frames. A

mechanism to specify this already exists in LTE, originally for the purpose of specifying sub-frames for use in MBSFN.

It will be appreciated that various modifications can be made to the embodiments described above without departing from the scope of the present invention as defined in the appended claims. In particular although embodiments of the invention have been described with reference to an LTE mobile radio network, it will be appreciated that the present invention can be applied to other forms of network such as GSM, 3G / UMTS, CDMA2000, etc. The term MTC terminal as used herein can be replaced with user equipment (UE), mobile communications device, mobile terminal etc. Furthermore, although the term base station has been used interchangeably with e-nodeB it should be understood that there is no difference in functionality between these network entities.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

REFERENCES

[1] Holma H. and Toskala A, "*LTE for UMTS OFDMA and SC-FDMA based radio access*", John Wiley and Sons, 2009.

CLAIMS

1. A wireless communications system, comprising:

a base station,

one or more terminal devices of a first type; and

one or more terminal devices of a second type; wherein

the base station is operable

to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and

to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

2. A wireless communications system according to claim 1, wherein

the radio resource segments are sub-frames of radio frames, each radio frame comprising a plurality of sub-frames, and

sub-frames are allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set, the subordinate carrier sub-frame allocation set determining which sub frames within a repeating group of one or more radio frames are allocated to the subordinate carrier.

3. A wireless communications system according to claim 2, wherein the subordinate carrier sub-frame allocation set is defined by one or more reserved sub-frame allocation patterns.

4. A wireless communications system according to claim 3, wherein the one or more reserved sub-frame allocation patterns comprise all or a sub-set of all reserved sub-frame allocation patterns defined for the host carrier.

5. A wireless communications system according to claim 3 or 4, wherein

acquisition information required for a terminal device of the second type to receive the subordinate carrier is allocated to sub-frames of the subordinate carrier using at least a portion of the subframes in one or more of the reserved sub-frame allocation patterns defining the subordinate carrier.

6. A wireless communications system according to one of claims 2 to 5, wherein said base station is operable to transmit an indication of the radio resources of all reserved sub-frames to terminal devices of the first type.

7. A wireless communications system according to claim 6, wherein the indication of the radio resources of the reserved sub-frames are presented to the terminal devices of the first type as a reserved subframe allocation within a system information block outside of the second frequency band of the subordinate carrier.

8. A wireless communications system according to any preceding claim, wherein the base station is operable

to transmit, using radio resources within the second frequency band, subordinate carrier information indicating that a subordinate carrier is available within the host carrier.

9. A wireless communications system according to claim 8, wherein a terminal device of the second type is responsive to subordinate carrier information indicating that a subordinate carrier is not available within the host carrier to terminate a camp-on procedure for camping on to the network.

10. A wireless communications system according to claim 8 or claim 9, wherein the subordinate carrier information is provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the system information of the host carrier.

11. A wireless communications system according to claim 10, wherein the first acquisition information is a master information block transmitted on a physical broadcast channel within radio resources of the host carrier.

12. A wireless communications system according to any preceding claim, wherein the first type of terminal devices are capable of receiving the full bandwidth of the first frequency band, and the second type of terminal devices are not capable of receiving the full bandwidth of the first frequency band but are capable of receiving the full bandwidth of the second frequency band.

13. A wireless communications system according to any preceding claim, wherein the bandwidth of the subordinate carrier is predetermined and is known in advance to terminal devices of the second type.

14. A wireless communications system according to any one of claims 1 to 12, wherein the base station is operable to transmit, using radio resources within the second frequency band, an indication of the bandwidth of the subordinate carrier.

15. A wireless communications system according to claim 14, wherein the indication of the bandwidth of the subordinate carrier is provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being provided to permit a terminal device of the first type to receive the host carrier downlink and camp on to the host carrier.

16. A wireless communications system according to any one of claims 1 to 14, wherein the base station is operable to transmit, using radio resources of the subordinate carrier, an indication of the bandwidth of the subordinate carrier.

17. A wireless communications system according to any preceding claim, wherein the base station is operable to transmit, using radio resources of the subordinate carrier, second acquisition information required for a terminal device of the second type to receive the subordinate carrier downlink and camp on to the subordinate carrier.

18. A wireless communications system according to claim 17, wherein the second acquisition information is transmitted on predetermined radio resources which are known in advance to terminal devices of the second type.

19. A wireless communications system according to claim 17, wherein the second acquisition information comprises an indication of the bandwidth of the subordinate carrier.

20. A wireless communications system according to claim 17, wherein the radio resource segments are sub-frames of radio frames in the time direction, each radio frame comprising a plurality of sub-frames, and wherein the second acquisition information is transmitted in at least some of the sub-frames allocated to the subordinate carrier.

21. A wireless communications system according to claim 20, wherein a terminal device of the second type is operable to determine whether a sub-frame contains second acquisition information from a current radio frame number and a first sub-frame allocation set for allocating the second acquisition information to sub-frames within the subordinate carrier, said first sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames contain the second acquisition information.

22. A wireless communications system according to claim 21, wherein the current radio frame number is determined from first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the host carrier downlink and camp on to the network.

23. A wireless communications system according to claim 21 or claim 22, wherein the first sub-frame allocation set is predetermined and known in advance to terminal devices of the second type.

24. A wireless communications system according to claim 17, wherein the second acquisition information comprises an indication of the current radio frame number.

25. A wireless communications system according to claim 20, wherein a terminal device of the second type is operable to determine whether a sub-frame is allocated to the subordinate carrier from a current radio frame number and a second sub-frame allocation set

for the subordinate carrier, said second sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames are allocated to the subordinate carrier.

26. A wireless communications system according to claim 25, wherein the current radio frame number is determined from the second acquisition information.

27. A wireless communications system according to claim 25, wherein the current radio frame number is determined from the first acquisition information and updated by counting radio frames.

28. A wireless communications system according to claim 25, wherein the second sub-frame allocation set is predetermined and known in advance to terminal devices of the second type.

29. A wireless communications system according to claim 25, wherein the second sub-frame allocation set is specified in the second acquisition information.

30. A wireless communications system according to any preceding claim, wherein the first type of terminal device is an LTE device and the second type of device is a low data rate device.

31. A wireless communications system according to any preceding claim, wherein the first type of terminal device is an LTE device and the second type of device is a low data rate device for providing machine-to-machine (M2M) communication.

32. A wireless communications system according to any preceding claim, wherein at least a portion of the radio resources, comprising a third frequency band, of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier and which are outside of the second frequency band are allocated to another subordinate carrier.

33. A wireless communications system according to any preceding claim, wherein at least a portion of the radio resources outside of the second frequency band of the subset of the radio

resource segments of the host carrier allocated to the subordinate carrier are used for communicating with terminal devices of the first type.

34. A base station for communicating with terminal devices, said base station being operable

to communicate with terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and

to communicate with terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

35. A method of communicating between a base station and terminal devices of a first type and a second type, comprising:

communicating between the base station and terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and

communicating between the base station and terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

36. A computer program, which when executed on a computer will cause the computer to perform a method according to claim 35.

37. A recording medium storing the computer program of claim 36.

38. A wireless communications method substantially as hereinbefore described with reference to the accompanying drawings.

39. A method of communicating substantially as hereinbefore described with reference to the accompanying drawings.

ABSTRACT

WIRELESS COMMUNICATIONS SYSTEM AND METHOD

A wireless communications system is described which comprises a base station, one or more terminal devices of a first type, and one or more terminal devices of a second type. The base station is operable to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band. In this way, an efficient and flexible mechanism for specifying and controlling an amount and location of radio resources to be dedicated to a subordinate carrier for use by a particular (e.g. reduced capability) type of device can be provided.

[Figure 3]

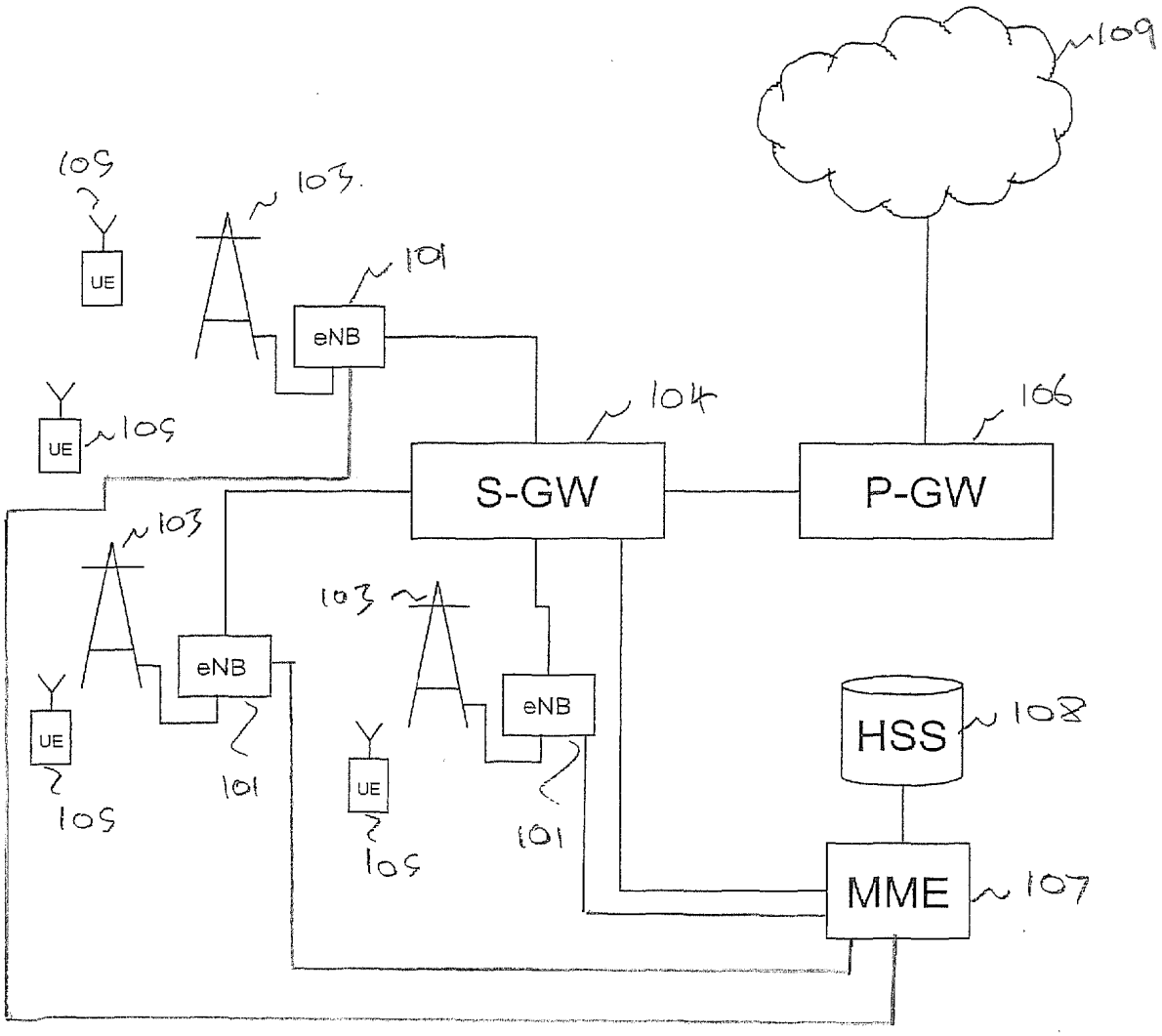


Fig 1

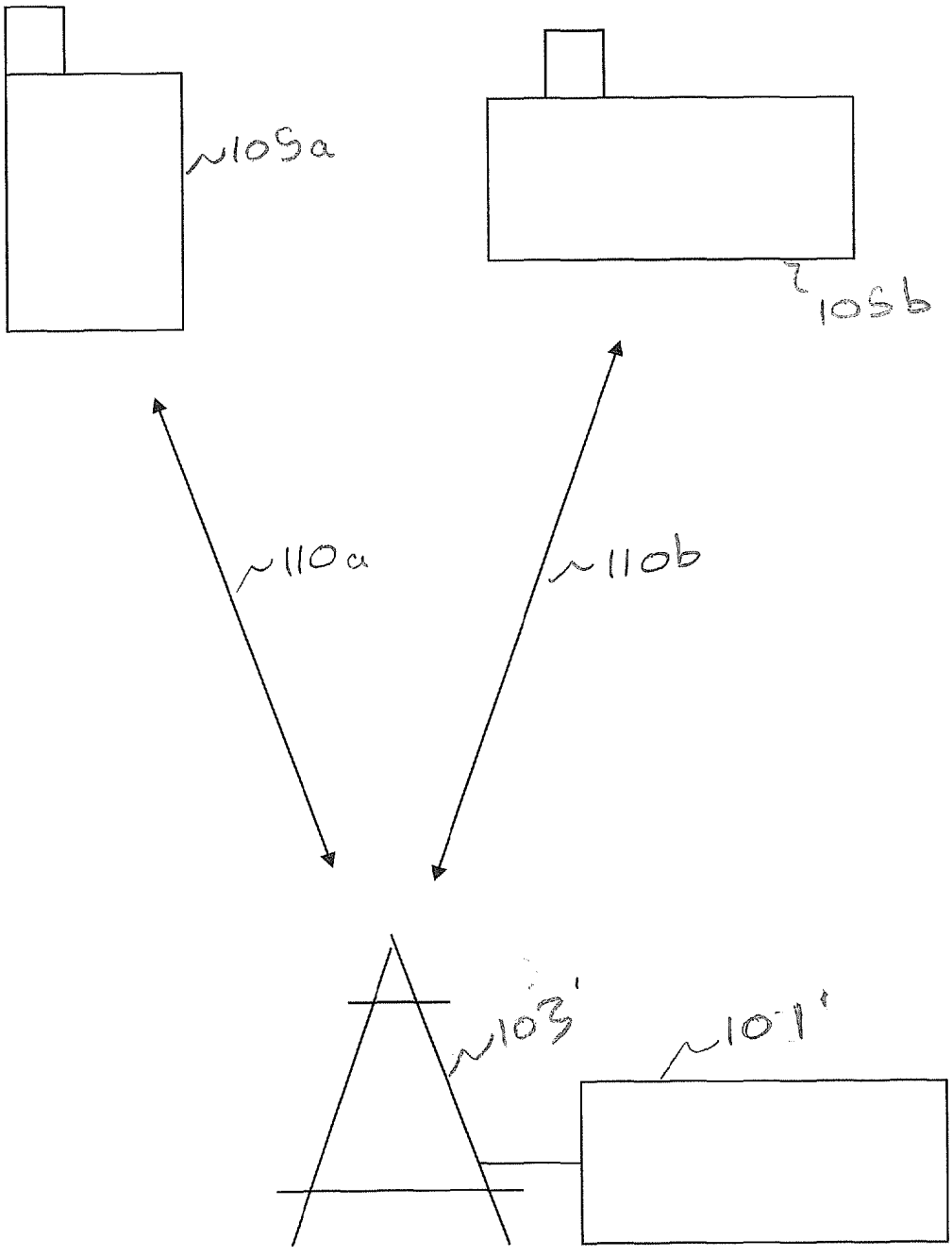


Fig 2

318

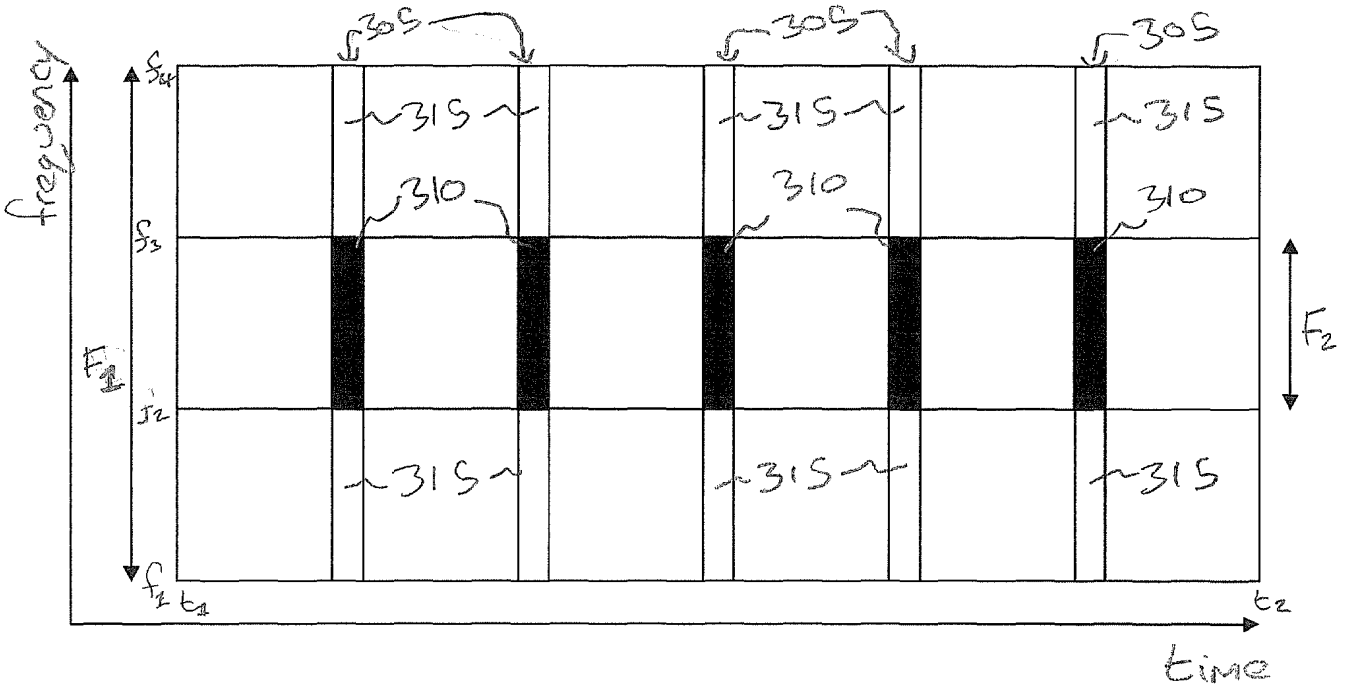

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315
315
frequency
f_{s4}
f_{s3}
f_{s2}
f_{s1}
F_1
F_2
t_1
t_2
time

Fig 3

418

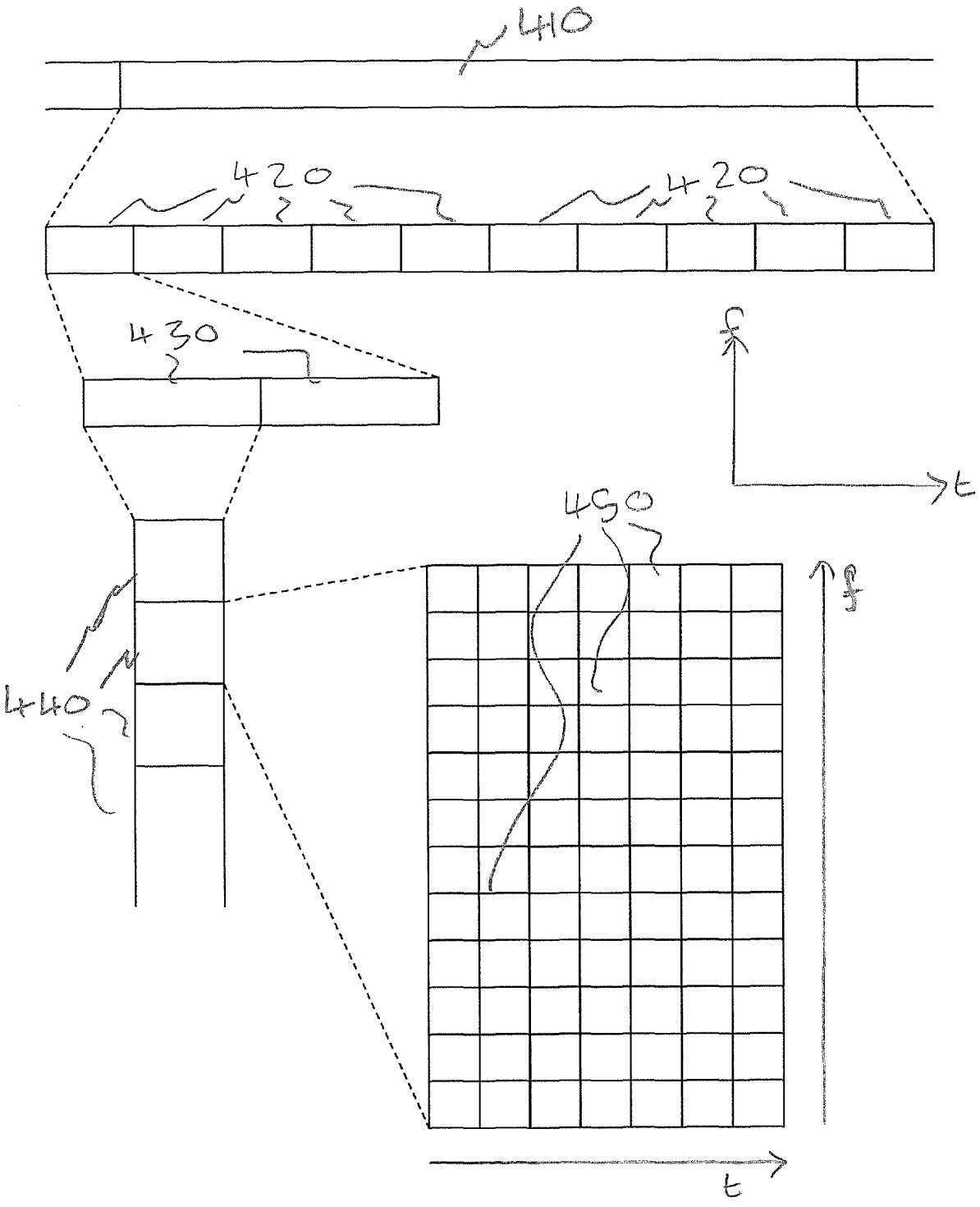


Fig 4

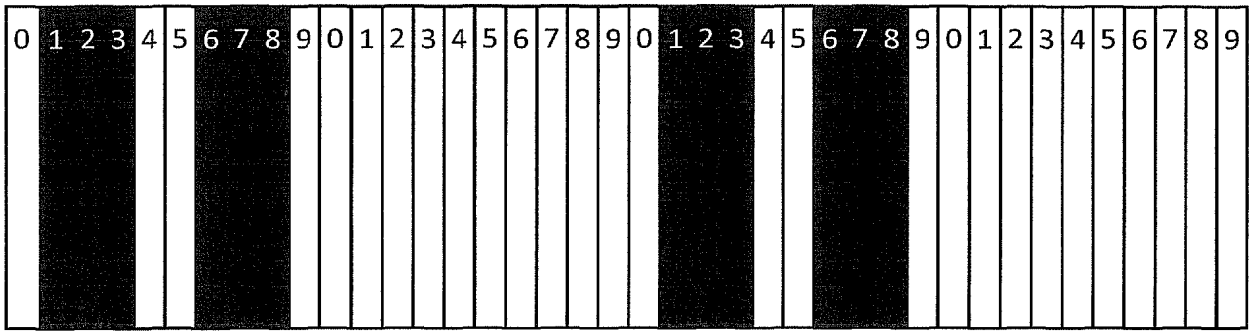


Fig 5A

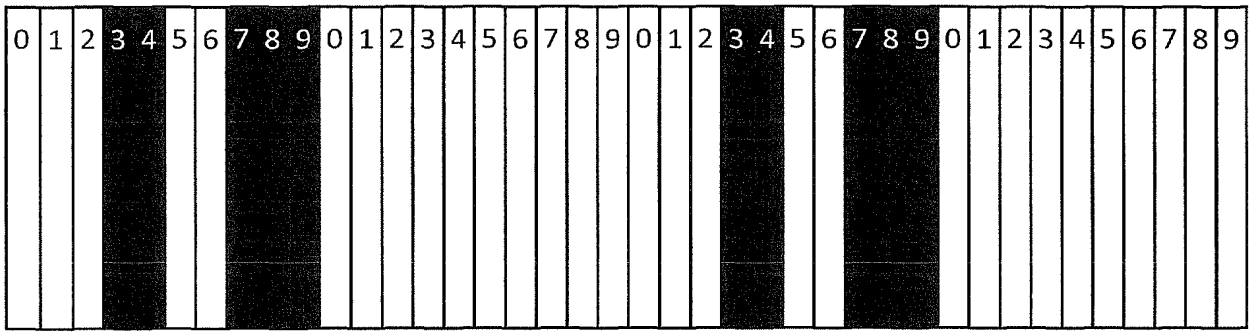


Fig 5B

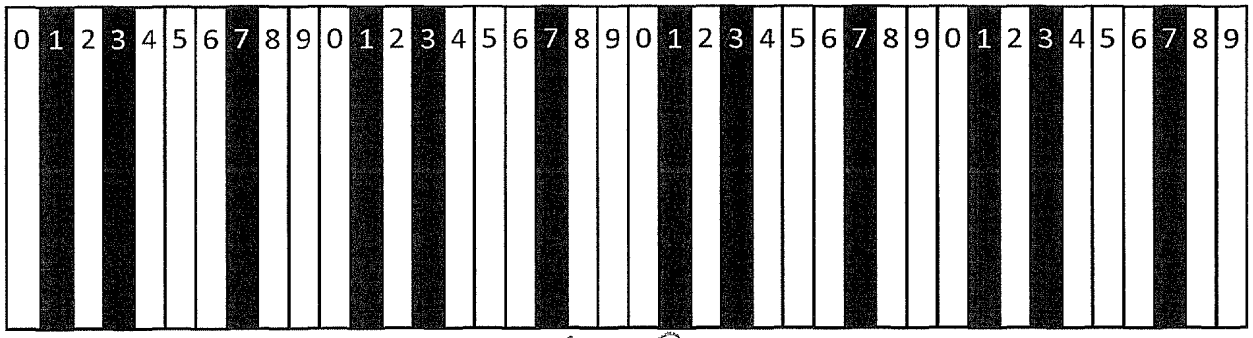


Fig 5C

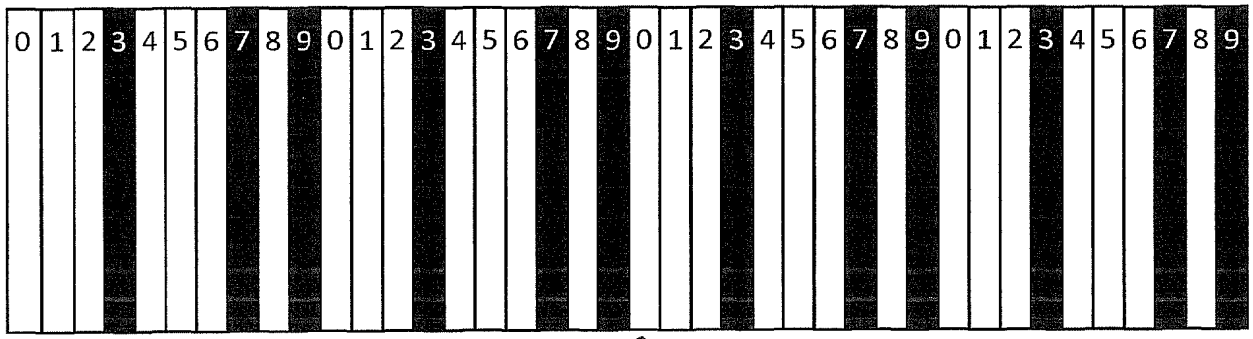


Fig 5D

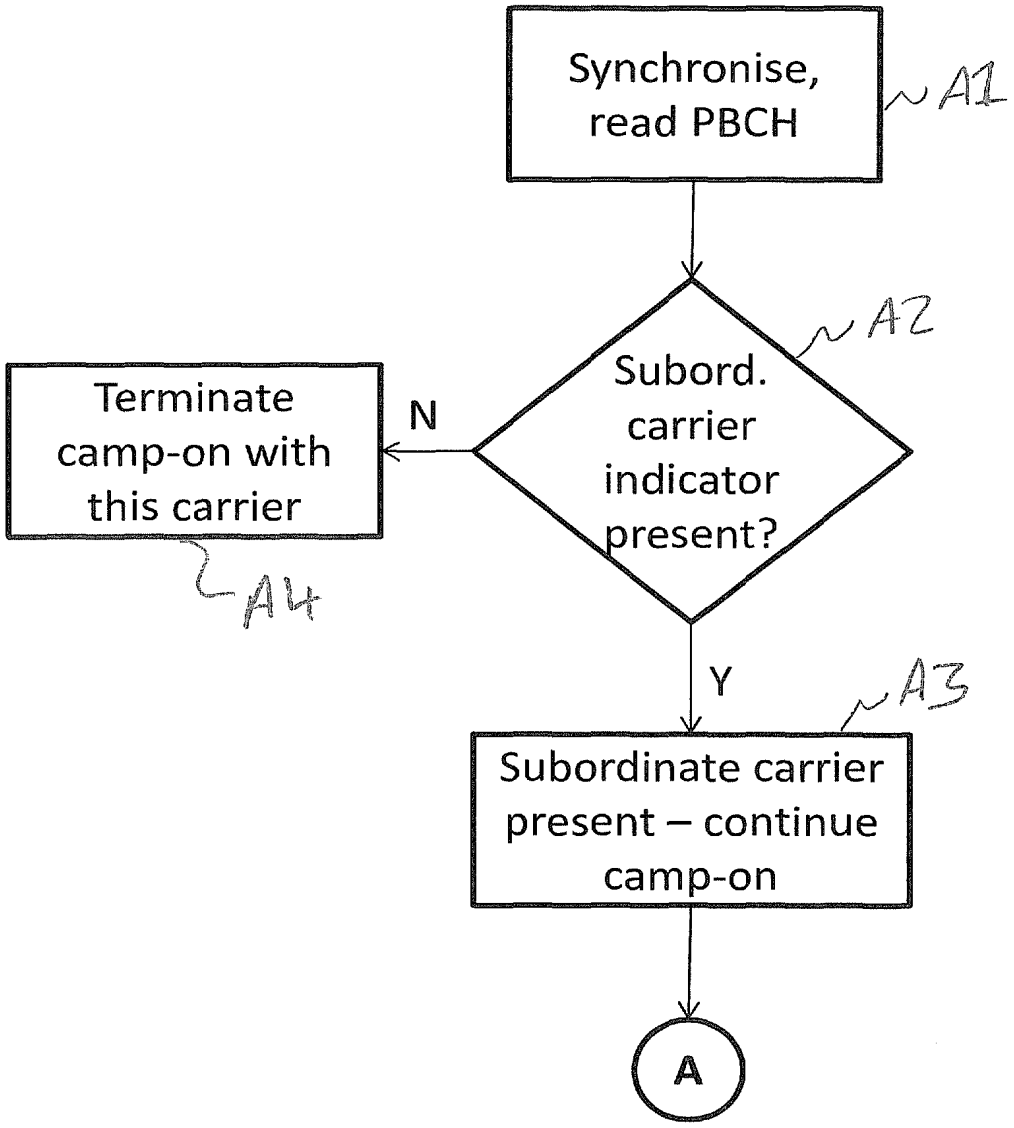

Synchronise, read PBCH
A1
Subord. carrier indicator present?
A2
N
Terminate camp-on with this carrier
A4
Y
Subordinate carrier present – continue camp-on
A3
A

Fig 6

718

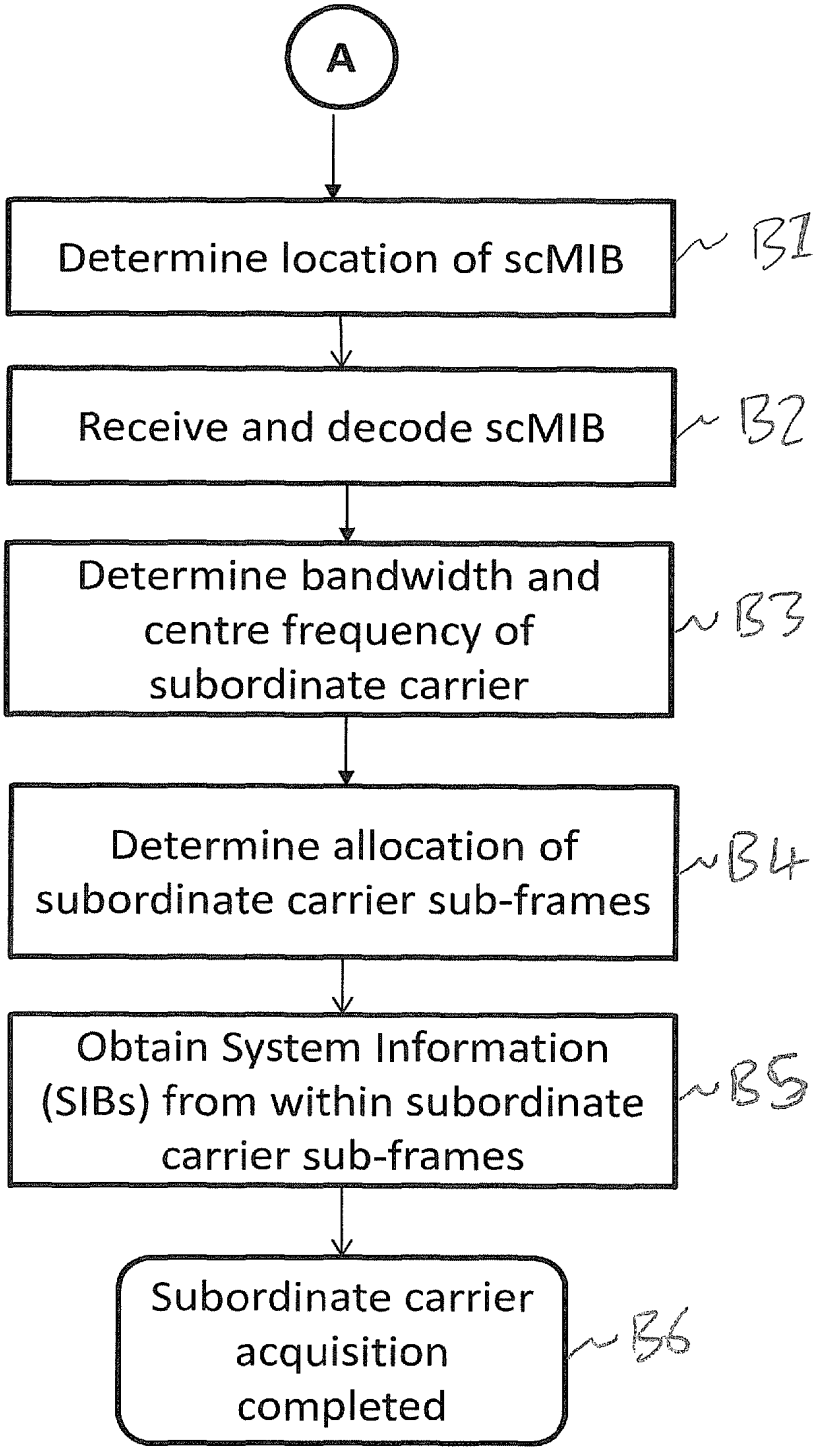

A
Determine location of scMIB
B1
Receive and decode scMIB
B2
Determine bandwidth and centre frequency of subordinate carrier
B3
Determine allocation of subordinate carrier sub-frames
B4
Obtain System Information (SIBs) from within subordinate carrier sub-frames
B5
Subordinate carrier acquisition completed
B6

Fig 7

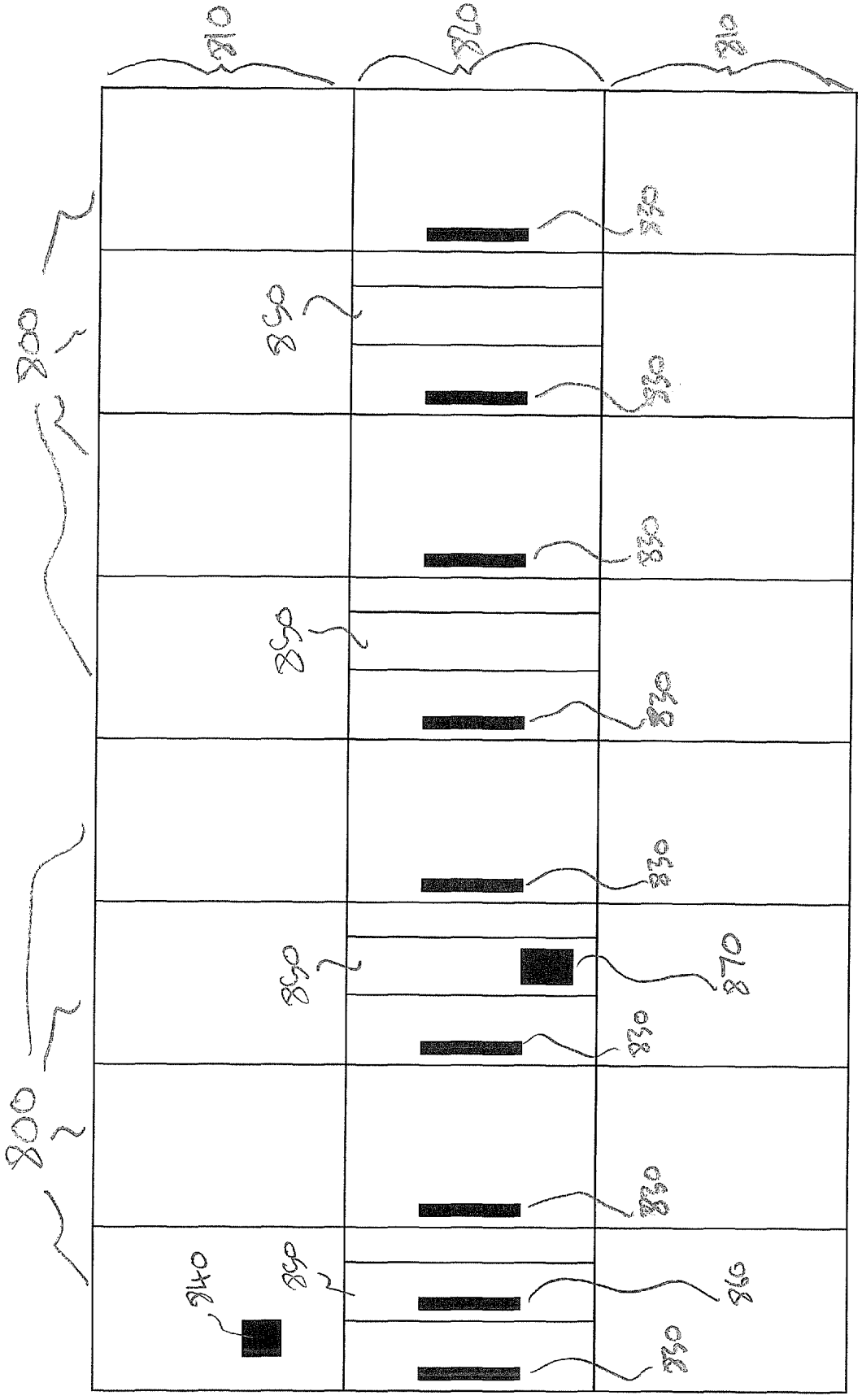


Fig 8

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DOCUMENT MADE AVAILABLE UNDER THE PATENT COOPERATION TREATY (PCT)

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www.wipo.int

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(71) Applicant *(for all designated States except US)*: **WIRELESS TECHNOLOGY SOLUTIONS LLC** [US/US]; 550 Madison Avenue, New York 10022 (US).

(72) Inventor; and
(71) Applicant *(for US only)*: **YOUNG, Philip** [GB/GB]; Sweet Briar, Hussell Lane, Medstead, Alton, Hampshire GU34 5PF (GB).

(74) Agents: **SMALL, Gary James** et al.; Carpmaels & Ransford, One Southampton Row, London WC1B 5HA (GB).

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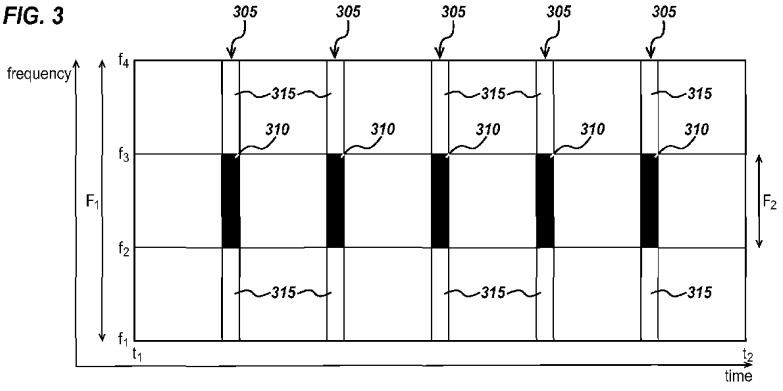
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(54) **Title**: WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

FIG. 3



(57) **Abstract**: A wireless communications system is described which comprises a base station, one or more terminal devices of a first type, and one or more terminal devices of a second type. The base station is operable to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band. In this way, an efficient and flexible mechanism for specifying and controlling an amount and location of radio resources to be dedicated to a subordinate carrier for use by a particular (e.g. reduced capability) type of device can be provided.

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WIRELESS COMMUNICATIONS SYSTEM WITH A NARROWER SUBORDINATE CARRIER

Field of the Invention

The present invention relates to wireless communications systems and methods, and in particular to a system, method, base station and terminal device for communicating using a subordinate carrier of a host carrier.

Background of the Invention

Mobile communication systems have evolved over the past ten years or so from the GSM System (Global System for Mobile communications) to the 3G system and now include packet data communications as well as circuit switched communications. The third generation partnership project (3GPP) is developing a fourth generation mobile communication system referred to as Long Term Evolution (LTE) in which a core network part has been evolved to form a more simplified architecture based on a merging of components of earlier mobile radio network architectures and a radio access interface which is based on Orthogonal Frequency Division Multiplexing (OFDM) on the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) on the uplink.

Third and fourth generation mobile telecommunication systems, such as those based on the 3GPP defined UMTS and Long Term Evolution (LTE) architectures, are able to support a more sophisticated range of services than simple voice and messaging services offered by previous generations of mobile telecommunication systems.

For example, with the improved radio interface and enhanced data rates provided by LTE systems, a user is able to enjoy high data rate applications such as mobile video streaming and mobile video conferencing that would previously only have been available via a fixed line data connection. The demand to deploy third and fourth generation networks is therefore strong and the coverage area of these networks, i.e. geographic locations where access to the networks is possible, is expected to increase rapidly.

The anticipated widespread deployment of third and fourth generation networks has led to the parallel development of a class of devices and applications which, rather than taking advantage of the high data rates available, instead take advantage of the robust radio interface and increasing ubiquity of the coverage area. Examples include so-called machine type communication (MTC) applications, also known as machine-to-machine (M2M) communications, some of which are in some respects typified by semi-autonomous or autonomous wireless communication devices (i.e. MTC devices) communicating small amounts of data on a relatively infrequent basis. Examples include so-called smart meters

which, for example, are located in a customer's home and periodically transmit data back to a central MTC server relating to the customer's consumption of a utility such as gas, water, electricity and so on.

Whilst it can be convenient for a terminal such as an MTC-type terminal to take advantage of the wide coverage area provided by a third or fourth generation mobile telecommunication network there are at present disadvantages. Unlike a conventional third or fourth generation mobile terminal such as a smartphone, a primary driver for MTC-type terminals will be a desire for such terminals to be relatively simple and inexpensive. The type of functions typically performed by a MTC-type terminal (e.g. simple collection and reporting of relatively small amounts of data) do not require particularly complex processing to perform, for example, compared to a smartphone supporting video streaming. However, third and fourth generation mobile telecommunication networks typically employ advanced data modulation techniques and support wide bandwidth usage on the radio interface which can require more complex and expensive radio transceivers to implement. It is usually justified to include such complex transceivers in a smartphone as a smartphone will typically require a powerful processor to perform typical smartphone type functions. However, as indicated above, there is now a desire to use relatively inexpensive and less complex devices to communicate using LTE type networks.

Summary of the Invention

According to a first aspect of the invention there is provided a wireless communications system, comprising a base station, one or more terminal devices of a first type and one or more terminal devices of a second type. The base station is operable to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

In this way, an efficient and flexible mechanism for specifying and controlling an amount and location of radio resources to be dedicated to a subordinate carrier for use by a particular (e.g. reduced capability) type of device can be provided.

One way of achieving this differentiated access between the terminal devices of the first type and second type is to allocate a part of the carrier resource that is dedicated to the

second type of device (e.g. MTC traffic) using normal eNB (base station) scheduling. The eNB differentiates between MTC and non-MTC (example of the first type of device) UEs and only schedules MTC UEs within the reserved part of the carrier resource and only schedules non-MTC UEs outside of the reserved part of the carrier resource. While this solution is viable, the simple scheduling approach places some restrictions on the MTC subordinate carrier that can be realised. For instance, it would be necessary to use the same carrier characteristics and/or reference signals. If it were advantageous to use different carrier characteristics or to use additional or modified reference signals then this may not be possible in an MTC subordinate carrier implemented purely by eNB scheduling.

The radio resource segments may be sub-frames of radio frames, each radio frame comprising a plurality of sub-frames. In this case, the sub-frames may be allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set, the subordinate carrier sub-frame allocation set determining which sub frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The subordinate carrier sub-frame allocation set may be defined by one or more reserved sub-frame allocation patterns. The one or more reserved sub-frame allocation patterns may comprise all or a sub-set of all reserved sub-frame allocation patterns defined for the host carrier.

In one example, the subframes selected for the subordinate carrier are so-called MBSFN (Multimedia Broadcast/multicast service over a Single Frequency Network) subframes. This embodiment relies on the fact that such subframes do not have to be used exclusively for MBSFN. The LTE Rel8/9/10 specifications define a means (in the standard LTE SystemInformationBlockType2 – SIB2) by which certain subframes can be excluded from normal allocation to the Physical Downlink Shared Channel (PDSCH). Furthermore, the specifications define signalling within the standard system information which allows some or all of these excluded subframes to be used for other defined purposes, such as MBMS (in SystemInformationBlockType13 – SIB13), relay and positioning reference signal transmission. However, reading of this system information may require reception across the whole carrier bandwidth.

Acquisition information required for a terminal device of the second type to receive the subordinate carrier may be allocated for inclusion in sub-frames of the subordinate carrier using at least a portion of the subframes in one or more of the reserved sub-frame allocation patterns defining the subordinate carrier.

The base station may be operable to transmit an indication of the radio resources of all reserved sub-frames to terminal devices of the first type. In this way, the first type of device is informed of subframes which are reserved for the subordinate carrier, another subordinate carrier, and for other purposes such as relay backhaul. A particular device of the first type is not required to know why a particular sub-frame is reserved, merely that it is not available to that device. This indication may be presented to the terminal devices of the first type as a reserved subframe allocation within a system information block transmitted using frequency resources not necessarily limited to the second frequency band of the subordinate carrier. In this way, it is possible to exclude non-MTC devices from a resource reserved for the subordinate carrier.

The base station may be operable to transmit, using radio resources within the second frequency band, subordinate carrier information indicating that a subordinate carrier is available within the host carrier. A terminal device of the second type may be responsive to subordinate carrier information indicating that a subordinate carrier is not available within the host carrier to terminate a camp-on procedure for camping on to the network.

The subordinate carrier information may be provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the system information of the host carrier. The first acquisition information may be a master information block transmitted on a physical broadcast channel within radio resources of the host carrier. In this way it is possible to signal via the first acquisition information, to terminal devices of the second type, the presence of an MTC subordinate carrier existing within the reserved resource and using only a restricted bandwidth. If the subordinate carrier information is not present then the camp-on process by a terminal device may be terminated early, thereby reducing time and power wastage at the terminal device.

The first type of terminal device may be capable of receiving the full bandwidth of the first frequency band, and the second type of terminal device may not be capable of receiving the full bandwidth of the first frequency band but be capable of receiving the full bandwidth of the second frequency band. The bandwidth of the subordinate carrier may be predetermined and be known in advance to terminal devices of the second type. Alternatively, the base station may be operable to transmit, using radio resources within the second frequency band, an indication of the bandwidth of the subordinate carrier. In this case the bandwidth need not necessarily be predetermined. The indication of the bandwidth of the

subordinate carrier may be provided within first acquisition information transmitted on radio resources within the second frequency band, the acquisition information being provided to permit a terminal device of the first type to receive the host carrier downlink and camp on to the host carrier. Alternatively, the base station may be operable to transmit, using radio resources of the subordinate carrier, an indication of the bandwidth of the subordinate carrier.

The base station may be operable to transmit, using radio resources of the subordinate carrier, second acquisition information required for a terminal device of the second type to receive the subordinate carrier downlink and camp on to the subordinate carrier. The second acquisition information may be transmitted on predetermined radio resources which are known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the bandwidth of the subordinate carrier. In this way, it is possible to signal system information defining the characteristics of the MTC subordinate carrier using only resources within the MTC subordinate carrier.

The radio resource segments may be sub-frames of radio frames in the time direction, each radio frame comprising a plurality of sub-frames. The second acquisition information may be transmitted in at least some of the sub-frames allocated to the subordinate carrier. A terminal device of the second type may be operable to determine whether a sub-frame contains second acquisition information from a current radio frame number and a first sub-frame allocation set for allocating the second acquisition information to sub-frames within the subordinate carrier, said first sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames contain the second acquisition information.

The current radio frame number may be determined from first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the host carrier downlink and camp on to the network. The first sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. The second acquisition information may comprise an indication of the current radio frame number. Accordingly, once the second acquisition information is available to a mobile terminal, it may from that point on obtain the current radio frame number from the second acquisition information rather than having to refer back to the first acquisition information.

A terminal device of the second type may be operable to determine whether a sub-frame is allocated to the subordinate carrier from a current radio frame number and a second sub-frame allocation set for the subordinate carrier, said second sub-frame allocation set

identifying which sub-frames within a repeating group of one or more radio frames are allocated to the subordinate carrier. The current radio frame number may be determined from the second acquisition information. Alternatively, the current radio frame number may be determined from the first acquisition information and updated by counting radio frames.

The second sub-frame allocation set may be predetermined and known in advance to terminal devices of the second type. Alternatively, the second sub-frame allocation set may be specified in the second acquisition information. It will be appreciated that the second sub-frame allocation set may be different to the first sub-frame allocation set, but will include all of the sub-frames of the first sub-frame allocation set (and probably additional sub-frames as well).

The first type of terminal device may be an LTE device and the second type of device may be a low data rate device. The first type of terminal device may be an LTE device and the second type of device may be a low data rate device for providing machine-to-machine (M2M) communication.

It will be appreciated that different radio resource segments of the same or a different frequency band may be used to support a further subordinate carrier.

At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier may be allocated to another subordinate carrier. In other words, a different frequency band of the same resource segments (in time) may support another carrier.

At least a portion of the radio resources outside of the second frequency band of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier may be used for communicating with terminal devices of the first type. In other words, a different frequency band of the same resource segments (in time) may support the host carrier.

Viewed from another aspect, there is provided a base station for communicating with terminal devices. The base station is operable to communicate with terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The base station is operable to communicate with terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

Viewed from another aspect, there is provided a terminal device for communicating with a base station which supports a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band. The terminal device is operable to communicate with the base station using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

Viewed from another aspect, there is provided a method of communicating between a base station and terminal devices of a first type and a second type. The method comprises communicating between the base station and terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and communicating between the base station and terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

Viewed from another aspect, there is provided a method of communicating with a base station from a terminal device, comprising communicating with the base station using a subordinate carrier of a host carrier comprising radio resource segments distributed in time, each radio resource segment of the host carrier providing radio resources across a first frequency band, the subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

It will be appreciated that features of the above-described aspects and embodiments of the invention may be combined with features of other aspects and embodiments of the invention as appropriate and in combinations other than those explicitly set out. For example, optional features of the first aspect of the invention may equally optionally be incorporated in embodiments according to other aspects of the invention, for example where the different aspects have corresponding features.

Brief Description of the Drawings

Example embodiments of the present invention will now be described with reference to the accompanying drawings in which like parts have the same designated references and in which:

Figure 1 is a schematic block diagram of a radio network and a plurality of user equipments forming a wireless communication system which operates in accordance with the 3GPP Long Term Evolution (LTE) standard;

Figure 2 schematically represents elements of a mobile telecommunications system for implementing embodiments of the invention;

Figure 3 schematically represents a time and frequency resource allocation between a host carrier and a subordinate carrier;

Figure 4 schematically illustrates a radio frame and resource grid structure of time and frequency resources;

Figures 5A to 5D schematically illustrate example allocations of resources to the subordinate carrier;

Figure 6 is a schematic flow diagram of a first part of a camp-on procedure for connecting to the subordinate carrier;

Figure 7 is a schematic flow diagram of a second part of the camp-on procedure for connecting to the subordinate carrier; and

Figure 8 schematically illustrates a signalling configuration according to an embodiment of the invention.

Detailed Description of the Example Embodiments

Network Structure

Embodiments of the present invention are described herein with particular reference to an example implementation in a wireless communication system having carriers based around the 3GPP Long Term Evolution (LTE) standard.

Figure 1 schematically shows an example architecture of an LTE system. The LTE system is provided by a telecommunications network operator to allow parties to communicate. As shown in Figure 1, mobile communications devices designated as user equipment (UE) 105 are arranged to communicate data to and from base stations (transceiver stations) 101 which are frequently referred to in LTE as E-UTRAN NodeBs (e-nodeB). Each of the base stations 101 comprises a transceiver unit 103 enabling communication of data to and from a plurality of mobile communication devices via a radio interface. The e-nodeBs 101 are connected to a serving gateway S-GW 104 and to a mobility management entity (MME) 107. The S-GW 104 is arranged to perform routing and management of mobile communications services to the communications devices 105 in the mobile radio network. In order to maintain mobility management and connectivity, the mobility management entity

(MME) 107 manages evolved packet system (EPS) connections with the communications devices 105 using subscriber information stored in a home subscriber server (HSS) 108. Other core network components include a packet data network gateway (P-GW) 106 which connects to an internet network 109 and finally to an external server (not shown). In the context of MTC communications a UE supporting MTC communications may, for example, be conveniently referred to as an MTC terminal or MTC UE, and a server with which the MTC terminal(s) communicate data may, for example, be conveniently referred to as an MTC server. More generally, devices in the system capable of supporting MTC communications may be referred to as MTC entities. The various elements of Figure 1 and their respective modes of operation are well-known and defined in the relevant standards administered by the 3GPP (RTM) body and also described in many books on the subject, for example, Holma H. and Toskala A [1]. These conventional aspects of LTE networks are not described further in the interest of brevity.

Two classes of device are considered herein. A first class of device is configured to communicate via a host carrier, and a second class of device is configured to communicate via a subordinate carrier. In some of the particular examples considered here, the first class of device and the host carrier are compliant with particular standards, for example, LTE Rel8/9/10 standards, and the second class of device and the subordinate carrier are compliant with modified versions of these particular standards, for example, based on versions of the standards modified to support lower-capability devices. Accordingly, and purely for the sake of reference and to aid explanation, the first class of device and the host carrier may be referred to here in some examples as legacy devices and legacy carrier, while the second class of device and the subordinate carrier may be referred to in some examples as MTC devices and MTC carrier (or in alternative DMN (Dedicated Messaging Network) devices and DMN carrier). However, it will be appreciated that these terms are simply used as labels for ease of explanation of particular implementations of embodiments of the invention for distinguishing the two classes of device and carrier. Thus, the term "legacy" should not be considered as indicating any form of obsolescence, and indeed the devices and carrier(s) referred to here as legacy devices and carrier(s) may equally correspond with devices and carrier(s) that comply with future releases of the LTE standards, for examples Rel11 and beyond. Equally, and as already noted above, DMN should not be taken to refer to a network which exclusively supports only basic messaging services. Furthermore, the second class of device and subordinate carrier that are described here as not being fully compliant with the operating

standards of the first class of device and first carrier (for example because of reduced capability) may nonetheless be compliant with their own standards. Furthermore, the functionality described herein as regards both the first and second classes of device and carriers might comply with different aspects of a future standard, for example a future release of the LTE standards.

Referring now to Figure 2, a base station 101' is shown communicatively connected to an LTE device 105a via a transceiver unit 103' and a first (host) carrier 110a, and communicatively connected to an MTC device 105b via the transceiver unit 103' and a second (subordinate) carrier 110b. The base station 101' is responsible for a coverage area in which both the LTE device 105a and the MTC device 105b are located. The single base station 101' is able to communicate on both the first carrier 110a and the second carrier 110b. The first carrier 110a is a host carrier having a broad bandwidth, while the second carrier 110b is a subordinate carrier having a narrower bandwidth located within the frequency band of the host carrier. As will be explained in more detail below, the time and frequency resources of the first (host) carrier and the second (subordinate) carrier are logically separate for the purposes of data transmission and most control signalling, but some time and frequency resources are accessible to and used by devices connected to both the first and second carriers.

Host Carrier and Subordinate Carrier Overview

Referring to Figure 3, the time and frequency resources constituting the host carrier and the subordinate carrier are schematically illustrated. The horizontal axis of Figure 3 is time, with a time period from t_1 to t_2 being shown in Figure 3. The vertical axis of Figure 3 is frequency, the frequency increasing from a frequency f_1 to a frequency f_4. The host carrier has a frequency band F_1, extending from the frequency f_1 to the frequency f_4. The subordinate carrier has a frequency band F_2, extending from a frequency f_2 to a frequency f_3. The subordinate carrier is intended primarily for use by terminal devices which do not have the capability to receive or transmit between the frequencies f_1 and f_2, and between the frequencies f_3 and f_4. The subordinate carrier does not occupy all of the time and frequency resources within the frequency band F_2. Instead, certain time periods 305 of the frequency band F_2 are allocated to the subordinate carrier (and potentially to other subordinate carriers), with the unallocated time periods within the frequency band F_2 forming part of the host carrier resources. The shaded portions 310 of Figure 3 indicates those time and frequency resources allocated to the subordinate carrier. When a time period 305 is allocated to the subordinate

carrier, the time and frequency resources 315 falling outside of the frequency band F_2 (but within the frequency band F_1) are not allocated to the subordinate carrier. In some implementations these time and frequency resources may be available to the host carrier (or to another subordinate carrier having a different (and non-overlapping) frequency band). In other implementations these time and frequency resources may be "lost" and unusable by either the first type of device or the second type of device. It is envisaged that the central frequency and bandwidth of the frequency bands F_1 and F_2 would be fixed for a given host carrier/subordinate carrier, although implementations in which they are not fixed may be possible. The particular time periods allocated to the subordinate carrier may be fixed, or may be dynamically variable, for example to increase or decrease the amount of radio resources allocated to the subordinate carrier to adapt to traffic conditions of the subordinate carrier (and/or possibly of the host carrier).

Radio Frame and Resource Grid Structure

Referring now to Figure 4, a radio frame and resource grid structure for an LTE type network are schematically illustrated. At the top of Figure 4, a radio frame 410 is shown. This occupies the full width of the frequency band of the host carrier, and has a duration of 10ms. The radio frame 410 is one of a sequence of radio frames which are used to communicate data between a base station and a terminal device. The radio frame 410 comprises 10 sub-frames 420, which again occupy the fully width of the frequency band of the host carrier. Each of these sub-frames 420 has a duration of 1ms. Each of the sub-frames 420 comprises two slots 430, each slot occupying the full width of the frequency band of the host carrier and having a duration of 0.5ms. Each slot comprises a plurality of resource blocks 440 in the frequency direction, and only a single resource block 440 in the time direction. In other words each resource block 440 has a duration of 0.5ms (the same as the duration of the slot 430), but occupies only a portion of the bandwidth of the host carrier. Each resource block 440 comprises a two-dimensional array of resource elements 450 distributed in both the time direction and the frequency direction. Each resource element 450 has a length (duration) of one modulation symbol, and a frequency range of one subcarrier (e.g. 15kHz). In the present case the resource block 440 has a dimension of 12 resource elements 450 in the frequency dimension and 7 resource elements 450 in the time dimension, resulting in an overall bandwidth of 12 subcarriers and a duration of 7 symbols.

In operation, data transmissions between a base station and a terminal device may be scheduled to use particular resource blocks. This scheduling is usually carried out by the base

station or a related network entity. Certain resource blocks may be permanently allocated to carry predetermined signalling information.

3GPP LTE Releases 8, 9 and 10 (Rel8/9/10) define 6 downlink transmission bandwidth configurations from 1.4 MHz to 20 MHz representing the use of 6, 15, 25, 50, 75 or 100 resource blocks. As noted above, all Rel8/9/10 terminal devices are required to support the maximum single carrier bandwidth of 20 MHz for compliance with the Rel8/9/10 standards. Nevertheless, for all bandwidth configurations Rel8/9/10 has specified that basic physical layer synchronisation signals (Primary Synchronisation Signals - PSS, and Secondary Synchronisation Signals - SSS), and the most fundamental system information (Master Information Block - MIB) is transmitted using only the central 6 resource blocks which are receivable with a 1.4 MHz transceiver. However, in order to receive the remainder of the carrier system information the terminal device is required to be able to receive the full bandwidth of the carrier.

However, and as also noted above, for some applications, for example in situations relating to machine type communications (MTC) and/or dedicated messaging networks (DMN), there is a drive to build low cost and hence low capability devices. Ideally, device simplification should permit a reduction in required bandwidth of operation as well as reduction of features and throughput. Terminal devices with a lower bandwidth capability than that specified for Rel8/9/10 may mean that such devices are unable to operate properly on Rel8/9/10 compliant networks which specify higher bandwidth capabilities. For example, terminal devices with a lower bandwidth capability may not even be able to receive any more system information than that contained in the MIB of a Rel8/9/10 compliant network.

Low capability devices will ideally be able to find and camp-on the carrier associated with their target dedicated messaging network(s) even in the presence of Rel8/9/10 higher bandwidth carriers. Furthermore, there is a desire that DMN carriers are not swamped by Rel8/9/10 capable devices camping-on the DMN, even though the Rel8/9/10 capable devices are in the coverage area of a higher bandwidth Rel8/9/10 carrier which they could otherwise use.

Subordinate Carrier Definition

As described in relation to Figure 3, the subordinate carrier resources (for use by MTC devices) may be defined by a certain bandwidth in the frequency domain (frequency band F_2 in Figure 3 for example) and a certain pattern of time periods in the time domain. The certain pattern of time periods may be a sequence of subframes as described above with reference to

Figure 4. The sequence of subframes may be a sequence of MBSFN subframes as defined by signalling within SystemInformationBlockType2 (SIB2) of the legacy LTE host carrier. However, it will be recognised that the subordinate carrier may be delineated by other means, for example by scheduling by a base station. The pattern of subframes may be a subset (or all) of those subframes reserved by the information element mbsfn-SubframeConfigList in the host carrier SIB2.

Conveniently, non-MTC UEs will read SIB2 of the legacy LTE host carrier and determine that a configured pattern of subframes are reserved for other purposes (such as MBMS, relay or as in the present case MTC subordinate carrier operation). The non-MTC UEs will therefore ignore the subframes allocated to the subordinate carrier. The configured pattern of reserved subframes is defined in a flexible manner by the information element mbsfn-SubframeConfigList.

In particular, mbsfn-SubframeConfigList comprises a set of 1 or more subframe allocations each of which is defined by the following fragment of ASN.1 from TS 36.331:

```
MBSFN-SubframeConfig ::=          SEQUENCE {
    radioframeAllocationPeriod          ENUMERATED {n1, n2, n4, n8, n16, n32},
    radioframeAllocationOffset          INTEGER (0..7),
    subframeAllocation                      CHOICE {
        oneFrame                                BIT STRING (SIZE(6)),
        fourFrames                              BIT STRING (SIZE(24))
    }
}
```

For a given allocation, the "radioframeAllocationPeriod" indicates the periodicity, in radio frames, with which MBSFN subframes are included in the allocation. "n1" indicates that MBSFN subframes are present in every radio frame, while "n2" indicates that MBSFN subframes are present in every other radio frame. A radioframeAllocationPeriod of "n32" indicates that one in every 32 radio frames includes one or more MBSFN subframes. Radio-frames that contain MBSFN subframes occur when equation SystemFrameNumber mod radioFrameAllocationPeriod = radioFrameAllocationOffset is satisfied. In other words, the radioframeAllocationOffset parameter sets an offset for a start position of the repeating pattern of radio frames. The subframeAllocation parameter defines the subframes that are allocated for MBSFN within the radio frame allocation period defined by the radioFrameAllocationPeriod and the radioFrameAllocationOffset parameters. The subframe

allocation can either be specified for a single radio frame within the radio frame allocation period (oneFrame) or for four consecutive radio frames within the radio frame allocation period (fourFrames). The subFrameAllocation parameter is a 6 bit (oneFrame) or 24 bit (fourFrame) mask, indicating whether each of 6 (oneFrame) or 24 (fourFrame) predetermined subframes are to be reserved. The LTE specification places restrictions on which subframes may be reserved for other purposes by this method, in order that there is no conflict with the requirement to receive system information and paging. In an FDD LTE system one or more of subframes 1, 2, 3, 6, 7 and 8 may be reserved for other purposes. In a TDD LTE system the subframes that may be reserved are 3, 4, 7, 8 and 9. The system frame number can be derived from the MIB of the host carrier.

Figures 5A to 5D are example subframe patterns. Each of Figures 5A to 5D shows a portion of a repeating pattern which could be specified by mbsfn-SubframeConfigList or by a similar pattern specifying function. Four radio frames having ten subframes each are shown in Figures 5A to 5D. The subframes are labelled from 0 (zero) to 9 (nine). The shaded subframes are those allocated to the subordinate carrier, with the unshaded subframes being retained for use on the host carrier. Figure 5A schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 111111 (thereby selecting each of subframes 1, 2, 3, 6, 7 and 8). It will be appreciated that this subframe allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

Figure 5B schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to n2 (MBSFN subframes present in every other radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 11111x (thereby selecting each of subframes 3, 4, 7, 8 and 9). It should be noted that the last bit of the mask is not used for TDD. The difference between Figures 5A and 5B results from the different subframes mapped to the bit mask in the FDD and TDD schemes.

Figure 5C schematically illustrates an FDD pattern in which radioFrameAllocationPeriod is set to n1 (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 101010 (thereby selecting each of subframes 1, 3 and 7). It will be appreciated that this subframe

allocation is a "oneFrame" allocation. A longer bit string would be used for the subframeAllocation if subframes were to be provided over four consecutive radio frames.

Figure 5D schematically illustrates a TDD pattern based on the same parameters as Figure 5A. Specifically, radioFrameAllocationPeriod is set to n1 (MBSFN subframes present in every radio frame), the radioFrameAllocationOffset is 0 (zero) and the subframeAllocation mask is 10101x (thereby selecting each of subframes 3, 7 and 9). It should be noted that the last bit of the mask is not used for TDD. Again, the difference between Figures 5C and 5D results from the different subframes mapped to the bit mask in the FDD and TDD schemes. All of the patterns shown in Figures 5A to 5D will repeat until the mbsfn-SubframeConfigList is altered. The set of allocation patterns specified in mbsfn-SubframeConfigList , which is signalled in SIB2, defines the "reserved set". A sub-set of the allocation patterns could be used to define the subordinate carrier. Also, two mutually exclusive sub-sets could be used to define two separate subordinate carriers delimited in the time domain.

It will be appreciated that this mechanism provides a great deal of flexibility in how much carrier resource is to be allocated to the subordinate carrier, and also how that resource is distributed with respect to time. The minimum (non-zero) amount of resources (in the time domain) which can be allocated is 1 in 320 subframes (when radioframeAllocationPeriod is set to n32 and only one bit is set in the subframeAllocation bit mask). The maximum amount of resources (in the time domain) which can be allocated is 192 in 320 subframes (when radioframeAllocationPeriod is set to n1 and all six bits are set in the subframeAllocation bit mask). In some implementations the allocation might be static to provide a fixed resource subordinate carrier. The fixed resources could in this case be known to a terminal device in advance. In other implementations the allocation might be dynamic, resulting in a subordinate carrier having a resource allocation which can be increased or decreased to for example meet traffic loading conditions on the subordinate carrier and/or on the host carrier. These increases or decreases could be based on requests from terminal devices for additional resource, or based on decisions made at the base station or a related entity. An increase in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined above, or by adding a new subframe allocation according to the principles set out above. A decrease in the amount of resources allocated to the subordinate carrier could be achieved either by altering the parameters of an existing subframe allocation as defined above, or by removing an existing subframe allocation.

In other words, it is possible to use multiple subframe allocations to achieve allocation patterns which would not be possible with a single subframe allocation, and to provide a simple way of increasing (or decreasing, if one of multiple subframe allocations is removed) the amount of resources allocated to the subordinate carrier. In one implementation, a first subframe allocation with a relatively low allocation period and subframe allocation could be used to maintain a low resource subordinate carrier which can be camped onto by a low capability terminal device, and then further subframe allocations could be added to service the communication needs of the low capability terminal device when it has successfully camped on. In this way, the resources available to the host carrier are retained at a high level to serve LTE traffic when the subordinate carrier is not in use.

Signalling the presence of the Subordinate Carrier

Certain resource blocks may be used to carry control signalling including synchronisation signals and system information. As explained above, a problem can therefore arise if essential control signalling from the base station is transmitted outside of the frequency range which can be received by a low-capability device. Fortunately, as described above, the synchronisation signals and the Master Information Block (MIB) of the system information are present within a frequency range which is likely to be receivable by a low-capability device. However, further system information, carried in System Information Blocks (SIBs), and the associated control signalling may be transmitted at a frequency which cannot be received by the low-capability device. This would cause problems, potentially preventing the low-capability device from being able to camp on to the network. It will be appreciated that not all host carriers will necessary support a subordinate carrier. If a low-capability device attempts to camp-on to a network which does not support a subordinate carrier then the camp-on procedure will ultimately fail. This is a waste of time and power for the low-capability device.

It would therefore be desirable to signal to an MTC UE which has restricted reception bandwidth the presence of an MTC subordinate carrier within a larger bandwidth LTE carrier accessible to legacy UEs (LTE Rel 8/9/10 UEs). It was discussed above that for all LTE bandwidths (Rel8/9/10) the basic physical layer synchronisation signals and the most important system information (Master Information Block) is transmitted using only the central 6 resource blocks (72 subcarriers). The Master Information Block (MIB) is transmitted in the Physical Broadcast Channel (PBCH) which is allocated to the central 72 subcarriers and to just the first 4 OFDMA symbols of the second slot of every 10ms radio frame. Thus,

assuming that the low bandwidth MT UE is able to receive at least 6 resource blocks in the frequency domain, then the PBCH (for example the MIB) may be used to signal the presence of an MTC subordinate carrier.

In Figure 6, a schematic flow diagram of a first part of a camp-on procedure is shown. At a step A1, an MTC device seeking to camp-on to a subordinate carrier, for example following power-up, seeks to identify and decode PSS (Primary Synchronisation Signals) and SSS (Secondary Synchronisation Signals) signalling being broadcast in its location. Once the MTC device synchronises to a carrier using the PSS and SSS, the MTC device determines the frame timing and proceeds to decode the PBCH to determine the MIB for the carrier. At a step A2, the MTC device determines whether or not a subordinate carrier indicator flag is present in the MIB. The MTC subordinate carrier indicator flag may be signalled in one (or more) of the MIB bits that are spare in LTE Release 8 / 9 / 10 (10 bits are currently spare). If the MTC device determines that the MIB contains a subordinate carrier indicator flag then the camp-on process continues at a step A3. If on the other hand the MTC subordinate carrier indicator flag was found not to be present, then the camp-on procedure to this carrier would be terminated. This would allow the device to decide upon proceeding with camp-on (or not) simply based upon decoding of the legacy LTE MIB, and to discontinue with camp-on immediately after the decoding of the legacy LTE MIB should the subordinate carrier indicator flag not be present. As an alternative to using the MIB to signal the presence of a subordinate carrier, a subordinate carrier indicator signal could be provided at a known time / frequency somewhere other than in the MIB. The particular time / frequency may be defined referentially with respect to the MIB (for example). The subordinate carrier indicator signal may be relative to the host carrier PBCH and/or the System Frame Number conveyed in the host carrier PBCH / MIB. In this case the MTC device would, following synchronisation (at the step A1), search for the subordinate carrier indicator signal at the expected time / frequency (at the step A2). If it is found, then the MTC device knows that one (or more) subordinate carriers are present and continues its discovery of the MTC subordinate carrier and the subsequent camp-on process.

In either implementation, it will be appreciated that the presence of the subordinate carrier indicator is derivable by the MTC device without being required to decode any system information block (SIB) of the host carrier since the MTC device may be unable to receive the host carrier SIBs which are signalled across the full host carrier frequency band F1.

If the MTC device does not find a subordinate carrier associated with the host carrier, then it may search for and seek to camp-on to another carrier by returning to the step A1 to seek to synchronise with and decode PBCH for a different carrier.

Signalling the bandwidth of the subordinate carrier(s)

Having detected the presence of an MTC subordinate carrier the UE needs to determine the bandwidth of the subordinate carrier in order to be able to read the further system information which will contain the other characteristics of the subordinate carrier. There are a number of alternative ways in which the subordinate carrier bandwidth may be signalled to the MTC UE:

(1) The simplest method is to fix the bandwidth of the subordinate carrier in the 3GPP specifications. Having detected the presence of a subordinate carrier in the manner described above, the MTC UE would know by definition the MTC subordinate carrier bandwidth (e.g. 1.4MHz, 3MHz or 5 MHZ).

(2) The downlink bandwidth of the MTC subordinate carrier may be signalled in the legacy LTE MIB. For example if the subordinate carrier indicator flag were signalled in the PBCH by using a 2 bit field, 4 states could be signalled (absence of a subordinate carrier and three different subordinate carrier bandwidths, e.g. 1.4MHz, 3MHz and 5 MHZ).

(3) The downlink bandwidth (and possibly other characteristics) of the MTC subordinate carrier could be signalled in a Subordinate Carrier Master Information Block (scMIB). The scMIB would be signalled in fixed time / frequency resources, known in advance to the mobile terminal and preferably defined in the 3GPP specifications. The possibilities for signalling the scMIB are described in the following section.

Signalling the Subordinate Carrier Master Information Block (scMIB)

In the above section three methods of determining the downlink bandwidth of an MTC subordinate carrier by an MTC UE have been described. The first two of these methods involve a priori knowledge of when decoding of the subordinate carrier begins. The last of the described methods involves signalling the downlink bandwidth in a Master Information Block of the subordinate carrier itself.

A Master Information Block may be regarded as collection of parameters giving values to configurable characteristics of the carrier and other information to achieve/maintain radio frame synchronisation. A Master Information Block is required to be supplied in fixed time/frequency resources and must be received and decoded before a more flexible scheme of

downlink message exchange may be employed. According to the above description, at the point at which the UE tries to decode the scMIB, the UE will know:

- That an MTC subordinate carrier is present (from the indicator flag / signal).
- The subordinate carrier centre frequency (it may generally be assumed that this will be the same as the centre frequency of the host legacy LTE carrier).

In addition the UE may know the MTC subordinate carrier bandwidth, if this has been fixed in the specifications, conveyed in the host carrier MIB or conveyed by some other a priori means. In order to receive and decode the scMIB the UE must be able to determine in which resource elements it is carried. The number of resource elements used for the scMIB could be related to the subordinate carrier bandwidth or it could be fixed (as is the case for the legacy LTE MIB). If the number of resource elements were defined to be dependent upon the subordinate carrier bandwidth, this would require the value of the subordinate carrier bandwidth to be known a priori. There are a limited number of spare bits available in the legacy host carrier LTE MIB, and so it may be considered that there are not sufficient available to use 1 or more of these to carry subordinate carrier bandwidth information. In this case, the UE will not have a priori knowledge of the subordinate carrier bandwidth so the UE will be unable to derive the scMIB resource elements from the bandwidth.. Accordingly, for the purposes of the following description it is assumed that the scMIB is always signalled in a fixed set of resource elements defined within the 3GPP specifications. Nonetheless, it should be understood that the present invention is not limited to this, and that in certain implementations the set of resource elements used to convey the scMIB may not be fixed.

The fixed set of resource elements is contained within a subset (or all) of those subframes reserved by one (or more) of the subframe allocations configured in the information element mbsfn-SubframeConfigList broadcast in the host carrier SIB2. The fixed subframe allocation to convey the scMIB should:

- Be frequent enough to occasion an acceptable latency for acquisition of the scMIB by MTC UEs.
- Not be too frequent that excessive resources are consumed from the host carrier and subordinate carrier.

It should be noted that it is common for MTC devices to exhibit low mobility and be able to tolerate comparatively high latencies in message transmission. However, this may not be the case with all possible MTC traffic and it is therefore preferable that the frequency of

MIB transmission be fixed within the 3GPP specification and thus cannot be configured dependent upon the expected MTC traffic characteristics.

Various fixed characteristics of the scMIB transmission scheme, including the following, should preferably be defined within the 3GPP specifications:

- The number, periodicity and relationship to host carrier System Frame Number of the subframes used for scMIB.
- The level of repetition encoding employed.
- Within the subframes used, the number and location of resource elements used to convey the scMIB (that is, exactly which slot(s), subcarriers and symbols are to be used).

The number of resource elements used for the scMIB will be a function of the number of bits of information that must be conveyed by this method, which will be influenced by the further details of the subordinate carrier design, but the number will also be constrained by the overhead that this imposes. The System Frame Number, necessary for the UE to maintain radio frame synchronisation, upon which many LTE higher layer processes are dependent, may be read from the host carrier MIB. However, for efficiency reasons it is likely that once the UE synchronises to the subordinate carrier, it would be undesirable for the UE to have to keep re-reading the host carrier MIB to maintain this information. Thus, System Frame Number is likely to be carried by the scMIB, although the UE might depend upon the host carrier MIB for this information.

Any combination of parameters conforming to and fully resolving the definition of MBSFN-SubframeConfig may be chosen to define which subframes convey the scMIB. However, use of a single subframe allocation pattern will provide a solution involving least complexity. For example a single pattern comprising a single subframe allocation once per radio frame allocation period of 32 frames and with an offset value of zero may be considered adequate to convey the scMIB dependent upon other details of the subordinate carrier design. Alternatively, if more MIB bits are required then a shorter allocation period of, for example, 16 or 8 radio frames could be used and/or more subframes per allocation period. Note that while the subframes used to convey the scMIB may be defined by such a subframe allocation pattern or patterns, not all slots or resource elements in the subframes defined by the pattern(s) are necessarily used to convey the scMIB. Use of a shorter allocation period but sparse use of the resource elements for the scMIB may offer the best compromise in relation to scMIB acquisition time and resource overhead.

The subframe allocation pattern or patterns chosen to define the subframes used for the scMIB will be included in the mbsfn-SubframeConfigList of SIB2 of the host carrier in order to reserve these subframes for special use within the context of the host carrier. However, low bandwidth MTC UEs searching for a suitable subordinate carrier will not be required to read SIB2 of the host carrier to gain this information, since the subframe allocation pattern(s) for the scMIB will be fixed and defined in the 3GPP specifications.

Camp-on procedure

Referring to Figure 7, the camp-on procedure following the initial steps shown in Figure 6 is schematically illustrated. At a step B1 the location of the scMIB is determined. As discussed above, the location of the scMIB is likely to be fixed in the 3GPP standards, and so the MTC UE will be able to frame synchronise with the scMIB broadcast by comparing the location of the scMIB (radio frame and sub-frame known from the 3GPP specifications) with the current System Frame Number (which the MTC UE can derive from the host carrier MIB). At a step B2 the scMIB is received and decoded, whereby the system information specified therein can be acquired and used. At a step B3 the bandwidth and central frequency of the subordinate carrier is determined. The bandwidth of the subordinate carrier may be determined by one of the methods described above in the section "Signalling the Bandwidth of the Subordinate Carrier(s)". The central frequency may be assumed to be the same as that of the host carrier, but in some implementations may have a different central frequency which would need to be signalled to the MTC UE. The central frequency and bandwidth together identify the frequency band forming the subordinate carrier. Note that if the bandwidth is not determined from the scMIB then the step B3 can be performed before (or in parallel with) the steps B1 and B2.

At a step B4, the allocation of subordinate carrier subframes is determined. An indication of those subframes allocated to the subordinate carrier may be specified in the scMIB. As described above, sub-frames are allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set which determines which sub frames within a repeating group of radio frames are allocated to the subordinate carrier. At a step B5, further system information (System Information Blocks) relating to the subordinate carrier is obtained from subframes allocated to the subordinate carrier. This further system information can be used to complete the camp on procedure of the MTC UE to the subordinate carrier at a step B6. The further system information may be at a fixed location within the radio resources

of the subordinate carrier, or at a location within the radio resources of the subordinate carrier which has been scheduled by the base station, or a combination of both.

In Figure 8, example signalling on the host carrier and the subordinate carrier is schematically illustrated. In Figure 8, eight radio frames 800 are shown, each having a central frequency portion 820 usable by both the host carrier and the subordinate carrier, and outer frequency portions 810 usable only by the host carrier. In each radio frame, a MIB 830 is provided in the central frequency portion 820. The MIB 830 is readable by devices using both the host carrier and the subordinate carrier. Devices seeking to use a subordinate carrier may be able to determine from the MIB 830 whether a subordinate carrier exists based on a flag present in the MIB 830. In an outer frequency portion 810, system information 840 is provided for use by devices served by the host carrier. The system information 840 is shown to be outside of the central frequency portion 820 and is thus not available to the kind of low-capability devices intending to use the subordinate carrier. It will be appreciated that some system information may happen to be transmitted within the central frequency portion 820, but this cannot be guaranteed. The system information 840 is provided in the form of System Information Blocks (SIBs). Unlike the Master Information Block which is broadcast on the Physical Broadcast Channel (PBCH), the SIBs are mapped onto the Physical Downlink Shared Channel (PDSCH). Generally, the Master Information Block 830 provides sufficient information to gain access to the first of the System Information Blocks (SIB1), which in turn provides sufficient information to gain access to SIB2 et seq. SIB2 includes parameters relating to the reservation of MBSFN subframes (as described above). Legacy LTE devices using the host carrier will therefore be informed of the subframes reserved for use by the subordinate carrier (or for other purposes, for example MBMS or relay backhaul) when they decode SIB2. They will therefore know that these subframes cannot be used and to ignore them. Within the central portion 810 of some or all of the radio frames (every other radio frame in this example) is a portion 850 allocated to the subordinate carrier. For the sake of clarity the portion 850 shown in Figure 8 is contiguous, but it will be appreciated from Figures 5A to 5D for example that this may not be the case. The portions 850 are used to transmit data and signalling to low capability devices using the subordinate carrier. Within the allocated portion 850 of the first radio frame is a subordinate carrier MIB (scMIB) 860 carrying various information required for a low capability device to acquire the remainder of the subordinate carrier system information.

Within the allocated portion 850 of the second radio frame is system information 870 relating to the subordinate carrier. This system information 870 provides information required for a terminal device to camp on to the subordinate carrier. It will be appreciated that the locations of the scMIB 860 and the system information 870 is purely exemplary. The important point is that the scMIB 860 and the system information 870 are conveyed in the allocated portions 850. As described in detail above, the location and periodicity of the scMIB would probably be fixed (predetermined). The system information 870, which could be conveyed in the form of System Information Blocks in a similar manner to with the host carrier, may be predetermined, or dynamically allocated (scheduled), depending on implementation.

In the host carrier, the MIB and any associated SIBs together provide the parameters necessary for system access using the host carrier. Similarly, in the subordinate carrier, the scMIB and any associated SIBs carried in subframes allocated to the subordinate carrier provide the parameters necessary for system access using the subordinate carrier. In both cases, the UE (legacy or MTC) requires the MIB to decode the shared channel (and thus access SIBs). The MIB contains downlink system bandwidth of the host carrier and the system frame number.

The above embodiment describe a method of conveying a subordinate carrier for low bandwidth devices within a portion of a larger host carrier using for example MBSFN subframe allocation pattern(s) to reserve subframes for the subordinate carrier. This permits a flexible and efficient definition of a subordinate carrier within a host carrier. An indication of the presence of the MTC subordinate carrier is provided using a flag in the host carrier MIB. This may require the 3GPP standard to be updated, but will not require any change to legacy LTE devices because the flag is set in current spare bits which can and will be ignored by a legacy device. Various methods of signalling subordinate carrier downlink bandwidth have been described, including fixing the MTC subordinate carrier bandwidth in 3GPP specifications, signalling the subordinate carrier downlink bandwidth via a field in host carrier MIB, or signalling using a bit field within the subordinate carrier MIB (scMIB). A method of defining the subframes used for the subordinate carrier Master Information Block by using fixed (defined in 3GPP specifications) subframe allocation pattern(s) in relation to the System Frame Number of the host carrier has also been described above. A subordinate carrier has been described (in one example) to be specified using a repeating pattern of sub-frames. A

mechanism to specify this already exists in LTE, originally for the purpose of specifying sub-frames for use in MBSFN.

It will be appreciated that various modifications can be made to the embodiments described above without departing from the scope of the present invention as defined in the appended claims. In particular although embodiments of the invention have been described with reference to an LTE mobile radio network, it will be appreciated that the present invention can be applied to other forms of network such as GSM, 3G / UMTS, CDMA2000, etc. The term MTC terminal as used herein can be replaced with user equipment (UE), mobile communications device, mobile terminal etc. Furthermore, although the term base station has been used interchangeably with e-nodeB it should be understood that there is no difference in functionality between these network entities.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

REFERENCES

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CLAIMS

1. A wireless communications system, comprising:

a base station,

one or more terminal devices of a first type; and

one or more terminal devices of a second type; wherein

the base station is operable

to communicate with the terminal devices of the first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and

to communicate with the terminal devices of the second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

2. A wireless communications system according to claim 1, wherein

the radio resource segments are sub-frames of radio frames, each radio frame comprising a plurality of sub-frames, and

sub-frames are allocated to the subordinate carrier using a subordinate carrier sub-frame allocation set, the subordinate carrier sub-frame allocation set determining which sub frames within a repeating group of one or more radio frames are allocated to the subordinate carrier.

3. A wireless communications system according to claim 2, wherein the subordinate carrier sub-frame allocation set is defined by one or more reserved sub-frame allocation patterns.

4. A wireless communications system according to claim 3, wherein the one or more reserved sub-frame allocation patterns comprise all or a sub-set of all reserved sub-frame allocation patterns defined for the host carrier.

5. A wireless communications system according to claim 3 or 4, wherein

acquisition information required for a terminal device of the second type to receive the subordinate carrier is allocated to sub-frames of the subordinate carrier using at least a portion of the subframes in one or more of the reserved sub-frame allocation patterns defining the subordinate carrier.

6. A wireless communications system according to one of claims 2 to 5, wherein said base station is operable to transmit an indication of the radio resources of all reserved sub-frames to terminal devices of the first type.

7. A wireless communications system according to claim 6, wherein the indication of the radio resources of the reserved sub-frames are presented to the terminal devices of the first type as a reserved subframe allocation within a system information block outside of the second frequency band of the subordinate carrier.

8. A wireless communications system according to any preceding claim, wherein the base station is operable

to transmit, using radio resources within the second frequency band, subordinate carrier information indicating that a subordinate carrier is available within the host carrier.

9. A wireless communications system according to claim 8, wherein a terminal device of the second type is responsive to subordinate carrier information indicating that a subordinate carrier is not available within the host carrier to terminate a camp-on procedure for camping on to the network.

10. A wireless communications system according to claim 8 or claim 9, wherein the subordinate carrier information is provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the system information of the host carrier.

11. A wireless communications system according to claim 10, wherein the first acquisition information is a master information block transmitted on a physical broadcast channel within radio resources of the host carrier.

12. A wireless communications system according to any preceding claim, wherein the first type of terminal devices are capable of receiving the full bandwidth of the first frequency band, and the second type of terminal devices are not capable of receiving the full bandwidth of the first frequency band but are capable of receiving the full bandwidth of the second frequency band.

13. A wireless communications system according to any preceding claim, wherein the bandwidth of the subordinate carrier is predetermined and is known in advance to terminal devices of the second type.

14. A wireless communications system according to any one of claims 1 to 12, wherein the base station is operable to transmit, using radio resources within the second frequency band, an indication of the bandwidth of the subordinate carrier.

15. A wireless communications system according to claim 14, wherein the indication of the bandwidth of the subordinate carrier is provided within first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being provided to permit a terminal device of the first type to receive the host carrier downlink and camp on to the host carrier.

16. A wireless communications system according to any one of claims 1 to 14, wherein the base station is operable to transmit, using radio resources of the subordinate carrier, an indication of the bandwidth of the subordinate carrier.

17. A wireless communications system according to any preceding claim, wherein the base station is operable to transmit, using radio resources of the subordinate carrier, second acquisition information required for a terminal device of the second type to receive the subordinate carrier downlink and camp on to the subordinate carrier.

18. A wireless communications system according to claim 17, wherein the second acquisition information is transmitted on predetermined radio resources which are known in advance to terminal devices of the second type.

19. A wireless communications system according to claim 17, wherein the second acquisition information comprises an indication of the bandwidth of the subordinate carrier.

20. A wireless communications system according to claim 17, wherein the radio resource segments are sub-frames of radio frames in the time direction, each radio frame comprising a plurality of sub-frames, and wherein the second acquisition information is transmitted in at least some of the sub-frames allocated to the subordinate carrier.

21. A wireless communications system according to claim 20, wherein a terminal device of the second type is operable to determine whether a sub-frame contains second acquisition information from a current radio frame number and a first sub-frame allocation set for allocating the second acquisition information to sub-frames within the subordinate carrier, said first sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames contain the second acquisition information.

22. A wireless communications system according to claim 21, wherein the current radio frame number is determined from first acquisition information transmitted on radio resources within the second frequency band, the first acquisition information being required for a terminal device of the first type to receive the host carrier downlink and camp on to the network.

23. A wireless communications system according to claim 21 or claim 22, wherein the first sub-frame allocation set is predetermined and known in advance to terminal devices of the second type.

24. A wireless communications system according to claim 17, wherein the second acquisition information comprises an indication of the current radio frame number.

25. A wireless communications system according to claim 20, wherein a terminal device of the second type is operable to determine whether a sub-frame is allocated to the subordinate carrier from a current radio frame number and a second sub-frame allocation set

for the subordinate carrier, said second sub-frame allocation set identifying which sub-frames within a repeating group of one or more radio frames are allocated to the subordinate carrier.

26. A wireless communications system according to claim 25, wherein the current radio frame number is determined from the second acquisition information.

27. A wireless communications system according to claim 25, wherein the current radio frame number is determined from the first acquisition information and updated by counting radio frames.

28. A wireless communications system according to claim 25, wherein the second sub-frame allocation set is predetermined and known in advance to terminal devices of the second type.

29. A wireless communications system according to claim 25, wherein the second sub-frame allocation set is specified in the second acquisition information.

30. A wireless communications system according to any preceding claim, wherein the first type of terminal device is an LTE device and the second type of device is a low data rate device.

31. A wireless communications system according to any preceding claim, wherein the first type of terminal device is an LTE device and the second type of device is a low data rate device for providing machine-to-machine (M2M) communication.

32. A wireless communications system according to any preceding claim, wherein at least a portion of the radio resources, comprising a third frequency band, of the subset of the radio resource segments of the host carrier allocated to the subordinate carrier and which are outside of the second frequency band are allocated to another subordinate carrier.

33. A wireless communications system according to any preceding claim, wherein at least a portion of the radio resources outside of the second frequency band of the subset of the radio

resource segments of the host carrier allocated to the subordinate carrier are used for communicating with terminal devices of the first type.

34. A base station for communicating with terminal devices, said base station being operable

to communicate with terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and

to communicate with terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

35. A method of communicating between a base station and terminal devices of a first type and a second type, comprising:

communicating between the base station and terminal devices of a first type using a host carrier comprising radio resource segments distributed in time, each radio resource segment providing radio resources across a first frequency band, and

communicating between the base station and terminal devices of a second type using a subordinate carrier comprising radio resources within a second frequency band of a subset of the radio resource segments of the host carrier, the second frequency band being narrower than and contained within the first frequency band.

36. A computer program, which when executed on a computer will cause the computer to perform a method according to claim 35.

37. A recording medium storing the computer program of claim 36.

38. A wireless communications method substantially as hereinbefore described with reference to the accompanying drawings.

39. A method of communicating substantially as hereinbefore described with reference to the accompanying drawings.

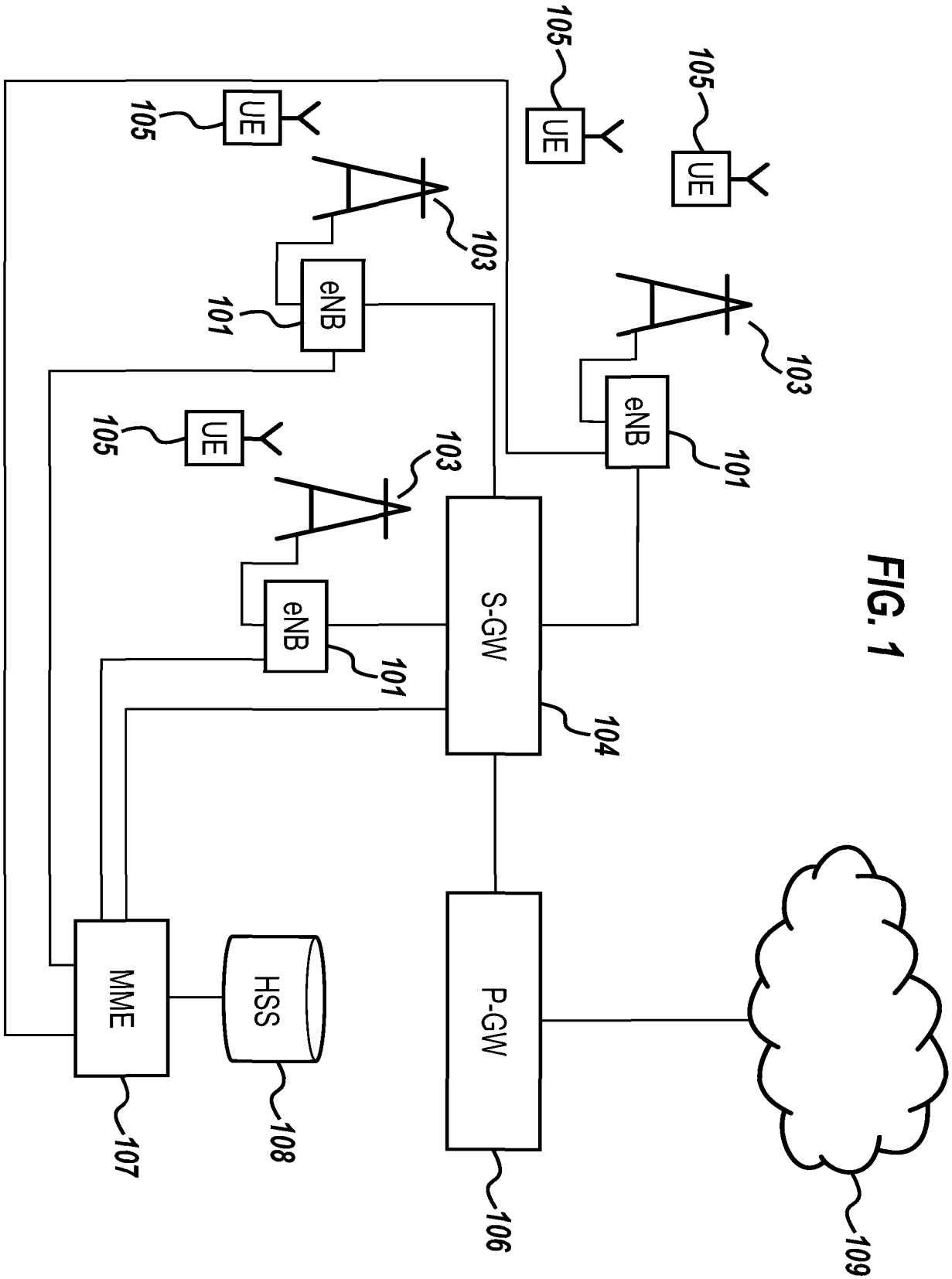
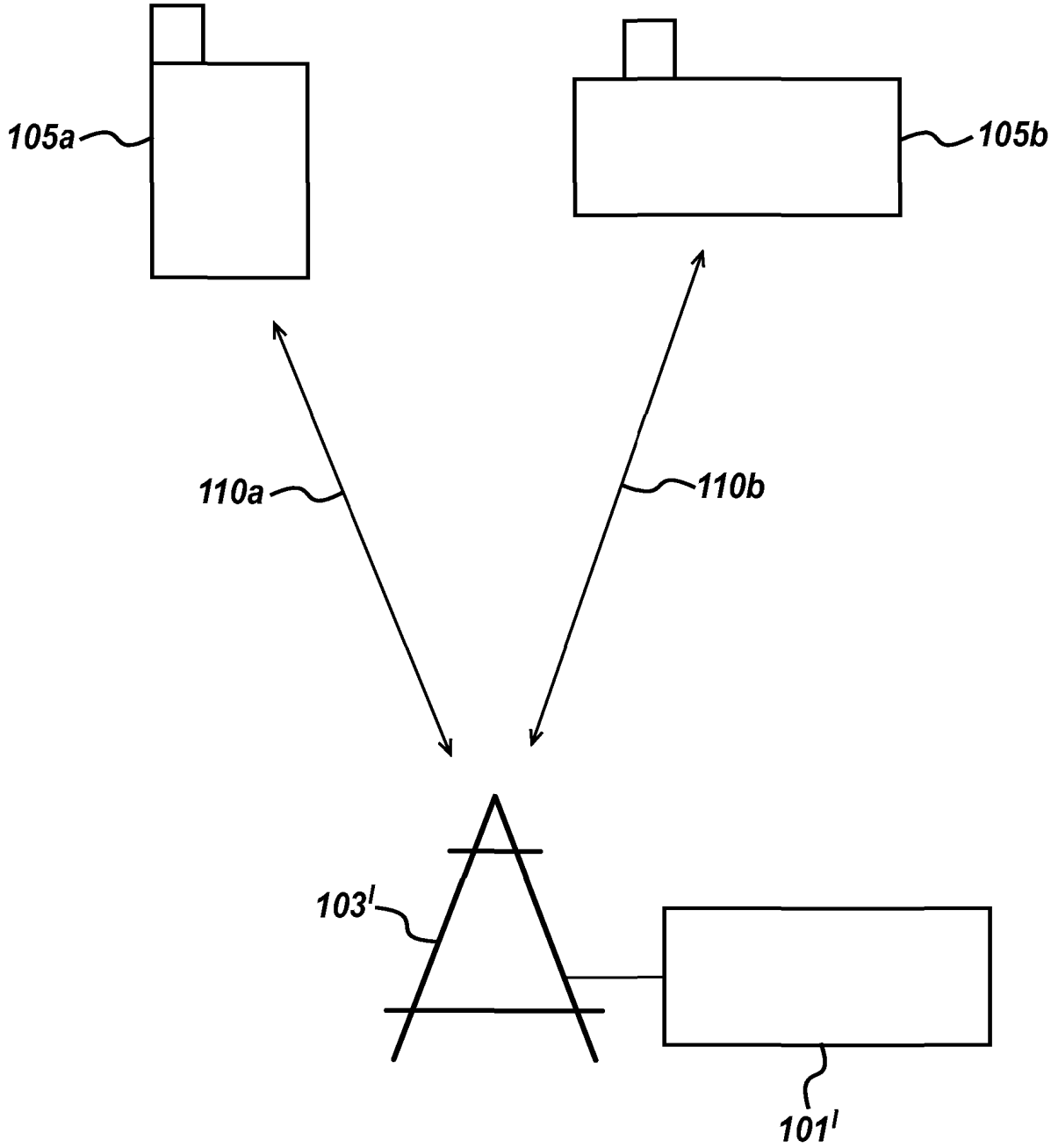


FIG. 1

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FIG. 2



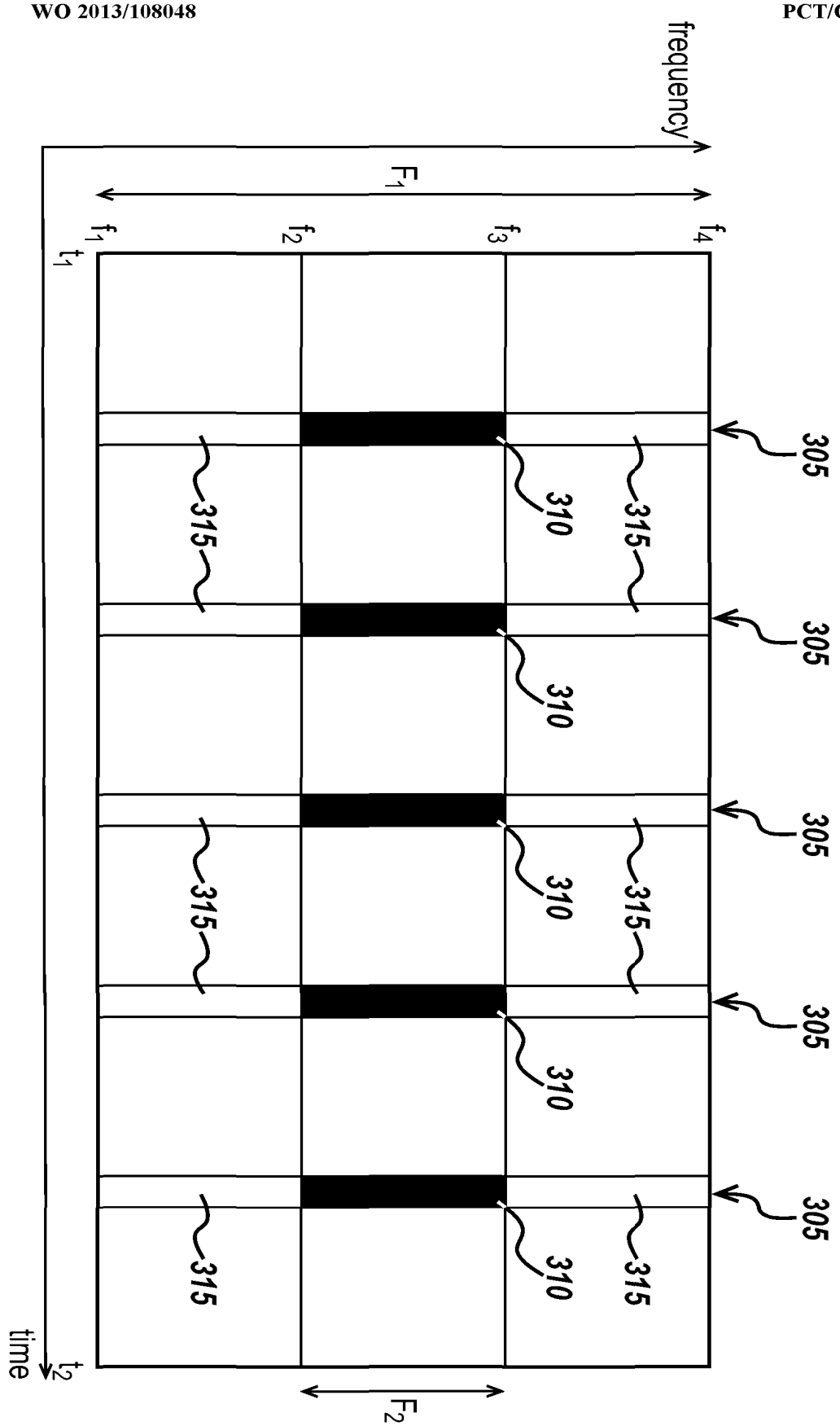
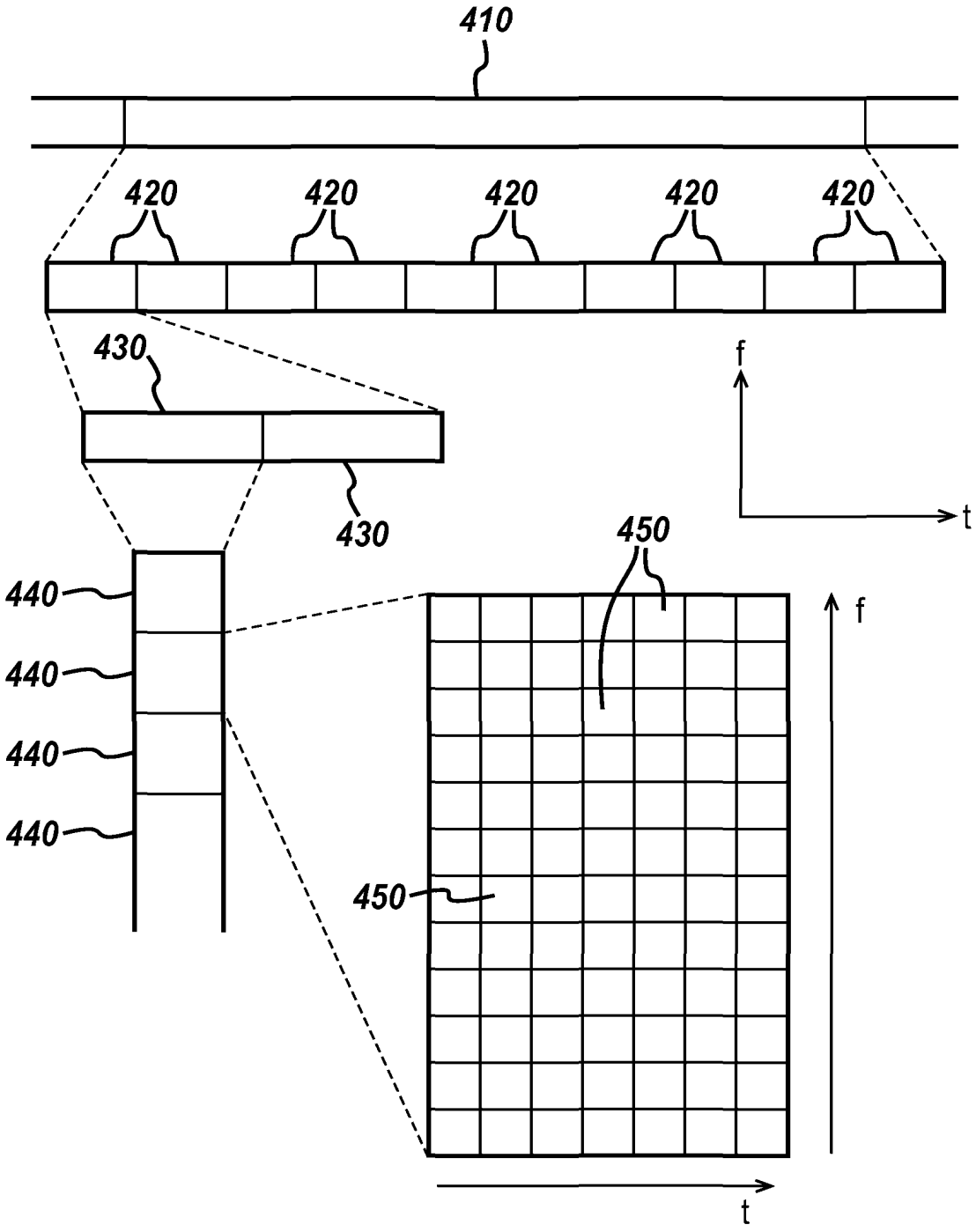


FIG. 3

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FIG. 4



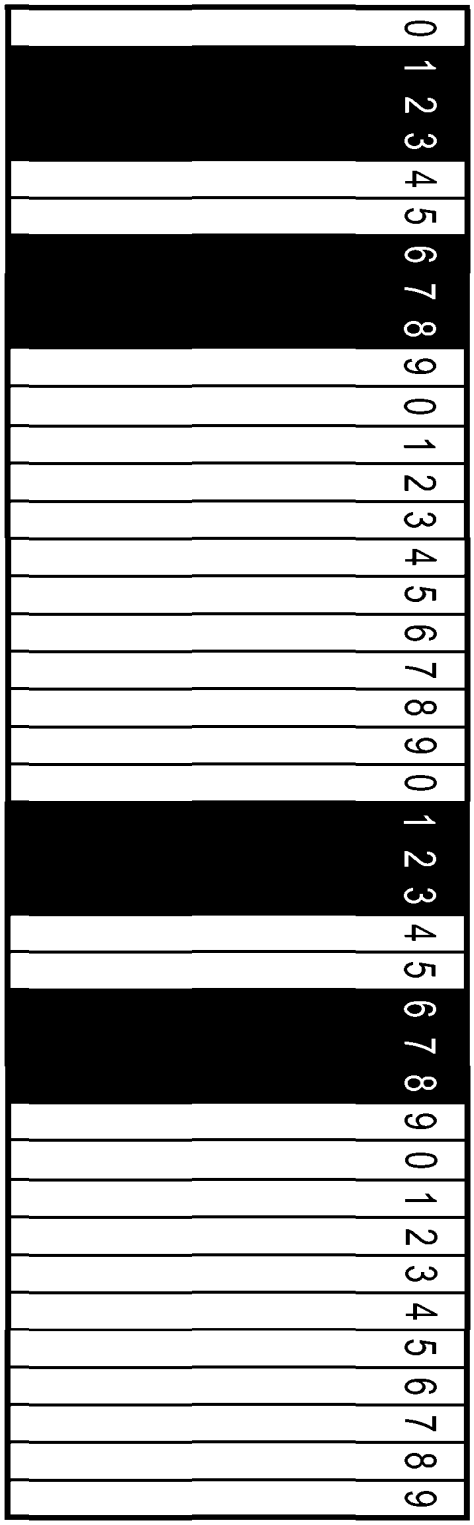


FIG. 5A

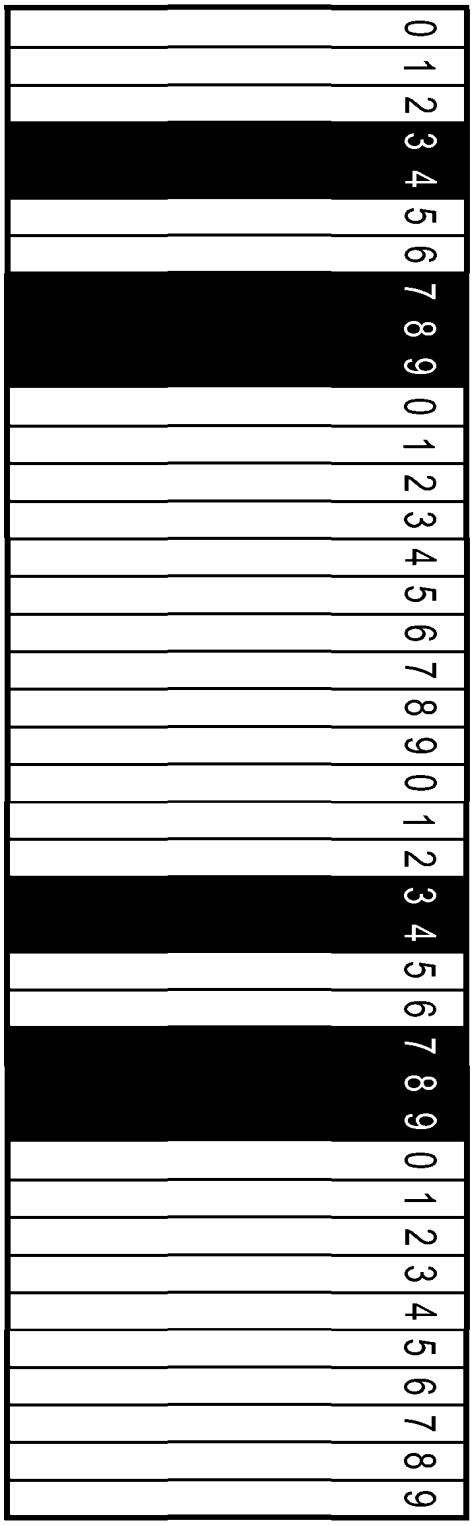


FIG. 5B

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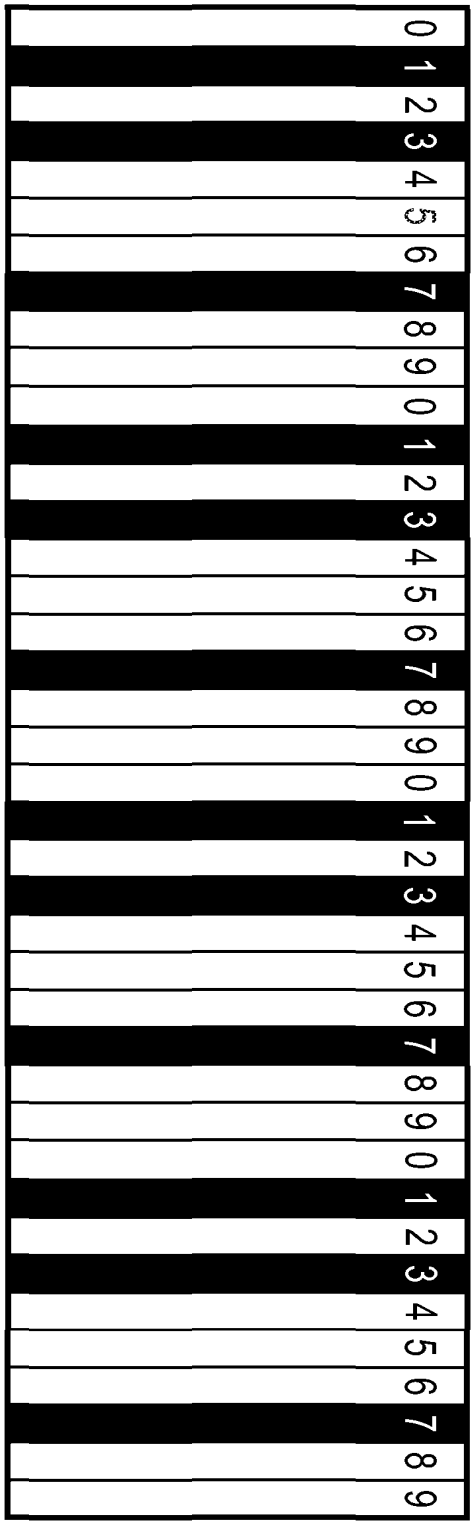


FIG. 5C

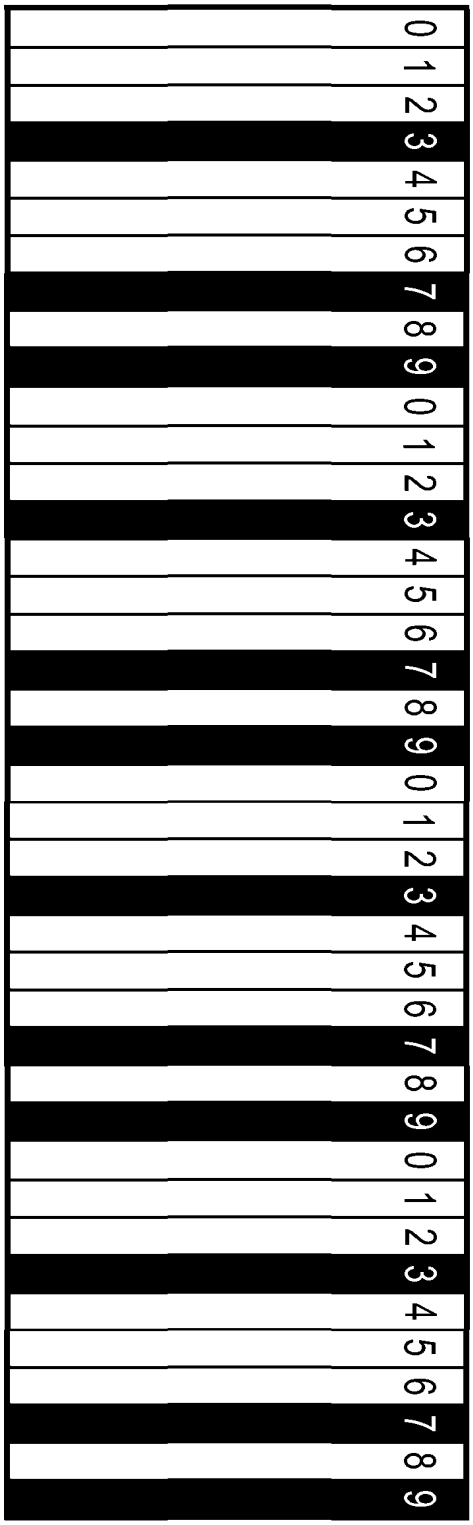


FIG. 5D

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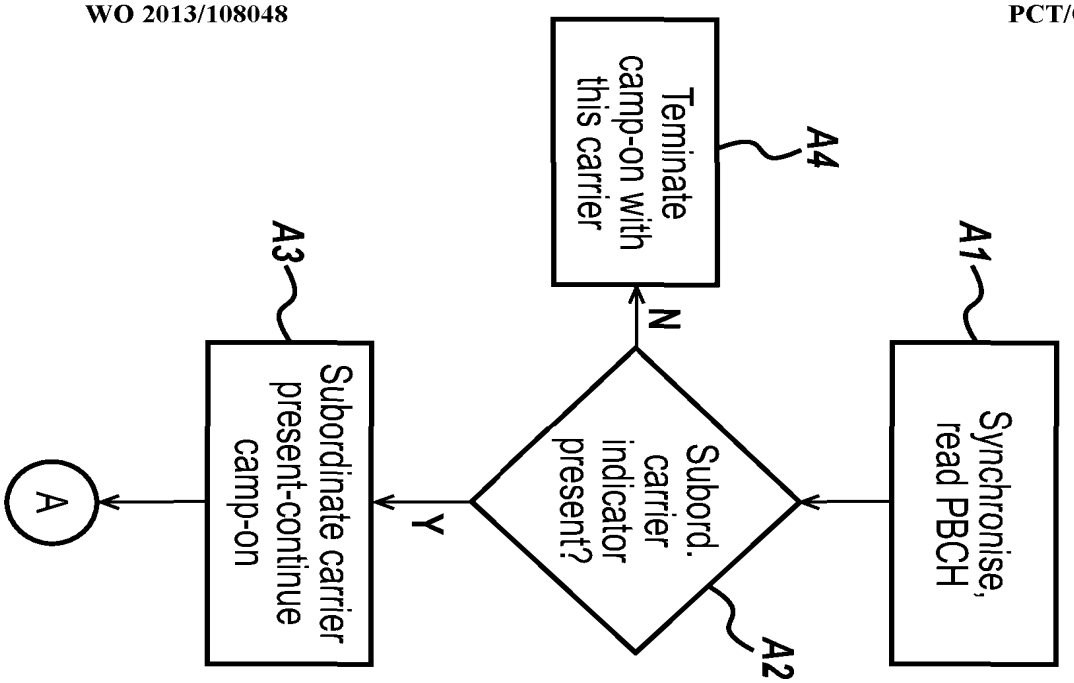


FIG. 6

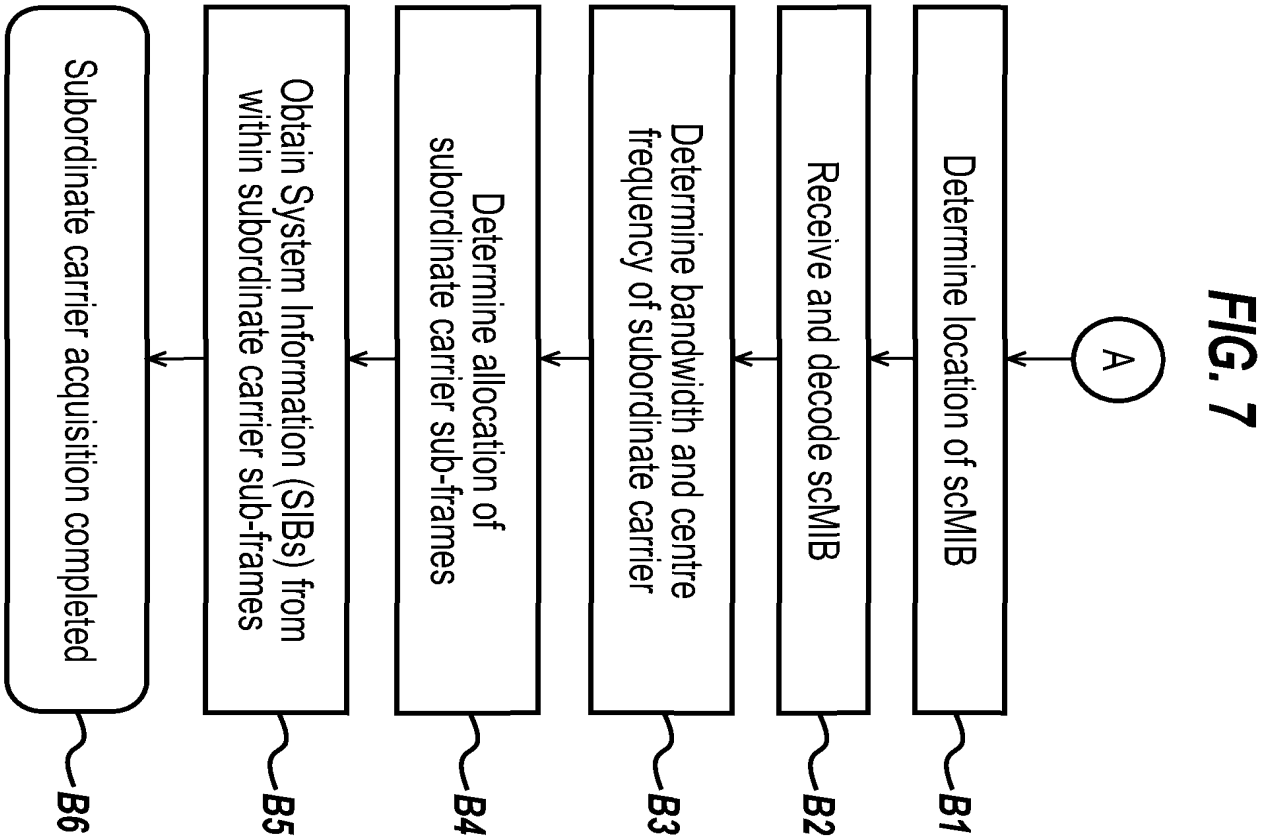


FIG. 7

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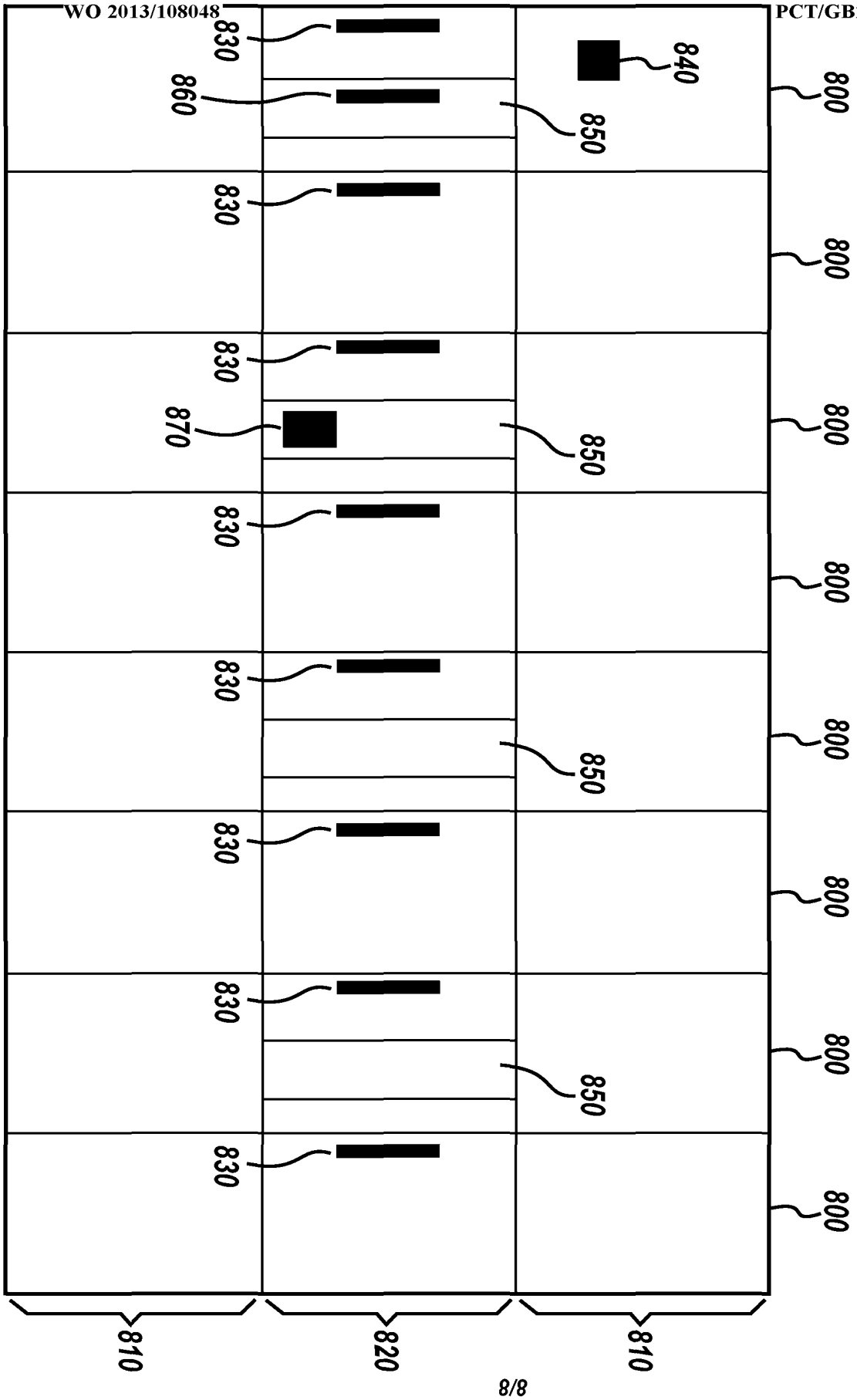


FIG. 8

SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050126

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00
ADD.

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)
H04L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/085457 A1 (CHEN WANSHI [US] ET AL) 14 April 2011 (2011-04-14) figure 4A figure 2 figure 5 figure 7a figure 7A paragraph [0007] paragraph [0044] - paragraph [0045] paragraph [0055] paragraph [0060] paragraph [0051] paragraph [0068] paragraph [0075] - paragraph [0076] paragraph [0065] paragraph [0158] ----- -/--	1-39

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2013	06/05/2013

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, Fax: (+31-70) 340-3016	Hanus, Pavol

2

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HUAWEI ET AL: "Considerations on the bandwidth reduction for low cost MTC UE", 3GPP DRAFT; R1-113659, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. San Francisco, USA; 20111114 - 20111118, 8 November 2011 (2011-11-08), XP050561799, title, section 3.1	1-39
A	Erik Dahlman ET AL: "Access Procedures (Chapter 14)" In: "4G LTE/LTE-Advanced for Mobile Broadband", 29 March 2011 (2011-03-29), Academic Press in Elsevier, XP055061127, pages 301-321, section 14.2	1-39
A	NTT DOCOMO: "Issues Regarding LTE Network for Low Cost MTC", 3GPP DRAFT; R1-114082 LOW COST MTC, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. San Francisco, USA; 20111114 - 20111118, 8 November 2011 (2011-11-08), XP050562063, section 3.2	1-39

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2013/050126

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011085457 A1	14-04-2011	CN 102388665 A	21-03-2012
		EP 2417814 A1	15-02-2012
		JP 2012523772 A	04-10-2012
		TW 201136241 A	16-10-2011
		US 2011085457 A1	14-04-2011
		WO 2010118382 A1	14-10-2010

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 14/372,363	Filing Date 07/15/2014	☐ 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

07/15/2014	(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))	* 12	Minus	** 20	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	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.

LIE
/BRENDA TURNER/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
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PTO/SB/06 (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 14/372,363	Filing Date 07/15/2014	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)		
FOR	NUMBER FILED	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

		(Column 1)		(Column 2)	(Column 3)		
	07/15/2014	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
AMENDMENT	Total (37 CFR 1.16(i))	* 12	Minus	** 20	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)		
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
AMENDMENT	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.

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