



- (51) **International Patent Classification:**
H04W 24/10 (2009.01)
- (21) **International Application Number:**
PCT/EP2015/057709
- (22) **International Filing Date:**
9 April 2015 (09.04.2015)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
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- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, 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, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, 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, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

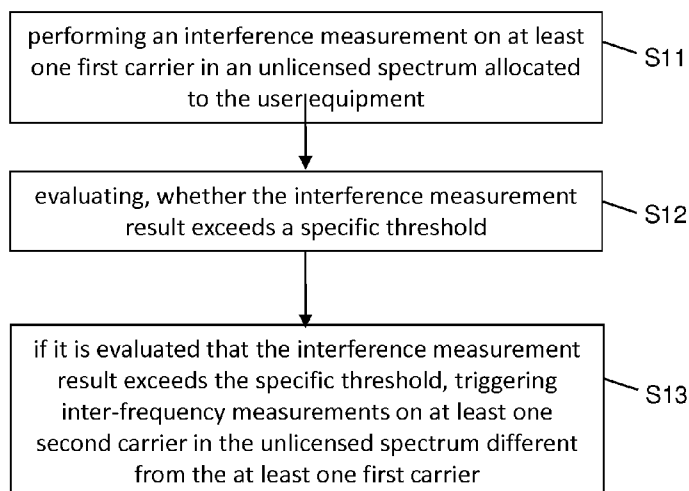
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

- (54) **Title:** METHOD FOR TRIGGERING INTER-FREQUENCY MEASUREMENTS IN UNLICENSED SPECTRUM IN LICENSED ASSISTED ACCESS

Fig. 1



- (57) **Abstract:** The present invention provides apparatuses, methods, computer programs, computer program products and computer-readable media regarding a method for triggering inter-frequency measurements in unlicensed spectrum in Licensed Assisted Access (LAA). The present invention comprises performing an interference measurement on at least one first carrier allocated to the user equipment, evaluating, whether the interference measurement result exceeds a specific threshold, and if it is evaluated that the interference measurement result exceeds the specific threshold, triggering inter-frequency measurements on at least one second carrier different from the at least one first carrier.

DESCRIPTION

Method for triggering inter-frequency measurements in unlicensed spectrum in
Licensed Assisted AccessField of the invention

The present invention relates to apparatuses, methods, systems, computer programs, computer program products and computer-readable media regarding a method for triggering inter-frequency measurements in unlicensed spectrum in Licensed Assisted Access (LAA).

Background of the invention

In 3GPP (3rd Generation Partnership Project), a study item on Licensed Assisted Access (LAA), also known as LTE (Long Term Evolution) on unlicensed band (LTE-U) has been opened. LAA allows operators to benefit from the additional capacity available from the unlicensed spectrum, especially in hotspots and corporate environments. With LAA, the extra spectrum resource in the 5 GHz frequency band can complement licensed band LTE operation. LAA reuses the CA framework meaning that the UE is always connected to an LTE licensed cell (operated as the primary cell) while using one or several LAA carriers configured as secondary cells. The licensed cell is used for control information, mobility and the most delay critical data.

Compared to operation in the licensed band, there is one major difference when using LTE in unlicensed bands: there may be interference from other operators LAA networks and/or Wi-Fi access points. However, LTE is designed to only handle interference from the same operator's network, and assumes interference coordination can be done without inter-operator coordination.

LAA can use Dynamic Frequency Selection (DFS), which means the eNB/BTS (evolved NodeB / Base Transceiver Station) will try to avoid the channels/carriers where high levels of interference are detected. This can be done by the eNB/BTS directly scanning the different channels. On the other hand, the eNB/BTS is not necessarily aware of the exact interference situation at the UE. So the situation may happen that the eNB/BTS estimates that a channel has low interference while a UE connected to that eNB/BTS is experiencing interference from another source, like another operator's LAA eNB/BTS and/or one or several Wi-Fi APs (Access Points) operating on the same unlicensed channel. As the LAA eNB/BTS does not see the interference, DFS will not act automatically and the situation will thus not change. This is the classical hidden node problem.

Therefore, it is a general understanding that channel selection at the eNB/BTS for LAA should also be assisted by UE measurements. However, a mechanism based on the UE continuously performing and reporting measurements can be quite expensive in terms of both signaling overhead and UE power consumption.

Thus, the problems underlying the present invention can therefore be summarized as follows:

1. In uncoordinated network deployments, typically of unlicensed spectrum, it is difficult to detect at the transmission point (eNB) the interference problems at the reception point (UE) using traditional LTE channel quality measurements (e.g. CSI).
2. Because of 1) and in order to assist channel selection at the eNB, UE assistance in the form of measurement reports is needed. However, in unlicensed spectrum, the interference conditions might change very often, which can cause continuous measurement reporting by the involved UEs (potentially causing excessive signaling overhead and UE power consumption).

The RTS/CTS (Request to Send / Clear to Send) mechanism (i.e. one node sending a probe packet and the other node responding to it) is a method used in

WiFi to solve the hidden node problem. However implementation of RTS/CTS mechanism is not very common in commercial WiFi deployments and therefore it is quite unlikely that a similar mechanism will be introduced to solve the hidden node problem in LAA.

Some of the RAN2 papers recently discussed in 3GPP (see reference [1]) propose the possibility to introduce RSSI (Received Signal Strength Indicator) measurements in LAA, and the possibility for the UE to measure and report channel measurements on a larger amount of carriers than the allocated active component carriers. However, though such measurements could be used to assist the eNB in selecting the most appropriate channel(s) for transmission in the unlicensed spectrum, none of the discussed papers addressed how to detect the hidden node problem. Also, using configuration of inter-frequency measurement objects and triggering criteria standardized for legacy LTE might not be particularly efficient with LAA system neither in terms of signaling overhead nor in terms UE power consumption.

Further, reference [2] has introduced the idea of performing one-time measurement on a specific subset of carrier frequencies (which could be either pre-configured or signaled to the UE when requesting the measurements) and reporting them to the eNB. The target is to reduce the signaling and procedural overhead of setting up and releasing measurement objects every time the eNB needs to require measurement reports to assist channel selection. However, also this solution does not address the hidden node problem.

Another 3GPP contribution (see reference [3]) additionally proposes to report the detected energy from signals not being LAA on the LAA frequency band, though details of this proposal are not disclosed in the 3GPP contribution. However, the introduction of this measurement reports by itself does not guarantee the possibility to detect hidden WiFi APs – not to mention hidden LAA nodes (e.g. from other operators).

References:

[1]: 3GPP R2-150181

[2]: WO 2013 059999

[3]: 3GPP R2-150182

Summary of the Invention

It is therefore an object of the present invention to overcome the above mentioned problems and to provide apparatuses, methods, systems, computer programs, computer program products and computer-readable media regarding a method for triggering inter-frequency measurements in unlicensed spectrum in Licensed Assisted Access (LAA).

According to an aspect of the present invention there is provided a method for use in a user equipment, comprising

- performing an interference measurement on at least one first carrier allocated to the user equipment,

- evaluating, whether the interference measurement result exceeds a specific threshold, and

- if it is evaluated that the interference measurement result exceeds the specific threshold,

- triggering inter-frequency measurements on at least one second carrier different from the at least one first carrier.

According to another aspect of the present invention there is provided a method for use in a base station, comprising

- configuring at least one second carrier in an unlicensed spectrum on which a user equipment should perform inter-frequency measurements, and

- informing the user equipment about

- a condition, when the user equipment should perform interference measurements on at least one first carrier different from the at least one second carrier, and

- a threshold for the interference measurement results triggering inter-frequency measurements on the at least one second carrier.

According to another aspect of the present invention there is provided an apparatus for use in a user equipment, comprising

at least one processor,

and

at least one memory for storing instructions to be executed by the processor, wherein

the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:

performing an interference measurement on at least one first carrier allocated to the user equipment,

evaluating, whether the interference measurement result exceeds a specific threshold, and

if it is evaluated that the interference measurement result exceeds the specific threshold,

triggering inter-frequency measurements on at least one second carrier different from the at least one first carrier.

According to another aspect of the present invention there is provided an apparatus for use in a base station, comprising

at least one processor,

and

at least one memory for storing instructions to be executed by the processor, wherein

the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:

configuring at least one second carrier in an unlicensed spectrum on which a user equipment should perform inter-frequency measurements, and

informing the user equipment about

a condition, when the user equipment should perform interference measurements on at least one first carrier different from the at least one second carrier, and

a threshold for the interference measurement results triggering inter-frequency measurements on the at least one second carrier.

According to another aspect of the present invention there is provided an apparatus for use in a user equipment, comprising:

- means for performing an interference measurement on at least one first carrier allocated to the user equipment,

- means for evaluating, whether the interference measurement result exceeds a specific threshold, and

- if it is evaluated that the interference measurement result exceeds the specific threshold,

- means for triggering inter-frequency measurements on at least one second carrier different from the at least one first carrier.

According to another aspect of the present invention there is provided an apparatus for use in a base station, comprising:

- means for configuring at least one second carrier in an unlicensed spectrum on which a user equipment should perform inter-frequency measurements, and

- means for informing the user equipment about

- a condition, when the user equipment should perform interference measurements on at least one first carrier different from the at least one second carrier, and

- a threshold for the interference measurement results triggering inter-frequency measurements on the at least one second carrier.

According to another aspect of the present invention there is provided a computer program product comprising code means adapted to produce steps of any of the methods as described above when loaded into the memory of a computer.

According to a still further aspect of the invention there is provided a computer program product as defined above, wherein the computer program product comprises a computer-readable medium on which the software code portions are stored.

According to a still further aspect of the invention there is provided a computer program product as defined above, wherein the program is directly loadable into an internal memory of the processing device.

Brief Description of the Drawings

These and other objects, features, details and advantages will become more fully apparent from the following detailed description of aspects/embodiments of the present invention which is to be taken in conjunction with the appended drawings, in which:

Fig. 1 is a flowchart illustrating an example of a method according to example versions of the present invention;

Fig. 2 is a flowchart illustrating an example of another method according to example versions of the present invention;

Fig. 3 is block diagram illustrating an example of an apparatus according to example versions of the present invention.

Description of exemplary embodiments

Exemplary aspects of the present invention will be described herein below. More specifically, exemplary aspects of the present invention are described hereinafter with reference to particular non-limiting examples and to what are presently considered to be conceivable embodiments of the present invention. A person skilled in the art will appreciate that the invention is by no means limited to these examples, and may be more broadly applied.

It is to be noted that the following description of the present invention and its embodiments mainly refers to specifications being used as non-limiting examples for certain exemplary network configurations and deployments. Namely, the present invention and its embodiments are mainly described in relation to 3GPP specifications being used as non-limiting examples for certain exemplary network

configurations and deployments. As such, the description of exemplary embodiments given herein specifically refers to terminology which is directly related thereto. Such terminology is only used in the context of the presented non-limiting examples, and does naturally not limit the invention in any way. Rather, any other network configuration or system deployment, etc. may also be utilized as long as compliant with the features described herein.

Some example versions of the disclosure and embodiments are described with reference to the drawings. In the following, different exemplifying examples will be described using, as an example of a communication network, a cellular wireless communication network, such as an LTE or LTE-Advanced based system. However, it is to be noted that the present invention is not limited to an application using such types of communication system, but is also applicable in other types of communication systems, be it wireless systems, wired systems or systems using a combination thereof.

Hereinafter, various embodiments and implementations of the present invention and its aspects or embodiments are described using several alternatives. It is generally noted that, according to certain needs and constraints, all of the described alternatives may be provided alone or in any conceivable combination, also including combinations of individual features of the various alternatives.

In particular, the following examples versions and embodiments are to be understood only as illustrative examples. Although the specification may refer to "an", "one", or "some" example version(s) or embodiment(s) in several locations, this does not necessarily mean that each such reference is to the same example version(s) or embodiment(s), or that the feature only applies to a single example version or embodiment. Single features of different embodiments may also be combined to provide other embodiments. Furthermore, words "comprising" and "including" should be understood as not limiting the described embodiments to consist of only those features that have been mentioned and such example versions and embodiments may also contain also features, structures, units, modules etc. that have not been specifically mentioned.

In general, a telecommunication network comprises plural network elements, such as evolved NodeB's (eNB; i.e. base station in LTE environment), user equipments UE (e.g. mobile phone, smart phone, Computer, etc.), controllers, interfaces, etc, and in particular any equipment used in the provision of a telecommunications service.

The general functions and interconnections of the described elements, which also depend on the actual network type, are known to those skilled in the art and described in corresponding specifications, so that a detailed description thereof is omitted herein. However, it is to be noted that several additional network elements and signaling links may be employed for a communication to or from a base station and a communication network besides those described in detail herein below.

A starting point of the present invention is a solution as described in the following.

First, specific (time/frequency) resources are determined for Hidden Node Detection Measurement (HNDM). The resources are preferably CSI-IM (Channel State Information Interference Measurement) resources and are configured to the UE via RRC signaling. The LTE LAA cells (eNodeBs) operating on the same carrier may coordinate the CSI-IM allocation so that each eNodeB assigns the same resources for HNDM (Hidden Node Detection Measurement) (this should be easy at least among the LTE LAA cells of the same operator).

Then, for each subframe for which HNDM resources are configured, the UE determines whether the serving eNodeB/cell has occupied the channel or not.

Thereafter, the UE performs HNDM according to the determined resources if (and only if), the serving eNodeB is occupying the operating channel.

Measurements to aid hidden node detection by performing the specified measurements are performed only if the eNB, the UE is connected to, using LAA

has occupied the corresponding unlicensed channel. However, the above described solution present the following limitations:

Namely, in view of the above, it is still required that the UE reports a specific measurement report performed on the unlicensed band before eNB can detect the hidden node problem and consequently ask the UE to perform (and report) inter-frequency measurements (e.g. RSSI) on a sub-set of additional carriers.

Moreover, the CSI-IM reported by the UE cannot by itself say if there is a hidden node problem transmitting on the corresponding carrier. A low value of the CSI-IM could be due to a hidden node as well as to the fact that the UE is moving out of the LAA cell coverage. The CSI-IM reports therefore need be combined with information about e.g. the RSRP (Reference Signal Received Power) received by the UE on the corresponding carrier, meaning additional signaling from the UE to the network is needed.

Thus, according to some example versions of the present invention, there is proposed a new solution that:

- Introduces UE measurements allowing the detection of interference problems due to hidden node problem directly at the UE, and
- Allows automatic triggering of inter-frequency measurement (and reporting to the eNB) based on specifically configured interference/energy detection thresholds.

Thus, according to some example versions of the present invention, when the UE reliably detects transmission on a carrier, a measurement of a set of carriers is triggered and a measurement report is sent to the UE serving cell. The reliability criteria and the set of carriers to measure and report may be configured by the serving cell.

In summary, the invention consists of the following steps.

In a first step, the eNB configures a set of carriers (in the unlicensed spectrum) the UE should measure and report on (e.g. the RSSI) when certain conditions

(that are e.g. either configured by the eNB or predetermined by e.g. UE capabilities) are met.

In a second step, the network may also configure an interference/energy detection threshold, or may instruct the UE to use a fixed threshold, or let the UE decide on the threshold by itself.

In a third step, when there is data transmission on the unlicensed carrier currently being used by the UE in LAA, the UE performs an “interference measurement” on the carrier (e.g. CSI/CSI-IM, as mentioned above, or RSSI, for example, by comparing the CSI/CSI-IM with the RSSI and/or RSRP). This measurement will contain also the received interference from other interfering sources on the corresponding carrier (or a subset of the interfering sources depending on e.g. whether CSI or CSI-IM resources are configured).

In a fourth step, if the measured interference level is above the threshold value configured in the second step, the UE triggers additional inter-frequency measurement (e.g. RSSI, RSRP) on the set of carriers configured in the first step. Additionally or alternatively, additional inter-frequency measurements could also be performed on other carriers than the set of carriers configured in the first step.

Then, in a fifth step, once the triggered measurements are completed, the UE finally reports the corresponding measurements (or a subset of those, e.g. those fulfilling a threshold criterion similar to the one in the second and third step) to the eNB via RRC signaling (typically transmitted over the licensed carrier).

According to some example versions of the present invention, in one possible implementation, the interference threshold is an energy detection threshold similar to the one defined for clear channel assessment (CCA) in the listen before talk (LBT) procedure used in LAA/WiFi. The UE could be configured to always measure the total received interference and compare it to this threshold value independently on whether it is a configured HNDM CSI-IM resource, as mentioned above. In another possible implementation, the UE removes the

interference contributions according to the configured CSI-IM resources before comparing the measured interference to the configured threshold. In still another possible implementation, the measurement is an RSSI measurement similar to the one used in LTE RSRQ (Reference Signal Received Quality) measurement or in WLAN (Wireless Local Area Network) RSSI measurement. In yet another implementation, the interference measurement is obtained by comparing the CSI/CSI-IM measurement and the RSRP (Reference Signal Received Power) measured on the same carrier.

When configuring the set of (unlicensed) carriers where the UE should do measurements (e.g. RSSI), the eNB can give e.g.

- 1) explicit WLAN channel number,
- 2) explicit LTE EARFCN (EUTRA (Universal Mobile Telecommunications System Terrestrial Radio Access) Absolute Radio Frequency Channel Number) (or another way that will be used to determine the unlicensed carrier),
- 3) explicit or implicit carrier bandwidth centered on the triggering frequency (so that UE may measure e.g. carriers close to the current configuration), or
- 4) any combination of these.

Whether the UE performs WLAN measurements or LTE measurements (i.e. WLAN RSSI or LTE-based RSSI) could also be configurable by the eNB. In general, LTE-based measurements make more sense, however one use case for also configuring WLAN measurements could be if the UE can measure if a partially overlapping WLAN carrier carries a hidden node. Which measurement is performed could also be implicitly determined depending on whether the carrier is indicated to be a WLAN carrier (e.g. with WLAN channel number) or an LTE carrier (e.g. with EARFCN).

For how long the UE performs the measurements after they are triggered could also be configurable by the eNB, e.g. similarly as it is done today with event-triggered periodical RRM (Radio Resource Management) measurements.

According to some example versions of the present invention, in one possible implementation, the UE always sends a report when the inter-frequency measurements in unlicensed spectrum are triggered.

In another possible implementation, the UE sends a report only if some of the measurements are above the detection threshold.

In still another possible implementation, the triggering conditions for the measurement reports are configured as a separate event (i.e. specific triggering conditions need to be satisfied for the UE to report the measurements performed on a specific unlicensed carrier).

The advantages of proposed solution, in particular compared to the above mentioned case, where the eNB gets the CSI/CSI-IM reports from the UE, compares those again with the respective RSRP measurements, and requests the UE to perform and report measurements (e.g. RSSI) on a set of carriers in unlicensed spectrum are as follows:

Firstly, the signaling overhead is reduced since the UE only sends reports when it has detected a cell on a frequency where the LAA cell is (interested in) operating.

A second advantage is a faster reaction to the hidden node problem. Namely, when the hidden node situation is detected, UE sends a report and eNB can react to the situation.

Further, basing the triggering of inter-frequency measurements in unlicensed spectrum directly on interference measurements done at the UE (rather than combine information conveyed by the UE via CSI/CSI-IM and RSRP measurements) is a better way to detect the hidden node problem, since the hidden node problem occurs at the receiving point (and a CSI/CSI-IM result could be low simply because the UE is moving away from the LAA node).

In the following, a more general description of example versions of the present invention is made with respect to Figs. 1 to 3.

Fig. 1 is a flowchart illustrating an example of a method according to example versions of the present invention.

According to example versions of the present invention, the method may be implemented in or may be part of a user equipment or the like. The method comprises performing an interference measurement on at least one first carrier in an unlicensed spectrum allocated to the user equipment in a step S11, evaluating, whether the interference measurement result exceeds a specific threshold in a step S12, and if it is evaluated in step S12 that the interference measurement result exceeds the specific threshold, triggering inter-frequency measurements on at least one second carrier in the unlicensed spectrum different from the at least one first carrier in a step S13.

According to some example versions of the present invention, the method further comprises transmitting a measurement report including all or a subset of the inter-frequency measurement results, which exceed a predetermined threshold, to a cell serving the user equipment.

According to some example versions of the present invention, the at least one second carrier in the unlicensed spectrum, where the user equipment performs inter-frequency measurements on, is configured by a cell serving the user equipment.

According to some example versions of the present invention, the specific threshold is configured by the cell serving the user equipment or decided at the user equipment.

According to some example versions of the present invention, the interference measurement includes measuring at least one of Channel State Information, CSI, and Received Signal Strength Indicator, RSSI.

According to some example versions of the present invention, the interference measurement is obtained by comparing channel state information, CSI, and reference signal received power, RSRP, measurements in the user equipment.

According to some example versions of the present invention, the inter-frequency measurement includes measuring at least one of Received Signal Strength Indicator, RSSI, and Reference Signal Received Power, RSRP.

According to some example versions of the present invention, the method further comprises determining, whether for the at least one first carrier in the unlicensed spectrum, a predetermined condition is met, wherein the interference measurement is performed, if it is determined that the predetermined condition is met.

According to some example versions of the present invention, the predetermined condition includes a data transmission being performed on the at least one first carrier.

Fig. 2 is a flowchart illustrating another example of a method according to some example versions of the present invention.

According to example versions of the present invention, the method may be implemented in or may be part of a network element like, for example, a radio base station of a mobile packet network, like for example, a NodeB or evolved NodeB, eNB, or the like. The method comprises configuring at least one second carrier in an unlicensed spectrum on which a user equipment should perform inter-frequency measurements in a step S21, and informing the user equipment in a step S22 about a condition, when the user equipment should perform interference measurements on at least one first carrier in the unlicensed spectrum different from the at least one second carrier, and a threshold for the interference measurement results triggering inter-frequency measurements on the at least one second carrier.

According to some example versions of the present invention, the method further comprises receiving inter-frequency measurement results from the user equipment.

According to some example versions of the present invention, informing the user equipment about the condition comprises defining the condition and transmitting the condition to the user equipment, or informing the user equipment that the condition is predetermined based on capabilities of the user equipment.

According to some example versions of the present invention, informing the user equipment about the threshold comprises configuring the threshold and transmitting the threshold to the user equipment, instructing the user equipment to use a predetermined threshold, or instructing the user equipment to decide the threshold by itself.

According to some example versions of the present invention, configuring the at least one second carrier in the unlicensed spectrum to perform inter-frequency measurements on comprises at least one of indicating a channel number according to a first wireless communication technology, indicating a channel number according to a second wireless communication technology, and indicating a bandwidth centering around a specific frequency.

Fig. 3 is a block diagram showing an example of an apparatus according to some example versions of the present invention.

In Fig. 3, a block circuit diagram illustrating a configuration of an apparatus 30 is shown, which is configured to implement the above described aspects of the invention. It is to be noted that the apparatus 30 shown in Fig. 3 may comprise several further elements or functions besides those described herein below, which are omitted herein for the sake of simplicity as they are not essential for understanding the invention. Furthermore, the apparatus may be also another device having a similar function, such as a chipset, a chip, a module etc., which can also be part of an apparatus or attached as a separate element to the apparatus, or the like.

The apparatus 30 may comprise a processing function or processor 31, such as a CPU or the like, which executes instructions given by programs or the like. The processor 31 may comprise one or more processing portions dedicated to specific processing as described below, or the processing may be run in a single processor. Portions for executing such specific processing may be also provided as discrete elements or within one or further processors or processing portions, such as in one physical processor like a CPU or in several physical entities, for example. Reference sign 32 denotes transceiver or input/output (I/O) units (interfaces) connected to the processor 31. The I/O units 32 may be used for communicating with one or more other network elements, entities, terminals or the like. The I/O units 32 may be a combined unit comprising communication equipment towards several network elements, or may comprise a distributed structure with a plurality of different interfaces for different network elements. The apparatus 30 further comprises at least one memory 33 usable, for example, for storing data and programs to be executed by the processor 31 and/or as a working storage of the processor 31.

The processor 31 is configured to execute processing related to the above described aspects. In particular, the apparatus 30 may be implemented in or may be part of a user equipment, or the like, and may be configured to perform a method as described in connection with Fig. 1. Thus, the processor 31 is configured to perform performing an interference measurement on at least one first carrier allocated to the user equipment, evaluating, whether the interference measurement result exceeds a specific threshold, and if it is evaluated that the interference measurement result exceeds the specific threshold, triggering inter-frequency measurements on at least one second carrier different from the at least one first carrier.

According to some example versions of the present invention, the apparatus 30 may be implemented in or may be part of a network element like, for example, a radio base station of a mobile packet network, like for example, a NodeB or evolved NodeB, eNB, or the like, and may be configured to perform a method as described in connection with Fig. 2. Thus, the processor 31 is configured to

perform configuring at least one second carrier in an unlicensed spectrum on which a user equipment should perform inter-frequency measurements, and informing the user equipment about a condition, when the user equipment should perform interference measurements on at least one first carrier different from the at least one second carrier, and a threshold for the interference measurement results triggering inter-frequency measurements on the at least one second carrier.

For further details regarding the functions of the apparatus 30, reference is made to the description of the methods according to some example versions of the present invention as described in connection with Figs. 1 and 2.

Thus, it is noted that the apparatus for use in a base station, and the apparatus for use in a user equipment, generally have the same structural components, wherein these components are configured to execute the respective functions of the base station and the user equipment, respectively, as set out above.

Even though the examples above have been described from the viewpoint of LAA and operation utilizing unlicensed spectrum, features as described herein are equally valid for other co-existence scenarios utilizing also licensed spectrum. For example, Licensed Shared Access LSA is an example of such a scenario. LSA is a spectrum sharing concept enabling access to spectrum that is identified for International Mobile Telecommunications IMT, but not cleared for IMT deployment. Co-primary sharing is another example. Co-primary sharing refers to spectrum sharing where several primary users (operators) share the spectrum dynamically or semi-statically. This may be used for small cells at 3.5 GHz for example. Spectrum sharing between operators will happen if regulators force it and/or operators need it. Thus, features as described herein are also applicable to LSA and Co-primary sharing.

In the foregoing exemplary description of the apparatus, only the units/means that are relevant for understanding the principles of the invention have been described using functional blocks. The apparatus may comprise further units/means that are necessary for its respective operation, respectively.

However, a description of these units/means is omitted in this specification. The arrangement of the functional blocks of the apparatus is not construed to limit the invention, and the functions may be performed by one block or further split into sub-blocks.

When in the foregoing description it is stated that the apparatus (or some other means) is configured to perform some function, this is to be construed to be equivalent to a description stating that a (i.e. at least one) processor or corresponding circuitry, potentially in cooperation with computer program code stored in the memory of the respective apparatus, is configured to cause the apparatus to perform at least the thus mentioned function. Also, such function is to be construed to be equivalently implementable by specifically configured circuitry or means for performing the respective function (i.e. the expression "unit configured to" is construed to be equivalent to an expression such as "means for").

For the purpose of the present invention as described herein above, it should be noted that

- method steps likely to be implemented as software code portions and being run using a processor at an apparatus (as examples of devices, apparatuses and/or modules thereof, or as examples of entities including apparatuses and/or modules therefore), are software code independent and can be specified using any known or future developed programming language as long as the functionality defined by the method steps is preserved;
- generally, any method step is suitable to be implemented as software or by hardware without changing the idea of the aspects/embodiments and its modification in terms of the functionality implemented;
- method steps and/or devices, units or means likely to be implemented as hardware components at the above-defined apparatuses, or any module(s) thereof, (e.g., devices carrying out the functions of the apparatuses according to the aspects/embodiments as described above) are hardware independent and can be implemented using any known or future developed hardware technology or any hybrids of these, such as MOS (Metal Oxide Semiconductor), CMOS (Complementary MOS), BiMOS (Bipolar MOS), BiCMOS (Bipolar CMOS), ECL

(Emitter Coupled Logic), TTL (Transistor-Transistor Logic), etc., using for example ASIC (Application Specific IC (Integrated Circuit)) components, FPGA (Field-programmable Gate Arrays) components, CPLD (Complex Programmable Logic Device) components or DSP (Digital Signal Processor) components;

- devices, units or means (e.g. the above-defined apparatuses, or any one of their respective units/means) can be implemented as individual devices, units or means, but this does not exclude that they are implemented in a distributed fashion throughout the system, as long as the functionality of the device, unit or means is preserved;

- an apparatus may be represented by a semiconductor chip, a chipset, or a (hardware) module comprising such chip or chipset; this, however, does not exclude the possibility that a functionality of an apparatus or module, instead of being hardware implemented, be implemented as software in a (software) module such as a computer program or a computer program product comprising executable software code portions for execution/being run on a processor;

- a device may be regarded as an apparatus or as an assembly of more than one apparatus, whether functionally in cooperation with each other or functionally independently of each other but in a same device housing, for example.

In general, it is to be noted that respective functional blocks or elements according to above-described aspects can be implemented by any known means, either in hardware and/or software, respectively, if it is only adapted to perform the described functions of the respective parts. The mentioned method steps can be realized in individual functional blocks or by individual devices, or one or more of the method steps can be realized in a single functional block or by a single device.

Generally, any method step is suitable to be implemented as software or by hardware without changing the idea of the present invention. Devices and means can be implemented as individual devices, but this does not exclude that they are implemented in a distributed fashion throughout the system, as long as the functionality of the device is preserved. Such and similar principles are to be considered as known to a skilled person.

Software in the sense of the present description comprises software code as such comprising code means or portions or a computer program or a computer program product for performing the respective functions, as well as software (or a computer program or a computer program product) embodied on a tangible medium such as a computer-readable (storage) medium having stored thereon a respective data structure or code means/portions or embodied in a signal or in a chip, potentially during processing thereof.

It is noted that the aspects/embodiments and general and specific examples described above are provided for illustrative purposes only and are in no way intended that the present invention is restricted thereto. Rather, it is the intention that all variations and modifications which fall within the scope of the appended claims are covered.

Abbreviations:

3GPP	Third Generation Partnership Project
BTS	Base Transceiver Station
CCA	Clear Channel Assessment
CSI	Channel State Information
CSI-IM	CSI Interference Measurement
DFS	Dynamic Frequency Selection
EARFCN	EUTRA Absolute Radio Frequency Channel Number
EUTRA	Evolved UMTS Terrestrial Radio Access
eNB	Evolved NodeB (LTE)
HNDM	Hidden Node Detection Measurement
LAA	Licensed Assisted Access
LBT	Listen-Before-Talk
LTE	3GPP Long Term Evolution standard
LTE-U	LTE operating in un-license band
RRC	Radio Resource Control
RRM	Radio Resource Management
RSRP	Reference Signal Received Power
RSSI	Received Signal Strength Indicator

UE	UE Equipment
UMTS	Universal Mobile Telecommunications System
WiFi	Wireless Fidelity
WLAN	Wireless Local Area Network

CLAIMS

1. A method for use in a user equipment, comprising
 - performing an interference measurement on at least one first carrier in an unlicensed spectrum allocated to the user equipment,
 - evaluating, whether the interference measurement result exceeds a specific threshold, and
 - if it is evaluated that the interference measurement result exceeds the specific threshold,
 - triggering inter-frequency measurements on at least one second carrier in the unlicensed spectrum different from the at least one first carrier.
2. The method according to claim 1, further comprising:
 - transmitting a measurement report including all or a subset of the inter-frequency measurement results, which exceed a predetermined threshold, to a cell serving the user equipment.
3. The method according to any one of claims 1 to 2, wherein
 - the at least one second carrier in the unlicensed spectrum, where the user equipment performs inter-frequency measurements on, is configured by a cell serving the user equipment.
4. The method according to any one of claims 1 to 3, wherein
 - the specific threshold is configured by the cell serving the user equipment or decided at the user equipment.
5. The method according to any one of claims 1 to 4, wherein
 - the interference measurement includes measuring at least one of Channel State Information, CSI, and Received Signal Strength Indicator, RSSI.
6. The method according to any one of claims 1 to 5, wherein
 - the interference measurement is obtained by comparing channel state information, CSI, and reference signal received power, RSRP, measurements in the user equipment.

7. The method according to anyone of claims 1 to 6, wherein
the inter-frequency measurement includes measuring at least one of Received Signal Strength Indicator, RSSI, and Reference Signal Received Power, RSRP.
8. The method according to anyone of claims 1 to 7, further comprising
determining, whether for the at least one first carrier in the unlicensed spectrum, a predetermined condition is met,
wherein the interference measurement is performed, if it is determined that the predetermined condition is met.
9. The method according to claim 8, wherein
the predetermined condition includes a data transmission being performed on the at least one first carrier.
10. A method for use in a base station, comprising:
configuring at least one second carrier in an unlicensed spectrum on which a user equipment should perform inter-frequency measurements, and
informing the user equipment about
a condition, when the user equipment should perform interference measurements on at least one first carrier in the unlicensed spectrum different from the at least one second carrier, and
a threshold for the interference measurement results triggering inter-frequency measurements on the at least one second carrier.
11. The method according to claim 10, further comprising
receiving inter-frequency measurement results from the user equipment.
12. The method according to claim 10 or 11, wherein
informing the user equipment about the condition comprises
defining the condition and transmitting the condition to the user equipment, or

informing the user equipment that the condition is predetermined based on capabilities of the user equipment.

13. The method according to any one of claims 10 to 12, wherein
informing the user equipment about the threshold comprises
 configuring the threshold and transmitting the threshold to the user equipment,
 instructing the user equipment to use a predetermined threshold, or
 instructing the user equipment to decide the threshold by itself.
14. The method according to any one of claims 10 to 13, wherein
 configuring the at least one second carrier in the unlicensed spectrum to perform inter-frequency measurements on comprises at least one of
 indicating a channel number according to a first wireless communication technology,
 indicating a channel number according to a second wireless communication technology, and
 indicating a bandwidth centering around a specific frequency.
15. An apparatus for use in a user equipment, comprising
 at least one processor,
 and
 at least one memory for storing instructions to be executed by the processor,
wherein
 the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:
 performing an interference measurement on at least one first carrier allocated to the user equipment,
 evaluating, whether the interference measurement result exceeds a specific threshold, and
 if it is evaluated that the interference measurement result exceeds the specific threshold,

triggering inter-frequency measurements on at least one second carrier different from the at least one first carrier.

16. The apparatus according to claim 15, wherein the at least one memory and the instructions are further configured to, with the at least one processor, cause the apparatus at least to perform:

transmitting a measurement report including all or a subset of the inter-frequency measurement results, which exceed a predetermined threshold, to a cell serving the user equipment.

17. The apparatus according to claim 15 or 16, wherein

the at least one second carrier in the unlicensed spectrum, where the user equipment performs inter-frequency measurements on, is configured by a cell serving the user equipment.

18. The apparatus according to any one of claims 15 to 17, wherein

the specific threshold is configured by the cell serving the user equipment or decided at the user equipment.

19. The apparatus according to any one of claims 15 to 18, wherein

the interference measurement includes measuring at least one of Channel State Information, CSI, and Received Signal Strength Indicator, RSSI.

20. The apparatus according to any one of claims 15 to 19, wherein

the interference measurement is obtained by comparing channel state information, CSI, and reference signal received power, RSRP, measurements in the user equipment.

21. The apparatus according to anyone of claims 15 to 20, wherein

the inter-frequency measurement includes measuring at least one of Received Signal Strength Indicator, RSSI, and Reference Signal Received Power, RSRP.

22. The apparatus according to anyone of claims 15 to 21, wherein the at least one memory and the instructions are further configured to, with the at least one processor, cause the apparatus at least to perform:

determining, whether for the at least one first carrier in the unlicensed spectrum, a predetermined condition is met,

wherein the interference measurement is performed, if it is determined that the predetermined condition is met.

23. The apparatus according to claim 22, wherein

the predetermined condition includes a data transmission being performed on the at least one first carrier.

24. An apparatus for use in a base station, comprising:

at least one processor,

and

at least one memory for storing instructions to be executed by the processor, wherein

the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:

configuring at least one second carrier in an unlicensed spectrum on which a user equipment should perform inter-frequency measurements, and

informing the user equipment about

a condition, when the user equipment should perform interference measurements on at least one first carrier different from the at least one second carrier, and

a threshold for the interference measurement results triggering inter-frequency measurements on the at least one second carrier.

25. The apparatus according to claim 24, wherein the at least one memory and the instructions are further configured to, with the at least one processor, cause the apparatus at least to perform:

receiving inter-frequency measurement results from the user equipment.

26. The apparatus according to claim 24 or 25, wherein
 informing the user equipment about the condition comprises
 defining the condition and transmitting the condition to the user
 equipment, or
 informing the user equipment that the condition is predetermined based
 on capabilities of the user equipment.
27. The apparatus according to any one of claims 24 to 26, wherein
 informing the user equipment about the threshold comprises
 configuring the threshold and transmitting the threshold to the user
 equipment,
 instructing the user equipment to use a predetermined threshold, or
 instructing the user equipment to decide the threshold by itself.
28. The apparatus according to any one of claims 24 to 27, wherein
 configuring the at least one second carrier in the unlicensed spectrum to
perform inter-frequency measurements on comprises at least one of
 indicating a channel number according to a first wireless communication
technology,
 indicating a channel number according to a second wireless communication
technology, and
 indicating a bandwidth centering around a specific frequency.
29. A computer program product including a program for a processing device,
comprising software code portions for performing the method of any one of claims 1
to 14 when the program is run on the processing device.
30. The computer program product according to claim 29, wherein the computer
program product comprises a computer-readable medium on which the software
code portions are stored.
31. The computer program product according to claim 29, wherein the program is
directly loadable into an internal memory of the processing device.

32. An apparatus for use in a user equipment, comprising:

means for performing an interference measurement on at least one first carrier allocated to the user equipment,

means for evaluating, whether the interference measurement result exceeds a specific threshold, and

if it is evaluated that the interference measurement result exceeds the specific threshold,

means for triggering inter-frequency measurements on at least one second carrier different from the at least one first carrier.

33. An apparatus for use in a base station, comprising:

means for configuring at least one second carrier in an unlicensed spectrum on which a user equipment should perform inter-frequency measurements, and

means for informing the user equipment about

a condition, when the user equipment should perform interference measurements on at least one first carrier different from the at least one second carrier, and

a threshold for the interference measurement results triggering inter-frequency measurements on the at least one second carrier.

Fig. 1

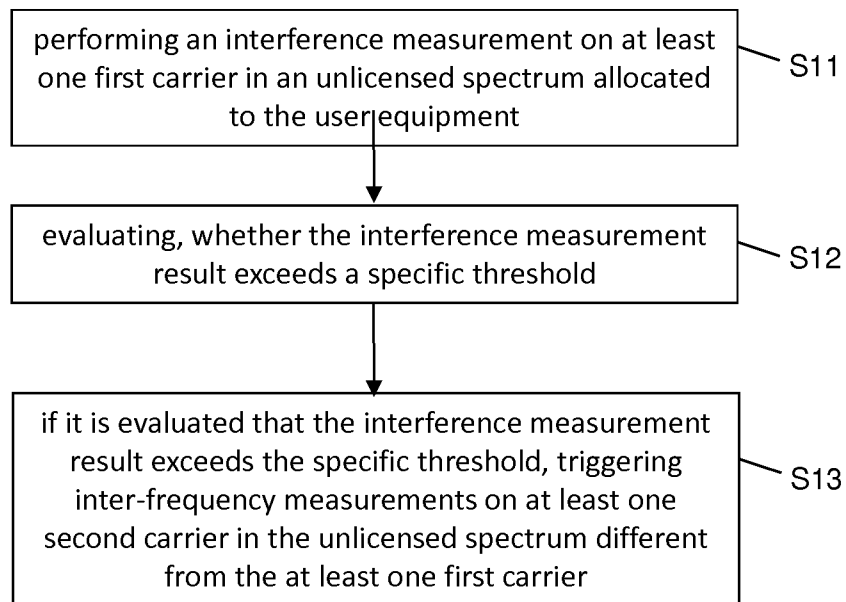


Fig. 2

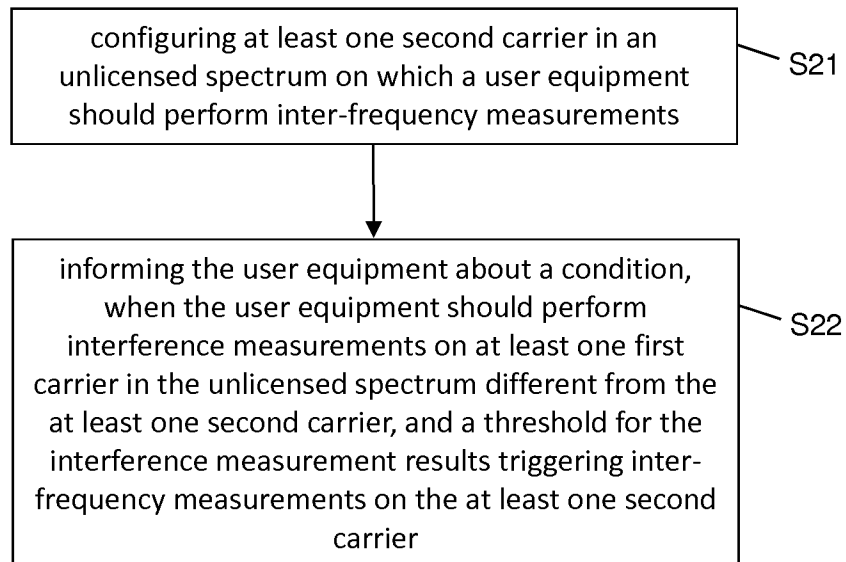
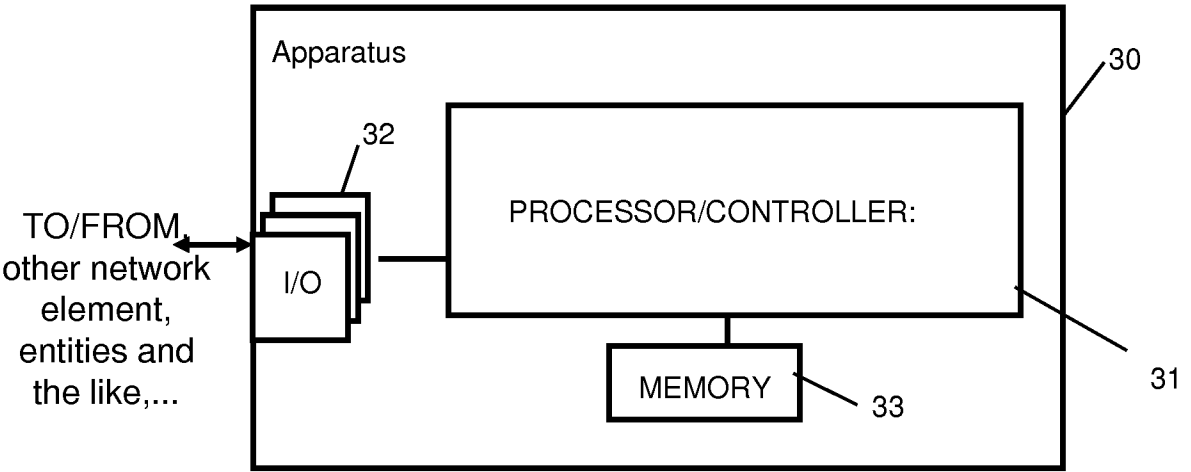


Fig. 3



INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/057709

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W24/10
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)
H04W

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/010687 A1 (GAAL PETER [US] ET AL) 10 January 2013 (2013-01-10)	1-3, 5-11, 15-17, 19-25, 29-33
Y	paragraphs [0058] - [0068], [0075] figure 7B	4,12-14, 18,26-28
Y	----- WO 2013/059999 A1 (RENESAS MOBILE CORP [JP]; BAI WEI [CN]; HENTTONEN TERO [FI]; WEI NA [C] 2 May 2013 (2013-05-02) cited in the application page 2, line 24 - page 3, line 1 page 7, line 23 - page 12, line 5 ----- -/-	4,12-14, 18,26-28



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

9 September 2015

Date of mailing of the international search report

15/09/2015

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/057709

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

PCT/EP2015/057709

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