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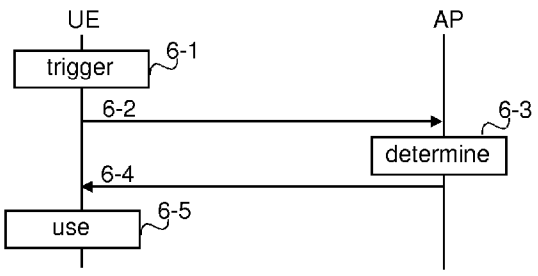


FIG.6

(57) Abstract: Existence of wireless networks on unlicensed frequency bands is constantly increasing. By its nature, the unlicensed spectrum is shared among numerous technologies that co-exist with each other, without necessarily knowing their co-existence. To increase knowledge on co-existence, a user device comprising two or more transceivers for providing different radio access to at least one unlicensed band is configured to monitor at least states of the two or more transceivers, and to send information on at least one of the states to a network element providing services at least on the unlicensed band. The network element is configured to use the information to determine at least one or more channel parameters for the unlicensed band, and to inform the user device on the channel parameters. The user device is configured to use the channel parameters.

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UNLICENCED BANDS

TECHNICAL FIELD

Various example embodiments relates to wireless communications.

BACKGROUND

Wireless communication systems are under constant development. The need for faster communication and huge increase of the data amount create challenges for the wireless communications systems. One way to tackle the challenges is to make use of unlicensed spectrum. By its nature, the unlicensed spectrum is shared among numerous technologies that co-exist with each other, without necessarily knowing their co-existence.

BRIEF DESCRIPTION

According to an aspect, there is provided the subject matter of the independent claims. Some embodiments are defined in the dependent claims.

An aspect provides a user device comprising: two or more transceivers for providing different radio access to one or more unlicensed bands; at least one processor; and at least one memory including computer program code; the at least one memory and computer program code configured to, with the at least one processor, cause the user device at least to perform: monitoring at least states of the two or more transceivers; causing sending at least one of the states to a network element providing services on at least one of the one or more unlicensed bands; and using, in response to receiving from the network element information on one or more parameters for the at least one of the one or more unlicensed bands, the one or more parameters.

In a further aspect the at least one memory and computer program code configured to, with the at least one processor, further cause the user device at least to perform the causing sending in response to at least one of the following: detecting, by the user device, a change in a state of a transceiver; associating, by the user device, to the network element; and receiving, by the user device, from the network element a request for the states.

In another aspect, the at least one memory and computer program code configured to, with the at least one processor, further cause the user device at least to perform the causing sending in response to at least one of the following: main-

taining in the memory as configuration information different parameter sets; receiving the information on the one or more parameters as an indication of a parameter set to be used; and using the parameter set indicated.

An aspect provides a network element comprising: at least one processor; and at least one memory including computer program code; the at least one memory and computer program code configured to, with the at least one processor, cause the network element at least to perform: determining, based on at least state information on co-existing radios on an unlicensed band received from one or more user devices, one or more channel parameters for the unlicensed band; and causing informing the one or more user devices on the one or more channel parameters.

In an aspect the at least one memory and computer program code configured to, with the at least one processor, further cause the network element at least to perform causing sending request for the state information to the one or more user devices.

In another aspect the at least one memory and computer program code configured to, with the at least one processor, further cause the network element at least to perform the informing by broadcasting either an indication of a parameter set to be used or the one or more parameters.

An aspect provides a method comprising: monitoring, by a user device, at least states of two or more transceivers of the user devices, said transceivers providing different radio access to one or more unlicensed bands; causing sending from the user device at least one of the states to a network element providing services on at least one of the one or more unlicensed bands; receiving, by the user device, from the network element, information on one or more parameters for the at least one of the one or more unlicensed bands; and using the one or more parameters.

In another aspect the method further comprises; detecting, by the user device, a change in a state of a transceiver; and causing the sending in response to the detecting.

In an aspect, the method further comprises associating, by the user device, to the network element; and causing the sending in response to the associating.

In a still further aspect, the method further comprises: receiving, by the user device, from the network element a request for the states; and causing the sending in response to the receiving the request.

In another aspect, the method further comprises: maintaining, by the user device, in a memory different parameter sets as configuration information; receiving, by the user device, the information on the one or more parameters as an indication of a parameter set to be used; and using, by the user device, the parameter set indicated.

Still another aspect provides a method comprising: receiving, by an network element, from one or more user devices, state information on co-existing radios on an unlicensed band; determining, by the network element, based on at least received state information, one or more channel parameters for the unlicensed band; and causing, by the network element, informing the one or more user devices on the one or more channel parameters.

In an aspect, the method further comprises causing, by the network element, sending request for the state information to the one or more user devices.

In an aspect, the method further comprises performing the informing by broadcasting either an indication of a parameter set to be used or the one or more parameters.

An aspect provides a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: monitoring at least states of two or more transceivers of the apparatus; causing sending at least one of the states to a network element providing services on at least one of the one or more unlicensed bands; and using, in response to receiving from the network element information on one or more parameters for the at least one of the one or more unlicensed bands, the one or more parameters.

Another aspect provides a computer program comprising instructions for causing an apparatus to perform at least the following: monitoring at least states of two or more transceivers of the apparatus; causing sending at least one of the states to a network element providing services on at least one of the one or more unlicensed bands; and using, in response to receiving from the network element information on one or more parameters for the at least one of the one or more unlicensed bands, the one or more parameters.

Still another aspect provides a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: determining, based on at least state information on co-existing radios on an unlicensed band received from one or more user devices, one or more channel parameters for the unlicensed band; and causing informing the one or more user devices on the one or more channel parameters.

An aspect provides a computer program comprising instructions for causing an apparatus to perform at least the following: determining, based on at least state information on co-existing radios on an unlicensed band received from one or more user devices, one or more channel parameters for the unlicensed band; and causing informing the one or more user devices on the one or more channel parameters.

An aspect provides a signal with embedded data comprising at least one or more values to indicate transceivers that provide in a user device different radio access to one or more unlicensed bands and tranceivers' current state.

Another aspect provides a signal with embedded data comprising at least one or more values to indicate one or more channel parameters for an unlicensed band to user devices with transceivers providing different radio access to the unlicensed band.

In an aspect the one or more values are within action frames.

One or more examples of implementations are set forth in more detail in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF DRAWINGS

In the following, example embodiments will be described in greater detail with reference to the attached drawings, in which

Figures 1 and 2 illustrate exemplified wireless communication systems;

Figures 3 to 7 illustrate exemplified processes; and

Figures 8 and 9 are schematic block diagrams.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

The following embodiments are only presented as examples. Although the specification may refer to "an", "one", or "some" embodiment(s) and/or example(s) in several locations of the text, this does not necessarily mean that each reference is made to the same embodiment(s) or example(s), or that a particular feature only applies to a single embodiment and/or example. Single features of different embodiments and/or examples may also be combined to provide other embodiments and/or examples.

Embodiments and examples described herein may be implemented in any communications system comprising wireless connection(s). In the following, different exemplifying embodiments will be described using, as an example of an

access architecture to which the embodiments may be applied, a radio access architecture based on long term evolution advanced (LTE Advanced, LTE-A) or new radio (NR, 5G), without restricting the embodiments to such an architecture, however. It is obvious for a person skilled in the art that the embodiments may also be applied to other kinds of communications networks having suitable means by adjusting parameters and procedures appropriately. Some examples of other options for suitable systems are the universal mobile telecommunications system (UMTS) radio access network (UTRAN or E-UTRAN), long term evolution (LTE, the same as E-UTRA), beyond 5G, wireless local area network (WLAN or WiFi), worldwide interoperability for microwave access (WiMAX), Bluetooth®, personal communications services (PCS), ZigBee®, wideband code division multiple access (WCDMA), systems using ultra-wideband (UWB) technology, sensor networks, mobile ad-hoc networks (MANETs) and Internet Protocol multimedia subsystems (IMS) or any combination thereof.

Figure 1 depicts examples of simplified system architectures only showing some elements and functional entities, all being logical units, whose implementation may differ from what is shown. The connections shown in Figure 1 are logical connections; the actual physical connections may be different. It is apparent to a person skilled in the art that the system typically comprises also other functions and structures than those shown in Figure 1.

The embodiments are not, however, restricted to the system given as an example but a person skilled in the art may apply the solution to other communication systems provided with necessary properties.

The example of Figure 1 shows a part of an exemplifying radio access network.

Figure 1 shows user devices 101 and 101' configured to be in a wireless connection on one or more communication channels in a cell with an access node (such as (e/g)NodeB) 102 providing the cell. The physical link from a user device to a (e/g)NodeB is called uplink or reverse link and the physical link from the (e/g)NodeB to the user device is called downlink or forward link. It should be appreciated that (e/g)NodeBs or their functionalities may be implemented by using any node, host, server or access point etc. entity suitable for such a usage.

A communications system 100 typically comprises more than one (e/g)NodeB in which case the (e/g)NodeBs may also be configured to communicate with one another over links, wired or wireless, designed for the purpose. These links may be used for signalling purposes. The (e/g)NodeB is a computing device

configured to control the radio resources of communication system it is coupled to. The NodeB may also be referred to as a base station, an access point (AP), an access node or any other type of interfacing device including a relay station capable of operating in a wireless environment. The (e/g)NodeB includes or is coupled to transceivers. From the transceivers of the (e/g)NodeB, a connection is provided to an antenna unit that establishes bi-directional radio links to user devices. The antenna unit may comprise a plurality of antennas or antenna elements. The (e/g)NodeB is further connected to core network 105 (CN or next generation core NGC). Depending on the system, the counterpart on the CN side can be a serving gateway (S-GW, routing and forwarding user data packets), packet data network gateway (P-GW), for providing connectivity of user devices (UEs) to external packet data networks, or mobile management entity (MME), etc.

The user device (also called UE, user equipment, user terminal, terminal device, etc.) illustrates one type of an apparatus to which resources on the air interface are allocated and assigned, and thus any feature described herein with a user device may be implemented with a corresponding apparatus, such as a relay node. An example of such a relay node is a layer 3 relay (self-backhauling relay) towards the base station.

The user device typically refers to a portable computing device that includes wireless mobile communication devices operating with or without a subscriber identification module (SIM), including, but not limited to, the following types of devices: a mobile station (mobile phone), smartphone, personal digital assistant (PDA), handset, device using a wireless modem (alarm or measurement device, etc.), laptop and/or touch screen computer, tablet, game console, notebook, and multimedia device. It should be appreciated that a user device may also be a nearly exclusive uplink only device, of which an example is a camera or video camera loading images or video clips to a network. A user device may also be a device having capability to operate in Internet of Things (IoT) network which is a scenario in which objects are provided with the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The user device may also utilise cloud. In some applications, a user device may comprise a small portable device with radio parts (such as a watch, earphones or eyeglasses) and the computation is carried out in the cloud. The user device (or in some embodiments a layer 3 relay node) is configured to perform one or more of user equipment functionalities. The user device may also be called a subscriber unit, mobile

station, remote terminal, access terminal, user terminal or user equipment (UE) just to mention but a few names or apparatuses.

Various techniques described herein may also be applied to a cyber-physical system (CPS) (a system of collaborating computational elements controlling physical entities). CPS may enable the implementation and exploitation of massive amounts of interconnected ICT devices (sensors, actuators, processors microcontrollers, etc.) embedded in physical objects at different locations. Mobile cyber physical systems, in which the physical system in question has inherent mobility, are a subcategory of cyber-physical systems. Examples of mobile physical systems include mobile robotics and electronics transported by humans or animals.

Additionally, although the apparatuses have been depicted as single entities, different units, processors and/or memory units (not all shown in Figure 1) may be implemented.

5G enables using multiple input – multiple output (MIMO) antennas, many more base stations or nodes or corresponding network devices than the LTE (a so-called small cell concept), including macro sites operating in co-operation with smaller stations and employing a variety of radio technologies depending on service needs, use cases and/or spectrum available. 5G mobile communications supports a wide range of use cases and related applications including video streaming, augmented reality, different ways of data sharing and various forms of machine type applications (such as (massive) machine-type communications (mMTC), including vehicular safety, different sensors and real-time control. 5G is expected to have multiple radio interfaces, namely below 6GHz, cmWave and mmWave, and also being integradable with existing legacy radio access technologies, such as the LTE. Integration with the LTE may be implemented, at least in the early phase, as a system, where macro coverage is provided by the LTE and 5G radio interface access comes from small cells by aggregation to the LTE. In other words, 5G is planned to support both inter-RAT operability (such as LTE-5G) and inter-RI operability (inter-radio interface operability, such as below 6GHz – cmWave, below 6GHz – cmWave – mmWave). One of the concepts considered to be used in 5G networks is network slicing in which multiple independent and dedicated virtual sub-networks (network instances) may be created within the same infrastructure to run services that have different requirements on latency, reliability, throughput and mobility.

The current architecture in LTE networks is fully distributed in the radio and fully centralized in the core network. The low latency applications and services in 5G require to bring the content close to the radio which leads to local break

out and multi-access edge computing (MEC). 5G enables analytics and knowledge generation to occur at the source of the data. This approach requires leveraging resources that may not be continuously connected to a network such as laptops, smartphones, tablets and sensors. MEC provides a distributed computing environment for application and service hosting. It also has the ability to store and process content in close proximity to cellular subscribers for faster response time. Edge computing covers a wide range of technologies such as wireless sensor networks, mobile data acquisition, mobile signature analysis, cooperative distributed peer-to-peer ad hoc networking and processing also classifiable as local cloud/fog computing and grid/mesh computing, dew computing, mobile edge computing, cloudlet, distributed data storage and retrieval, autonomic self-healing networks, remote cloud services, augmented and virtual reality, data caching, Internet of Things (massive connectivity and/or latency critical), critical communications (autonomous vehicles, traffic safety, real-time analytics, time-critical control, healthcare applications).

The communication system is also able to communicate with other networks, such as a public switched telephone network or the Internet 106, or utilise services provided by them. The communication network may also be able to support the usage of cloud services, for example at least part of core network operations may be carried out as a cloud service (this is depicted in Figure 1 by "cloud" 107). The communication system may also comprise a central control entity, or a like, providing facilities for networks of different operators to cooperate for example in spectrum sharing.

Edge cloud may be brought into radio access network (RAN) by utilizing network function virtualization (NVF) and software defined networking (SDN). Using edge cloud may mean access node operations to be carried out, at least partly, in a server, host or node operationally coupled to a remote radio head or base station comprising radio parts. It is also possible that node operations will be distributed among a plurality of servers, nodes or hosts. Application of cloudRAN architecture enables RAN real time functions being carried out at the RAN side (in a distributed unit, DU 102) and non-real time functions being carried out in a centralized manner (in a centralized unit, CU 104).

It should also be understood that the distribution of labour between core network operations and base station operations may differ from that of the LTE or even be non-existent. Some other technology advancements probably to be

used are Big Data and all-IP, which may change the way networks are being constructed and managed. 5G (or new radio, NR) networks are being designed to support multiple hierarchies, where MEC servers can be placed between the core and the base station or nodeB (gNB). It should be appreciated that MEC can be applied in 4G networks as well.

5G may also utilize satellite communication to enhance or complement the coverage of 5G service, for example by providing backhauling. Possible use cases are providing service continuity for machine-to-machine (M2M) or Internet of Things (IoT) devices or for passengers on board of vehicles, or ensuring service availability for critical communications, and future railway/maritime/aeronautical communications. Satellite communication may utilise geostationary earth orbit (GEO) satellite systems, but also low earth orbit (LEO) satellite systems, in particular mega-constellations (systems in which hundreds of (nano)satellites are deployed). Each satellite 103 in the mega-constellation may cover several satellite-enabled network entities that create on-ground cells. The on-ground cells may be created through an on-ground relay node 102 or by a gNB located on-ground or in a satellite.

It is obvious for a person skilled in the art that the depicted system is only an example of a part of a radio access system and in practice, the system may comprise a plurality of (e/g)NodeBs, the user device may have an access to a plurality of radio cells and the system may comprise also other apparatuses, such as physical layer relay nodes or other network elements, etc. At least one of the (e/g)NodeBs or may be a Home(e/g)nodeB. Additionally, in a geographical area of a radio communication system a plurality of different kinds of radio cells as well as a plurality of radio cells may be provided. Radio cells may be macro cells (or umbrella cells) which are large cells, usually having a diameter of up to tens of kilometers, or smaller cells such as micro-, femto- or picocells. The (e/g)NodeBs of Figure 1 may provide any kind of these cells. A cellular radio system may be implemented as a multilayer network including several kinds of cells. Typically, in multilayer networks, one access node provides one kind of a cell or cells, and thus a plurality of (e/g)NodeBs are required to provide such a network structure.

For fulfilling the need for improving the deployment and performance of communication systems, the concept of "plug-and-play" (e/g)NodeBs has been introduced. Typically, a network which is able to use "plug-and-play" (e/g)Node Bs, includes, in addition to Home (e/g)NodeBs (H(e/g)nodeBs), a home node B gate-

way, or HNB-GW (not shown in Figure 1). A HNB Gateway (HNB-GW), which is typically installed within an operator's network may aggregate traffic from a large number of HNBs back to a core network.

As mentioned, existence of wireless networks on unlicensed frequency bands is constantly increasing. Base stations, called below access nodes, may support one or more radio access technologies configured to operate on the unlicensed, licensed and/or shared frequency bands, and user devices may be configured to support multiple radio access technologies, on the unlicensed, licensed, and/or on shared frequency bands. Examples of radio access technologies using the unlicensed band include IEEE 802.11 (Wi-Fi), IEEE 802.15, IEEE 802.16, Long-Term Evolution Unlicensed (LTE-U), Licensed Assisted Access (LAA), LTE-Wi-Fi Aggregation (LWA), New Radio Licensed Assisted Access (NR-LAA), other unlicensed variants standardized as a part of 5G technology, MulteFire. Many of the user devices can send and receive data on multiple radio access technologies, such as cellular, Long Term Evolution (LTE), IEEE 802.11 (Wi-Fi), IEEE 802.15.1 (Bluetooth®), and other radio access technologies. Some radio access technologies operate also on licensed frequency bands. Further, some radio access technologies may operate on several unlicensed frequency band. For example, IEEE 802.11 operates on 2.4 GHz, 5 GHz, and 60 GHz unlicensed frequency bands. An example of a shared frequency band (shared wireless access) is Citizens Broadband Radio Service (CBRS) that operates on 3.5 GHz band, using the same radio interface as LTE in the licensed spectrum or in the unlicensed 5 GHz band.

Figure 2 illustrates a simplified example of a wireless system 200 having co-existing wireless networks operating on unlicensed bands. Wireless networks operating on unlicensed frequency bands have typically overlapping coverage areas in an uncontrolled manner. This arises from the fact that entities that establish the networks, e.g. business, communal, or private entities, are not mandated to negotiate about the spectrum utilization. For example, in a shopping centre various shops may each provide a wireless network for customers. Access nodes (or equally access points, APs) 220, 220', 220'' of different managers (private or public) are illustrated in Figure 2. Accordingly, the different access nodes supporting different radio access technologies or the same radio access technology with different bands, or in different networks, may occupy radio resources, e.g. time-frequency resources that overlap and reduce capacity of one or more of the access nodes. When the spectrum gets more crowded with networks operating on overlapping resources, there exists a need to share information on the spectrum

usage. With the help of active information sharing on the spectrum usage one may, for example, implement different type of network etiquettes to facilitate band and channel sharing.

An access node may be configured to support information sharing. For that purpose, an access node 220 sending and receiving information via one or more radios 221 may comprise a co-existence management unit 222 and one or more memories 223 storing at least temporarily co-existence related information. In the example illustrated in Figure 2, it is assumed that the access node 220 provides a wireless local area network (WLAN), and therefore the radio 221 is a WLAN radio, the co-existence management unit 222 is called a clear channel assessment (CCA) manager and that the co-existence related information in the memory 223 is presence related information, without limiting the solution to such an example. Further, it should be appreciated that the other access nodes 220', 220'' may also be configured correspondingly, or one or both of them may be legacy access node not configured to support information sharing. Although in the example of Figure 2 it is assumed that each access node, which is configured to support information sharing, comprises a co-existence management unit (CCA manager) 222, it should be appreciated that some, or all, access nodes, which are configured to support information sharing, may be configured to use a common co-existence management unit. The common co-existence management unit may be a cloud-based unit.

The user devices 210 (only one depicted in Figure 2), or some of them, that are configured to support different radio access technologies, or different bands, including one or more unlicensed bands, may be configured to support the information sharing. For that purpose the user device 210, comprising two or more different transceivers 211, 211' for different types of radio access technologies, comprises an unlicensed band unit 212 and in its memory 213 at least temporary information on at least states of the different types, and one or more parameters to be used for the unlicensed band. Since WLAN is used as an example in Figure 2, the unlicensed band unit 212 comprises, as sub-units, a device radio manager (DRM) unit 212-1, and an enhanced WLAN station module unit (e-STA-m) 212-2, without limiting the solution to such an example. Further, herein term "radio" is used as a synonym to "a transceiver for a radio access technology" and term "user device" is used for the sake of clarity in the same meaning as station or non-AP STA is used in IEEE 802.11, i.e. as a device that is not operating as an access node.

Although in Figure 2 the unlicensed band unit 212 is divided into two sub-units, in the examples below the division is not highlighted. In principle, the

device radio manager unit 212-1 will be aware of at least transceiver types available in the user device for unlicensed bands, and in a general level aware of their usage, for example whether a transceiver type is idle or active, i.e. its state, and informs the enhanced WLAN station module unit on presence of transceiver types and/or their states and/or state changes. The device radio manager unit 212-1 may be aware of transmission/reception schedules. However, that is not necessary for the information sharing. The enhanced WLAN station module unit is the unit responsible for information exchange with the access node. In other words, the device radio manager unit gathers information on transceiver usage, or at least states, and informs the enhanced WLAN station module units, that in turn informs the access node, via WLAN transceiver in the user device. The device radio manager unit may be implemented in several different ways, for example, using function calls or using status registers that are readable and writable by different modules, like the enhances WLAN station module unit.

Figures 3 and 4 illustrate different functionality relating to information sharing in a user device, or more precisely different functionality of the unlicensed band unit.

Referring to Figure 3, to provide the access node with information from the user device, states of the different transceiver types, i.e. different radios, are monitored in block 301, and sending at least information on one or more states of one or more radios is caused in block 302. The sending may be caused in response to detecting a change in the state information, and/or at certain intervals and/or in response to receiving from the access node a request for the state information.

For example, information sent in block 302 may convey to the access node following information: “this user device has a new radio (NR) which went from idle to active”.

Referring to Figure 4, to adjust the user device according to the information received by the user device from the access node, when indication on one or more parameters to be used for the unlicensed spectrum are received in block 401, the indicated parameters are used in block 402 as long as new parameters are received (block 401), or otherwise indicated/configured (not shown in Figures).

Figure 5 illustrates an example of how to implement the information sharing in an access node. More precisely, it illustrates an example of functionalities of the co-existence management unit.

Referring to Figure 5, state information, i.e. information on at least one or more states of one or more radios, is received in block 501 from one or more

user devices. The information is used in block 502 to determine one or more parameters that are to be used, and informing user devices on the one or more parameters is caused in block 503. The way the parameters are determined bears no significance, and therefore there is no need to describe the actual determining in detail.

For example, information sent in block 503 may indicate to the user devices to use for all transceiver types the same energy detection threshold. Such a uniform parameterization to determine when a channel is free enable fair use of the unlicensed medium. It should be appreciated that the energy detection threshold is used herein only as an example of parameters for a concept, which can be called a channel sharing etiquette. Such parameters relate to how devices, which operate on the same channel or on the same band, operate in terms of channel/band sharing. For example, signal level based etiquette, applied in 5 GHz unlicensed band, for example, may be applied herein. Another example includes having one or more parameters that indicate limits in a frequency domain, such as giving a bandwidth limit to the user devices. Still a further example includes one or more parameters relating to an allowable channel operation time, i.e. time one is allowed to operate in the channel. For example, a duty cycle parameter could have a value between 0 and 1, the value indicating the relative use of the channel by the device. Other examples include parameter(s) indicating an upper limit for contiguous transmission and/or a minimum time between two consecutive transmissions. Figures 6 and 7 illustrate different information exchange scenarios, assuming that WLAN is used in information sharing, without limiting the examples to such a solution. Further, it should be appreciated that even though one user device UE is illustrated in the examples, the user device is actually illustrating several user devices served by the access node.

Referring to Figure 6, the user device UE triggers in point 6-1 sending state information to the access node (i.e., the access point, AP), and the information is sent in message 6-2.

For example, presence of another radio, other than WLAN radio, such as the new radio (NR, 5G), is detected, or a state of a radio changes, which then triggers the sending. In such a case the information may be sent as an unsolicited radio measurement report. For example, an action frame sent in message 6-2 may be as follows:

Action Frame:

category = 5 “radio measurement”
radio measurement action = 1 “radio measurement report”
dialog token = 0 “unsolicited”
measurement report elements = new element defined in 9.4.22.19 “co-existence report”

In another example, the information is sent when the user device UE associates to the access node AP, or for some other reason issues a query to one of the access nodes APs. In such a case message 6-2 may be an association request message, a probe request message, or a general advertisement service (GAS) based message including radio measurement report, for example.

The access node AP, i.e. the clear channel assessment manager, gathers radio measurement reports received from user devices and determines, in point 6-3, the CCA parameter set to be used. For example, the access node AP may determine not to set a presence flag, if the user device has reported a radio that is not using the same resources as the access node. For example, the report may indicate that the radio uses different channels and/or time schedules. It should be appreciated that there are multiple different ways how to convey the information, and further that a variety of information may be communicated. However, at the simplest the report indicates or comprises the CCA parameter set.

Once the CCA parameter set is determined, the user device is (actually user devices are) informed on the set when the user device UE receives message 6-4 sent by the access node AP. Message 6-4 may be a beacon message (i.e. broadcast message) that comprises an information element conveying information on the CCA parameter set. Alternatively, the message 6-4 may be a unicast message like a probe response or an association response message that comprises an information element conveying information on the CCA parameter set. After being informed, the user device UE uses (point 6-5) the CCA parameter set communicated in the message. (The CCA parameter set may comprise the energy detection threshold, for example.)

In one implementation the user device has been preconfigured to contain different CCA parameter sets, or the access node has sent prior the information exchange of Figure 6 one or more configuration messages to the user device UE, thereby configuring the user device with the different CCA parameter sets. For example, the parameter sets with associated index values may be communicated over the air in beacon messages, and the parameter value set that the access node AP

wants to be used is indicated with another parameter that is also communicated over the air, for example in a beacon message, a probe response, or an association response message. In such implementations, the information element in message 6-4 may be a bit indicating which one of the CCA parameter sets to use. Naturally, the same approach may be used if, in future, possible parameter value sets have been specified in a specification, for example in IEEE 802.11 specification, and thereby also implemented in the user devices, with an associated set index, or corresponding information.

In another implementation the information element in message 6-4 contains the CCA parameter set that is to be used.

As is evident from the above, message 6-4 may be used to indicate various information relating to co-existence. In a further example, the access node AP may use message 6-4 to indicate, in addition to the CCA parameter set, also whether there are other radio technologies used (present) in the environment, for example by a flag (a kind of presence flag). In a further example such a flag, or any corresponding piece of information, may be used, for example by different values of the flag, to indicate (directly determine) one or more actions to be performed by the user device and/or type(s) of the other radio technology (types of other technologies), such as NR (by means of an NR flag "on " or "off", for example). Further, such a flag, or any corresponding piece of information, may be used to indicate whether the other technology operates in another channel on the same band, or in the same channel (i.e. shares the channel). It is also possible that such channel/band information may indicate (determine), which CCA parameters are to be used. Naturally, such a flag may just be sent to the user device(s) as background information on the operating information.

Referring to Figure 7, the access node AP triggers sending state information from the user device UE to the access node AP by sending message 7-1 querying states of their radios, and the user device sends the state information in message 7-2. After that the process continues as in Figure 6, so determining in point 7-3 corresponds to determining in point 6-3, message 7-4 corresponds to message 6-4, and using in point 7-5 corresponds to using in point 6-5, and therefore they are not described in more detail with Figure 7.

Message 7-1 may be a message containing in its frame body part "Action Frame: radio measurement request", and message 7-2 may be a message containing in its frame body part "Action Frame: radio measurement report, dialog token = next".

The messages may re-use existing radio measurement category. For example, category field value '5' defined for radio measurement may be used in action frames, and in measurement request elements as an element identifier value '38' may be used, but for measurement type a new value, such as '17', which has not yet been defined to specify a specific measurement, may be used to specify that the measurement is for co-existence measurement. Further, in the same radio request element, after the measurement type, the value in a field "measurement request" could be used to indicate what the user device should report. For example, value '0' requests the user device to report to the access node information on the user device's radios (radio interfaces). Another value could be used to request the user device to report on state changes in the user device's radios (radio interfaces). For example, the user device may be requested to report whenever any of the radio interfaces that operates in an unlicensed band is activated or deactivated. The user device may be also requested to report on changes in a mode of an active radio interface. A radio interface may be operated, for example, in different modes, and the mode may have an impact on the behavior and requirements of the radio interface. Examples of different modes include discovery mode, paging mode, power save mode, and active mode. It should be appreciated that if only one report type is in use, the measurement request field may be left empty.

In another example, that re-uses existing radio measurement category, category field value '5' defined for radio measurement may be used in action frames, but in the following field defining radio measurement action, new values are used. For example value '6' defines that the message is for co-existence measurement request and value '7' defines that the message is a corresponding measurement report message.

Instead of re-using existing radio measurement category, a new category value, such as '22' may be defined for co-existence measurements, and the first octet after the category value may be used to indicate, whether the frame is a co-existence measurement request frame (e.g. value '0'), or a co-existence measurement response frame (e.g. value '1'). The request and report elements may be the same as those described above.

The measurement report may contain a list of radios in the user device and their current state (active/inactive), for example using following values with following meanings:

0=no non-WLAN radio active

1=NR radio becomes active

2=NR radio becomes inactive
3=NR radio active outside used WLAN band
4=....
X=MulteFire becomes active,
etc.

Further, several values may be concatenated, since some of the above possibilities are not mutually exclusive. The same applies to the reports discussed above with Figure 6.

Although not separately illustrated above, a user device may send information on the state(s) of the transceiver(s) to those access nodes to which the user device is connected to (associated to).

In some embodiments, the actions performed by the access node (i.e., a network node or network element providing wireless access) according to any embodiments as described above may be performed fully or partly by another network node or network element or even by multiple network nodes/elements. For example, said actions (or at least some of said actions) may be performed, instead of the access node, by a core element or by an edge cloud (element).

The blocks, related functions, and information exchanges described above by means of Figures 3 to 7 are in no absolute chronological order, and some of them may be performed simultaneously or in an order differing from the given one. Other functions can also be executed between them or within them, and other information may be sent, and/or other rules applied. Some of the blocks or part of the blocks or one or more pieces of information can also be left out or replaced by a corresponding block or part of the block or one or more pieces of information.

The techniques and methods described herein may be implemented by various means so that an apparatus/device configured to support information sharing based on at least partly on what is disclosed above with any of Figures 1 to 7, including implementing one or more functions/operations of a corresponding user device or access node (or network element) described above with an embodiment/example, for example by means of any of Figures 3 to 7, comprises not only prior art means, but also means for implementing the one or more functions/operations of a corresponding functionality described with an embodiment, for example by means of any of Figures 3 to 7, and it may comprise separate means for each separate function/operation, or means may be configured to perform two or more

functions/operations. For example, one or more of the means and/or the unlicensed band unit, or its sub-units, and/or the co-existence management unit, or its sub-units, described above may be implemented in hardware (one or more devices), firmware (one or more devices), software (one or more modules), or combinations thereof. For a hardware implementation, the apparatus(es) of embodiments may be implemented within one or more application-specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, logic gates, decoder circuitries, encoder circuitries, other electronic units designed to perform the functions described herein by means of Figures 1 to 7, or a combination thereof. For firmware or software, the implementation can be carried out through modules of at least one chipset (e.g. procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in a memory unit and executed by processors. The memory unit may be implemented within the processor or externally to the processor. In the latter case, it can be communicatively coupled to the processor via various means, as is known in the art. Additionally, the components described herein may be rearranged and/or complemented by additional components in order to facilitate the achievements of the various aspects, etc., described with regard thereto, and they are not limited to the precise configurations set forth in the given figures, as will be appreciated by one skilled in the art.

Figure 8 provides a user device (apparatus, equipment) according to some embodiments. Figure 8 illustrates a user device configured to carry out at least the functions described above in connection with information sharing. Each user device may comprise one or more communication control circuitry, such as at least one processor 802, and at least one memory 804, including one or more algorithms 803, such as a computer program code (software) wherein the at least one memory and the computer program code (software) are configured, with the at least one processor, to cause the user device to carry out any one of the exemplified functionalities of the user device described above.

Referring to Figure 8, at least one of the communication control circuitries in the user device (apparatus) 800 is configured to provide the unlicensed band unit, or its sub-units, and to carry out functionalities described above by means of any of Figures 2 to 7 by one or more circuitries.

Referring to Figure 8, the memory 804 may be implemented using any suitable data storage technology, such as semiconductor based memory devices,

flash memory, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory.

Referring to Figure 8, the user device may further comprise different interfaces 801 such as two or more communication interfaces (TX/RX) comprising hardware and/or software for realizing communication connectivity over the medium according to one or more communication protocols. The communication interface may provide the user device with communication capabilities to communicate in the cellular communication system and enable communication between terminal devices and different network nodes or elements, for example. The communication interface may comprise standard well-known components such as an amplifier, filter, frequency-converter, (de)modulator, and encoder/decoder circuitries, controlled by the corresponding controlling units, and one or more antennas. The communication interfaces comprise radio interface components providing the user device radio communication capability to use the unlicensed band. The user device may also comprise different user interfaces.

Figure 9 provides an access node or other network node or network element (apparatus, device) according to some embodiments. Figure 9 illustrates an access node or other network element (in the following, simply "the access node" for brevity) configured to carry out at least the functions described above in connection with information sharing. Each access node may comprise one or more communication control circuitry, such as at least one processor 902, and at least one memory 904, including one or more algorithms 903, such as a computer program code (software) wherein the at least one memory and the computer program code (software) are configured, with the at least one processor, to cause the access node to carry out any one of the exemplified functionalities of the access node described above.

Referring to Figure 9, at least one of the communication control circuitries in the access node 900 is configured to provide the co-existence management unit, or its sub-units, and to carry out functionalities described above by means of any of Figures 2 to 7 by one or more circuitries.

Referring to Figure 9, the memory 904 may be implemented using any suitable data storage technology, such as semiconductor based memory devices, flash memory, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory.

Referring to Figure 9, the access node may further comprise different interfaces 901 such as one or more communication interfaces (TX/RX) comprising

hardware and/or software for realizing communication connectivity over the medium according to one or more communication protocols. The communication interface may provide the access node with communication capabilities to communicate in the cellular communication system and enable communication between user devices (terminal devices) and different network nodes or elements and/or a communication interface to enable communication between different network nodes or elements, for example. The communication interface may comprise standard well-known components such as an amplifier, filter, frequency-converter, (de)modulator, and encoder/decoder circuitries, controlled by the corresponding controlling units, and one or more antennas. The communication interfaces comprise radio interface components providing the access node radio communication capability to provide a cell with at least an unlicensed band. The communication interfaces may comprise optical interface components providing the base station with optical fibre communication capability. As used in this application, the term 'circuitry' may refer to one or more or all of the following: (a) hardware-only circuit implementations, such as implementations in only analog and/or digital circuitry, and (b) combinations of hardware circuits and software (and/or firmware), such as (as applicable): (i) a combination of analog and/or digital hardware circuit(s) with software/firmware and (ii) any portions of hardware processor(s) with software, including digital signal processor(s), software, and memory(ies) that work together to cause an apparatus, such as a user device or an access node, to perform various functions, and (c) hardware circuit(s) and processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g. firmware) for operation, but the software may not be present when it is not needed for operation. This definition of 'circuitry' applies to all uses of this term in this application, including any claims. As a further example, as used in this application, the term 'circuitry' also covers an implementation of merely a hardware circuit or processor (or multiple processors) or a portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term 'circuitry' also covers, for example and if applicable to the particular claim element, a baseband integrated circuit for an access node or a user device or other computing or network device.

In embodiments, the at least one processor, the memory, and the computer program code form processing means or comprises one or more computer program code portions for carrying out one or more operations according to any one of the embodiments of Figures 2 to 7 or operations thereof.

Embodiments as described may also be carried out in the form of a computer process defined by a computer program or portions thereof. Embodiments of the methods described in connection with Figures 1 to 7 may be carried out by executing at least one portion of a computer program comprising corresponding instructions. The computer program may be provided as a computer readable medium comprising program instructions stored thereon or as a non-transitory computer readable medium comprising program instructions stored thereon. The computer program may be in source code form, object code form, or in some intermediate form, and it may be stored in some sort of carrier, which may be any entity or device capable of carrying the program. For example, the computer program may be stored on a computer program distribution medium readable by a computer or a processor. The computer program medium may be, for example but not limited to, a record medium, computer memory, read-only memory, electrical carrier signal, telecommunications signal, and software distribution package, for example. The computer program medium may be a non-transitory medium. Coding of software for carrying out the embodiments as shown and described is well within the scope of a person of ordinary skill in the art.

Even though the invention has been described above with reference to examples according to the accompanying drawings, it is clear that the invention is not restricted thereto but can be modified in several ways within the scope of the appended claims. Therefore, all words and expressions should be interpreted broadly and they are intended to illustrate, not to restrict, the embodiment. It will be obvious to a person skilled in the art that, as technology advances, the inventive concept can be implemented in various ways. Further, it is clear to a person skilled in the art that the described embodiments may, but are not required to, be combined with other embodiments in various ways.

CLAIMS

1. A user device comprising:

two or more transceivers for providing different radio access to one or more unlicensed bands;

at least one processor; and

at least one memory including computer program code;

the at least one memory and computer program code configured to, with the at least one processor, cause the user device at least to perform:

monitoring at least states of the two or more transceivers;

causing sending at least one of the states to a network element providing services on at least one of the one or more unlicensed bands; and

using, in response to receiving from the network element information on one or more parameters for the at least one of the one or more unlicensed bands, the one or more parameters.

2. The user device of claim 1, wherein the at least one memory and computer program code configured to, with the at least one processor, further cause the user device at least to perform the causing sending in response to at least one of the following:

detecting, by the user device, a change in a state of a transceiver;

associating, by the user device, to the network element; and

receiving, by the user device, from the network element a request for the states.

3. The user device of claim 1 or 2, wherein the at least one memory and computer program code configured to, with the at least one processor, further cause the user device at least to perform the causing sending in response to at least one of the following:

maintaining in the memory as configuration information different parameter sets;

receiving the information on the one or more parameters as an indication of a parameter set to be used; and

using the parameter set indicated.

4. A network element comprising:

at least one processor; and

at least one memory including computer program code;

the at least one memory and computer program code configured to, with the at least one processor, cause the network element at least to perform:

determining, based on at least state information on co-existing radios on an unlicensed band received from one or more user devices, one or more channel parameters for the unlicensed band; and

causing informing the one or more user devices on the one or more channel parameters.

5. The network element of claim 4, wherein the at least one memory and computer program code configured to, with the at least one processor, further cause the network element at least to perform causing sending request for the state information to the one or more user devices.

6. The network element of claim 4 or claim 5, wherein the at least one memory and computer program code configured to, with the at least one processor, further cause the network element at least to perform the informing by broadcasting either an indication of a parameter set to be used or the one or more parameters.

7. A method comprising:

monitoring, by a user device, at least states of two or more transceivers of the user devices, said transceivers providing different radio access to one or more unlicensed bands;

causing sending from the user device at least one of the states to a network element providing services on at least one of the one or more unlicensed bands;

receiving, by the user device, from the network element, information on one or more parameters for the at least one of the one or more unlicensed bands; and

using the one or more parameters.

8. The method of claim 7, further comprising:

detecting, by the user device, a change in a state of a transceiver; and

causing the sending in response to the detecting.

9. The method of claim 7 or 8, further comprising:
associating, by the user device, to the network element; and
causing the sending in response to the associating.

10. The method of claim 7, 8 or 9, further comprising:
receiving, by the user device, from the network element a request for the states; and
causing the sending in response to the receiving the request.

11. The method of any of claims 7 to 10, further comprising:
maintaining, by the user device, in a memory different parameter sets as configuration information;
receiving, by the user device, the information on the one or more parameters as an indication of a parameter set to be used; and
using, by the user device, the parameter set indicated.

12. A method comprising:
receiving, by a network element, from one or more user devices, state information on co-existing radios on an unlicensed band;
determining, by the network element, based on at least received state information, one or more channel parameters for the unlicensed band; and
causing, by the network element, informing the one or more user devices on the one or more channel parameters.

13. The method of claim 12, further comprising causing, by the network element, sending request for the state information to the one or more user devices.

14. The method of claim 12 or claim 13, further comprising performing the informing by broadcasting either an indication of a parameter set to be used or the one or more parameters.

15. A non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following:
monitoring at least states of two or more transceivers of the apparatus;
causing sending at least one of the states to a network element providing services on at least one of the one or more unlicensed bands; and

using, in response to receiving from the network element information on one or more parameters for the at least one of the one or more unlicensed bands, the one or more parameters.

16. A computer program comprising instructions for causing an apparatus to perform at least the following:

monitoring at least states of two or more transceivers of the apparatus;

causing sending at least one of the states to a network element providing services on at least one of the one or more unlicensed bands; and

using, in response to receiving from the network element information on one or more parameters for the at least one of the one or more unlicensed bands, the one or more parameters.

17. A non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following:

determining, based on at least state information on co-existing radios on an unlicensed band received from one or more user devices, one or more channel parameters for the unlicensed band; and

causing informing the one or more user devices on the one or more channel parameters.

18. A computer program comprising instructions for causing an apparatus to perform at least the following:

determining, based on at least state information on co-existing radios on an unlicensed band received from one or more user devices, one or more channel parameters for the unlicensed band; and

causing informing the one or more user devices on the one or more channel parameters.

19. A signal with embedded data comprising at least one or more values to indicate transceivers that provide in a user device different radio access to one or more unlicensed bands and tranceivers' current state.

20. A signal with embedded data comprising at least one or more values to indicate one or more channel parameters for an unlicensed band to user devices with transceivers providing different radio access to the unlicensed band.

21. The signal of claim 19 or 20, wherein the one or more values are within action frames.

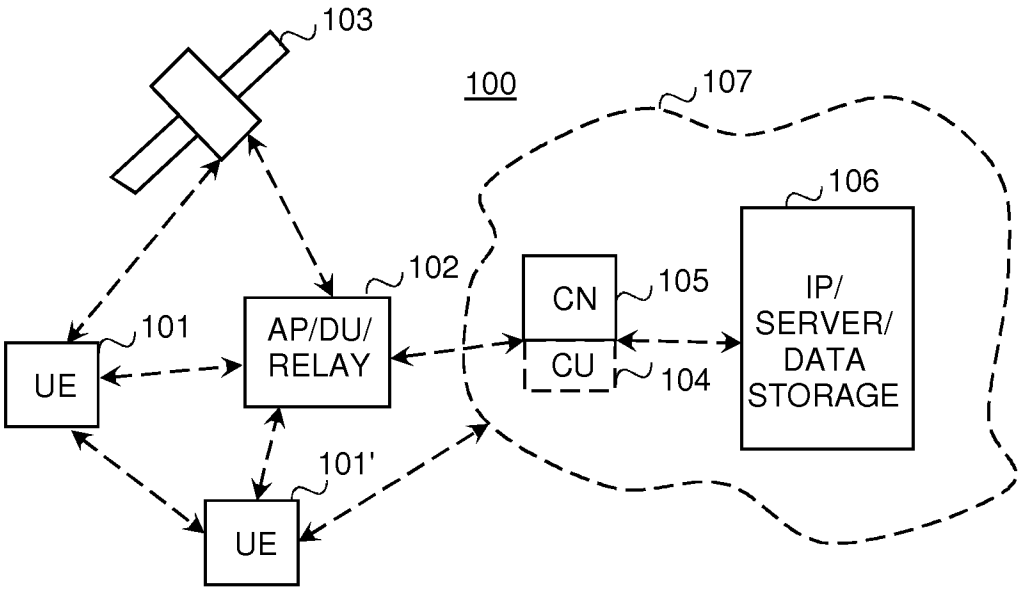

103
100
107
106
102
CN
105
IP/
SERVER/
DATA
STORAGE
101
AP/DU/
RELAY
CU
104
UE
101'
UE

FIG.1

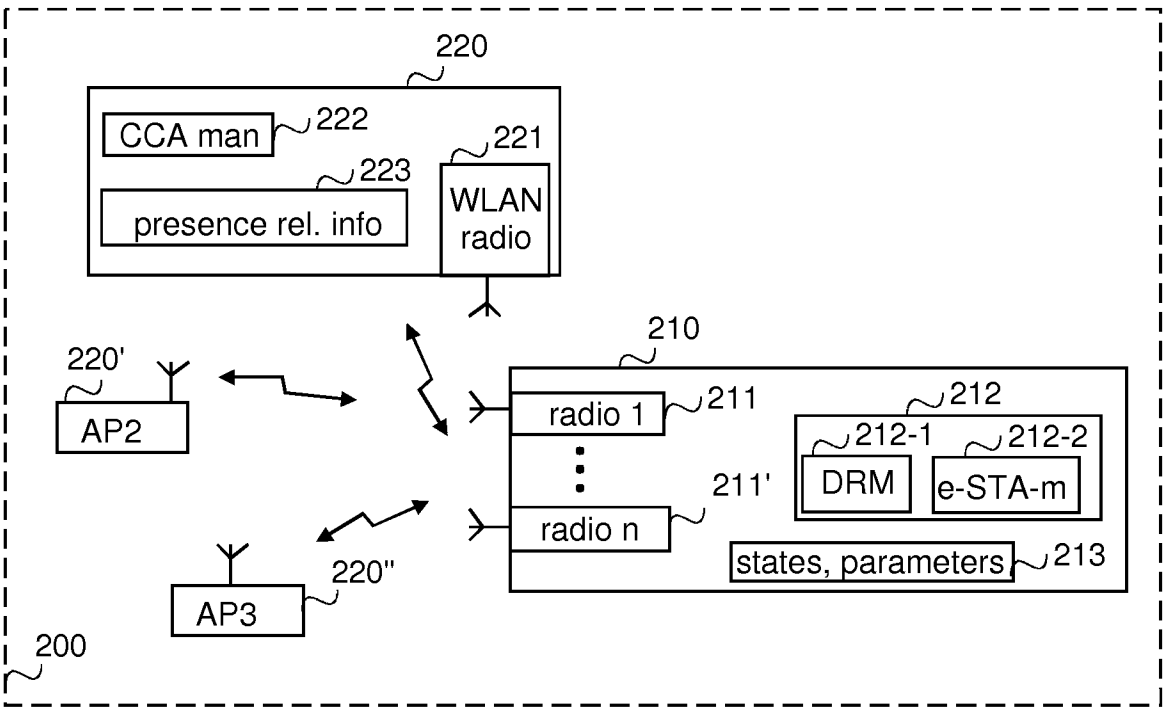

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CCA man
222
221
223
presence rel. info
WLAN
radio
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AP2
radio 1
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211'
radio n
states, parameters
213
220"
AP3
200

FIG.2

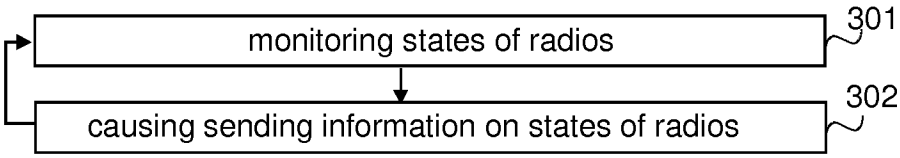


FIG.3

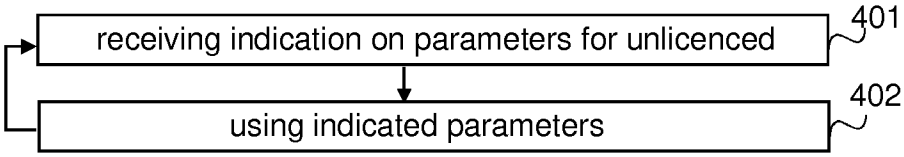


FIG.4

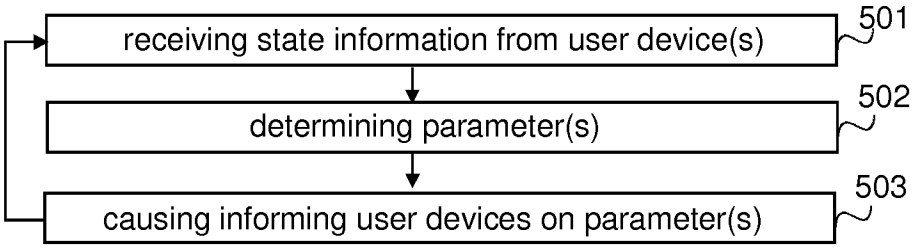


FIG.5

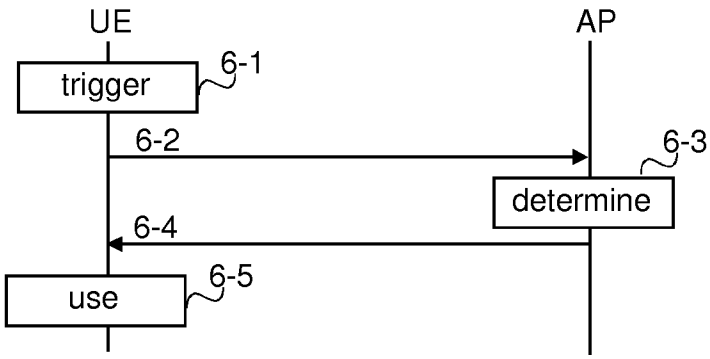


FIG.6

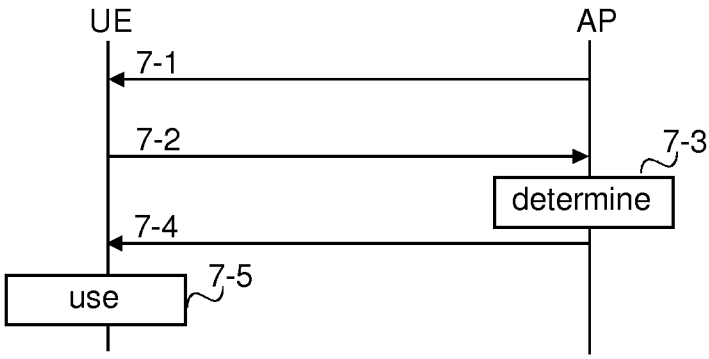


FIG.7

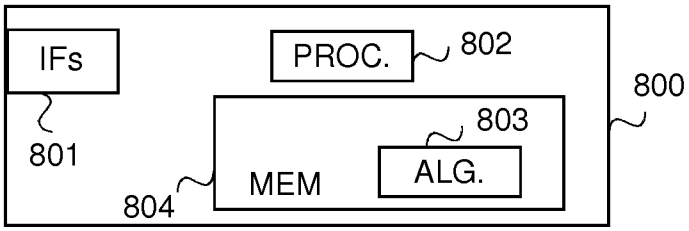

IFs
PROC.
802
800
803
801
MEM
ALG.
804

FIG.8

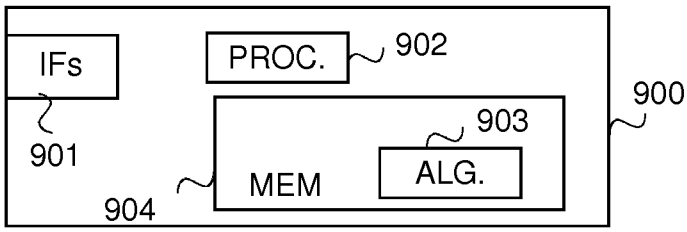

IFs
PROC.
902
900
903
901
MEM
ALG.
904

FIG.9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/060081

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W74/08
ADD. H04W16/14

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, 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	EP 3 214 889 A2 (SAMSUNG ELECTRONICS CO LTD [KR]) 6 September 2017 (2017-09-06) figures 7A, 7C, 11, 12 paragraphs [0015], [0016], [0056], [0074], [0085], [0088] - [0094], [0109] - [0142] paragraphs [0151] - [0162], [0165], [0176] - [0183] table 6 ----- -/--	1-21

[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
28 November 2018	07/12/2018

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	Konstantopoulou, P

1

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	INTERDIGITAL INC: "On Physical Layer Procedures for NR-U", 3GPP DRAFT; R1-1804870 ON PHYSICAL LAYER PROCEDURES FOR NR-U, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Sanya, China; 20180416 - 20180420 15 April 2018 (2018-04-15), XP051427133, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings%5F3GPP%5FSYNC/RAN1/Docs/ [retrieved on 2018-04-15] Chapter 1. "Introduction", Chapter 2. "Initial access procedure", Chapter 4. "gNB/UE handshaking", Chapter 5. "Procedures for PUSCH" -----	1,2,4,5, 7,9,10, 12,13, 15-20
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Information on patent family members

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