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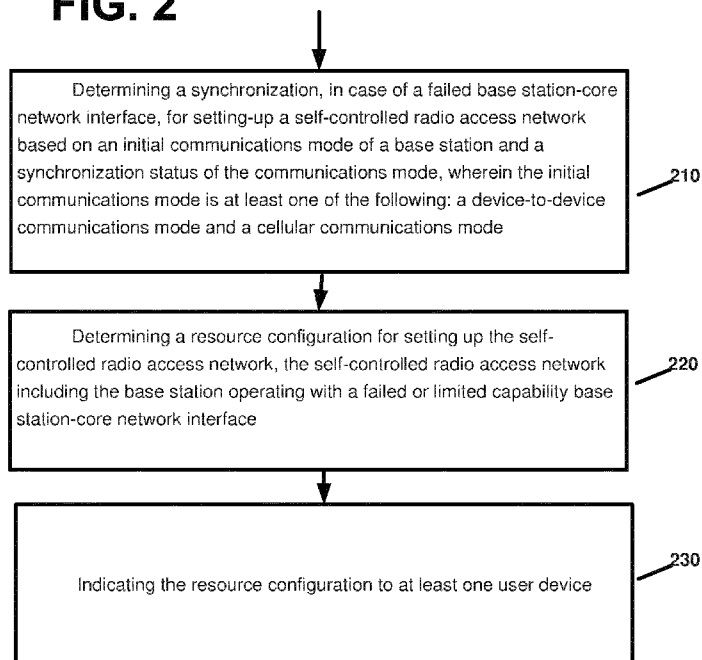
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(54) **Title:** FACILITATING EFFECTIVE ISOLATED WIRELESS NETWORK OPERATION

FIG. 2



(57) **Abstract:** An example technique is provided for determining a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio access network based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode, determining a resource configuration for setting up the self-controlled radio access network, the self-controlled radio access network including the base station operating with a failed or limited capability base station-core network interface, and indicating the resource configuration to at least one user device.

DESCRIPTION

TITLE

FACILITATING EFFECTIVE ISOLATED WIRELESS NETWORK OPERATION

TECHNICAL FIELD

5 This description relates to wireless networks.

Background

A communication system may be a facility that enables communication between two or more nodes or devices, such as fixed or mobile communication devices. Signals can be carried on wired or wireless carriers.

10 An example of a cellular communication system is an architecture that is being standardized by the 3rd Generation Partnership Project (3GPP). A recent development in this field is often referred to as the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. E-UTRA (evolved UMTS Terrestrial Radio Access) is the air interface of 3GPP's Long Term Evolution (LTE)
15 upgrade path for mobile networks. In LTE, base stations, which are referred to as evolved Node Bs (eNBs), provide wireless access within a coverage area or cell. In LTE, mobile devices, or mobile stations are referred to as a user equipment (UE). LTE has included a number of improvements or developments. 5G wireless networks are also being developed.

20

summary

According to an example implementation, a method may include determining a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio access network based on an initial communications mode of a base
25 station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode; determining a resource configuration for setting up the self-controlled radio access network, the self-controlled radio access network including the base station operating with a failed or limited capability base station-
30 core network interface; and indicating the resource configuration to at least one user device.

According to an example implementation, an apparatus may include at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to: determine a synchronization, in case of a
35 failed base station-core network interface, for setting-up a self-controlled radio access network based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode; determine a resource configuration for setting up the self-
40 controlled radio access network, the self-controlled radio access network including the

base station operating with a failed or limited capability base station-core network interface; and indicate the resource configuration to at least one user device.

A computer program product may include a non-transitory computer-readable storage medium and storing executable code that, when executed by at least one data processing apparatus, is configured to cause the at least one data processing apparatus to perform a method including: determining a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio access network based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode; determining a resource configuration for setting up the self-controlled radio access network, the self-controlled radio access network including the base station operating with a failed or limited capability base station-core network interface; and indicating the resource configuration to at least one user device.

According to another example implementation, an apparatus may include means for determining a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio access network based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode; means for determining a resource configuration for setting up the self-controlled radio access network, the self-controlled radio access network including the base station operating with a failed or limited capability base station-core network interface; and means for indicating the resource configuration to at least one user device.

According to an example implementation, a method may include controlling receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station-core network interface occurs; determining one or more established services or applications for the user device and a status of each of the one or more established services or applications; indicating, by the user device to the base station, the determined one or more established services or applications and the status of each service or application; and controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

According to an example implementation, an apparatus may include at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to: control receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station-core network interface occurs; determine one or more established services or applications for the user device and a status of each of the one or more established services or applications; indicate, by the user device to the base station, the determined one or more established services or applications and the status of each service or application; and control receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

According to an example implementation, a computer program product may include a non-transitory computer-readable storage medium and storing executable code that, when executed by at least one data processing apparatus, is configured to cause the at least one data processing apparatus to perform a method including: controlling receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station–core network interface occurs; determining one or more established services or applications for the user device and a status of each of the one or more established services or applications; indicating, by the user device to the base station, the determined one or more established services or applications and the status of each service or application; and controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

According to an example implementation, an apparatus may include means for controlling receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station–core network interface occurs, means for determining one or more established services or applications for the user device and a status of each of the one or more established services or applications, means for indicating, by the user device to the base station, the determined one or more established services or applications and the status of each service or application, and means for controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

The details of one or more implementations are set forth 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 the drawings

FIG. 1 is a block diagram of a wireless network according to an example implementation.

FIG. 2 is a flow chart illustrating operation of a base station according to an example implementation.

FIG. 3 is a flow chart illustrating operation of a user device according to another example implementation.

FIG. 4 is a diagram illustrating operation of a base station and a user device according to an example implementation.

FIG. 5 is a block diagram of a network node (e.g., BS or user device) according to an example implementation.

Detailed description

FIG. 1 is a block diagram of a wireless network 130 according to an example implementation. In the wireless network 130 of FIG. 1, user devices 131, 132 and 133, which may also be referred to as mobile stations (MSs) or user equipments (UEs), may be connected (and in communication) with a base station (BS) 134, which may also be

referred to as an access node or an enhanced Node B (eNB), network node, access node or any other suitable apparatus. BS 134 provides wireless coverage within a cell 136. Although only three user devices are shown within cell 136 (connected or attached to BS 134), any number of user devices may be provided. BS 134 is also connected to a core network 150 via a base station-core network (BS-core network) interface 151. A BS-core network interface may also be referred to as, for example, a S1 interface 151 or a backhaul connection. This is merely one simple example of a wireless network, and others may be used. According to an example implementation, at least part of the functionalities of a base station or (e)Node B (eNB) may be also be carried out by any node, server or host which may be operably coupled to a transceiver, such as a remote radio head.

According to an example implementation, a user device (user terminal, user equipment (UE)) may refer 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 (MS), a mobile phone, a cell phone, a smartphone, a personal digital assistant (PDA), a handset, a device using a wireless modem (alarm or measurement device, etc.), a laptop and/or touch screen computer, a tablet, a phablet, a game console, a notebook, and a multimedia device, as examples. 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.

In LTE, core network 150 may be referred to as Evolved Packet Core (EPC), which may include a mobility management entity (MME) which may handle or assist with mobility/handover of user devices between BSs, one or more gateways that may forward data and control signals between the BSs and packet data networks or the Internet, and other control functions or blocks. Only a few of the blocks or functions of the example core network are described, and the core network 150 may include different and/or additional blocks/functions, for example. LTE may be used as an example. However, the various implementations or techniques described herein may be applied to a 5G wireless network or other wireless networks.

In some situations, the S1 interface 151 or link (or BS-core network interface or backhaul connection) may fail or break, which may interrupt or prevent transmission of (e.g., all or some of the) data or signals between the BS 134 and the core network 150. A failed or broken S1 interface 151 may occur due to a variety of circumstances, such as natural disasters (e.g., fire, earthquakes, hurricane or storm), war, failure of power company infrastructure, or other crisis or emergency. These are merely some example situations where a failed S1 interface 151 is likely to occur, but there may be other situations as well. A S1 interface failure may include, for example, a complete failure of the S1 interface 151 in which no signals or data may be transmitted or received over the S1 interface 151, or a partial failure, in which the S1 interface 151 may operate in some degraded or reduced capacity, e.g., lower bandwidth, or only some types of signals may be transmitted or received, or some other limitation or reduced operational ability for the S1 interface. When the S1 interface 151 fails (complete failure), packets or data or

signals from the core network 150 will no longer be received by the BS 134, and BS 134 is unable to send or forward data or other signals to the core network 150.

A BS 134 may detect a failure of a S1 interface 151. For example, certain data, signals or reports that may be expected by the BS 134 from the core network 150 may not be received by the BS 134 before a timer expires. When this occurs, as an example, the BS 134 may assume or determine that a failure to the S1 interface 151 has occurred. Other techniques may be used by BS 134 to detect a complete or partial failure of the S1 interface 151.

After BS 134 detects a failure of the S1 interface 151, the BS 134 may set up a self-controlled radio access network. An example of a self-controlled radio access network may include an isolated wireless network that may include one or more BSs that may provide some limited wireless services to one or more user devices, even though the S1 interface 151 for the one or more BSs has failed (either completely failed or partially failed, and/or completely failed and then S1 interface 151 may be partially re-established). Thus, according to an example implementation, the self-controlled radio access network may be considered to be self-controlled, e.g., where control for the self-controlled radio access network may be provided by such one or more BSs without (e.g., necessarily) receiving control from the core network 150, e.g., without necessarily sending/receiving control signals and/or data between the BS 134 and the core network 150. In another example implementation, a self-controlled radio access network may also include the possibility of a partial S1 interface failure (or complete failure followed by a partial re-establishment of S1 interface or network connection), where the BS 134 may send/receive some limited control/control signals and/or data to/from the core network 150, for example. Thus, in this case, for example, the S1 interface 151 may operate in a degraded or reduced capacity, e.g., which may be considered to be a partial failure of the S1 interface 151, or which, as another example, may result from a complete failure of the S1 interface 151 and then partially restoring the S1 interface 151 via alternative network resources (e.g., via an alternative network connection).

According to an example implementation, the self-controlled radio access network (or isolated wireless network) may be set up to provide some wireless services to one or more select or limited classes of user devices. According to an example implementation, access to the self-controlled radio access network (or isolated wireless network) may be limited to public safety user devices (e.g., policemen, firemen, doctors, and other emergency or rescue personnel). When limited to public safety user devices/users, the self-controlled or isolated wireless network may be referred to, for example, as an isolated operation for public safety (IOPS) wireless network. For example, after a natural disaster or other emergency situation, an IOPS wireless network may be set up to allow public safety (PS) users (e.g., firemen, policemen, doctors, military, rescue personnel) to communicate in a situation where a S1 interface has completely or partially failed, or the S1 interface does not exist, for example.

According to an example implementation, BSs and user devices in a wireless network may initially operate in one of multiple communications modes, e.g., before a S1 interface 151 failure is detected. According to an example implementation, after the S1 interface

failure has been detected, the BS and/or user devices may then switch to operate in a self-controlled radio access network. Further details are described below.

As noted, BSs and/or user devices may operate in an initial communications mode, such as, for example, in one of the following initial communications modes: 1) a cellular communications mode in which a base station (or base stations) may provide wireless coverage via one or more cells, and communications/data may be transmitted through the BS; and 2) and a device-to-device (D2D) or proximity services (ProSe) communications mode in which user devices may directly communicate with each other. For example, user devices 131, 132 and 133 may be members of a D2D group/cluster 125 (FIG. 1), and may directly communicate with each other, when they are operating in a D2D/ProSe communications mode.

According to an example implementation, after one or more BSs and/or user devices operate in an initial communications mode, a failure in the S1 interface 151 may be detected by the BS 134, for example. The BS 134 may then set up or establish a self-controlled radio access network (such as, for example, a IOPS wireless network). In one example implementation, a network configuration, which may include a synchronization, a resource configuration, etc., for the self-controlled radio access network may be determined or established based on a status or configuration of the initial communications mode for the BS 134/user devices. In another example implementation, a BS may be pre-configured (at least partially) with a configuration (or one or more configuration parameters) to establish or set up the self-controlled radio access network. Or, a self-controlled radio access network may be established based on a combination of both pre-configured configuration parameters/information and configuration information determined based on a status or configuration of an initial communications mode for a network. Two example situations are described below in which a self-controlled radio access network may be set up or established, such as: 1) a nomadic BS is brought to an incident scene, e.g., after a disaster or after a S1 interface failure to establish a self-controlled radio access network; and 2) a BS operating in an initial communications mode may detect a S1 interface failure and then switch the communications mode for the network (or at least for the BS) from the initial communications mode to the self-controlled radio access network.

Therefore, according to a first illustrative example, a self-controlled radio access network capable-BS (e.g., IOPS-capable BS) may be brought to an incident scene, e.g., after a disaster or after a S1 interface failure to establish a self-controlled radio access network (e.g., IOPS wireless network). Such a BS may be referred to as a nomadic BS or nomadic eNB, since the nomadic BS may be moved to the incident or disaster location, and was not necessarily providing wireless services at such location before the incident/disaster or S1 interface failure, for example. The nomadic BS may then be used to set up a self-controlled radio access network (e.g., IOPS wireless network) for a group of (or multiple) user devices. The nomadic BS, in some cases, may at least in part, be preconfigured with a configuration (or part of a configuration) for the self-controlled radio access network to be established or set up. Alternatively, the nomadic BS may determine a configuration (or a part of a configuration) for the self-controlled radio access network based on a status or configuration of an existing network/initial communications mode for

user devices or BSs, for example. In some cases, according to an example implementation, a failed (e.g., failed or non-existent) S1 interface 151 may be partially re-established via an alternative network connection (e.g., via satellite connection or wireless relay, DSL connection, or other alternate network connection). In some cases, the failed S1 interface may include a S1 interface that failed due to some disaster or other condition, or may include a non-existent S1 interface, e.g., such as where no S1 interface initially existed, but a nomadic BS/nomadic eNB (NeNB) may be brought to the scene/location to allow a IOPS (for example) wireless network to be set up based on the nomadic BS.

In a second example situation a BS 134 (e.g., IOPS-capable BS or self-controlled radio access network-capable BS) and/or user devices may initially be operating in an initial communications mode (e.g., cellular communications mode, or device-to-device (D2D) communications mode, where for D2D mode the BS 134 may be assisting with D2D communication or in communication with one or more D2D user devices or simply listening to D2D user devices). A failure of the S1 interface may be detected by the BS 134 (either before or after operation of the D2D network begins). The BS134 may then be used to support or set up a self-controlled radio access network, where the configuration of the self-controlled radio access network may be based upon the status or configuration of the initial communications mode. For example, the BS 134 may be operating as a BS in a cellular communications mode, and then the BS 134 may detect a failure of a S1 interface. In another example implementation, a failure of a S1 interface 151 may occur, and then a group of user devices may set up a device-to-device (D2D) network, and the BS 134 may receive signals from (or listen to) one or more user devices/D2D devices in the D2D network to determine or learn the status and/or configuration of the D2D network, such as determining a synchronization status (e.g., synchronization timing reference) of the D2D network. The BS 134 may then determine the synchronization timing reference (e.g., timing/boundaries of frames, subframes and/or symbols) for the self-controlled radio access network based on the synchronization of the D2D network, for example, or may use a synchronization timing reference for the self-controlled radio access network to be based upon or the same as the cellular communications network/mode. Thus, one or more configuration parameters for the self-controlled radio access (e.g., IOPS) network may be determined based on a status or configuration of the initial communications mode, e.g., based on the status or configuration of the D2D network or cellular network, for example.

In either example situation (a nomadic BS that is provided to establish a self-controlled radio access network, e.g., after a S1 failure or incident, or a BS that is operating in an initial communications mode and then switches to the self-controlled radio access network after a S1 failure), the BS may be preconfigured with one or more configuration parameters for the self-controlled radio access network, and/or the BS may determine or learn a configuration for the self-controlled radio access network based on a status or configuration of an existing network or an initial communications mode.

According to an example implementation, a BS (such as a nomadic BS, or other BS) may be preconfigured with one or more configuration details or information for setting up the self-controlled radio access network. For example, a BS may be preconfigured with network configuration for setting up or establishing a self-controlled radio access

network(e.g., an IOPS wireless network), such as one or more of: 1) a synchronization for the self-controlled radio access network, e.g., including synchronization timing (e.g., boundaries for symbols, frames, subframe); 2) user device (or UE) contexts (e.g., user device IDs, group IDs) for one or more user devices to be allowed access to the self-controlled radio access network; and/or 3) resource configurations for the self-controlled radio access network, including, for example: which applications/services of one or more devices will be (or can be) supported by the self-controlled radio access network, whether wireless service continuity will be provided for one or more user devices, whether routing of data (e.g., local routing of data) will be provided by the BS/self-controlled radio access network, etc.

In an example case of a nomadic BS or of a BS that is operating in an initial communications mode and then switches modes to the self-controlled radio access network after a S1 failure, the BS may learn or determine a configuration (or one or more configuration parameters) for the self-controlled radio access network (e.g., IOPS network), e.g., based on a status or configuration of the initial communications mode for the BS, user devices or other BSs.

FIG. 2 is a flow chart illustrating operation of a base station according to an example implementation. Operation 210 may include determining a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio access network based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode. Operation 220 may include determining a resource configuration for setting up the self-controlled radio access network, the self-controlled radio access network including the base station operating with a failed or limited capability base station-core network interface. And, operation 230 may include indicating the resource configuration to at least one user device.

According to an example implementation of the method of FIG. 2, the method may further include: determining an alternative network connection for the base station; and re-establishing at least a limited capability base station-core network interface via the alternative network connection.

According to an example implementation of the method of FIG. 2, the method may further include controlling receiving, from one or more user devices, an indication of one or more services or applications operating on the user device when the failure of the base station-core network interface occurs; and determining an updated base station-core network interface status, including determining whether at least a limited capability base station-core network interface has been re-established, and determining one or more capabilities of the re-established base station-core network interface; and wherein the determining a resource configuration includes: determining, based on the indicated services or applications for one or more user devices and the updated base station-core network interface status, which, if any, of the indicated services or applications will be supported by the self-controlled radio access network.

According to another example implementation of the method of FIG. 2, the determining an updated base station-core network interface status may include determining an ability of a re-established base station-core network interface to provide a signaling backhaul and/or a user data backhaul for the user device.

- 5 According to another example implementation of the method of FIG. 2, the determining which, if any, of the indicated services or applications will be supported by the self-controlled radio access network may include at least one of the following: determining whether wireless service continuity will be provided by the self-controlled radio access network for one or more user devices; and determining whether routing of data will be
10 provided by the self-controlled radio access network.

According to another example implementation of the method of FIG. 2, the self-controlled radio access network may include an isolated radio access network providing public safety related applications and services to one or more user devices.

- 15 According to another example implementation of the method of FIG. 2, the determining synchronization may include: determining a synchronization timing reference of the initial communications mode of the base station; and determining a synchronization timing reference for the self-controlled radio access network based on the synchronization timing reference of the initial communications mode.

- 20 According to another example implementation of the method of FIG. 2, the method may further include controlling sending synchronization reference signals for the self-controlled radio access network based on the synchronization timing reference for the self-controlled radio access network.

- 25 According to another example implementation of the method of FIG. 2, wherein the determining a resource configuration may include at least one of the following:
determining whether to support routing of user data for at least one user device via the base station; and determining whether to provide wireless service continuity for at least one user device that was served by the base station in the communications mode.

- 30 According to another example implementation of the method of FIG. 2, the determining a resource configuration may include: controlling receiving user device contexts for one or more user devices for the communications mode, the user device contexts including, for a user device, a user device identification and a user device group identification; and applying the user device contexts for one or more user devices to operation of the self-controlled radio access network.

- 35 According to another example implementation of the method of FIG. 2, wherein the method may further include: authenticating or authorizing a user device to operate in the self-controlled radio access network based on the received user device context for the user device for the communications mode.

- 40 According to another example implementation of the method of FIG. 2, the method may further include one or more of the following: indicating to a first user device whether routing of user data will be provided via the self-controlled radio access network for the first user device; and indicating to a second user device, which was served by the at least

one access node in the communications mode, whether wireless service continuity will be provided via the self-controlled radio access network for the second user device.

FIG. 3 is a flow chart illustrating operation of a user device according to an example implementation. Operation 310 includes controlling receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station–core network interface occurs. Operation 320 includes determining one or more established services or applications for the user device and a status of each of the one or more established services or applications. Operation 330 includes indicating, by the user device to the base station, the determined one or more established services or applications and the status of each service or application. And, operation 340 includes controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

According to another example implementation of the method of FIG. 3, the method may further include controlling receiving, by the user device, a request to provide a user device context to the base station; and indicating, by the user device to the base station, the user device context.

According to another example implementation of the method of FIG. 3, wherein the user device context may include one or more of the following: a proximity services network user device identifier; a proximity services network group identifier for the user device; a cellular network user device identifier; application/service level tolerance of Internet Protocol (IP) address change; other information for assisting with isolated network operation for public safety user devices.

According to another example implementation of the method of FIG. 3, wherein the controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network may include: controlling receiving, by the user device from the base station, an indication of one or more applications or services operating on the user device that will be supported for the user device by the self-controlled radio access network.

According to another example implementation of the method of FIG. 3, wherein the controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network may include at least one of the following: controlling receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for routing of user data; and controlling receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for wireless service continuity.

According to another example implementation of the method of FIG. 3, wherein the controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network may include: controlling receiving, by the user device from the base station, a cell identifier or network identification information for the self-controlled radio access network; and controlling

receiving, by the user device from the base station, a synchronization timing reference for the self-controlled radio access network.

Further example implementations or further example details associated with the examples described with respect to FIGs. 2-3 are described herein.

5 FIG. 4 is a diagram illustrating operation of a base station and a user device according to an example implementation. According to an illustrative example implementation, a BS or eNB may, for example, perform one or more of the operations shown or described in FIG. 4. As shown in FIG. 4, a BS 134 may be in communication with one or more user devices (or UEs), such as with user device 132, for example. BS 134 may also be in
10 communication with other user devices, not shown. At 410, BS 134 may detect/determine a failure or loss of a BS-core network (e.g., S1) interface151 (which may also be referred to as a backhaul connection).

In an illustrative example implementation, a BS 134 that may have been operating in an initial communications mode (e.g., cellular mode), such a BS 134 may typically already
15 have synchronization (e.g., synchronization timing references) for transmission of signals to/from user devices in the initial communications (e.g., cellular) mode, and this existing timing reference (and/or other configuration parameters) may be used for the self-controlled radio access (e.g., IOPS) network. Therefore, in such case, the BS 134 may omit operations 412 and 414, according to one example implementation. For other cases,
20 e.g., for a nomadic BS, or for a BS that may not have a synchronization that may be used for the self-controlled radio access (e.g., IOPS) network, the BS may perform operations 412 and/or 414 to obtain such synchronization for the self-controlled radio access (e.g., IOPS) network, according to an example illustrative implementation.

For an example of operations 412 and 414, in one example implementation, one or more
25 user devices may be operating in a D2D communications mode, e.g., in response to a S1 interface failure, for example. At 412, BS 134 may, according to an example implementation, operate as a D2D/ProSe user device, and/or may listen and receive one or more signals from one or more D2D user devices that may have set up a D2D wireless network after the loss/failure of the S1 interface 151. For example, the BS 134 may listen
30 to or receive synchronization signals (or synchronization reference signals) from a D2D user device that may be operating as a synchronization source, for example, to determine a synchronization status of the initial communications mode (e.g., of the D2D network). The synchronization status of the D2D network may include, for example, a timing reference (or timing/boundaries) for frames, subframes and/or symbols transmitted by one
35 or more D2D user devices.

At 414, the BS 134 may determine a synchronization (e.g., a synchronization timing reference) for a self-controlled radio access (e.g., IOPS) network based on the synchronization status of the initial communications mode (e.g., based on the synchronization status of the D2D network). For example, the BS 134 may determine or
40 establish the timing reference (e.g., timing/boundaries) for frames, subframes and/or symbols for the self-controlled radio access (e.g., IOPS) network to be the same as, or may be an offset from (or otherwise based upon), the synchronization status or timing reference for the initial communications mode/D2D network.

At 416, the BS 134 may send one or more control signals to one or more user devices, e.g., based on the determined synchronization for the self-controlled radio access (e.g., IOPS) network. For example, an IOPS network announcement may be transmitted by the BS 134 to announce one or more details regarding the self-controlled radio access (e.g., IOPS) network, such as a network identifier, cell ID, BS ID for BS 134, etc. BS 134 may also, for example, transmit downlink synchronization reference signals, a system frame, or other information for the self-controlled radio access (e.g., IOPS) network. This information may allow user devices, which may be operating in a D2D communications mode (or other communications mode), to obtain synchronization information and other information that may allow the user devices to connect to the BS 134 for the self-controlled radio access (e.g., IOPS) network, for example.

At operation 418, the BS 134 may send a request to one or more user devices for user device (or UE) context information. At operation 420, the user device(s) may send the BS 134 the requested user device/UE context information. If, for example, the S1 interface 151 has failed, then the BS 134 may have no way to validate or authenticate user devices (due to failed S1 interface, for example, BS 134 may be unable to access the core network 150 to perform user device validation/authentication). However, even after a failed S1 interface, the BS 134 may have a (existing) wireless connection to one or more of the user devices (which were previously authenticated or admitted to the network), and/or each user device in the D2D network may have a valid UE context that can be used by the BS 134 to address or communicate with the user device after establishment of the self-controlled radio access (e.g., IOPS) network. Therefore, e.g., after detecting a failed S1 interface 151, to allow future user device validation/authentication and/or communication for the self-controlled radio access (e.g., IOPS) network, the BS 134 may request each user device to send user device context information to the BS 134, such as a user device identification, e.g., temporary mobile subscriber identification (TMSI), a D2D UE identification (ID), a D2D group ID for the user device that identifies the D2D group(s)/cluster(s) for which the user device belongs, or other UE context information. This user device (or UE) context information may be later used by the BS 134 to validate/authenticate a user device, or otherwise communicate with the user device for the self-controlled radio access (e.g., IOPS) network, for example.

At operation 422, the BS 134 may use the user device/UE context information to perform admission control/validation/authentication for one or more user devices, and/or to perform paging, addressing or otherwise communicating with user devices for the self-controlled radio access (e.g., IOPS) network.

At operation 424, the BS 134 may determine an updated status of the BS-core network interface 151 (e.g., S1 interface or backhaul connection), which may have previously failed. For example, after a failure of the BS-core network (or S1) interface 151, e.g., due to failure of an initial network connection, the S1 interface 151 may be partially re-established via an alternate network connection. The partially re-established BS-core network/S1 interface 151 may have one or more capabilities, but may be operating in a limited or degraded capacity or ability, e.g., as compared to the original or initial BS-core network/S1 interface that may have failed, for example. Thus, operation 424 may include, for example, determining an updated BS-core network (S1) interface status, including

determining whether at least a limited capability BS-core network/S1 interface has been re-established (e.g., after a failure of an original S1 interface) , and determining one or more capabilities of the (at least partially) re-established BS-core network (S1) interface. For example, some capabilities that may be determined for the re-established S1 interface may include determining whether the re-established S1 interface may provide a signaling backhaul (e.g., communication of control signals/signaling) and/or data backhaul (communication of user data) for one or more user devices, a bandwidth or available data rate for the re-established S1 interface, etc.

At operation 426, the BS 134 may send a request to one or more user devices requesting a status of any established user device applications/services. At operation 428, user device 132 may send a response to BS 134 indicating a status of one or more user device applications/services for the user device 132. For example, user device 132 may initially be in communication with BS 134, or another BS, just prior to a failure in the S1 interface 151 is detected. At the time that a S1 interface failure occurs/or is detected, there may be several applications/services operating on the user device 132 that were supported by BS 134 (for example) via cellular communications mode, according to one example. For example, user device 132 may have included several application that were operating/running at the time the S1 interface failed: a voice call application was running, or a VOIP call application was running to support a telephone call made by a user; an email and calendar program was running; a texting or messaging application was running; a social media application was running; and/or a web page was open to a news site. These applications/services may have been supported by the BS 134, e.g., resources were allocated by the BS 134 and at the core network to support these applications/services. According to an example of operation 428, the user device 132 may report the existence of these running applications, a QoS (quality of service) or associated with each application or a resource request/indication for each application/service, an address (e.g., Internet Protocol/IP address) for the user device or for one or more applications, whether the user device would like to continue operating, or a request for one or more of these applications/services to continue operation (or a request for service continuity for) after the S1 interface failure via the self-controlled radio access (e.g., IOPS) network that is or will be established, whether the application/service can tolerate an IP address change, etc. For example, establishment of the self-controlled radio access (e.g., IOPS) network may involve a different service attachment point for the core network, different bearers, etc., which may involve or require a new different IP address being assigned to a user device 132 than the IP address that was previously assigned to user device 132 via the initial communications mode.

Thus, in some cases, the self-controlled radio access (e.g., IOPS) network may provide service continuity (e.g., continuing to provide support) for the user device or for one or more applications/services via a same (unchanged) IP address. In other instances, a service continuity for a user device or application/service may be possible by the self-controlled radio access (e.g., IOPS) network only through a new IP address that can be assigned to the user device. Thus, it may be useful for the BS 134/ self-controlled radio access (e.g., IOPS) network to determine whether a user device or application/service on the user device can tolerate an IP address change. If an IP address change can be tolerated by a user device or by an application/service, then the self-controlled radio

access (e.g., IOPS) network may provide (or attempt to provide) service continuity (continuing wireless service) to the user device (or to the application/service) even though a change in IP address may be required. If the user device (or application/service) cannot tolerate an IP address change, then the self-controlled radio access (e.g., IOPS) network
5 may not typically provide or attempt to provide service continuity for user device or such application/service. Rather, in that case of IP change intolerance, service continuity may not be provided and/or the user device and/or application/service may need to request new service from the self-controlled radio access (e.g., IOPS) network.

At operation 430, the BS 134 or the self-controlled radio access (e.g., IOPS) network may
10 determine a resource configuration for the self-controlled radio access (e.g., IOPS) network. A variety of different factors or information may be used to determine a configuration. Also, such a configuration for the self-controlled radio access (e.g., IOPS) network may include a range of configuration parameters. For example, operation 430 may include determining, based on the status of established applications/services
15 (operations 426, 428) and/or the updated status of the BS-core network (S1) interface 151 (operation 424), which, if any if the user devices and/or services/application will be supported by the self-controlled radio access (e.g., IOPS) network. Operation 430 may include, for example, determining whether wireless service continuity will be provided by the self-controlled radio access (e.g., IOPS) network for one or more user devices and/or
20 services/applications; and/or determining whether routing of data will be provided by the self-controlled radio access (e.g., IOPS) network for one or more user devices and/or services/applications.

At operation 432, the BS 134/ self-controlled radio access (e.g., IOPS) network may notify or send a message to user device 132 indicating a resource configuration for the self-
25 controlled radio access (e.g., IOPS) network. For example, at operation 432, the BS 134 may indicate to user device 132 whether the user device and/or which applications/services of the user device will be supported by the self-controlled radio access (e.g., IOPS) network, whether wireless service continuity will be provided to the user device 132 and/or service/application, whether routing of data (e.g., local routing of
30 data to other user devices connected to the BS 134) will be provided to the user device 132, etc. Some further example implementations will be described below.

Some of the example implementations described herein may provide techniques to configure and operate an effective IOPS network on RAN (radio access network) level, adapted to setting-up deployment or on-the-fly reconfiguration situation of the IOPS
35 serving BS/eNB, either a new nomadic BS/eNB (NeNB) or an existing serving BS/eNB, taking into account existence of ProSe D2D communication and availability of local IP connection to connect the serving BS/eNB (e.g., BS 134) to the Internet/alternative network connection (e.g., to at least partially re-establish a failed S1 interface). According to an example implementation, techniques or implementations may enable and/or facilitate
40 smart decision making for IOPS network at the BS/eNB in order to select and configure a best operational option for the wireless network so as to optimize IOPS in serving public safety (PS) users which can use ProSe/D2D communications inside or outside of IOPS network coverage.

According to an example implementation, BS 134 (or eNB) may adapt a synchronization timing reference for a IOPS network depending on (or based upon) existing operation of the BS/eNB before providing IOPS network (e.g., synchronization of the IOPS network may be based on a synchronization/synchronization status of an initial communications mode for the BS/eNB). For example, in the case of a nomadic BS (NBS or NeNB) brought to the location/incident scene to set up an IOPS network, the NBS/NeNB during the setting-up phase may begin by operating as a ProSe/D2D user device/UE in order to find and determine a synchronization source or timing reference within the D2D network , where the NBS/NeNB may then use this synchronization or timing reference for the upcoming IOPS network (or at least provide/determine an IOPS timing reference based on the synchronization/timing reference of the existing D2D/ProSe network). The NBS/NeNB, when acting/operating as a D2D/ProSe user device/UE may also announce or send an announcement regarding or announcing the upcoming NeNB and IOPS network in order to trigger D2D/ProSe user devices/UEs in its proximity to monitor for the upcoming NeNB IOPS network and switch to it if so decided according to the configured IOPS network related cell selection criteria. Note that setting up NBS/NeNB for IOPS network may take time and public safety (PS) user devices/UEs may be able to wait for the IOPS network to be established/set up, e.g., due to an urgent need of mission critical communications. This means that, for example, during the setting-up phase of IOPS network, PS user devices/UEs may use autonomous D2D/ProSe communications (device-to-device communications). Hence, the NBS/NeNB, acting/operating as a D2D/ProSe user device/UE during the setting-up phase of IOPS network, may find and adapt its synchronization timing reference according to received D2D/ProSe synchronization signals from a D2D/ProSe user device/UE acting as a synchronization source for the D2D/ProSe group or cluster, for example. In another option, the NeNB, acting as a ProSe UE during the setting-up phase, may find (receive and identify) and synchronize the upcoming IOPS network to another active BS/eNB or radio network system.

In the case of an existing BS/eNB that is serving user devices in an initial communications mode (e.g., cellular communications mode), and has just lost its S1 interface, the serving BS/eNB may keep using the existing synchronization timing reference (e.g., synchronization timing used by the BS/eNB for an initial communications mode may also be used to continue transmitting to/communicating with the user devices in the IOPS network that may be set up after detection of the failed S1 interface, for example).

In one embodiment, the IOPS serving BS/eNB may determine whether to support local routing of user-plane traffic via the BS/eNB or not and/or whether to support service continuity for certain PS users (or PS user devices) being served by the BS/eNB before being reconfigured to provide IOPS network service, or not, in addition to the support of (or coexistence with) direct D2D/ProSe communications (of other PS user groups that the BS/eNB does not serve). This determination may be based on: capability and capacity of the serving BS/eNB and user devices/UEs within the IOPS BS/eNB coverage area (e.g., maximum transmission power of the BS/eNB and user devices/UEs, local routing capability of the BS/eNB, the availability and possibility of utilizing a limited IP connection between the BS/eNB and the local gateway to provide Internet access for PS users/user devices, overall IOPS network coverage served by one or more BSs/eNBs, the ongoing user device/UE services or even the intended or expected services/applications that a

user device/UE may use, etc.). As an example, a NBS/NeNB which is brought to an incident site or mission site and set up to provide IOPS network for a certain user group of user devices within a limited radio coverage comparable to maximum D2D range may be configured to provide cellular access user-plane connection routed via the BS/eNB for only such unicast or relayed multicast/broadcast service requests which cannot be ensured with direct D2D communications, for example. To facilitate the smart determination of the operation mode at the BS/eNB, the BS/eNB may need to obtain sufficient information from individual user devices/UEs, e.g., their capability as well as ongoing/intended services/applications at the beginning of the IOPS network setup. In the case of an existing BS/eNB that is serving user devices in an initial communications mode, a PS user device/UE may be configured to indicate to the serving BS/eNB such information. For possible service continuity support, a PS user device/UE may indicate to the serving BS/eNB about the ongoing applications and services including whether a change of IP address is tolerable or not and at least baseline QoS requirements, for example. In the case of a NBS/NeNB, one option is that the NBS/NeNB may initially operate as (or appear to user devices to be) a D2D/ProSe user device/UE to communicate with other D2D/ProSe user devices/UEs using D2D direct discovery and communication, as discussed above, to request and gather the aforementioned necessary information of the other D2D/ProSe user devices/UEs. In another option, the NBS/NeNB may be initially set up according to a preconfigured default operation and then reconfigured its operation on-the-fly as determined based on received indication (or based on status or configuration of existing network/initial communications mode) or request from PS UEs. This option allows for a unified solution for both the cases (1) a nomadic BS (NBS or NeNB) that is set up at an incident site and (2) an existing BS/eNB that is initially serving user devices in an initial communications mode (e.g., cellular communications mode). That is, for a dynamic operation mode selection/reconfiguration at the BS/eNB, UE triggered mode selection and corresponding procedures may be introduced.

In one embodiment, the eNB may indicate to PS users/user devices about the determined support of IP connectivity services with/without possible service continuity; the indication may include IP addressing information from the new IP subnet if the IP point of attachment must be changed. This indication may be initiated and sent to individual user devices/UEs inside the cell by the serving BS/eNB using access stratum control signaling, either common or dedicated, for example. In the case (2) of an existing BS/eNB that is initially serving user devices in an initial communications mode, due to the expected transition from the initial communications mode (e.g., cellular network operation) to IOPS network operation, the earliest indication of the determined support of IP connectivity services if any may be used as a trigger for PS user device/UE being in a connected state to determine whether to terminate and release the ongoing IP connections and services or hold on to such ongoing IP connections and services at least for a preconfigured time interval for receiving possible network support for service continuity. The latter thus may include a reset or start certain timer(s) on RAN level corresponding to the preconfigured time interval for expecting the service continuity support. Those PS UEs being in a Connected state and expecting possible IP service continuity support may indicate to the serving BS/eNB necessary information related to the ongoing IP connectivity services in order to facilitate decision making and configuration determining at the serving BS/eNB. The serving BS/eNB may then provide the individual targeted or selected PS user

device/UE among those PS user devices/UEs being in a Connected state updated configuration information including a new (local) IP address or IPv6 prefix. Also, for example, user devices/UEs camping on IOPS network without a S1 interface/backhaul connection are no longer globally reachable. Hence, an indication and configuration on IOPS network from the serving BS/eNB may trigger IOPS network specific adaptation of Idle user device/UE behaviors and procedures as well. For examples, no actual location update is needed (in the case of missing S1 interface) but an Idle user device/UE may indicate its presence in the cell from time to time. In LTE, and other networks, a user device, may be either Idle or Connected state (with respect to a BS) and may select and/or request to use D2D/ProSe network communications mode or cellular communications mode/access via the serving BS/eNB for their service. The preconfigured unique D2D/ProSe user device/UE ID(s), or other UE context information, in addition to or instead of TMSI or IMSI, may be used to address the UE in IOPS network. In this regard, a PS user device/UE may indicate some of current UE contexts related to the serving network above the RAN level which the BS/eNB may already have (idle UE contexts, active UE contexts related to e.g., applications and services) to the serving BS/eNB. The serving BS/eNB may then use these user device/UE contexts to communicate with the user devices in the IOPS network.

According to an example implementation, an apparatus may include at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to: determine a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio access network based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode; determine a resource configuration for setting up the self-controlled radio access network, the self-controlled radio access network including the base station operating with a failed or limited capability base station-core network interface; and indicate the resource configuration to at least one user device.

According to another example implementation, the self-controlled radio access network may include an isolated radio access network providing public safety related applications and services to one or more user devices, and wherein the apparatus being caused to determine synchronization may include causing the apparatus to: determine a synchronization timing reference of the initial communications mode of the base station; and determine a synchronization timing reference for the self-controlled radio access network based on the synchronization timing reference of the initial communications mode.

According to another example implementation, the apparatus may be further configured to: control receiving, from one or more user devices, an indication of one or more services or applications operating on the user device when the failure of the base station-core network interface occurs; determine an updated base station-core network interface status, including determining whether at least a limited capability base station-core network interface has been re-established, and determining one or more capabilities of the re-established base station-core network interface; and wherein the determining a

resource configuration may include: determine, based on the indicated services or applications for one or more user devices and the updated base station-core network interface status, which, if any, of the indicated services or applications will be supported by the self-controlled radio access network.

- 5 According to an example implementation, the apparatus being caused to determine an updated base station-core network interface status may include causing the apparatus to determine an ability of a re-established base station-core network interface to provide a signaling backhaul and/or a user data backhaul for the user device.

10 According to an example implementation, the apparatus being caused to determine which, if any, of the indicated services or applications will be supported by the self-controlled radio access network may include causing the apparatus to perform at least one of the following: determine whether wireless service continuity will be provided by the self-controlled radio access network for one or more user devices; and determine whether routing of data will be provided by the self-controlled radio access network.

15 A computer program product, the computer program product comprising a non-transitory computer-readable storage medium and storing executable code that, when executed by at least one data processing apparatus, is configured to cause the at least one data processing apparatus to perform a method including: determining a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio
20 access network based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode; determining a resource configuration for setting up the self-controlled radio access network, the self-controlled radio access network including the
25 base station operating with a failed or limited capability base station-core network interface; and indicating the resource configuration to at least one user device.

According to another example implementation, an apparatus may include means (502A/502B and/or 504, FIG. 5; 210) for determining a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio access network
30 based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode; means (502A/502B and/or 504, FIG. 5; 220) for determining a resource configuration for setting up the self-controlled radio access network, the self-controlled
35 radio access network including the base station operating with a failed or limited capability base station-core network interface; and means (502A/502B and/or 504, FIG. 5; 230) for indicating the resource configuration to at least one user device.

40 According to an example implementation, the apparatus may further include: means (502A/502B and/or 504, FIG. 5) for determining an alternative network connection for the base station; and means (502A/502B and/or 504, FIG. 5) for re-establishing at least a limited capability base station-core network interface via the alternative network connection.

According to an example implementation, the apparatus may further include means (502A/502B and/or 504, FIG. 5) for controlling receiving, from one or more user devices, an indication of one or more services or applications operating on the user device when the failure of the base station–core network interface occurs; and means (502A/502B and/or 504, FIG. 5) for determining an updated base station-core network interface status, including means (502A/502B and/or 504, FIG. 5) for determining whether at least a limited capability base station-core network interface has been re-established, and means (502A/502B and/or 504, FIG. 5) for determining one or more capabilities of the re-established base station-core network interface; and wherein the means for determining a resource configuration includes: means (502A/502B and/or 504, FIG. 5) for determining, based on the indicated services or applications for one or more user devices and the updated base station-core network interface status, which, if any, of the indicated services or applications will be supported by the self-controlled radio access network.

According to another example implementation of the apparatus, the means for determining an updated base station-core network interface status may include means (502A/502B and/or 504, FIG. 5) for determining an ability of a re-established base station-core network interface to provide a signaling backhaul and/or a user data backhaul for the user device.

According to another example implementation of the apparatus, the means for determining which, if any, of the indicated services or applications will be supported by the self-controlled radio access network may include at least one of the following: means (502A/502B and/or 504, FIG. 5) for determining whether wireless service continuity will be provided by the self-controlled radio access network for one or more user devices; and means for (502A/502B and/or 504, FIG. 5) determining whether routing of data will be provided by the self-controlled radio access network.

According to another example implementation of the apparatus, the self-controlled radio access network may include an isolated radio access network providing public safety related applications and services to one or more user devices.

According to another example implementation of the apparatus, the means for determining synchronization may include: means (502A/502B and/or 504, FIG. 5) for determining a synchronization timing reference of the initial communications mode of the base station; and means (502A/502B and/or 504, FIG. 5) for determining a synchronization timing reference for the self-controlled radio access network based on the synchronization timing reference of the initial communications mode.

According to another example implementation of the apparatus, the apparatus may further include means (502A/502B and/or 504, FIG. 5) for controlling sending synchronization reference signals for the self-controlled radio access network based on the synchronization timing reference for the self-controlled radio access network.

According to another example implementation of the apparatus, the means for determining a resource configuration may include at least one of the following: means (502A/502B and/or 504, FIG. 5) for determining whether to support routing of user data for at least one user device via the base station; and means (502A/502B and/or 504, FIG. 5)

for determining whether to provide wireless service continuity for at least one user device that was served by the base station in the communications mode.

According to another example implementation of the apparatus, the means for determining a resource configuration may include: means (502A/502B and/or 504, FIG. 5) for controlling receiving user device contexts for one or more user devices for the communications mode, the user device contexts including, for a user device, a user device identification and a user device group identification; and applying the user device contexts for one or more user devices to operation of the self-controlled radio access network.

According to another example implementation, the apparatus may further include: means (502A/502B and/or 504, FIG. 5) for authenticating or authorizing a user device to operate in the self-controlled radio access network based on the received user device context for the user device for the communications mode.

According to another example implementation, the apparatus may further include one or more of the following: means (502A/502B and/or 504, FIG. 5) for indicating to a first user device whether routing of user data will be provided via the self-controlled radio access network for the first user device; and means (502A/502B and/or 504, FIG. 5) for indicating to a second user device, which was served by the at least one access node in the communications mode, whether wireless service continuity will be provided via the self-controlled radio access network for the second user device.

According to an example implementation, an apparatus may include at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to: control receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station–core network interface occurs; determine one or more established services or applications for the user device and a status of each of the one or more established services or applications; indicate, by the user device to the base station, the determined one or more established services or applications and the status of each service or application; and control receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

According to an example implementation of the apparatus, the apparatus may be further caused to control receiving, by the user device, a request to provide a user device context to the base station; and indicate, by the user device to the base station, the user device context.

According to an example implementation of the apparatus, the user device context may include one or more of the following: a proximity services network user device identifier; a proximity services network group identifier for the user device; a cellular network user device identifier; application/service level tolerance of Internet Protocol (IP) address change; and other information for assisting with isolated network operation for public safety user devices.

According to an example implementation of the apparatus, causing the apparatus to control receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network may include causing the apparatus to: control receiving, by the user device from the base station, an indication of one or more applications or services operating on the user device that will be supported for the user device by the self-controlled radio access network.

According to an example implementation of the apparatus, causing the apparatus to control receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network may include causing the apparatus to perform at least one of the following: control receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for routing of user data; and control receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for wireless service continuity.

According to an example implementation, a computer program product may include a non-transitory computer-readable storage medium and storing executable code that, when executed by at least one data processing apparatus, is configured to cause the at least one data processing apparatus to perform a method including: controlling receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station–core network interface occurs; determining one or more established services or applications for the user device and a status of each of the one or more established services or applications; indicating, by the user device to the base station, the determined one or more established services or applications and the status of each service or application; and controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

According to an example implementation, an apparatus may include means (502A/502B and/or 504, FIG. 5; 310) for controlling receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station–core network interface occurs, means (502A/502B and/or 504, FIG. 5; 320) for determining one or more established services or applications for the user device and a status of each of the one or more established services or applications, means (502A/502B and/or 504, FIG. 5; 330) for indicating, by the user device to the base station, the determined one or more established services or applications and the status of each service or application, and means (502A/502B and/or 504, FIG. 5; 340) for controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

According to another example implementation, the apparatus may further include means (502A/502B and/or 504, FIG. 5) for controlling receiving, by the user device, a request to provide a user device context to the base station; and means (502A/502B and/or 504, FIG. 5) for indicating, by the user device to the base station, the user device context.

According to another example implementation of the apparatus, the user device context may include one or more of the following: a proximity services network user device identifier; a proximity services network group identifier for the user device; a cellular network user device identifier; application/service level tolerance of Internet Protocol (IP) address change; other information for assisting with isolated network operation for public safety user devices.

According to another example implementation of the apparatus, the means for controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network may include: means for (502A/502B and/or 504, FIG. 5) controlling receiving, by the user device from the base station, an indication of one or more applications or services operating on the user device that will be supported for the user device by the self-controlled radio access network.

According to another example implementation of the apparatus, the means for controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network may include at least one of the following: means (502A/502B and/or 504, FIG. 5) for controlling receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for routing of user data; and means (502A/502B and/or 504, FIG. 5) for controlling receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for wireless service continuity.

According to another example implementation of the apparatus, the means for controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network may include: means (502A/502B and/or 504, FIG. 5) for controlling receiving, by the user device from the base station, a cell identifier or network identification information for the self-controlled radio access network; and controlling receiving, by the user device from the base station, a synchronization timing reference for the self-controlled radio access network.

FIG. 5 is a block diagram of a network node (e.g., BS or user device) 500 according to an example implementation. The network node (or wireless station) 500 may include, for example, two RF (radio frequency) or wireless transceivers 502A, 502B, where each wireless transceiver includes a transmitter to transmit signals and a receiver to receive signals. The wireless station also includes a processor 504 to execute instructions or software and control transmission and receptions of signals, and a memory 506 to store data and/or instructions.

Processor 504 may also make decisions or determinations, generate frames, packets or messages for transmission, decode received frames or messages for further processing, and other tasks or functions described herein. Processor 504, which may be a baseband processor, for example, may generate messages, packets, frames or other signals for transmission via wireless transceiver 502. Processor 504 may control transmission of signals or messages over a wireless network, and may receive signals or messages, etc., via a wireless network (e.g., after being down-converted by wireless transceiver 502, for example). Processor 504 may be programmable and capable of executing software or

other instructions stored in memory or on other computer media to perform the various tasks and functions described above, such as one or more of the tasks or methods described above. Processor 504 may be (or may include), for example, hardware, programmable logic, a programmable processor that executes software or firmware, and/or any combination of these. Using other terminology, processor 504 and transceiver 502 together may be considered as a wireless transmitter/receiver system, for example.

In addition, referring to FIG. 5, a controller (or processor) 508 may execute software and instructions, and may provide overall control for the network node 500, and may provide control for other systems not shown in FIG. 5, such as controlling input/output devices (e.g., display, keypad), and/or may execute software for one or more applications that may be provided on network node 500, such as, for example, an email program, audio/video applications, a word processor, a Voice over IP application, or other application or software.

In addition, a storage medium may be provided that includes stored instructions, which when executed by a controller or processor may result in the processor 504, or other controller or processor, performing one or more of the functions or tasks described above.

The embodiments are not, however, restricted to the system that is given as an example, but a person skilled in the art may apply the solution to other communication systems. Another example of a suitable communications system is the 5G concept. It is assumed that network architecture in 5G will be quite similar to that of the LTE-advanced. 5G is likely to use multiple input – multiple output (MIMO) antennas, many more base stations or nodes than the LTE (a so-called small cell concept), including macro sites operating in co-operation with smaller stations and perhaps also employing a variety of radio technologies for better coverage and enhanced data rates.

It should be appreciated that future networks will most probably utilise network functions virtualization (NFV) which is a network architecture concept that proposes virtualizing network node functions into “building blocks” or entities that may be operationally connected or linked together to provide services. A virtualized network function (VNF) may comprise one or more virtual machines running computer program codes using standard or general type servers instead of customized hardware. Cloud computing or data storage may also be utilized. In radio communications this may mean node operations may be carried out, at least partly, in a server, host or node operationally coupled to a remote radio head. It is also possible that node operations will be distributed among a plurality of servers, nodes or hosts. 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.

Implementations of the various techniques described herein may be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. Implementations may implemented as a computer program product, i.e., a computer program tangibly embodied in an information carrier, e.g., in a machine-readable storage device or in a propagated signal, for execution by, or to control the operation of, a data processing apparatus, e.g., a programmable processor, a computer, or multiple computers. Implementations may also be provided on a computer readable medium or

computer readable storage medium, which may be a non-transitory medium. Implementations of the various techniques may also include implementations provided via transitory signals or media, and/or programs and/or software implementations that are downloadable via the Internet or other network(s), either wired networks and/or wireless
5 networks. In addition, implementations may be provided via machine type communications (MTC), and also via an Internet of Things (IOT).

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, distribution medium, or computer readable medium, which may be any entity or device capable of carrying the
10 program. Such carriers include a record medium, computer memory, read-only memory, photoelectrical and/or electrical carrier signal, telecommunications signal, and software distribution package, for example. Depending on the processing power needed, the computer program may be executed in a single electronic digital computer or it may be distributed amongst a number of computers.

Furthermore, implementations of the various techniques described herein may use 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,...) embedded in physical objects at different locations. Mobile cyber
15 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. The rise in popularity of smartphones has increased interest in the area of mobile cyber-physical systems. Therefore, various implementations of techniques described herein may be provided via
20 one or more of these technologies.

A computer program, such as the computer program(s) described above, can be written in any form of programming language, including compiled or interpreted languages, and can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit or part of it suitable for use in a computing environment. A
30 computer program can be deployed to be executed on one computer or on multiple computers at one site or distributed across multiple sites and interconnected by a communication network.

Method steps may be performed by one or more programmable processors executing a computer program or computer program portions to perform functions by operating on
35 input data and generating output. Method steps also may be performed by, and an apparatus may be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application-specific integrated circuit).

Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of
40 any kind of digital computer, chip or chipset. Generally, a processor will receive instructions and data from a read-only memory or a random access memory or both. Elements of a computer may include at least one processor for executing instructions and one or more memory devices for storing instructions and data. Generally, a computer also

may include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto-optical disks, or optical disks. Information carriers suitable for embodying computer program instructions and data include all forms of non-volatile memory, including by way of example
5 semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks. The processor and the memory may be supplemented by, or incorporated in, special purpose logic circuitry.

To provide for interaction with a user, implementations may be implemented on a
10 computer having a display device, e.g., a cathode ray tube (CRT) or liquid crystal display (LCD) monitor, for displaying information to the user and a user interface, such as a keyboard and a pointing device, e.g., a mouse or a trackball, by which the user can provide input to the computer. Other kinds of devices can be used to provide for
15 interaction with a user as well; for example, feedback provided to the user can be any form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user can be received in any form, including acoustic, speech, or tactile input.

Implementations may be implemented in a computing system that includes a back-end component, e.g., as a data server, or that includes a middleware component, e.g., an
20 application server, or that includes a front-end component, e.g., a client computer having a graphical user interface or a Web browser through which a user can interact with an implementation, or any combination of such back-end, middleware, or front-end components. Components may be interconnected by any form or medium of digital data communication, e.g., a communication network. Examples of communication networks
25 include a local area network (LAN) and a wide area network (WAN), e.g., the Internet.

While certain features of the described implementations have been illustrated as described herein, many modifications, substitutions, changes and equivalents will now occur to those skilled in the art. It is, therefore, to be understood that the appended claims
30 are intended to cover all such modifications and changes as fall within the true spirit of the various embodiments.

WHAT IS CLAIMED IS:

1. A method comprising:

5 determining a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio access network based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode;

10 determining a resource configuration for setting up the self-controlled radio access network, the self-controlled radio access network including the base station operating with a failed or limited capability base station-core network interface; and

indicating the resource configuration to at least one user device.

2. The method of claim 1 and further comprising:

15 determining an alternative network connection for the base station; and

re-establishing at least a limited capability base station-core network interface via the alternative network connection.

3. The method of any of claims 1-2 and further comprising:

20 controlling receiving, from one or more user devices, an indication of one or more services or applications operating on the user device when the failure of the base station-core network interface occurs; and

25 determining an updated base station-core network interface status, including determining whether at least a limited capability base station-core network interface has been re-established, and determining one or more capabilities of the re-established base station-core network interface; and

wherein the determining a resource configuration comprises:

30 determining, based on the indicated services or applications for one or more user devices and the updated base station-core network interface status, which, if any, of the indicated services or applications will be supported by the self-controlled radio access network.

4. The method of claim 3 wherein the determining an updated base station-core network interface status comprises determining an ability of a re-established base station-core network interface to provide a signaling backhaul and/or a user data backhaul for the user device.

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5. The method of any of claims 3-4 wherein the determining which, if any, of the indicated services or applications will be supported by the self-controlled radio access network comprises at least one of the following:

- 5 determining whether wireless service continuity will be provided by the self-controlled radio access network for one or more user devices; and

determining whether routing of data will be provided by the self-controlled radio access network.

- 10 6. The method of any of claims 1-5 wherein the self-controlled radio access network comprises an isolated radio access network providing public safety related applications and services to one or more user devices.

- 15 7. The method of any of claims 1-6 wherein the determining synchronization comprises:

determining a synchronization timing reference of the initial communications mode of the base station; and

- 20 determining a synchronization timing reference for the self-controlled radio access network based on the synchronization timing reference of the initial communications mode.

8. The method of claim 7, and further comprising:

- 25 controlling sending synchronization reference signals for the self-controlled radio access network based on the synchronization timing reference for the self-controlled radio access network.

9. The method of any of claims 1-8 wherein the determining a resource configuration comprises at least one of the following:

- 30 determining whether to support routing of user data for at least one user device via the base station; and

determining whether to provide wireless service continuity for at least one user device that was served by the base station in the communications mode.

10. The method of any of claims 1-9 wherein the determining a resource configuration comprises:

controlling receiving user device contexts for one or more user devices for the communications mode, the user device contexts including, for a user device, a user device identification and a user device group identification; and

applying the user device contexts for one or more user devices to operation of the self-controlled radio access network.

11. The method of claim 10 and further comprising:

authenticating or authorizing a user device to operate in the self-controlled radio access network based on the received user device context for the user device for the communications mode.

12. The method of any of claims 1-11 and further comprising one or more of the following:

indicating to a first user device whether routing of user data will be provided via the self-controlled radio access network for the first user device; and

indicating to a second user device, which was served by the at least one access node in the communications mode, whether wireless service continuity will be provided via the self-controlled radio access network for the second user device.

13. An apparatus, comprising:

at least one processor; and

at least one non-transitory computer-readable storage medium comprising instructions for transmitting multicast data via a communication resources not dedicated to that multicast data stored thereon that, when executed by the at least one processor, are configured to cause the apparatus to perform the method of any of claims 1-12.

14. An apparatus comprising means for performing a method of any of claims 1-12.

15. A computer program product for a computer, comprising software code portions for performing the steps of any of claims 1-12 when said product is run on the computer.

16. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to:

5 determine a synchronization, in case of a failed base station-core network interface, for setting-up a self-controlled radio access network based on an initial communications mode of a base station and a synchronization status of the communications mode, wherein the initial communications mode is at least one of the following: a device-to-device communications mode and a cellular communications mode;

10 determine a resource configuration for setting up the self-controlled radio access network, the self-controlled radio access network including the base station operating with a failed or limited capability base station-core network interface; and

indicate the resource configuration to at least one user device.

17. The apparatus of claim 16 wherein the self-controlled radio access network
15 comprises an isolated radio access network providing public safety related applications and services to one or more user devices, and wherein the apparatus being caused to determine synchronization comprises causing the apparatus to:

determine a synchronization timing reference of the initial communications mode of the base station; and

20 determine a synchronization timing reference for the self-controlled radio access network based on the synchronization timing reference of the initial communications mode.

18. The apparatus of any of claims 16-17 wherein the apparatus is further configured to:

25 control receiving, from one or more user devices, an indication of one or more services or applications operating on the user device when the failure of the base station-core network interface occurs; and

30 determine an updated base station-core network interface status, including determining whether at least a limited capability base station-core network interface has been re-established, and determining one or more capabilities of the re-established base station-core network interface; and

wherein the determining a resource configuration comprises:

35 determine, based on the indicated services or applications for one or more user devices and the updated base station-core network interface status, which, if any, of the indicated services or applications will be supported by the self-controlled radio access network.

19. The apparatus of any of claims 16-18 wherein the apparatus being caused to determine an updated base station-core network interface status comprises causing the apparatus to determine an ability of a re-established base station-core network interface to provide a signaling backhaul and/or a user data backhaul for the user device.

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20. The apparatus of any of claim 18 wherein the apparatus being caused to determine which, if any, of the indicated services or applications will be supported by the self-controlled radio access network comprises causing the apparatus to perform at least one of the following:

10 determine whether wireless service continuity will be provided by the self-controlled radio access network for one or more user devices; and

determine whether routing of data will be provided by the self-controlled radio access network.

15 21. A method comprising:

controlling receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station-core network interface occurs;

20 determining one or more established services or applications for the user device and a status of each of the one or more established services or applications;

indicating, by the user device to the base station, the determined one or more established services or applications and the status of each service or application; and

controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

25

22. The method of claim 21 and further comprising:

controlling receiving, by the user device, a request to provide a user device context to the base station;

indicating, by the user device to the base station, the user device context.

30

23. The method of any of claims 21-22 wherein the user device context comprises one or more of the following:

a proximity services network user device identifier;

a proximity services network group identifier for the user device;

a cellular network user device identifier;

application/service level tolerance of Internet Protocol (IP) address change;

other information for assisting with isolated network operation for public safety user devices.

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24. The method of any of claims 21-23 wherein the controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network comprises:

10

controlling receiving, by the user device from the base station, an indication of one or more applications or services operating on the user device that will be supported for the user device by the self-controlled radio access network.

15

25. The method of any of claims 21-24 wherein the controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network comprises at least one of the following:

controlling receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for routing of user data; and

20

controlling receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for wireless service continuity.

25

26. The method of any of claims 21-25 wherein the controlling receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network comprises:

controlling receiving, by the user device from the base station, a cell identifier or network identification information for the self-controlled radio access network; and

controlling receiving, by the user device from the base station, a synchronization timing reference for the self-controlled radio access network.

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27. An apparatus comprising means for performing a method of any of claims 21-26.

28. An apparatus, comprising:

at least one processor; and

at least one non-transitory computer-readable storage medium comprising instructions for transmitting multicast data via a communication resources not dedicated to that multicast data stored thereon that, when executed by the at least one processor, are configured to cause the apparatus to perform the method of any of claims 21-26.

5

29. A computer program product for a computer, comprising software code portions for performing the steps of any of claims 21-26 when said product is run on the computer.

10 30. An apparatus comprising at least one processor and at least one memory including computer instructions, when executed by the at least one processor, cause the apparatus to:

control receiving, by a user device from a base station, a request to indicate a status of any established services or applications operating on the user device when a failure or partial failure of a base station–core network interface occurs;

15 determine one or more established services or applications for the user device and a status of each of the one or more established services or applications;

indicate, by the user device to the base station, the determined one or more established services or applications and the status of each service or application; and

20 control receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network.

31. The apparatus of claim 30 and further causing the apparatus to:

control receiving, by the user device, a request to provide a user device context to the base station;

25 indicate, by the user device to the base station, the user device context.

32. The apparatus of any of claims 30-31 wherein the user device context comprises one or more of the following:

a proximity services network user device identifier;

30 a proximity services network group identifier for the user device;

a cellular network user device identifier;

application/service level tolerance of Internet Protocol (IP) address change;

other information for assisting with isolated network operation for public safety user devices.

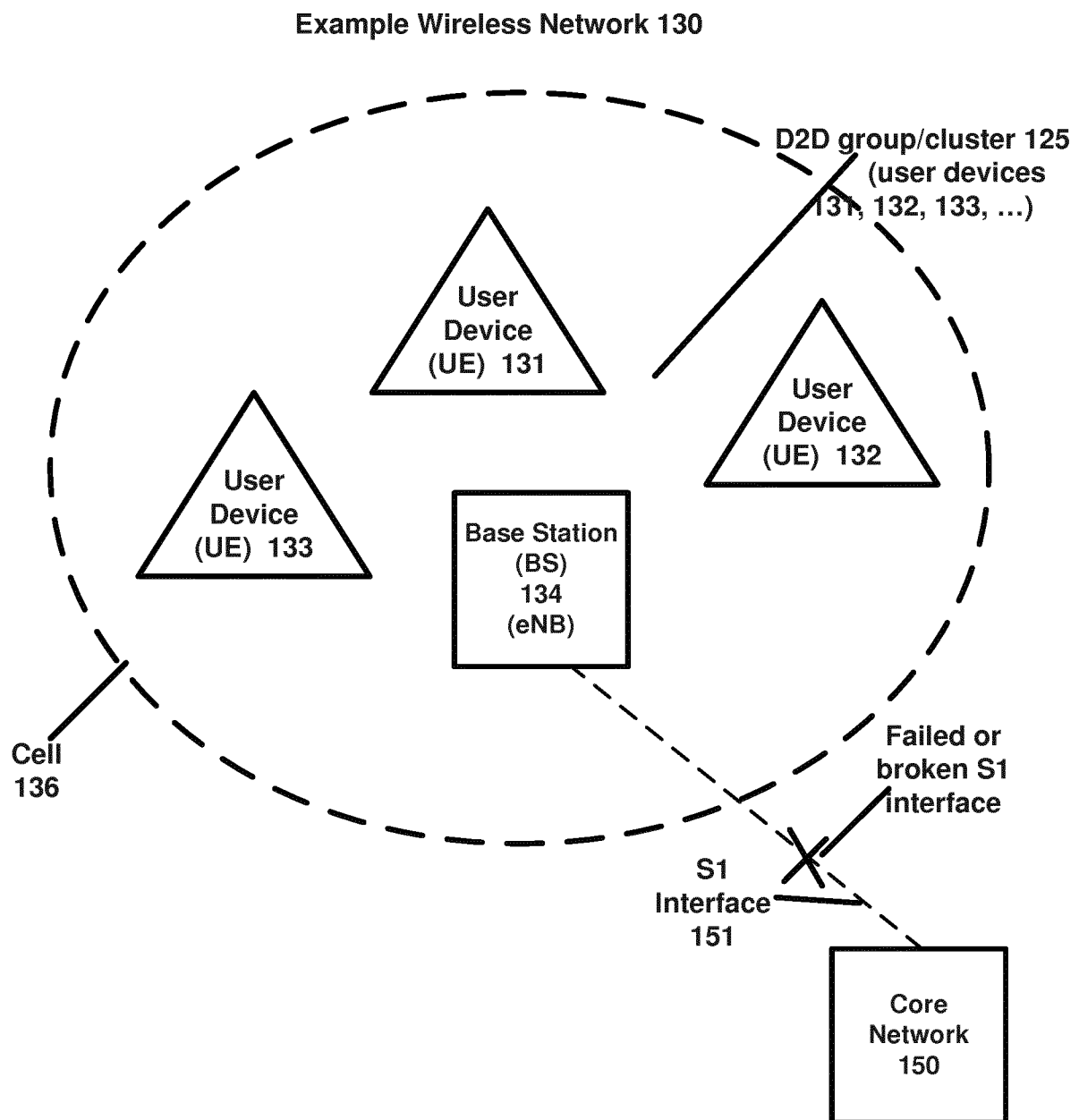
33. The apparatus of any of claim 30-32 wherein causing the apparatus to control receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network comprises causing the apparatus to:

control receiving, by the user device from the base station, an indication of one or more applications or services operating on the user device that will be supported for the user device by the self-controlled radio access network.

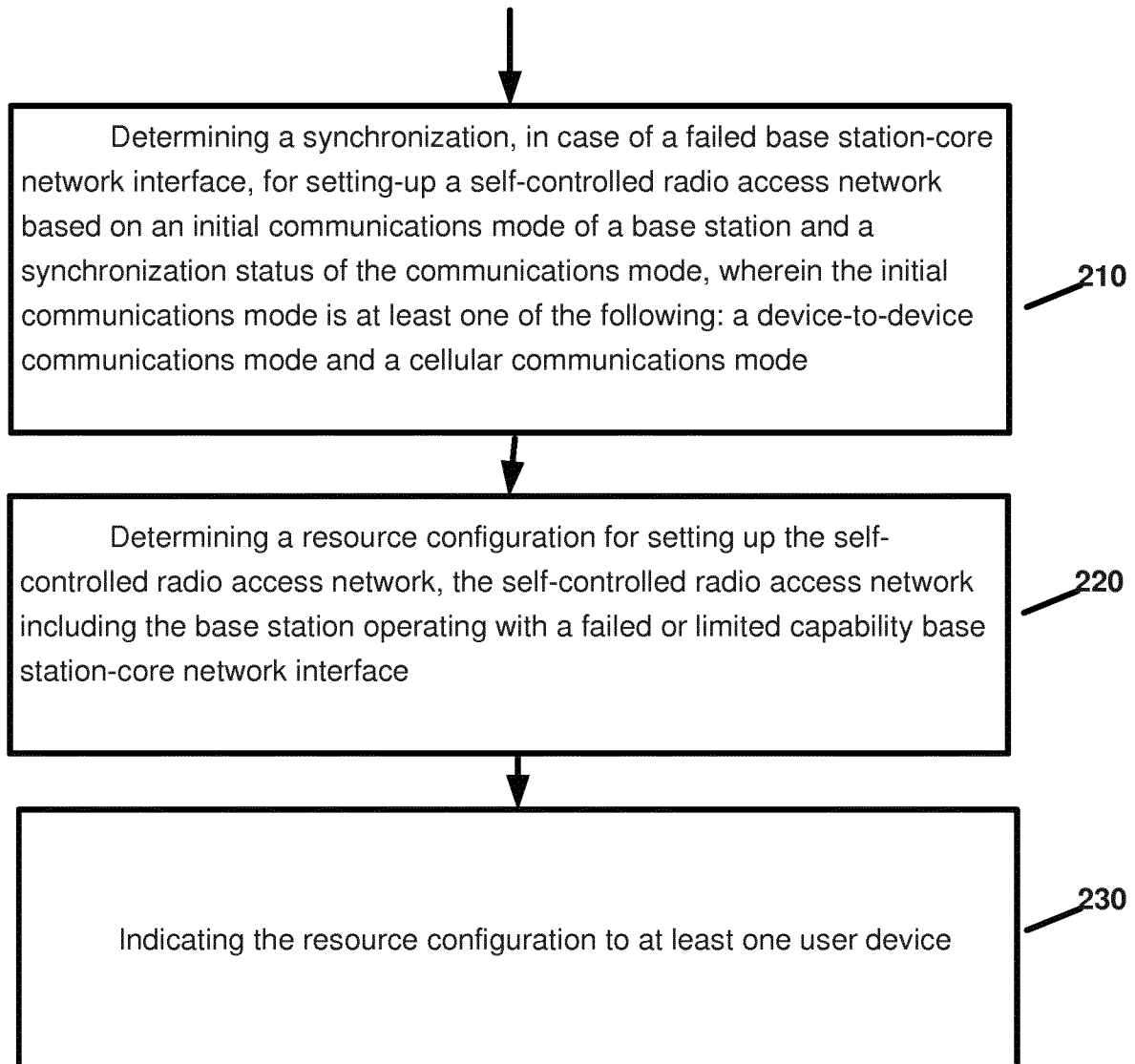
34. The apparatus of any of claims 30-33 wherein causing the apparatus to control receiving, by the user device from the base station, a resource configuration from the base station for setting-up a self-controlled radio access network comprises causing the apparatus to perform at least one of the following:

control receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for routing of user data; and

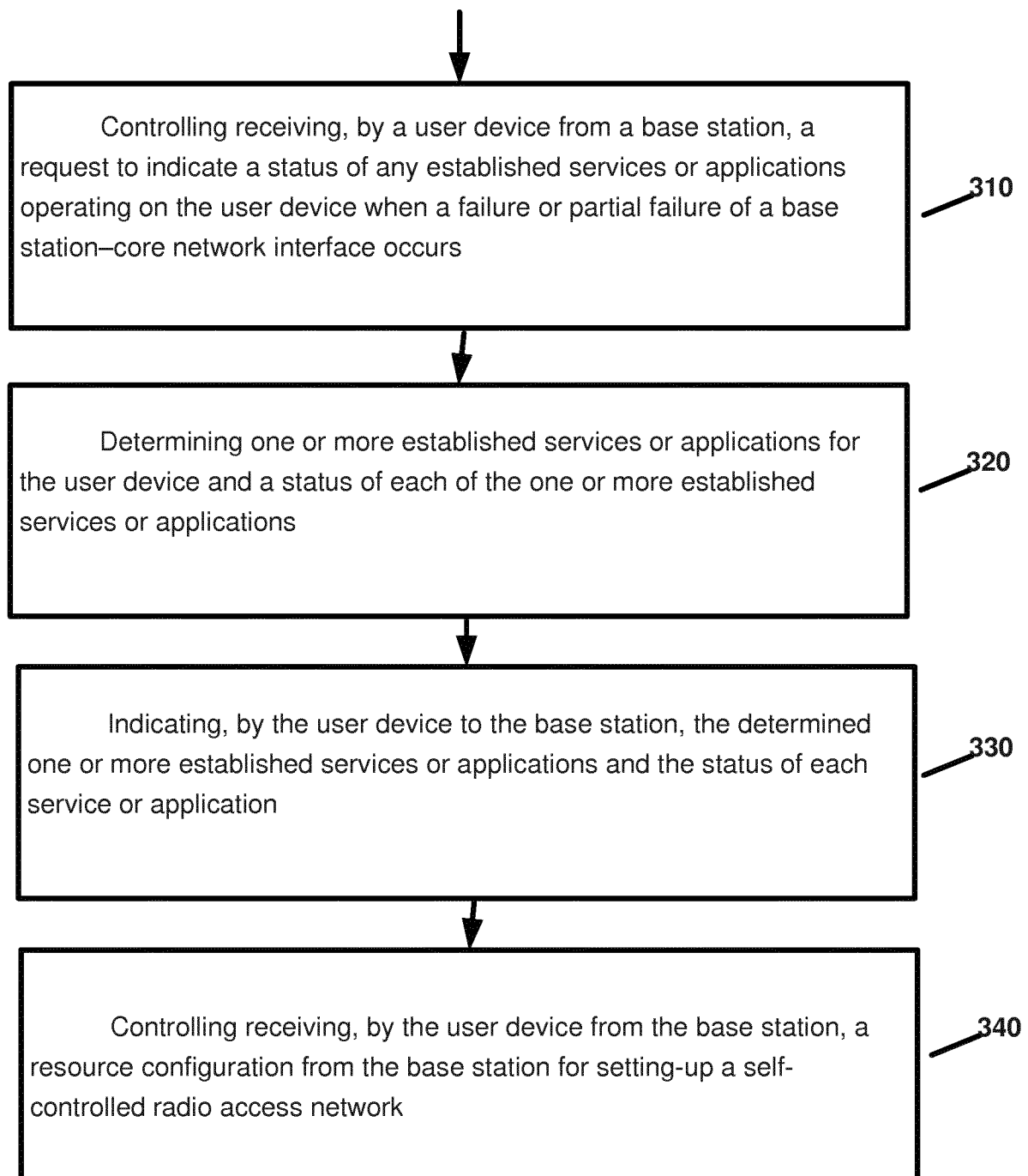
control receiving, by the user device from the base station, an indication of whether the self-controlled radio access network will provide support to the user device for wireless service continuity.

**FIG. 1**

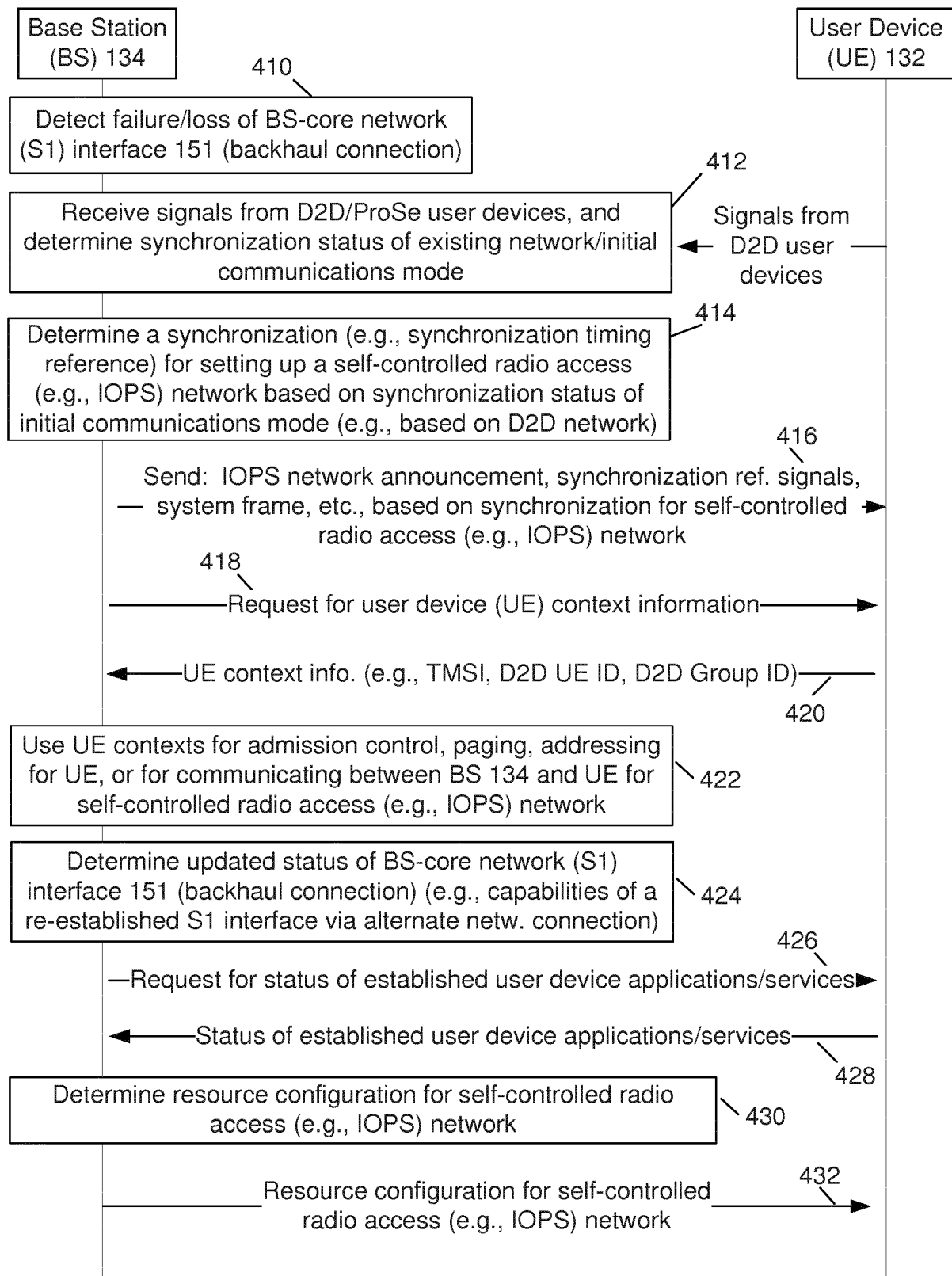
2 (5)

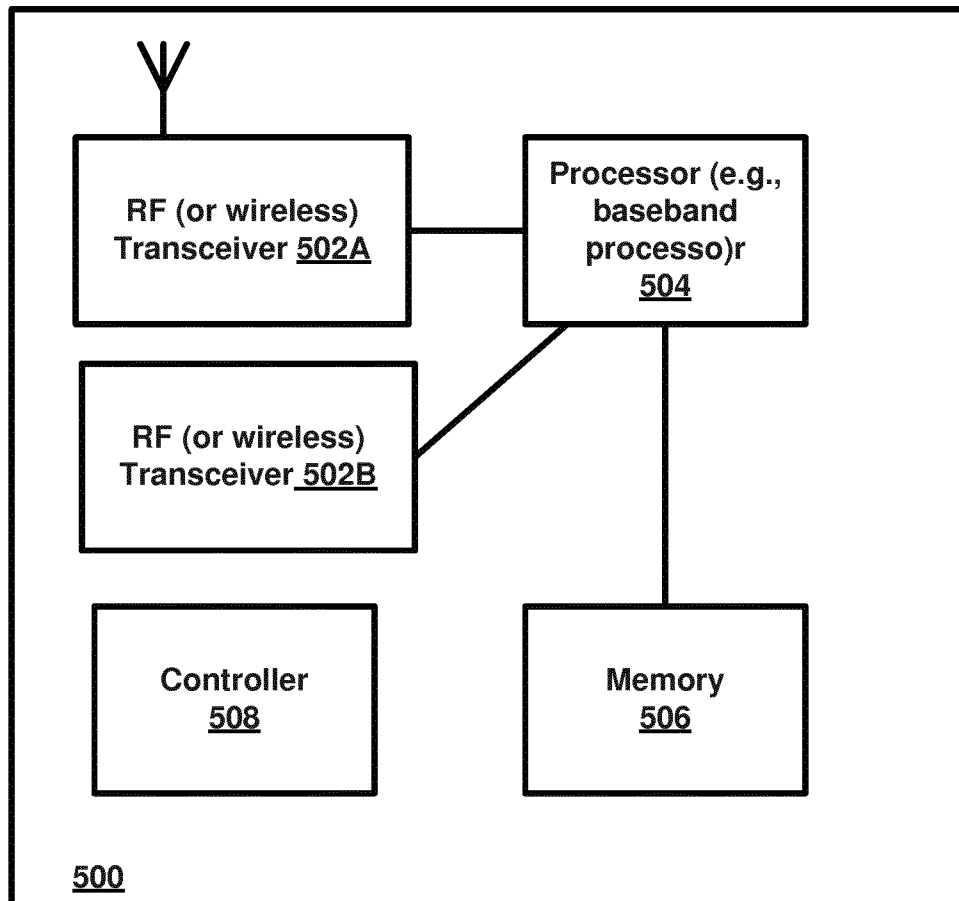
**FIG. 2**

3 (5)

**FIG. 3**

4 (5)

**FIG. 4**

**FIG. 5**

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/057471

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W24/04

ADD. H04W92/04

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 H04L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, INSPEC, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2014/095680 A1 (KONINKL KPN NV [NL]; TNO [NL]) 26 June 2014 (2014-06-26) column 3, line 5 - line 15 page 8, line 8 - page 9, line 28 ----- -/--	1-34



Further documents are listed in the continuation of Box C.



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

1 December 2015

Date of mailing of the international search report

09/12/2015

Name and mailing address of the ISA/

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Authorized officer

Hartweg, Norman

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/057471

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Isolated E-UTRAN Operation for Public Safety; Stage 1 (Release 13)", 3GPP DRAFT; S1-143299, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , 25 August 2014 (2014-08-25), XP050834781, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_sa/WG1_Serv/TSGS1_67_SophiaAntipolis/docs/[retrieved_on_2014-08-25] chapters 4 and 5 -----	1-34
A	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on Isolated Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Operation for Public Safety (Release 13)", 3GPP DRAFT; 22897-200, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , 10 June 2014 (2014-06-10), XP050801251, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/SA/Docs/[retrieved_on_2014-06-10] chapter 4 -----	1-34

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/057471

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014095680 A1	26-06-2014	CN 104838678 A	12-08-2015
		EP 2932747 A1	21-10-2015
		US 2015327306 A1	12-11-2015
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