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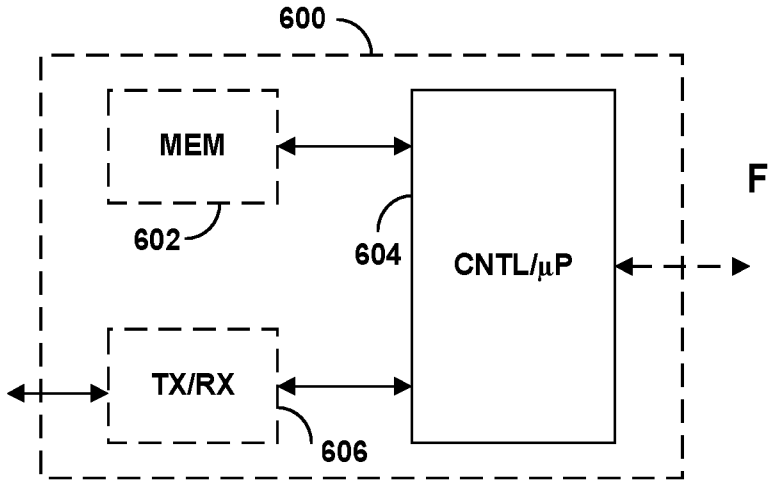

FIG. 6

(57) Abstract: An aspect of the invention is in relation to an apparatus comprising: at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to: transmit, by a user device, a connection request comprising information on service; receive configuration information in response to the connection request and establishing a connection based on the configuration information, and receive at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

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Connection Configuration

Field

The invention relates to communications.

Background

The following description of background art may include insights, discoveries, understandings or disclosures, or associations together with disclosures not known to the relevant art prior to the present invention but provided by the invention. Some such contributions of the invention may be specifically pointed out below, whereas other such contributions of the invention will be apparent from their context.

It is envisaged that wireless data traffic will grow 10,000 fold within the next 20 years due to ultra-high resolution video streaming, cloud-based work, entertainment and increased use of a variety of wireless devices. These will include smartphones, tablets and other devices, including machine type communications for the programmable world. Mobile communications will have a wider range of use cases and related applications including video streaming, augmented reality, different ways of data sharing and various forms of machine type applications, including vehicular safety, different sensors and real-time control.

Summary

According to an aspect of the present invention, there is provided an apparatus comprising: at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to: transmit, by a user device, a connection request comprising information on service; receive configuration information in response to the connection request and establishing a connection based on the configuration information, and receive at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

According to an aspect of the present invention, there is provided an apparatus comprising: at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to: receive, by an access node, a connection request for a user device, the connection

request comprising information on service; carry out a connection configuration in response to the connection request; detect an interruption in data transmission in relation to the configured connection, and carry out, in response to the interruption, either a reconfiguration to an intermediate state or a connection release based on the information on service.

According to yet another aspect of the present invention, there is provided a method comprising: transmitting, by a user device, a connection request comprising information on service; receiving configuration information in response to the connection request and establishing a connection based on the configuration information, and receiving at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service

According to yet another aspect of the present invention, there is provided a method comprising: receiving, by an access node, a connection request for a user device, the connection request comprising information on service; carrying out a connection configuration in response to the connection request; detecting an interruption in data transmission in relation to the configured connection, and carrying out, in response to the interruption, either a reconfiguration to an intermediate state or a connection release based on the information on service.

According to yet another aspect of the present invention, there is provided an apparatus comprising: means for transmitting a connection request comprising information on service; means for receiving configuration information in response to the connection request and means for establishing a connection based on the configuration information, and means for receiving at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

According to yet another aspect of the present invention, there is provided an apparatus comprising: means for receiving a connection request for a user device, the connection request comprising information on service, means for carrying out a connection configuration in response to the connection request, means for detecting an interruption in data transmission in relation to the configured connection, and means for carrying out, in response to the interruption, either a reconfiguration to an intermediate state or a connection release based on the information on service.

According to yet another aspect of the present invention, there is provided a computer program, comprising program code portions for controlling executing of a process, the process comprising: transmitting a connection request comprising information on service; receiving configuration information in response to the

connection request and establishing a connection based on the configuration information, and receiving at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

According to yet another aspect of the present invention, there is provided a computer program, comprising program code portions for controlling executing of a process, the process comprising: receiving a connection request for a user device, the connection request comprising information on service; carrying out a connection configuration in response to the connection request; detecting an interruption in data transmission in relation to the configured connection, and carrying out, in response to the interruption, either a reconfiguration to an intermediate state or a connection release based on the information on service.

List of drawings

Some embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which

Figure 1 illustrates an example of a system;

Figure 2 is a flow chart;

Figure 3 is another flow chart;

Figure 4 illustrates an example of a signaling chart;

Figure 5 illustrates use case examples;

Figure 6 illustrates examples of apparatuses, and

Figure 7 illustrates other examples of apparatuses.

Description of some embodiments

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

Embodiments are applicable to any user device, such as a user terminal, as well as to any network element, relay node, server, node, corresponding component, and/or to any communication system or any combination of different communication systems that support required functionalities. The communication system may be a wireless communication system or a communication system

utilizing both fixed networks and wireless networks. The protocols used, the specifications of communication systems, apparatuses, such as servers and user terminals, especially in wireless communication, develop rapidly. Such development may require extra changes to an embodiment. Therefore, all words and expressions should be interpreted broadly and they are intended to illustrate, not to restrict, embodiments.

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

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

The embodiments are not, however, restricted to the system given as an example but a person skilled in the art may apply the solution to other communication systems provided with necessary properties. Another example of a suitable communications system is the 5G concept. It is assumed that radio network architecture in 5G may 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. 5G will likely be comprised of more than one radio access technology (RAT), each optimized for

certain use cases and/or spectrum. 5G mobile communications will have a wider range of use cases and related applications including video streaming, augmented reality, different ways of data sharing and various forms of machine type applications, including vehicular safety, different sensors and real-time control.

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 to 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. Some other technology advancements probably to be used are Software-Defined Networking (SDN), Big Data, and all-IP, which may change the way networks are being constructed and managed.

Figure 1 shows a part of a radio access network based on E-UTRA, LTE, LTE-Advanced (LTE-A) or LTE/EPC (EPC = evolved packet core, EPC is enhancement of packet switched technology to cope with faster data rates and growth of Internet protocol traffic). E-UTRA is an air interface of LTE Release 8 (UTRA= UMTS terrestrial radio access, UMTS= universal mobile telecommunications system). Some advantages obtainable by LTE (or E-UTRA) are a possibility to use plug and play devices, and Frequency Division Duplex (FDD) and Time Division Duplex (TDD) in the same platform.

Figure 1 shows user devices 100 and 102 configured to be in a wireless connection on one or more communication channels 104 and 106 in a cell with a (e)NodeB 108 providing the cell. The physical link from a user device to a (e)NodeB is called uplink or reverse link and the physical link from the (e)NodeB to the user device is called downlink or forward link.

Two other nodes (eNodeBs) are also provided, namely 114 and 116 which may have communications channels 118 and 120 to eNode B 108. The nodes may belong to the network of a same operator or to the networks of different operators. It should be appreciated that the number of nodes may vary, as well as the number of networks. User devices communicating with nodes 114 and 116 are

not shown due to the sake of clarity. The nodes may have connections to other networks, as well.

The NodeB, or advanced evolved node B (eNodeB, eNB) in LTE-Advanced, is a computing device configured to control the radio resources of communication system it is coupled to. The (e)NodeB may also be referred to as a base station, an access point or any other type of interfacing device including a relay station capable of operating in a wireless environment.

The (e)NodeB includes or is coupled to transceivers. From the transceivers of the (e)NodeB, a connection is provided to an antenna unit that establishes bi-directional radio links to user devices. The antenna unit may comprise a plurality of antennas or antenna elements. The (e)NodeB is further connected to core network 110 (CN). Depending on the system, the counterpart on the CN side can be a serving gateway (S-GW, routing and forwarding user data packets), packet data network gateway (P-GW), for providing connectivity of user devices (UEs) to external packet data networks, or mobile management entity (MME), etc.

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

The communication system is also able to communicate with other networks, such as a public switched telephone network or the Internet 112. The communication network may also be able to support the usage of cloud services. It should be appreciated that (e)NodeBs or their functionalities may be implemented by using any node, host, server or access point etc. entity suitable for such a usage.

The communication system may also comprise a central control entity, or a like, providing facilities for networks of different operators to cooperate for example in spectrum sharing.

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

The user device typically refers to a portable computing device that includes wireless mobile communication devices operating with or without a subscriber identification module (SIM), including, but not limited to, the following types of devices: a mobile station (mobile phone), smartphone, personal digital

assistant (PDA), handset, device using a wireless modem (alarm or measurement device, etc.), laptop and/or touch screen computer, tablet, game console, notebook, and multimedia device. It should be appreciated that a user device may also be a nearly exclusive uplink only device, of which an example is a camera or video camera loading images or video clips to a network. A user device may also be a device having capability to operate in Internet of Things (IoT) network which is a scenario in which objects are provided with the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. A user device may also be a device operating in a cyber-physical system (CPS) which is a system of collaborating computational elements controlling physical entities.

The user device (or in some embodiments a layer 3 relay node or a self-backhauling node) is configured to perform one or more of user equipment functionalities. The user device may also be called a subscriber unit, mobile station, remote terminal, access terminal, user terminal or user equipment (UE) just to mention but a few names or apparatuses.

It should be understood that, in Figure 1, user devices are depicted to include 2 antennas only for the sake of clarity. The number of reception and/or transmission antennas may naturally vary according to a current implementation.

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

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

For fulfilling the need for improving the deployment and performance of communication systems, the concept of “plug-and-play” (e)NodeBs has been

introduced. Typically, a network which is able to use "plug-and-play" (e)Node Bs, includes, in addition to Home (e)NodeBs (H(e)nodeBs), a home node B gateway, or HNB-GW (not shown in Figure 1). A HNB Gateway (HNB-GW), which is typically installed within an operator's network may aggregate traffic from a large number of HNBs back to a core network.

In the following, an embodiment for connection configuration is disclosed by means of Figure 2. The embodiment may be carried out by a user device. The embodiment is suitable for adapting user device's operation mode to support different services and/or applications in a resource usage effective manner. For example, requirements of machine-type communications (MTC) often deviate from those of human centric communications (the various kinds of MTC will enable the wireless Internet of Things (IoT)). A method for controlling an operational state (and related common and dedicated system information) in the existence of multi-link, multi-layer, multi-RATs and/or diverse applications or services using service information based configurable states is provided. In describing embodiments and examples, LTE-related terminology may be used for clarification purposes. Such terminology should not be taken as limiting the embodiments or examples, however.

The embodiment starts in block 200.

In block 202, a connection request comprising information on service is transmitted.

A connection request is transmitted to a network the user device wishes to use for communications to inform the network on user device's service needs. The information in the message may vary, but in principle, information needed by the network for resource configuration is provided. The information on service may be a service identity (ID) and/or an application identity (ID). These identities may be standardized, informed as a part of random access or a corresponding procedure (unicast or multicast), informed in broadcasts an access node providing a cell transmits, negotiated between service providers, etc. They may be in the form of a list or table, for example. In 5G, it has been proposed that cells advertize more actively available services. Therefore a user device may request a service that provides the closest match to its capability and/or needs. The information on service may also comprise a mobility status of the user device. The mobility status information may be based on location or tracking information (such as using Global Position System or range detection) and/or information obtained from speed sensors or radars, for example.

Information on service may also comprise indication of resources dedicated to the service. This is useful information in network slicing, wherein a

machine-type-communication device may indicate to a network which network slice is applicable to the device or service.

A connection request may comprise information on user device's capabilities or a separate message comprising the information may be transmitted. For example, capabilities of a smart phone may vary from model to model. A connection request may also comprise information on user device's power saving configuration or a power saving request. For example, a certain service or application may have dedicated power saving settings or a power saving mode. A connection request may be transmitted after a random access procedure or a like using the resources reserved or configured for a connection request.

In block 204, configuration information is received in response to the connection request and a connection is established based on the configuration information.

As a response to the connection request, a network sends a confirmation or setup message or a like, wherein resources or configuration for the connection are informed. A user device establishes a connection to the network based on this information.

In block 206, at least one message is received indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

With an intermediate state it is mean a flexible operation state, which is not an idle state but not "full" active state, either. In the intermediate state, a user device may carry out operations adapted to the service or application in question. Operations which may be configured to be carried out by a user device, comprise one or more of the following: user device registration (a user device may be registered and known with a unique identifier in its tracking area which typically consists of multiple cells), tracking and/or location, packet forwarding, camping, reception of system information, monitoring a paging channel, authentication, contention based uplink data transmission, etc.

One example of how service or application affects to operations carried out in an intermediate state or that an idle state is not possible, is a user device participating in an activity, for example it is a vehicle moving along a road, when it has to gather certain information on itself and/or on its environment in which case configuration in relation to this user device may not be carried out freely by the access node, but the service and/or application determines the operations to be carried out in an intermediate state or prohibits an idle state. For example, a vehicle

using some kind of an automated driving aid may have to be able to communicate with a service control unit in a specified manner.

Mobility status may be taken into consideration when operations in relation to reconfiguration or connection release are carried out. Mobility status may differentiate a normal (=stationary, slowly moving or infrequent cell changes) and moving devices. Moving devices may have limitations in relation to an intermediate state. In one example, only those normal mobility state devices may be configured into an intermediate state. For another example, only those moving devices the speed of which is above that of pedestrian may be configured into an intermediate state, for example as a part of fleet management or some collision detection or driving automated vehicles. Other devices may be configured to an idle state for saving resources.

The embodiment ends in block 208. The embodiment is repeatable in many different ways, for example, reconfiguration may be repeated for changing the state from an intermediate state to an idle state or to active state.

In the following, another embodiment for connection configuration is disclosed by means of Figure 3. The embodiment may be carried out by an access node, server, host or a corresponding device. The access node, server or host may be a node providing a cellular coverage for general radio communications or it may an access node supporting a certain service, such as vehicle-to-vehicle (V2V) or vehicle to anything (V2X) communications. The embodiment is suitable for adapting user device's operation mode to support different services and/or applications in a resource usage effective manner. For example, requirements of machine-type communications (MTC) often deviate from those of human centric communications (the various kinds of MTC will enable the wireless Internet of Things (IoT)). A method for controlling an operational state (and related common and dedicated system information) in the existence of multi-link, multi-layer, multi-RATs and/or diverse applications or services using service information based configurable states is provided. In describing embodiments and examples, LTE-related terminology may be used for clarification purposes. Such terminology should not be taken as limiting the embodiments or examples, however.

The embodiment starts in block 300.

In block 302, a connection request for a user device is received. The connection request comprises information on service.

A connection request is transmitted to a network the user device wishes to use for communications to inform the network on user device's service needs. The information in the message may vary, but in principle, information needed by the

network for resource configuration is provided. The information on service may be a service identity (ID) and/or an application identity (ID). These identities may be standardized, informed as a part of random access or a corresponding procedure (unicast or multicast), informed in broadcasts an access node providing a cell transmits, negotiated between service providers, etc. They may be in the form of a list or table, for example. An access node may advertise information on its services by unicast, multicast or broadcast. Therefore a user device may request a service that provides the closest match to its capability and/or needs.

The information on service may also comprise a mobility status of the user device. The mobility status information may be based on location or tracking information (such as using Global Position System or range detection) and/or information obtained from speed sensors or radars, for example.

Information on service may also comprise indication of resources dedicated to the service. This is useful information in network slicing, wherein a machine-type-communication device may indicate to a network which network slice is applicable to the device or service.

A connection request may comprise information on user device's capabilities or a separate message comprising the information may be transmitted. For example, capabilities of a smart phone may vary from model to model. A connection request may also comprise information on user device's power saving configuration or a power saving request. For example, a certain service or application may have dedicated power saving settings or a power saving mode. A connection request may be transmitted after a random access procedure or a like using the resources reserved for a connection request.

In block 304, a connection configuration in response to the connection request is carried out.

Carrying out the connection configuration typically comprises transmitting a connection configuration response, a confirmation or setup message or a like, wherein resources or configuration for the connection are informed. A user device establishes a connection to the network based on this information.

In block 306, an interruption in data transmission in relation to the configured connection is detected.

The detection may be based on an inactivity timer, which counts the duration of a pause. When the duration exceeds a predetermined threshold, an interruption is registered. End-of-data -markers may also be used

In block 308, in response to the interruption, either a reconfiguration to an intermediate state or a connection release is carried out based on the information on service.

With an intermediate state it is mean a flexible operation state, which is not an idle state but not "full" active state, either. In the intermediate state, a user device may carry out operations adapted to the service or application in question. Operations which may be configured to be carried out by a user device, comprise one or more of the following: user device registration (a user device may be registered and known with a unique identifier in its tracking area which typically consists of multiple cells), tracking and/or location, packet forwarding, camping, reception of system information, monitoring a paging channel, authentication, contention based uplink data transmission, etc.

Connection may be released, for example, if it is a one-off kind of a service, such as uploading a video clip or making a call. In this case, a user device may be put in an idle state or mode.

One example of how service or application affects to operations carried out in an intermediate state or that an idle state is not possible, is a user device participating in an activity, for example it is a vehicle moving along a road, when it has to gather certain information on itself and/or its environment in which case configuration in relation to this user device may not be carried out freely by the access node, but the service and/or application determines the operations to be carried out in an intermediate state or prohibits an idle state. For example, a vehicle using some kind of an automated driving aid may have to be able to communicate with a service control unit in a specified manner.

Mobility status may be taken into consideration when operations in relation to reconfiguration or connection release are carried out. Mobility status may differentiate a normal (=stationary, slowly moving or infrequent cell changes) and moving devices. Moving devices may have limitations in relation to an intermediate state. In one example, only those normal mobility state devices may be configured into an intermediate state. For another example, only those moving devices the speed of which is above that of pedestrian may be configured into an intermediate state, for example as a part of fleet management or some collision detection or driving automated vehicles. Other devices may be configured to an idle state for saving resources.

Reconfiguration may be conveyed as a message comprising information on availability of a user device's subscription, capability, context information, security

and/or authentication information, paging information, location information, mobility status information and/or procedure to update the location information.

From an access node's perspective, an interruption of transmission on a connection can be seen as a function overloading that is to say creating multiple methods of the same name with different implementations. Calls to an overloaded function run a specific implementation of that function appropriate to the context of the call, allowing one function call to perform different tasks depending on context.

In one embodiment, a mobility management entity is informed on information on service as a part of a context setup procedure. Context may be used in authentication and/or accounting. With a mobility management entity it is meant an entity being responsible for idle mode user device paging, authentication and/or authorization, etc. When a mobility management entity is aware of information on service, it may, for example, carry out authentication service-based or application-based.

In another embodiment, the paging procedure may be initiated by the radio access network for system access based on the information on service.

The embodiment ends in block 310. The embodiment is repeatable in many different ways, for example, reconfiguration may be repeated for changing a state from an intermediate state to an idle state. Another option is a change from an intermediate state or idle state to active/connected state, when a user device transmits a new connection request.

In the following, an exemplifying signaling chart is shown by means of Figure 4. LTE-related terminology is used for clarification purposes. Such terminology should not be taken as limiting the embodiments or examples, however.

In the example, messages 1 (random access channel, RACH) and 2 (uplink grant) are for a random access process. By message 3 (radio resource control, RRC, a connection request comprising mobility management identity (MME_ID), user device's identity (UE ID) and service information (service_ID) is transmitted from user device to an access node (in this case eNB). The access node responses by transmitting a connection setup message (RRC conn. setup) to which the user devices responses by a connection setup complete message (RRC conn. setup complete). The user device (UE) is on active state and has resources for data transmission. Next, the access node detects an interruption in the data transmission. Depending on the information on service, the access node chooses either a connection release (7b) or reconfiguration to an intermediate state or mode (7a). From the access node's perspective, an interruption of transmission on a connection can be seen as a function overloading that is to say creating multiple methods of the

same name with different implementations. Calls to an overloaded function run a specific implementation of that function appropriate to the context of the call, allowing one function call to perform different tasks depending on context. In other words, interruption in transmission leads to either reconfiguration or connection release. As an option, a mobility management entity (MME) or similar functionality at radio access network is informed on information on service as a part of a context setup procedure (6).

In the following, some non-limiting case examples are presented by means of Figures 5a and 5b. LTE-related terminology is used for clarification purposes. Such terminology should not be taken as limiting the embodiments or examples, however. LTE related terms are, for example, RRC (radio resource control) and ECM (EPS connection management, wherein EPS means Evolved Packet System).

In Figure 5a, a user device may be a machine-type communications (MTC) device. Massive-MTC typically concerns massive deployments of low-cost battery-powered sensors, actuators, remote controlled and/or remote-read utility meters, etc.. One example is a meter reading reporting sensors with an extended battery life requirement. In this case, there is no need for camping in a cell, thus no need for the device to be in an idle mode or state. This kind of a device only needs a registration and it can be put into power saving mode (one type of an intermediate state) when it is not transmitting data to a service control unit, for example. In the case user device is an ultra-reliable machine-type communications (U-MTC) device, a user device, when in an intermediate state, may camp on a cell, carry out tracking area procedures and monitor continuously one or more paging channels. Ultra-reliable MTC relates to providing a certain service level with very high probability. Ultra-reliable MTC is also related to applications, where delay is a critical factor, such as remote driving, industrial control or remote surgery. The user device states in these cases are a connected/active state or an intermediate state. Therefore this example also depicts the case, wherein due to fast system access requirements, idle mode is not allowed.

Another example involves extreme mobile broadband (xMBB) which provides, for example, traffic volume and data rates required by applications as virtual reality and augmented reality or extreme-resolution 3-dimensional TV. In this case, user device registration and capacity or capability based camping are carried out (cell capacity or radio access capability can be considered as one of the factors to prioritize a cell).

In Figure 5b, another U-MTC case example is presented. This is applicable to V2V or V2I (vehicle to infrastructure) communications. It is assumed that a user device has an "unlimited" power source as it is comprised in a vehicle and moving with a medium or high speed (not pedestrian). One approach to provide the required ultra-reliability is using multi-connectivity and transmitting the same data through multiple links. In this case, an access node is selected based on its capability to provide the multi-connectivity. Another approach is to use information on mobility and/or service in reconfiguration to an intermediate state. The user device, when in an intermediate state, may camp on a cell, carry out tracking area procedures and monitor continuously one or more paging channels. The user device camps on a cell with wide area coverage and local access nodes are prohibited. The access node may provide the user device with a list of suitable cells. In this example, information on mobility and/or service is used to avoid frequent handovers form one local cell to another. These two approaches may also be combined. The user device states in these cases are a connected/active state, intermediate state or idle/disconnected state.

For quickly setting up a connection to a secondary cell, a user device needs to keep up-to-date information on cells for example with the strongest average received signal powers on different frequency layers. This information may be transferred as part of a connection request message sent to a master cell, when the user device changes its state from intermediate to active/connected, for example. A separate update message is also an option.

The steps/points, signaling messages and related functions described above in Figure 2, 3 and 4 are in no absolute chronological order, and some of the steps/points may be performed simultaneously or in an order differing from the given one. Other functions may also be executed between the steps/points or within the steps/points and other signaling messages sent between the illustrated messages. Some of the steps/points or part of the steps/points can also be left out or replaced by a corresponding step/point or part of the step/point.

It should be understood that conveying, broadcasting, unicasting, multicasting, signaling, transmitting and/or receiving may herein mean preparing a data conveyance, broadcast, transmission and/or reception, preparing a message to be conveyed, broadcast, signalled, transmitted and/or received, or a physical transmission and/or reception itself, etc. on a case by case basis. The same principle may be applied to terms transmission and reception as well.

An embodiment provides an apparatus which may be a user device or any other suitable apparatus capable to carry out processes described above in relation to Figure 2.

It should be appreciated that the apparatus may include or otherwise be in communication with a control unit, one or more processors or other entities capable of carrying out operations according to the embodiments described by means of Figure 2. It should be understood that each block of the flowchart of Figure 2 and any combination thereof may be implemented by various means or their combinations, such as hardware, software, firmware, one or more processors and/or circuitry.

Figure 6 illustrates a simplified block diagram of an apparatus according to an embodiment in relation to Figure 2 (a user device).

As an example of an apparatus according to an embodiment, it is shown apparatus 600 including facilities in control unit 604 (including one or more processors, for example) to carry out functions of embodiments according to Figure 2. The facilities may be software, hardware or combinations thereof as described in further detail below.

In Figure 6, block 606 includes parts/units/modules needed for reception and transmission, usually called a radio front end, RF-parts, radio parts, remote radio head, etc. The parts/units/modules needed for reception and transmission may be comprised in the apparatus or they may be located outside the apparatus the apparatus being operationally coupled to them. The apparatus may also include or be coupled to one or more internal or external memory units.

Another example of apparatus 600 may include at least one processor 604 and at least one memory 602 including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to: transmit a connection request comprising information on service, receive configuration information in response to the connection request and establishing a connection based on the configuration information, and receive at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

It should be understood that the apparatus may include or be coupled to other units or modules etc., such as radio parts or radio heads, used in or for transmission and/or reception. This is depicted in Figure 6 as optional block 606.

Yet another example of an apparatus comprises means (604, 606) for transmitting a connection request comprising information on service, means (604, 606) for receiving configuration information in response to the connection request

and means for (604, 606) establishing a connection based on the configuration information, and means (604, 606) for receiving at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

It should be understood that the apparatus may include or be coupled to other units or modules etc., such as radio parts or radio heads, used in or for transmission and/or reception. This is depicted in Figure 6 as optional block 606.

Although the apparatuses have been depicted as one entity in Figure 6, different modules and memory may be implemented in one or more physical or logical entities.

An embodiment provides an apparatus which may be a node, host or server or any other suitable apparatus capable to carry out processes described above in relation to Figure 3.

It should be appreciated that the apparatus may include or otherwise be in communication with a control unit, one or more processors or other entities capable of carrying out operations according to the embodiments described by means of Figure 3. It should be understood that each block of the flowchart of Figure 3 and any combination thereof may be implemented by various means or their combinations, such as hardware, software, firmware, one or more processors and/or circuitry.

Figure 7 illustrates a simplified block diagram of an apparatus according to an embodiment in relation to Figure 3. The apparatus may be an access point, node, host or server or any suitable apparatus to carry out processes described above in relation to Figure 3.

As an example of an apparatus according to an embodiment, it is shown apparatus 700 including facilities in control unit 704 (including one or more processors, for example) to carry out functions of embodiments according to Figure 3. The facilities may be software, hardware or combinations thereof as described in further detail below.

In Figure 7, block 706 includes parts/units/modules needed for reception and transmission, usually called a radio front end, RF-parts, radio parts, remote radio head, etc. The parts/units/modules needed for reception and transmission may be comprised in the apparatus or they may be located outside the apparatus the apparatus being operationally coupled to them. The apparatus may also include or be coupled to one or more internal or external memory units.

Another example of apparatus 700 may include at least one processor 704 and at least one memory 702 including a computer program code, the at least

one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to: receive a connection request for a user device, the connection request comprising information on service, carry out a connection configuration in response to the connection request, detect an interruption in data transmission in relation to the configured connection, an carry out, in response to the interruption, either a reconfiguration to an intermediate state or a connection release based on the information on service.

It should be understood that the apparatus may include or be coupled to other units or modules etc., such as radio parts or radio heads, used in or for transmission and/or reception. This is depicted in Figure 7 as optional block 706.

Yet another example of an apparatus comprises means (704, 706) for receiving a connection request for a user device, the connection request comprising information on service, means (704, 706) for carrying out a connection configuration in response to the connection request, means (704, 706) for detecting an interruption in data transmission in relation to the configured connection, and means (704, 706) for carrying out, in response to the interruption, either a reconfiguration to an intermediate state or a connection release based on the information on service.

It should be understood that the apparatus may include or be coupled to other units or modules etc., such as radio parts or radio heads, used in or for transmission and/or reception. This is depicted in Figure 7 as optional block 706.

Although the apparatuses have been depicted as one entity in Figure 7, different modules and memory may be implemented in one or more physical or logical entities.

An apparatus may in general include at least one processor, controller or a unit or module designed for carrying out functions of embodiments operationally coupled to at least one memory unit (or service) and to typically various interfaces. Further, the memory units may include volatile and/or non-volatile memory. The memory unit may store computer program code and/or operating systems, information, data, content or the like for the processor to perform operations according to embodiments described above in relation to Figures 2, 3, 4, 5a and/or 5b. Each of the memory units may be a random access memory, hard drive, etc. The memory units may be at least partly removable and/or detachably operationally coupled to the apparatus. The memory may be of any type suitable for the current technical environment and it may be implemented using any suitable data storage technology, such as semiconductor-based technology, flash memory, magnetic and/or optical memory devices. The memory may be fixed or removable.

The apparatus may be, include or be associated with at least one software application, module, unit or entity configured as arithmetic operation, or as a program (including an added or updated software routine), executed by at least one operation processor. Programs, also called program products or computer programs, including software routines, applets and macros, may be stored in any apparatus-readable data storage medium and they include program instructions to perform particular tasks. The data storage medium may be a non-transitory medium. The computer program or computer program product may also be loaded to the apparatus. A computer program product may comprise one or more computer-executable components which, when the program is run, for example by one or more processors possibly also utilizing an internal or external memory, are configured to carry out any of the embodiments or combinations thereof described above by means of Figures 2, 3, 4, 5a and 5b. The one or more computer-executable components may be at least one software code or portions thereof. Computer programs may be coded by a programming language or a low-level programming language.

Modifications and configurations required for implementing functionality of an embodiment may be performed as routines, which may be implemented as added or updated software routines, application circuits (ASIC) and/or programmable circuits. Further, software routines may be downloaded into an apparatus. The apparatus, such as a node device, or a corresponding component, may be configured as a computer or a microprocessor, such as single-chip computer element, or as a chipset, including at least a memory for providing storage capacity used for arithmetic operation and an operation processor for executing the arithmetic operation.

Embodiments provide computer programs embodied on a distribution medium, comprising program instructions which, when loaded into electronic apparatuses, constitute the apparatuses as explained above. The distribution medium may be a non-transitory medium.

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 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. The computer readable medium or computer readable storage medium may be a non-transitory medium.

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

The techniques described herein may be implemented by various means. For example, these techniques may be implemented in hardware (one or more devices), firmware (one or more devices), software (one or more modules), or combinations thereof. For a hardware implementation, the apparatus may be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, digitally enhanced circuits, other electronic units designed to perform the functions described herein, or a combination thereof. For firmware or software, the implementation may be carried out through modules of at least one chip set (e.g., procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in a memory unit and executed by processors. The memory unit may be implemented within the processor or externally to the processor. In the latter case it may be communicatively coupled to the processor via various means, as is known in the art. Additionally, the components of systems described herein may be rearranged and/or complimented by additional components in order to facilitate achieving the various aspects, etc., described with regard thereto, and they are not limited to the precise configurations set forth in the given figures, as will be appreciated by one skilled in the art.

It will be obvious to a person skilled in the art that, as technology advances, the inventive concept may be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

Claims

1. An apparatus comprising:

at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

transmit, by a user device, a connection request comprising information on service;

receive configuration information in response to the connection request and establishing a connection based on the configuration information, and

receive at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

2. The apparatus of claim 1, wherein the information on service is a service identity or an application identity.

3. The apparatus of claim 1 or 2, further comprising causing the apparatus to: define a mobility status and wherein the information on service further indicates the mobility status or the mobility status is taken into consideration when carrying out an operation according to the at least one message.

4. The apparatus of any preceding claim, wherein the information on service further indicates resources dedicated to the service.

5. The apparatus of any preceding claim, wherein the information on service is determined based on information on services provided in a cell the connection request is transmitted to.

6. The apparatus of any preceding claim, wherein the indication of the reconfiguration to the intermediate state comprises information on operations to be carried out in the intermediate state.

7. The apparatus of any preceding claim, wherein the connection request further comprises information on user device's capabilities and/or transmitting capability information in response to the reconfiguration.

8. The apparatus of any preceding claim, wherein the connection request further comprises information on user device's power saving configuration or a power saving request.

9. An apparatus comprising:

at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

receive, by an access node, a connection request for a user device, the connection request comprising information on service;

carry out a connection configuration in response to the connection request;

detect an interruption in data transmission in relation to the configured connection, and

carry out, in response to the interruption, either a reconfiguration to an intermediate state or a connection release based on the information on service.

10. The apparatus of claim 9, wherein the connection configuration is carried out based on the information on service.

11. The apparatus of claim 9 or 10, wherein the information on service is a service identity or an application identity.

12. The apparatus of any preceding claim 9 to 11, further comprising causing the apparatus to: convey information on provided services by broadcasting, multicasting or unicasting.

13. The apparatus of any preceding claim 9 to 12, wherein the reconfiguration message comprises information on availability of user device's context information, security and/or authentication information, paging information, location information, mobility status and/or procedure to update the location information.

14. The apparatus of any preceding claim 9 to 13, wherein the connection request further comprises information on user device's power saving configuration or a power saving request which are taken into consideration in the reconfiguration.

15. The apparatus of any preceding claim 9 to 14, further comprising causing the apparatus to: inform a mobility management entity on the information on service as a part of a context setup procedure.

16. The apparatus of any preceding claim 9 to 15, wherein the carrying out the reconfiguration further comprises information on operations to be carried out in the intermediate state.

17. The apparatus of any preceding claim 9 to 16, wherein the operations to be carried out in the intermediate state are determined based on the information on service and/or information on user device's capabilities.

18. A method comprising:

transmitting, by a user device, a connection request comprising information on service;

receiving configuration information in response to the connection request and establishing a connection based on the configuration information, and

receiving at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

19. The method of claim 18, wherein the information on service is a service identity or an application identity.

20. The method of claim 18 or 19, further comprising defining a mobility status and wherein the information on service further indicates the mobility status or the mobility status is taken into consideration when carrying out an operation according to the at least one message.

21. The method of any preceding claim 18 to 20, wherein the information on service further indicates resources dedicated to the service.

22. The method of any preceding claim 18 to 21, wherein the information on service is determined based on information on services provided in a cell the connection request is transmitted to.

23. The method of any preceding claim 18 to 22, wherein the indication of the reconfiguration to the intermediate state comprises information on operations to be carried out in the intermediate state.

24. The method of any preceding claim 18 to 23, wherein the connection request further comprises information on user device's capabilities and/or transmitting capability information in response to the reconfiguration.

25. The method of any preceding claim 18 o 24, wherein the connection request further comprises information on user device's power saving configuration or a power saving request.

26. A method comprising:

receiving, by an access node, a connection request for a user device, the connection request comprising information on service;

carrying out a connection configuration in response to the connection request;

detecting an interruption in data transmission in relation to the configured connection, and

carrying out, in response to the interruption, either a reconfiguration to an intermediate state or a connection release based on the information on service.

27. The method of claim 26, wherein the connection configuration is carried out based on the information on service.

28. The method of claim 26 or 27, wherein the information on service is a service identity or an application identity.

29. The method of any preceding claim 26 to 28, further comprising conveying information on provided services by broadcasting, multicasting or unicasting.

30. The method of any preceding claim 26 to 29, wherein the reconfiguration message comprises information on availability of user device's context information, security and/or authentication information, paging information, location information, mobility status and/or procedure to update the location information.

31. The method of any preceding claim 26 to 30, wherein the connection request further comprises information on user device's power saving configuration or a power saving request which are taken into consideration in the reconfiguration.

32. The method of any preceding claim 26 to 31, further comprising informing a mobility management entity on the information on service as a part of a context setup procedure.

33. The method of any preceding claim 26 to 32, wherein the carrying out the reconfiguration further comprises information on operations to be carried out in the intermediate state.

34. The method of any preceding claim 26 to 33, wherein the operations to be carried out in the intermediate state are determined based on the information on service and/or information on user device's capabilities.

35. An apparatus comprising means for carrying out the method according to any one of claims 18 to 34.

36. A computer program product for a computer, comprising software code portions for performing the steps of any one of claims 18 to 34, when said product is run on the computer.

37. A computer program embodied on a non-transitory computer-readable medium, the computer program comprising program code portions for controlling executing of a process, the process comprising:

transmitting, by a user device, a connection request comprising information on service;

receiving configuration information in response to the connection request and establishing a connection based on the configuration information, and

receiving at least one message indicating a reconfiguration to an intermediate state or a connection release based on the information on service.

38. A computer program embodied on a non-transitory computer-readable medium, the computer program comprising program code portions for controlling executing of a process, the process comprising:

receiving, by an access node, a connection request for a user device, the connection request comprising information on service;

carrying out a connection configuration in response to the connection request;

detecting an interruption in data transmission in relation to the configured connection, and

carrying out, in response to the interruption, either a reconfiguration to an intermediate state or a connection release based on the information on service.

39. The apparatus of claim 1 or 9, further comprising a radio interface entity providing the apparatus with capability for radio communications.

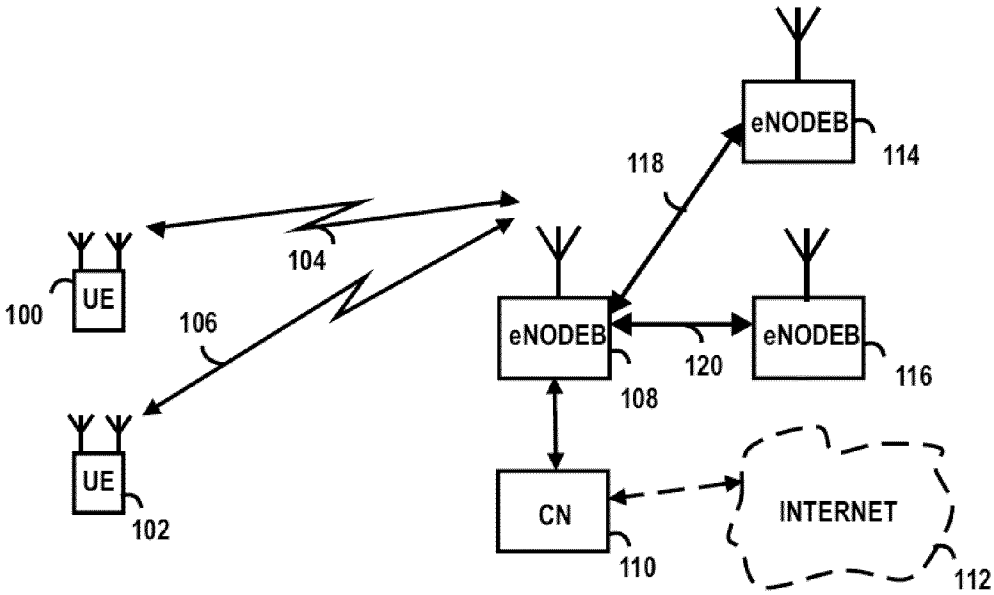
eNODEB
114
118
104
UE
100
106
eNODEB
120
eNODEB
116
108
UE
102
CN
110
INTERNET
112

FIG. 1

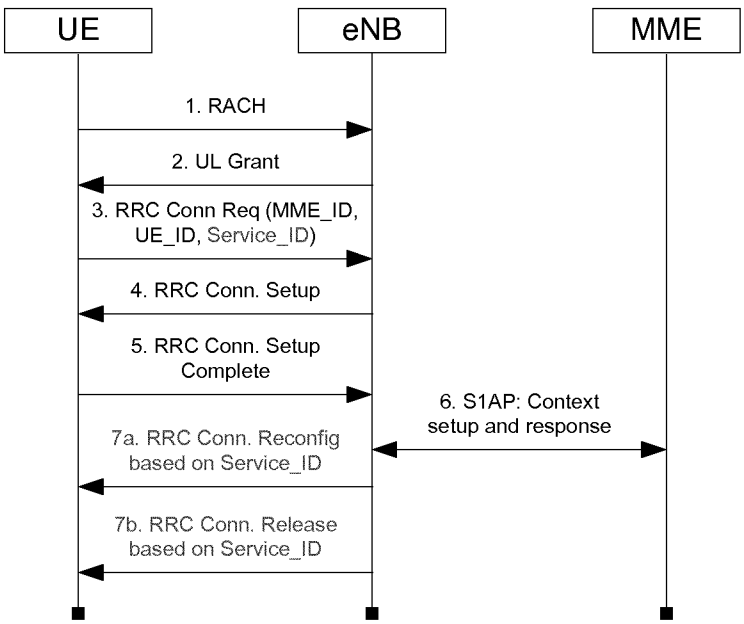
UE
eNB
MME
1. RACH
2. UL Grant
3. RRC Conn Req (MME_ID, UE_ID, Service_ID)
4. RRC Conn. Setup
5. RRC Conn. Setup Complete
6. S1AP: Context setup and response
7a. RRC Conn. Reconfig based on Service_ID
7b. RRC Conn. Release based on Service_ID

FIG 4

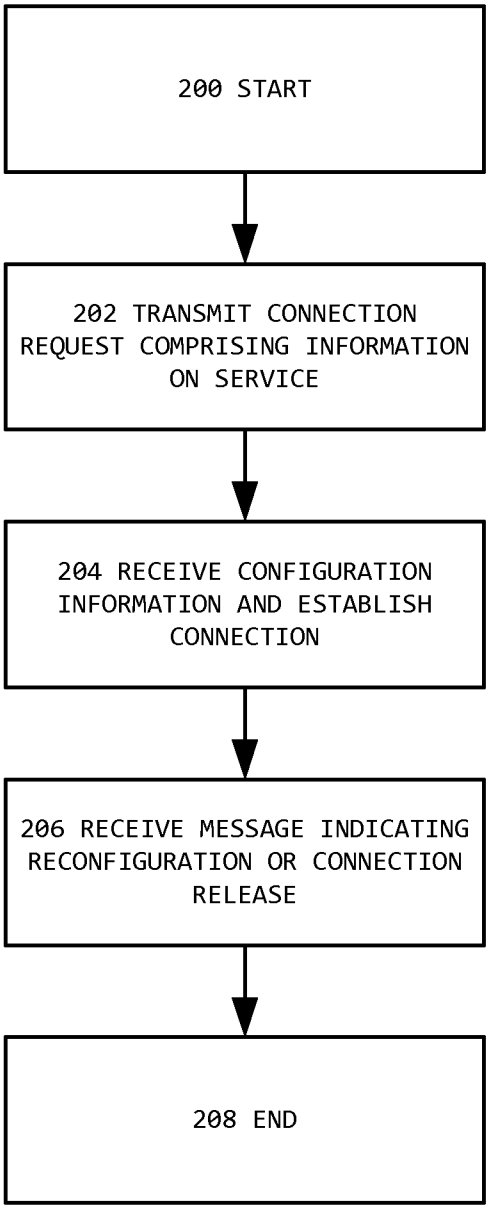
200 START
202 TRANSMIT CONNECTION REQUEST COMPRISING INFORMATION ON SERVICE
204 RECEIVE CONFIGURATION INFORMATION AND ESTABLISH CONNECTION
206 RECEIVE MESSAGE INDICATING RECONFIGURATION OR CONNECTION RELEASE
208 END

Figure 2

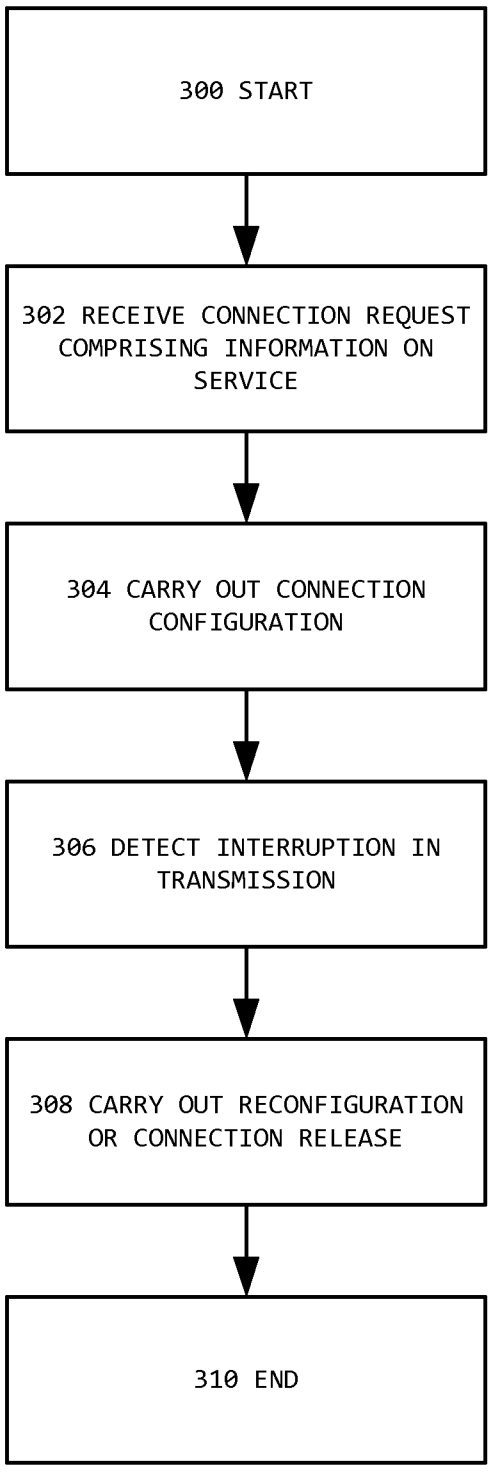
300 START
302 RECEIVE CONNECTION REQUEST COMPRISING INFORMATION ON SERVICE
304 CARRY OUT CONNECTION CONFIGURATION
306 DETECT INTERRUPTION IN TRANSMISSION
308 CARRY OUT RECONFIGURATION OR CONNECTION RELEASE
310 END

Figure 3

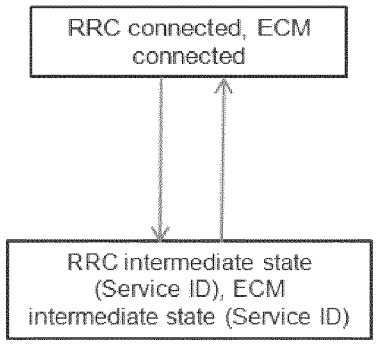
RRC connected, ECM connected
RRC intermediate state (Service ID), ECM intermediate state (Service ID)

FIG 5A

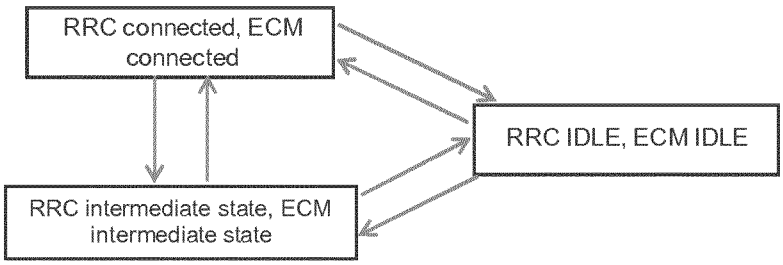
RRC connected, ECM connected
RRC IDLE, ECM IDLE
RRC intermediate state, ECM intermediate state

FIG 5B

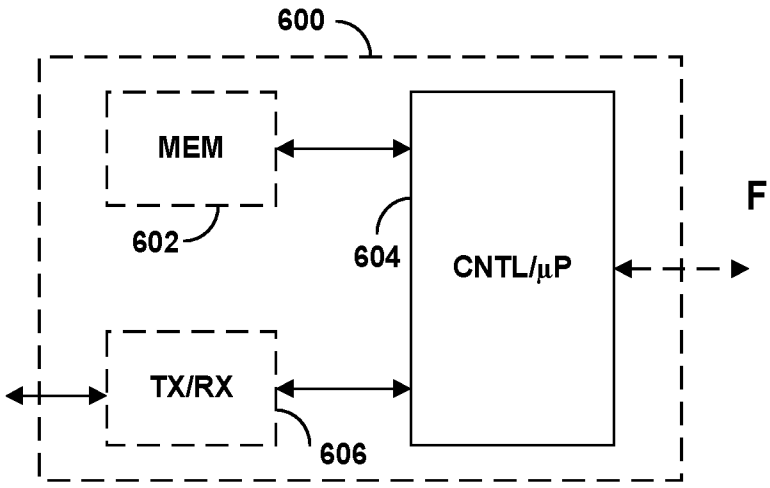
600
MEM
602
604
CNTL/µP
TX/RX
606

FIG. 6

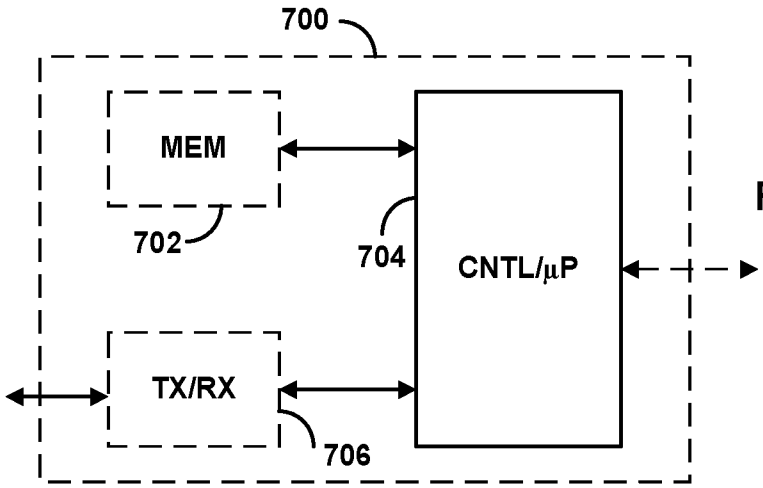
700
MEM
702
704
CNTL/µP
TX/RX
706

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/065424

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W76/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/044959 A1 (ERICSSON TELEFON AB L M [SE]; LUDWIG REINER [DE]; FERNANDEZ ALONSO SUS) 4 April 2013 (2013-04-04) abstract page 4, line 29 - page 5, line 5 page 6, line 29 - page 7, line 13 page 7, line 29 - page 8, line 25 page 10, line 35 - page 11, line 18 page 11, line 33 - page 12, line 16 page 13, line 19 - page 14, line 17 page 18, line 11 - line 30 page 19, line 6 - line 34 figures 1-5, 8 ----- -/--	1-39

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

[X] See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 March 2016	23/03/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Lombardi, Giuseppe

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/100570 A1 (INTERDIGITAL PATENT HOLDINGS [US]; PINHEIRO ANA LUCIA [US]; GAUVREAU J) 18 August 2011 (2011-08-18) abstract paragraph [0069] - paragraph [0071] paragraph [0072] - paragraph [0081] paragraph [0084] - paragraph [0088] -----	1-39
Y	VODAFONE: "Indications in the RAN for CN Overload Protection from low priority and MTC Devices", 3GPP DRAFT; R2-106272, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Jacksonville, USA; 20101115, 9 November 2010 (2010-11-09), XP050467072, [retrieved on 2010-11-09] paragraph [8.1.3.6] paragraph [10.2.41] -----	1-39
Y	US 2004/017792 A1 (KHALEGHI FARIDEH [US] ET AL) 29 January 2004 (2004-01-29) abstract paragraph [0008] paragraph [0016] - paragraph [0018] paragraph [0023] - paragraph [0025] -----	1-39
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