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(54) Title: APPARATUS AND METHOD FOR DATA TRANSMISSION

(57) Abstract: An apparatus and method for data transmission are presented. The method in an apparatus in a communication system, comprises receiving (202) from core network data to be transmitted to user terminal; allocating (204) resource for transmitting downlink control information of the resource and a paging message to the user terminal; transmitting (206) downlink control information and the paging message to the user terminal, indicating that there is data to be sent to the terminal and how to acknowledge the paging message; receiving (208) an acknowledgement from the user terminal; transmitting (210) downlink control information to the user terminal, the information indicating resource to be used in the transmission of data; transmitting (212) data to the user terminal and receiving (214) an acknowledgement from the user terminal.

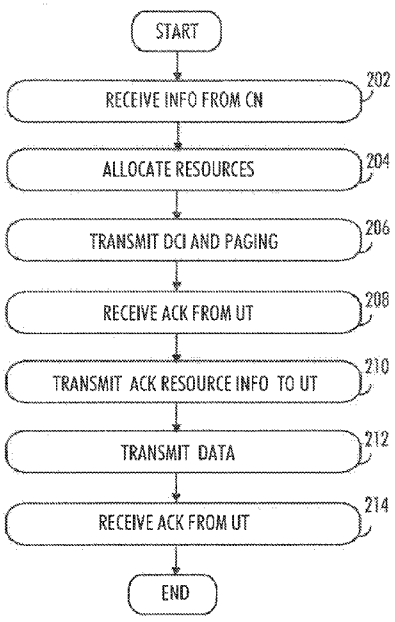

FIG. 2

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APPARATUS AND METHOD FOR DATA TRANSMISSION

Technical Field

The exemplary and non-limiting embodiments of the invention relate generally 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 of such contributions of the invention may be specifically pointed out below, whereas other such contributions of the invention will be apparent from their context.

In communication systems, connections between communicating parties have traditionally been single connections, where a communication resource has been allocated for a call or a data connection. When a resource has been reserved for a user terminal, the terminal has been said to be in connected state. After the communication when the resource has been released, the user terminal is in idle state. Regarding data traffic this kind of procedure is suitable when the data transfer is continuous for a period of time or when there is relatively large amount of data to be transferred. However, when the amount of data to be transferred is small and there is no need for continuous data connection the procedure is cumbersome as it take a considerable amount of signaling to set up. It may even be the case that the signaling involved takes more resources than the actual data traffic.

Brief description

According to an aspect of the present invention, there is provided an apparatus in a communication system of claim 1 and a user terminal apparatus of claim 8.

According to an aspect of the present invention, there are provided methods claims 13 and 18.

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

Brief description of the drawings

In the following the invention will be described in greater detail by means of preferred embodiments with reference to the accompanying drawings, in which

Figure 1 illustrates a general architecture of an exemplary communication system;

Figures 2, 3 and 4 are charts illustrating embodiments of the invention;

Figures 5, 6 and 7 illustrate simplified examples of apparatuses applying some embodiments of the invention.

Detailed description of some 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) or new radio (NR, 5G), without restricting the embodiments to such an architecture, however. It is obvious for a person skilled in the art that the embodiments may also be applied to other kinds of communications networks having suitable means by adjusting parameters and procedures appropriately. Some examples of other options for suitable systems are the universal mobile telecommunications system (UMTS) radio access network (UTRAN or E-UTRAN), long term evolution (LTE, the same as E-UTRA), 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.

Fig. 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 Fig. 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 Fig. 1.

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

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

Fig. 1 shows user devices 100 and 102 configured to be in a wireless connection on one or more communication channels in a cell with an access node (such as (e/g)NodeB) 104 providing the cell. The physical link from a user device to a (e/g)NodeB is called uplink or reverse link and the physical link from the (e/g)NodeB to the user device is called downlink or forward link. It should be appreciated that (e/g)NodeBs or their functionalities may be implemented by using any node, host, server or access point etc. entity suitable for such a usage.

A communications system typically comprises more than one (e/g)NodeB in which case the (e/g)NodeBs may also be configured to communicate with one another over links, wired or wireless, designed for the purpose. These links may be used for data and signaling purposes. The (e/g)NodeB is a computing device configured to control the radio resources of communication system it is coupled to. The NodeB may also be referred to as a base station, an access point or any other type of interfacing device including a relay station capable of operating in a wireless environment. The (e/g)NodeB includes or is coupled to transceivers. From the transceivers of the (e/g)NodeB, a connection is provided to an antenna unit that establishes bi-directional radio links to user devices. The antenna unit may comprise a plurality of antennas or antenna elements. The (e/g)NodeB is further connected to core network 106 (CN or next generation core NGC). Depending on the system, the counterpart on the CN side can be a serving gateway (S-GW, routing and forwarding user data packets), packet data network gateway (P-GW), for providing connectivity of user devices (UEs) to external packet data networks, or mobile management entity (MME), etc.

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

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

assistant (PDA), handset, device using a wireless modem (alarm or measurement device, etc.), laptop and/or touch screen computer, tablet, game console, notebook, and multimedia device. It should be appreciated that a user device may also be a nearly exclusive uplink only device, of which an example is a camera or video camera loading images or video clips to a network. A user device may also be a device having capability to operate in Internet of Things (IoT) network which is a scenario in which objects are provided with the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. One technology in the above network may be denoted as narrowband Internet of Things (NB-Iot). The user device may also be a device having capability to operate utilizing enhanced machine-type communication (eMTC). The user device may also utilize cloud. In some applications, a user device may comprise a small portable device with radio parts (such as a watch, earphones or eyeglasses) and the computation is carried out in the cloud. The user device (or in some embodiments a layer 3 relay node) is configured to perform one or more of user equipment functionalities. The user device may also be called a subscriber unit, mobile station, remote terminal, access terminal, user terminal or user equipment (UE) just to mention but a few names or apparatuses.

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

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

5G enables using 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 employing a variety of radio technologies depending on service needs, use cases and/or spectrum available. 5G mobile communications supports a wide range of use cases and related applications including video streaming, augmented reality,

different ways of data sharing and various forms of machine type applications (such as (massive) machine-type communications (mMTC), including vehicular safety, different sensors and real-time control. 5G is expected to have multiple radio interfaces, namely below 6GHz, cmWave and mmWave, and also being integradable with existing legacy radio access technologies, such as the LTE. Integration with the LTE may be implemented, at least in the early phase, as a system, where macro coverage is provided by the LTE and 5G radio interface access comes from small cells by aggregation to the LTE. In other words, 5G is planned to support both inter-RAT operability (such as LTE-5G) and inter-RI operability (inter-radio interface operability, such as below 6GHz – cmWave, above 6GHz –mmWave). One of the concepts considered to be used in 5G networks is network slicing in which multiple independent and dedicated virtual sub-networks (network instances) may be created within the same infrastructure to run services that have different requirements on latency, reliability, throughput and mobility.

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

The communication system is also able to communicate with other networks, such as a public switched telephone network or the Internet 112, or utilize services provided by them. The communication network may also be able

to support the usage of cloud services, for example at least part of core network operations may be carried out as a cloud service (this is depicted in Fig. 1 by "cloud" 114). The communication system may also comprise a central control entity, or a like, providing facilities for networks of different operators to cooperate for example in spectrum sharing.

Edge cloud may be brought into radio access network (RAN) by utilizing network function virtualization (NVF) and software defined networking (SDN). Using edge cloud may mean access node operations to be carried out, at least partly, in a server, host or node operationally coupled to a remote radio head or base station comprising radio parts. It is also possible that node operations will be distributed among a plurality of servers, nodes or hosts. Application of cloudRAN architecture enables RAN real time functions being carried out at the RAN side (in a distributed unit, DU 104) and non-real time functions being carried out in a centralized manner (in a centralized unit, CU 108).

It should also be understood that the distribution of labor between core network operations and base station operations may differ from that of the LTE or even be non-existent. Some other technology advancements probably to be used are Big Data and all-IP, which may change the way networks are being constructed and managed. 5G (or new radio, NR) networks are being designed to support multiple hierarchies, where MEC servers can be placed between the core and the base station or nodeB (gNB). It should be appreciated that MEC can be applied in 4G networks as well.

In an embodiment, 5G may also utilize satellite communication to enhance or complement the coverage of 5G service, for example by providing backhauling. Possible use cases are providing service continuity for machine-to-machine (M2M) or Internet of Things (IoT) devices or for passengers on board of vehicles, or ensuring service availability for critical communications, and future railway/maritime/aeronautical communications. Satellite communication may utilize geostationary earth orbit (GEO) satellite systems, but also low earth orbit (LEO) satellite systems, in particular mega-constellations (systems in which hundreds of (nano)satellites are deployed). Each satellite 110 in the mega-constellation may cover several satellite-enabled network entities that create on-ground cells. The on-ground cells may be created through an on-ground relay node 104 or by a gNB located on-ground or in a satellite.

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

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

As mentioned, radio access network may be split into two logical entities called Central Unit (CU) and Distributed Unit (DU). In prior art, both CU and DU supplied by the same vendor. Thus they are designed together and interworking between the units is easy. The interface between CU and DU is currently being standardized by 3GPP and it is denoted F1 interface. Therefore in the future the network operators may have the flexibility to choose different vendors for CU and DU. Different vendors can provide different failure and recovery characteristics for the units. If the failure and recovery scenarios of the units are not handled in a coordinated manner, it will result in inconsistent states in the CU and DU (which may lead to subsequent call failures, for example). Thus there is a need to enable the CU and DU from different vendors to coordinate operation to handle failure conditions and recovery, taking into account the potential differences in resiliency capabilities between the CU and DU.

There may be situations where user terminal and communication network may transmit relatively small amounts of data to each other. Currently, if

Core Network or Mobile Management Entity MME of the Core Network needs to send small downlink data to user terminal after paging, the data can be sent only after a Radio Resource Control RRC connection has been set up between the user terminal and the base station the terminal is connected to. Usually this RRC connection setup is complete after a so called Msg5 (RRC connections setup complete message) has been transmitted. This procedure contains significant signaling overhead compared to the amount of data to be transmitted.

To reduce the signaling overhead so called connectionless small data transmission in downlink is proposed. The procedure may be denoted as early data transmission, EDT, and it avoids additional signaling overhead of random access procedure and associated contention resolution by proposing a solution to extend the downlink resource allocation for paging along with additional resource for the user terminal to send a page-response. The procedure is especially suitable for user terminals which are known as stationary and also for user terminals for which the downlink data transmission is scheduled within short interval after uplink EDT transmission where the timing advance information is expected to be valid.

Fig. 2 is a flowchart and Fig. 3 is a signaling chart illustrating an embodiment of the invention. Fig. 2 illustrates an example of the operation of an apparatus or a network element such as base station (gNB) or a part of a base station, the apparatus being configured to communicate with a user terminal.

In step 202, the apparatus is configured to receive from core network data to be transmitted to user terminal. In an embodiment, Mobile Management Entity MME of the Core Network may inform the base station as part of a paging message that early downlink small data is pending for the user terminal. MME may also include the small data in the paging message. MME also include additional indication that whether the downlink transmission to the user terminal can be scheduled without getting timing advance information.

In step 204, the apparatus is configured to allocate resource for transmitting downlink control information, DCI of the resource and a paging message to the user terminal;

In step 206, the apparatus is configured to transmit downlink control information 300 and the paging message 302 to the user terminal, indicating that there is data to be sent to the terminal and how to acknowledge the paging message.

In an embodiment, the apparatus is configured to indicate in the paging message 302 that there is data to be sent to the terminal. In an embodiment, the apparatus is configured to indicate in the downlink control information 300 that the paging message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2 and indicate the resource allocation for Physical Uplink Shared Channel Format 2 transmission.

In an embodiment, the downlink control information 300 is included in Physical Downlink Control Channel which is scrambled with a new early data transmission paging radio network temporary identifier, EDT-P-RNTI.

In an embodiment, the above Physical Uplink Shared Channel Format 2 may be either Narrowband Physical Uplink Shared Channel Format 2, NPUSCH-F2 or MTC Physical Uplink Shared Channel Format 2, MPUSCH-F2.

In an embodiment, a new DCI format can be used for scheduling paging message for early data transmission. Here the base station may utilize different procedures depending on the properties of the user terminal. As the new DCI format needs to be used for this transmission, Rel-16 user terminals capable of supporting downlink EDT may use different Paging Radio Network Temporary identifier, P-RNTI, on the Common Search Space, CSS, for paging and a different P-RNTI for user terminals of earlier releases and Rel-16 user terminals not capable of supporting downlink EDT.

In an embodiment, the base station may indicate in the DCI that another DCI will follow on the current PDCCH, the DCI containing the PUSCH-F2 resource for the user terminal to send acknowledge for the paging message. The indication may be a one bit information, for example.

In an embodiment, the apparatus is configured to indicate in the paging message 302 that the paging message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2, PUSCH-F2, and indicate the resource allocation for PUSCH-F2 transmission. In such a case, a new DCI form at is not required.

In step 208, the apparatus is configured to receive on PUSCH-F2 an acknowledgement 304 from the user terminal.

In step 210, the apparatus is configured to transmit downlink control information, DCI, 306, to the user terminal, the information indicating resource to be used in the transmission of EDT. In an embodiment, the base station may transmit DCI on PDCCH with DL-EDT-RNTI to inform the resource on PDSCH for transmission of the data. Here the common search space corresponding to

Random Access Response, RAR, may be used for sending the DCI. Alternatively a new CSS for DL-EDT can be configured.

In step 212, the apparatus is configured to transmit data 308 to the user terminal using the resources on PDSCH.

In step 214, the apparatus is configured to receive an acknowledgement 310 from the user terminal. In an embodiment, the acknowledgement is received on PUSCH-F2.

The new DCI Format mentioned in step 202 above corresponds to scheduling paging message to include additional resource for PUSCH-F2 for reception of acknowledgement message, ACK. These resources can be used by the user terminal. This corresponds to downlink small data transmission to send ACK of PDSCH which also can be served as paging response. Here the user terminal is assumed to have valid timing advance.

In the existing mechanisms the DCI for scheduling a paging message does not include any resource for receiving HARQ-ACK as the response to the paging is expected to be a random access procedure. In the proposed solution the random access procedure is completely avoided.

In an embodiment, the above PUSCH-F2 may be either Narrowband Physical Uplink Shared Channel Format 2, NPUSCH-F2 or MTC Physical Uplink Shared Channel Format 2, MPUSCH-F2. The same applies to example below.

In an embodiment, the above PDCCH may be either Narrowband Physical Downlink Control Channel, NPDCCH or MTC Physical Downlink Control Channel, MPDCCH. The same applies to example below.

Fig. 4 is a flowchart illustrating an embodiment of the invention. Fig. 4 illustrates an example of the operation of an apparatus such as a user terminal or a part of a user terminal, the apparatus being configured to communicate with a base station.

In step 402, the apparatus is configured to receive from a base station downlink control information DCI 300 and a paging message 302 indicating there is data to be sent to the terminal and how to acknowledge the paging message. The DCI may be received on Physical Downlink control channel, PDCCH. If the paging message contains one or more paging records for which downlink early data transmission, EDT, transmission is pending, the base station may indicate in the DCI additional resource allocation for Physical Uplink Shared Channel Format 2, PUSCH-F2, so that the user terminal may for acknowledge the paging message.

In an embodiment, when the user terminal receives DCI along with PUSCH-F2 resource allocation it may be configured first to decode the PDSCH and check whether its paging record is included in the PDSCH. If it contains the paging record, the user terminal may be configured to transmit the PUSCH-F2 304 corresponding to this paging record on the assigned resources in step 404.

After sending PUSCH-F2 304 as page-response, the user terminal is configured to wait for DCI from the base station on the PDCCH scrambled with its DL-EDT-RNTI. In step 408, the apparatus is configured to receive from the base station the DCI 306 indicating resource to be used in the transmission of data.

In step 410, the apparatus is configured to receive data on PDSCH.

In step 412, the apparatus is configured to transmit an acknowledgement on PUSCH regarding the data.

In an embodiment, the solution may be further extended for user terminals without valid timing advance by replacing the dedicated resource for PUSCH in the same DCI with the transmission of dedicated preambles on the same resource. For shorter resource allocation, the short PRACH Formats of TDD which can fit within 2 msec may be used.

In an embodiment, the apparatus may detect from the paging message that there is data to be sent to the terminal.

In an embodiment, the apparatus may detect from the downlink control information that the message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2.

Fig. 5 illustrates an embodiment. The figure illustrates a simplified example of an apparatus applying embodiments of the invention. In some embodiments, the apparatus may be a base station (gNB) or a part of a base station.

It should be understood that the apparatus is depicted herein as an example illustrating some embodiments. It is apparent to a person skilled in the art that the apparatus may also comprise other functions and/or structures and not all described functions and structures are required. Although the apparatus has been depicted as one entity, different modules and memory may be implemented in one or more physical or logical entities.

The apparatus of the example includes a control circuitry 500 configured to control at least part of the operation of the apparatus.

The apparatus may comprise a memory 502 for storing data. Furthermore the memory may store software 504 executable by the control circuitry 500. The memory may be integrated in the control circuitry.

The apparatus comprises a transceiver 506. The transceiver is operationally connected to the control circuitry 500. It may be connected to an antenna arrangement (not shown).

The apparatus may further comprise interface circuitry 508 configured to connect the apparatus to other devices and network elements of communication system, for example to other corresponding apparatuses and network elements, such as the Core Network. The interface may provide a wired or wireless connection to the communication network.

The software 504 may comprise a computer program comprising program code means adapted to cause the control circuitry 500 of the apparatus to receive from core network data to be transmitted to user terminal; allocate resource for transmitting downlink control information of the resource and a paging message to the user terminal; transmit downlink control information and the paging message to the user terminal, indicating that there is data to be sent to the terminal and how to acknowledge the paging message; receive an acknowledgement from the user terminal; transmit downlink control information to the user terminal, the information indicating resource to be used in the transmission of data; transmit data to the user terminal; receive an acknowledgement from the user terminal.

In an embodiment, as shown in Fig. 6, at least some of the functionalities of the apparatus of Fig. 5 may be shared between two physically separate devices, forming one operational entity. Therefore, the apparatus may be seen to depict the operational entity comprising one or more physically separate devices for executing at least some of the described processes. Thus, the apparatus of Fig. 6, utilizing such shared architecture, may comprise a remote control unit RCU 600, such as a host computer or a server computer, operatively coupled (e.g. via a wireless or wired network) to a remote radio head RRH 602 located in the base station. In an embodiment, at least some of the described processes may be performed by the RCU 600. In an embodiment, the execution of at least some of the described processes may be shared among the RRH 602 and the RCU 600.

In an embodiment, the RCU 600 may generate a virtual network through which the RCU 600 communicates with the RRH 602. In general, virtual

networking may involve a process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a virtual network. Network virtualization may involve platform virtualization, often combined with resource virtualization. Network virtualization may be categorized as external virtual networking which combines many networks, or parts of networks, into the server computer or the host computer (e.g. to the RCU). External network virtualization is targeted to optimized network sharing. Another category is internal virtual networking which provides network-like functionality to the software containers on a single system. Virtual networking may also be used for testing the terminal device.

In an embodiment, the virtual network may provide flexible distribution of operations between the RRH and the RCU. In practice, any digital signal processing task may be performed in either the RRH or the RCU and the boundary where the responsibility is shifted between the RRH and the RCU may be selected according to implementation.

Fig. 7 illustrates an embodiment. The figure illustrates a simplified example of an apparatus applying embodiments of the invention. In some embodiments, the apparatus may be a user terminal or a part of a user terminal.

It should be understood that the apparatus is depicted herein as an example illustrating some embodiments. It is apparent to a person skilled in the art that the apparatus may also comprise other functions and/or structures and not all described functions and structures are required. Although the apparatus has been depicted as one entity, different modules and memory may be implemented in one or more physical or logical entities.

The apparatus of the example includes a control circuitry 700 configured to control at least part of the operation of the apparatus.

The apparatus may comprise a memory 702 for storing data. Furthermore the memory may store software 704 executable by the control circuitry 700. The memory may be integrated in the control circuitry.

The apparatus comprises a transceiver 706. The transceiver is operationally connected to the control circuitry 700. It may be connected to an antenna arrangement (not shown).

In an embodiment, the apparatus may further comprise user interface circuitry 708 configured to enable user of the apparatus to communicate with the apparatus. The user interface may comprise a microphone, a speaker, a display which may be touch sensitive, a keyboard (which may be realized with the touch

sensitive display) and other devices known in the art. connect the apparatus to other devices and network elements of communication system, for example to other corresponding apparatuses and network elements, such as the Core Network. The interface may provide a wired or wireless connection to the communication network.

The software 604 may comprise a computer program comprising program code means adapted to cause the control circuitry 600 of the apparatus to control the apparatus to receive from a base station downlink control information and a paging message indicating there is data to be sent to the terminal and how to acknowledge the paging message, transmit an acknowledgement regarding the paging message, receive from the base station downlink control information indicating resource to be used in the transmission of data, receive data, and transmit an acknowledgement regarding the data.

The steps and related functions described in the above and attached figures are in no absolute chronological order, and some of the steps may be performed simultaneously or in an order differing from the given one. Other functions can also be executed between the steps or within the steps. Some of the steps can also be left out or replaced with a corresponding step.

The apparatuses or controllers able to perform the above-described steps may be implemented as an electronic digital computer, which may comprise a working memory (RAM), a central processing unit (CPU), and a system clock. The CPU may comprise a set of registers, an arithmetic logic unit, and a controller. The controller is controlled by a sequence of program instructions transferred to the CPU from the RAM. The controller may contain a number of microinstructions for basic operations. The implementation of microinstructions may vary depending on the CPU design. The program instructions may be coded by a programming language, which may be a high-level programming language, such as C, Java, etc., or a low-level programming language, such as a machine language, or an assembler. The electronic digital computer may also have an operating system, which may provide system services to a computer program written with the program instructions.

As used in this application, the term 'circuitry' refers to all of the following: (a) hardware-only circuit implementations, such as implementations in only analog and/or digital circuitry, and (b) combinations of circuits and software (and/or firmware), such as (as applicable): (i) a combination of processor(s) or (ii) portions of processor(s)/software including digital signal processor(s),

software, and memory(ies) that work together to cause an apparatus to perform various functions, and (c) circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present.

This definition of 'circuitry' applies to all uses of this term in this application. As a further example, as used in this application, the term 'circuitry' would also cover an implementation of merely a processor (or multiple processors) or a portion of a processor and its (or their) accompanying software and/or firmware. The term 'circuitry' would also cover, for example and if applicable to the particular element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in a server, a cellular network device, or another network device.

An embodiment provides a computer program embodied on a distribution medium, comprising program instructions which, when loaded into an electronic apparatus, are configured to control the apparatus to execute the embodiments described above.

The computer program may be in source code form, object code form, or in some intermediate form, and it may be stored in some sort of carrier, which may be any entity or device capable of carrying the program. Such carriers include a record medium, computer memory, read-only memory, and a 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 apparatus may also be implemented as one or more integrated circuits, such as application-specific integrated circuits ASIC. Other hardware embodiments are also feasible, such as a circuit built of separate logic components. A hybrid of these different implementations is also feasible. When selecting the method of implementation, a person skilled in the art will consider the requirements set for the size and power consumption of the apparatus, the necessary processing capacity, production costs, and production volumes, for example.

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can 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.

WHAT IS CLAIMED IS:

1. An apparatus in a communication system, configured to communicate with a user terminal and core network of the communication system, the apparatus comprising:

at least one processor; and

at least one memory including 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 perform:

receive from core network data to be transmitted to user terminal;

allocate resource for transmitting downlink control information of the resource and a paging message to the user terminal;

transmit downlink control information and the paging message to the user terminal, indicating that there is data to be sent to the terminal and how to acknowledge the paging message;

receive an acknowledgement from the user terminal;

transmit downlink control information to the user terminal, the information indicating resource to be used in the transmission of data;

transmit data to the user terminal;

receive an acknowledgement from the user terminal.

2. The apparatus of claim 1, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus further to perform:

indicate in the paging message that there is data to be sent to the terminal.

3. The apparatus of claim 1, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus further to perform:

indicate in the downlink control information that the paging message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2, and indicate the resource allocation for the Physical Uplink Shared Channel Format 2transmission.

4. The apparatus of claim 3, wherein the downlink control information is included in Physical Downlink Control Channel which is scrambled with a early data transmission paging radio network temporary identifier (EDT-P-RNTI).

5. The apparatus of claim 1, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus further to perform:

indicate in the paging message that the paging message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2, and indicate the resource allocation for Physical Uplink Shared Channel Format 2 transmission.

6. The apparatus of any preceding claim, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus further to perform:

indicate to the user terminal that the data will be scrambled with a given downlink early data transmission radio network temporary identifier.

7. The apparatus of any preceding claim, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus further to perform:

repeat the steps of transmitting downlink control information to the user terminal, the information indicating resource to be used in the transmission of data and the transmitting data to the user terminal as long as there is data to be sent to the user terminal.

8. A user terminal apparatus in a communication system, configured to communicate with a base station of the communication system, the apparatus comprising:

at least one processor; and

at least one memory including 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 perform:

receive from a base station downlink control information and a paging message indicating there is data to be sent to the terminal and how to acknowledge the paging message;

transmit an acknowledgement regarding the paging message;

receive from the base station downlink control information indicating resource to be used in the transmission of data;

receive data;

transmit an acknowledgement regarding the data.

9. The user terminal apparatus of claim 8, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus further to perform:

detect from the paging message that there is data to be sent to the terminal.

10. The user terminal apparatus of claim 8, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus further to perform:

detect from the downlink control information that the message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2.

11. The user terminal apparatus of claim 8, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus further to perform:

detect from the paging message that the message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2.

12. The user terminal apparatus of any preceding claim 8 or 11, the at least one memory and computer program code configured to, with the at least one processor, cause the apparatus further to perform:

receive from the base station indication that the data will be scrambled with a given downlink early data transmission radio network temporary identifier.

13. A method in an apparatus in a communication system, comprising:

receiving from core network data to be transmitted to user terminal;

allocating resource for transmitting downlink control information of the resource and a paging message to the user terminal;

transmitting downlink control information and the paging message to the user terminal, indicating that there is data to be sent to the terminal and how to acknowledge the paging message;

receiving an acknowledgement from the user terminal;

transmitting downlink control information to the user terminal, the information indicating resource to be used in the transmission of data;

transmitting data to the user terminal;

receiving an acknowledgement from the user terminal.

14. The method of claim 13, further comprising:

indicating in the paging message that there is data to be sent to the terminal.

15. The method of claim 13, further comprising:

indicating in the downlink control information that the paging message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2 and indicate the resource allocation for Physical Uplink Shared Channel Format 2 transmission.

16. The method of claim 15, wherein the downlink control information is included in Physical Downlink Control Channel which is scrambled with early data transmission paging radio network temporary identifier (EDT-P-RNTI).

17. The method of claim 13, further comprising:

indicating in the paging message that the paging message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2, and indicate the resource allocation for Physical Uplink Shared Channel Format 2 transmission.

18. A method in a user terminal apparatus in a communication system, the method comprising:

receiving from a base station downlink control information and a paging message indicating there is data to be sent to the terminal and how to acknowledge the paging message;

transmitting an acknowledgement regarding the paging message;

receiving from the base station downlink control information indicating resource to be used in the transmission of data;

receiving data;

transmitting an acknowledgement regarding the data.

19. The method of claim 18, further comprising:

detecting from the paging message that there is data to be sent to the terminal.

20. The method of claim 18, further comprising:

detecting from the downlink control information that the message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2.

21. The method of claim 18, further comprising:

detecting from the paging message that the message is to be acknowledged utilizing Physical Uplink Shared Channel Format 2.

22. A computer program comprising instructions for causing an apparatus of a communication system to perform any of the method steps of claims 13 to 21.

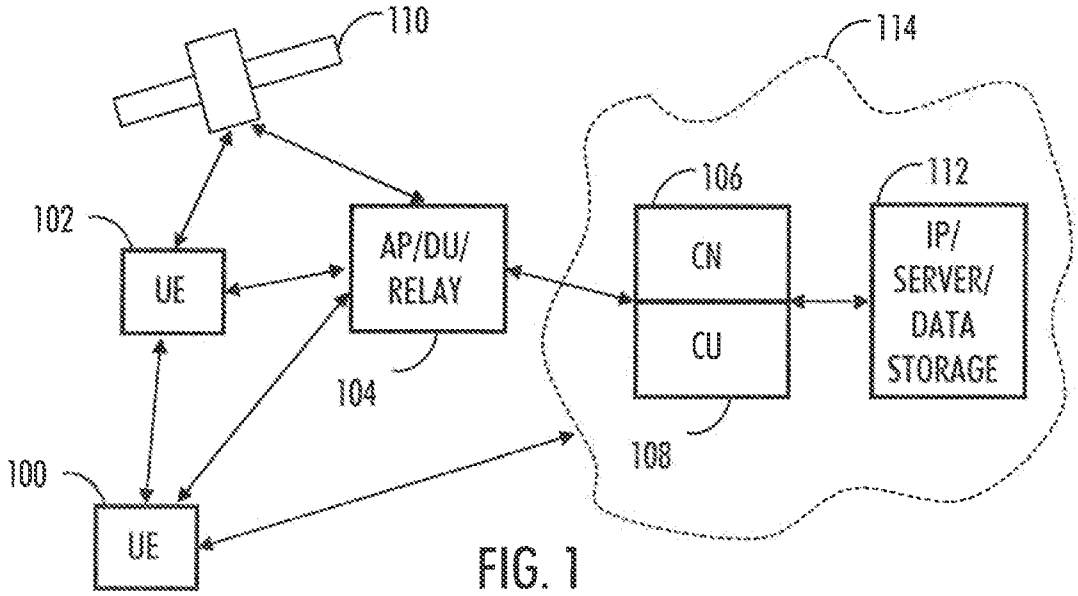

110
114
102
106
112
UE
AP/DU/
RELAY
CN
IP/
SERVER/
DATA
STORAGE
CU
104
108
100
UE

FIG. 1

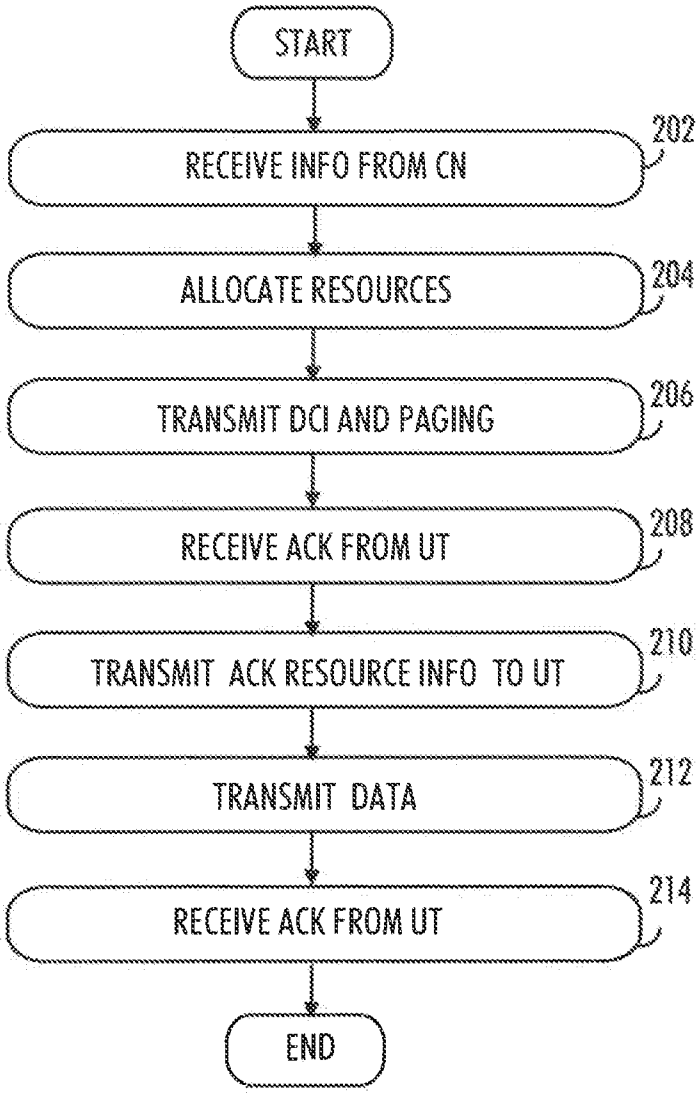
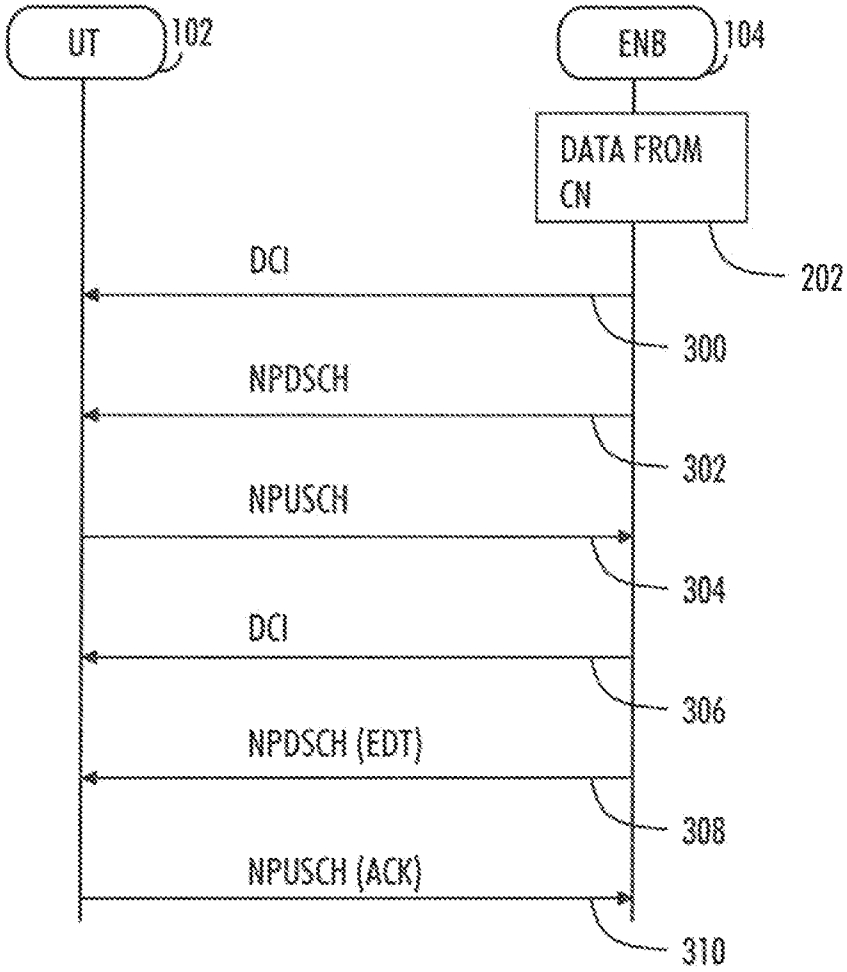

START
RECEIVE INFO FROM CN
202
ALLOCATE RESOURCES
204
TRANSMIT DCI AND PAGING
206
RECEIVE ACK FROM UT
208
TRANSMIT ACK RESOURCE INFO TO UT
210
TRANSMIT DATA
212
RECEIVE ACK FROM UT
214
END

FIG. 2


UT
102
ENB
104
DATA FROM CN
202
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300
NPDSCH
302
NPUSCH
304
DCI
306
NPDSCH (EDT)
308
NPUSCH (ACK)
310

FIG. 3

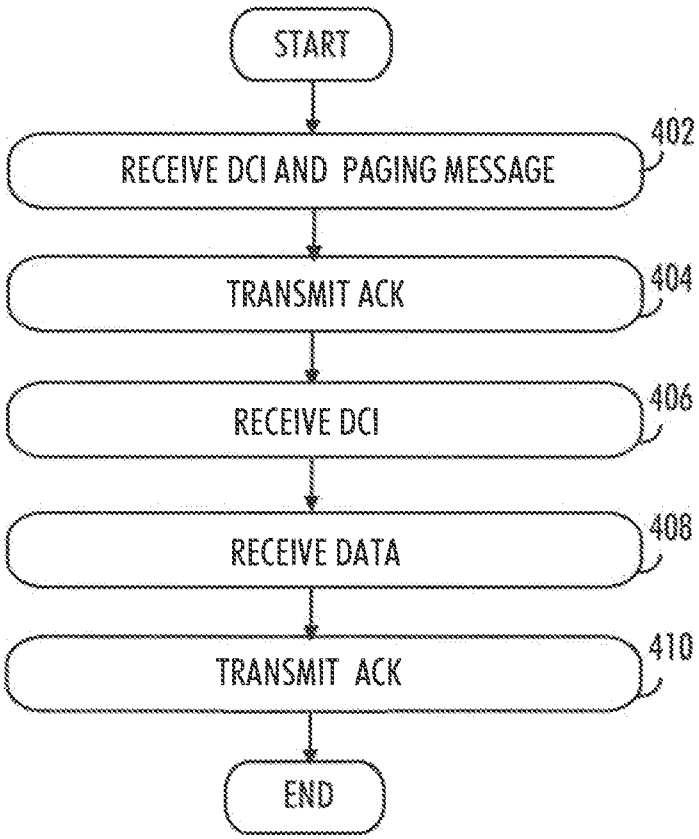
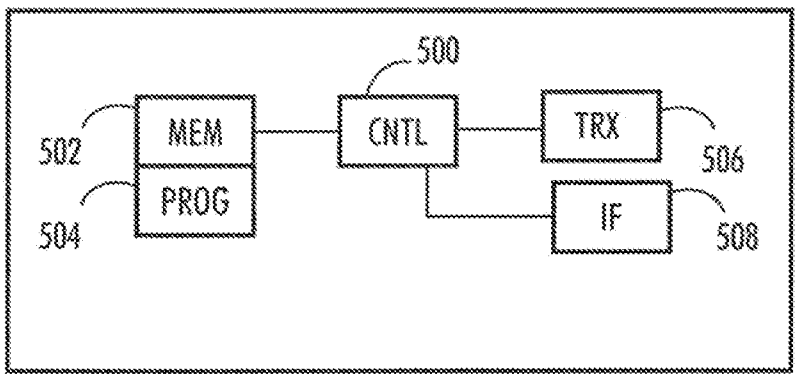

START
RECEIVE DCI AND PAGING MESSAGE
402
TRANSMIT ACK
404
RECEIVE DCI
406
RECEIVE DATA
408
TRANSMIT ACK
410
END

FIG.4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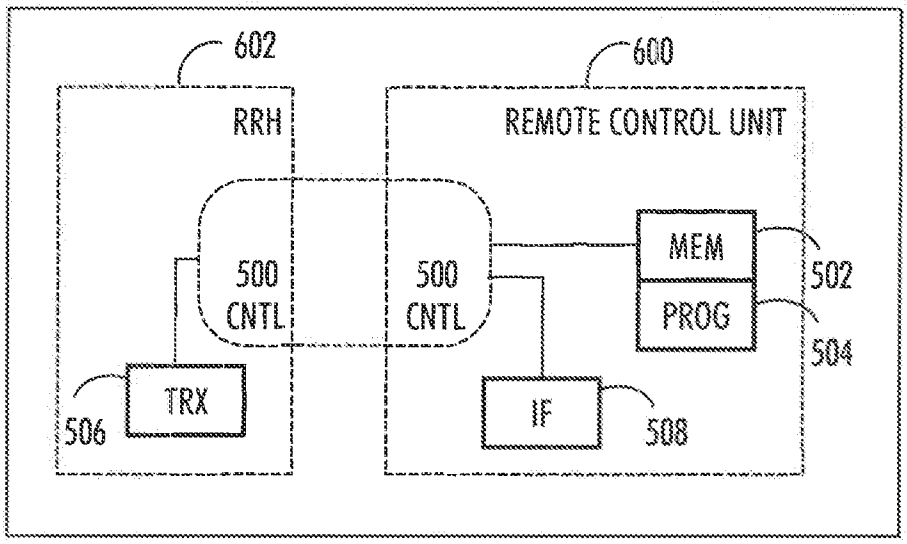
PROG
504
CNTL
TRX
506
IF
508

FIG. 5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RRH
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REMOTE CONTROL UNIT
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CNTL
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CNTL
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PROG
502
504
TRX
506
IF
508

FIG. 6

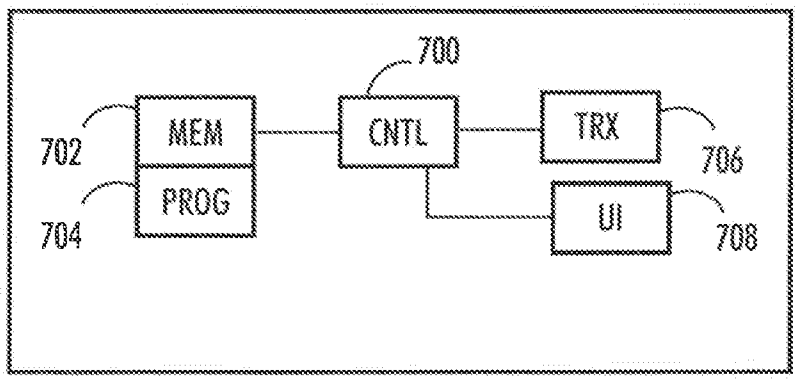
700
MEM
CNTL
TRX
702
706
PROG
UI
704
708

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/106284

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/12(2009.01)i

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)

CPRSABS,CNTXT,CNKI,VEN,USTXT,EPTXT,WOTXT:acknowledgement, ACK, RNTI, DCI, downlink control information, scrambl+, resource, format, UE, core network, paging, UE, user terminal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 102300331 A (CHINA ACADEMY TELECOMMUNICATIONS TECHNOLOGY) 28 December 2011 (2011-12-28) claims 2 and 5	1-22
Y	CN 104782207 A (QUALCOMM INC.) 15 July 2015 (2015-07-15) description paragraphs [0003]-[0049]	1-22
A	CN 107466101 A (ZTE CORP.) 12 December 2017 (2017-12-12) the whole document	1-22
A	WO 2016021957 A1 (LG ELECTRONICS INC.) 11 February 2016 (2016-02-11) the whole document	1-22

☐ 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	Date of mailing of the international search report
20 December 2018	**28 December 2018**

Name and mailing address of the ISA/CN	Authorized officer
National Intellectual Property Administration, PRC **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing** **100088** **China**	**ZHANG,Bo**
Facsimile No. **(86-10)62019451**	Telephone No. **62088428**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/106284

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	102300331	A	28 December 2011	EP	2747508	B1	30 September 2015
				EP	2747508	A4	02 July 2014
				WO	2013026374	A1	28 February 2013
				CN	102300331	B	27 November 2013
				US	2014233538	A1	21 August 2014
				EP	2747508	A1	25 June 2014
CN	104782207	A	15 July 2015	WO	2014077996	A1	22 May 2014
				JP	6125654	B2	10 May 2017
				KR	20150084973	A	22 July 2015
				KR	101744916	B1	08 June 2017
				JP	2016501461	A	18 January 2016
				EP	2921014	A1	23 September 2015
				US	9386576	B2	05 July 2016
				US	2014133370	A1	15 May 2014
				IN	201500979	P3	27 May 2016
CN	107466101	A	12 December 2017	WO	2017206959	A1	07 December 2017
WO	2016021957	A1	11 February 2016	US	2017207895	A1	20 July 2017