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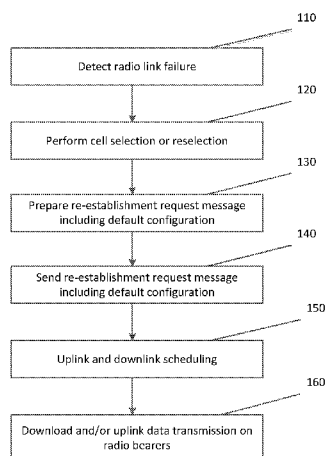
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Figure 1



(57) Abstract: Various communications systems may benefit from techniques and devices for properly re-establishing connections. For example, radio communication systems of the third generation partnership project may benefit from a radio resource connection re-establishment with default configuration. A method can include sending a re-establishment request message from a user equipment. The re-establishment request message can include at least one radio link default configuration

TITLE:

Radio Resource Control Connection Re-Establishment with Default Configuration

CROSS REFERENCE:

- 5 [0001] This application claims priority to U.S. Provisional Application No. 62/158,973 filed on May 8, 2015. The entire contents of the above application are hereby incorporated by reference.

BACKGROUND:

Field:

- 10 [0002] Various communications systems may benefit from techniques and devices for properly re-establishing connections. For example, radio communication systems of the third generation partnership project may benefit from a radio resource connection re-establishment having a radio link default configuration.

15 **Description of the Related Art:**

- [0003] In radio communication systems such as Long-Term Evolution (LTE), a user equipment (UE) can be in one of two Radio Resource Control (RRC) states: RRC idle mode or RRC connected mode. In connected mode, LTE may utilize a UE cell reselection based mobility scheme or a network controlled handover mobility scheme, which is either hard or soft. In idle mode, only
20 cell reselection based mobility can be used.

- [0004] In a network controlled hard handover mobility scheme, the network configures a set of measurements for the UE regarding neighboring cells and frequencies. The UE then performs measurements based on those configurations, and reports the results to the network. Based on those UE reports, the network initiates handover (HO) by preparing a target cell or an E-UTRAN Node
25 B/evolved Node B (eNB), and sending the HO command to the UE. The UE acts on the HO command, stops operating in the source cell, enters the target cell based on the HO command, and sends HO completion information to the target cell. During this process, the network initiates data re-routing from a source eNB to target eNB and informs the core network of any needed path switches.

- 30 [0005] In addition to the hard HO described above, the Universal Mobile Telecommunication System (UMTS) supports soft HO and UE based mobility. In soft HO, the UE can maintain the connection to source cell when a new target cell is added, and combines the received signal from the source cell and the new target cell before decoding.

- [0006] In UE based mobility, a UE may reselect a new target cell based on UE internal
35 measurements that are performed according to the configuration given by the network. Cell

reselection can involve the UE dropping reception in a source cell and entering a target cell. The UE can then send a Cell Update message to the Universal Terrestrial Radio Access Network (UTRAN). UTRAN then responds with a Cell Update Confirm message to re-establish data connection.

5 [0007] In certain situations, an error can occur which causes a break in the radio link between the UE and the network. The UE will then need to undergo re-establishment procedures in which the UE attempts to re-establish the radio link with the network. Radio link failure is an example of one such error. Other examples may include integrity check failure and reconfiguration failure. In the following paragraphs, a general description of radio link failure and handover failure is given.

10 [0008] In radio link failure, the UE loses the connection to the serving cell(s), and the UE is forced to select a new cell with which to re-establish a connection, leading to a break in the radio link. This radio link failure causes an unwarranted disruption in UE connectivity, and a procedure is needed to minimize its undesirable effects.

[0009] In handover failure, the network gives new configuration to the handover target cell for the UE. During handover, however, the UE is not able to establish radio link to the target cell(s), and is forced to either try to come back to the source cell or consider the radio link to have failed and select a new cell with which to re-establish for a connection, leading to a break in the radio link. This handover failure causes an unwarranted disruption in UE connectivity, and a procedure is needed to minimize its undesirable effects.

20

SUMMARY:

[0007] According to certain embodiments, a method can include preparing a re-establishment request message. The re-establishment request message includes at least one radio link default configuration. The method also includes sending the re-establishment request message from a user equipment to a network node.

25 [0008] According to certain other embodiments, a method can include receiving a re-establishment request message from a user equipment. The re-establishment request message includes at least one radio link default configuration. The method also includes scheduling downlink and uplink for the user equipment based on the at least one radio link default configuration.

30 [0009] An apparatus, according to certain embodiments, may include at least one processor and at least one memory including computer program code. The at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to prepare a re-establishment request message. The re-establishment request message includes at least one radio link default configuration. The at least one memory and the computer program

35

code are configured to, with the at least one processor, also cause the apparatus to send the re-establishment request message from a user equipment to a network node.

[0010] An apparatus, according to certain embodiments, may include at least one processor and at least one memory including computer program code. The at least one memory and the
5 computer program code are configured to, with the at least one processor, cause the apparatus to receive a re-establishment request message from a user equipment. The re-establishment request message includes at least one radio link default configuration. The at least one memory and the computer program code are configured to, with the at least one processor, also cause the apparatus to schedule downlink and uplink for the user equipment based on the at least one
10 radio link default configuration.

[0011] According to certain embodiments, a non-transitory computer-readable medium encoding instructions that, when executed in hardware, perform a process. The process includes preparing a re-establishment request message. The re-establishment request message includes at least one radio link default configuration. The process also includes sending the re-
15 establishment request message from a user equipment to a network node.

[0012] According to certain embodiments, a non-transitory computer-readable medium encoding instructions that, when executed in hardware, perform a process. The process includes receiving a re-establishment request message from a user equipment. The re-establishment request message includes at least one radio link default configuration. The process also includes
20 scheduling downlink and uplink for the user equipment based on the at least one radio link default configuration.

[0013] An apparatus, according to certain embodiments, may include preparing means for preparing a re-establishment request message. The re-establishment request message includes at least one radio link default configuration. The apparatus can also include sending means for
25 sending the re-establishment request message from a user equipment to a network node.

[0014] An apparatus, according to certain embodiments, may include receiving means for receiving a re-establishment request message from a user equipment. The re-establishment request message includes at least one radio link default configuration. The apparatus can also include scheduling means for scheduling downlink and/or uplink for the user equipment based
30 on the at least one radio link default configuration.

[0015] Certain embodiments may include a computer program product encoding instructions for performing a process. The process may include preparing a re-establishment request message. The re-establishment request message can include at least one radio link default configuration. The process may also include sending the re-establishment request message from
35 a user equipment to a network node.

[0016] Certain embodiments may include a computer program product encoding instructions for performing a process. The process may include receiving a re-establishment request message from a user equipment. The re-establishment request message can include at least one radio link default configuration. The process may also include scheduling downlink and/or
5 uplink for the user equipment based on the at least one radio link default configuration.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0017] For proper understanding of the invention, reference should be made to the accompanying drawings, wherein:

10 [0018] Figure 1 illustrates a signal flow diagram according to certain embodiments.
[0019] Figure 2 illustrates a method according to certain embodiments.
[0020] Figure 3 illustrates a system according to certain embodiments.
[0021] Figure 4 illustrates a signal flow diagram according to certain embodiments.

15 DETAILED DESCRIPTION:

[0022] Certain embodiments minimize both the data interruption time and the required signaling exchange needed to re-establish data communication after a radio link failure in radio communication. Some embodiments may specifically focus on cases of required ultra-reliable communication (URC), while other embodiments may focus on normal communication in which
20 UE based mobility can be utilized.

[0023] In the embodiment shown in Figure 1, the UE detects a radio link failure in step 110. In certain other embodiments involving UE mobility, the UE meets certain criteria that will cause it to change cells rather than detecting a radio link failure. In other embodiments, the UE may detect any other error which causes a break in the radio link between a UE and a network node.

25 [0024] The UE, in certain embodiments, will then perform cell reselection or selection, as shown in step 120. In some embodiments, the reselection or selection can be initiated by the UE, while in other embodiments the reselection or selection can be initiated by the network.

[0025] The UE may then prepare an uplink re-establishment message indicating utilization of at least one default configuration, as shown in step 130. The UE can then send then uplink re-establish
30 message including the at least one default configuration 140, and/or other configuration information, to a network node. The indication provided by the re-establishment message can point to any of the configurations defined herein or any earlier configuration signaled to the UE by the Network. In certain embodiments, only a single uplink re-establishment message may be needed.

[0026] The at least one default configuration, in certain embodiments, is based on measurements
35 performed by the UE. In other embodiments, the at least one default configuration is preconfigured

by the network in the connection establishment phase. The default configuration may include default configuration for all or some of the existing radio bearers (RB), signaling radio bearers (SRBs), and/or RB carrying URC data. The UE may then await downlink data transmission based on the default configuration or uplink grants for uplink transmission based on the default configuration, for example, scheduled uplink access.

[0027] In certain embodiments, the network node receives the re-establishment request message, and may then immediately start downlink and uplink scheduling in step 150 for the UE by utilizing the default configuration, and/or the other configuration information, the network node received in the re-establishment request message. Downlink and/or uplink data transmission on the RB in step 160 may then begin, after only a single uplink re-establishment request message was exchanged 140, in certain embodiments. When only a single uplink message is needed to re-establish the radio link after radio link failure, the delay to deliver uplink and downlink data can be reduced to a minimum.

[0028] The RRC connection re-establishment request message, according to certain embodiments, can contain the following information elements illustrated in the code below:

```

RRCConnectionReestablishmentRequest-r8-IEs ::= SEQUENCE {
    ue-Identity                ReestabUE-Identity,
    reestablishmentCause       ReestablishmentCause,
    spare                      BIT STRING (SIZE (2))
}

```

```

ReestabUE-Identity ::= SEQUENCE {
    c-RNTI                    C-RNTI,
    physCellId                PhysCellId,
    shortMAC-I                 ShortMAC-I
}

```

[0029] The *ue-Identity* function shown above may include the UE identity. The UE identity may be included for a variety of reasons, including to retrieve UE context and to facilitate contention resolution by lower layers. The *physCellId* function illustrated above may include the physical cell identity of the physical cell the UE was connected to prior to the failure. The *reestablishmentCause* may include an indication of the cause of the failure that triggered the re-establishment procedure. The *ShortMac-I* is the 16 least significant bits of the message authentication code for integrity (MAC-I), which can be calculated using the security configuration of the source physical cell. The *ShortMac-I* can be used to identify and verify the UE at RRC connection re-establishment.

[0030] In certain embodiments, in addition to the above information, an RRC connection re-establishment request message may be prepared to include default configuration information and/or other configuration information. As discussed above, adding such information may facilitate the efficient re-establishment of the radio bearers between the UE and the network node,

and after re-establishment of radio bearers UE and Network are able to send and receive uplink and/or downlink data on uplink and downlink data channels.

[0031] The transmission to the data channels may be based on network scheduled decisions relating to access to the data channel network scheduled. In such embodiments, the UE waits until
5 uplink grants to initiate uplink transmissions and downlink allocations indicating downlink data transmission for it. In other embodiments, the access to the uplink data channel may be contention based random access. In such embodiments, the UE initiates corresponding random access procedure based on default configuration after sending the re-establishment request message. In other embodiments, the re-establishment request message may also include a buffer status of the
10 UE. The buffer status can allow the network to immediately schedule uplink transmission. In some embodiments, therefore, a re-establishment request message that includes the buffer status of the UE may be sent from a user equipment and received by a network node.

[0032] In certain other embodiments, the re-establishment request message can also include identifications (IDs) of radio bearer which may require URC. In some embodiments, therefore, a
15 re-establishment request message that includes IDs of radio bearer which may require URC may be sent from a user equipment and received by a network node.

[0033] The re-establishment request message may include, in certain embodiments, channel quality indicator (CQI) and precoding matrix indicator (PMI) information of the channel. The CQI and PMI information of the channel may permit modulation and coding scheme (MCS)
20 selection, and beamforming for the network. In some embodiments, the CQI and PMI information may be coded as separate bits in a physical layer (PHY) part of the message, to allow fast encoding and decoding, rather than including the information as part of the Abstract Syntax Notation One (ASN.1) coding. In some embodiments, these physical layer bits may be mapped to a different time and/or frequency, which acts to separate various symbols from those symbols carrying the
25 actual re-establishment message.

[0034] In certain embodiments, therefore, a re-establishment request message that includes CQI and PMI information of the channel is sent from a user equipment and received by a network node. In other embodiments, a re-establishment request message that includes the CQI and PMI information as separate bits in PHY rather than including the information in the ASN.1 coding is
30 sent from a user equipment and received by a network node.

[0035] In certain embodiments, the re-establishment request message can also include the ciphering algorithm that was used by the UE. This embodiment may permit networks to use multiple ciphering algorithms. In some embodiments, therefore, a re-establishment request message that includes a used ciphering algorithm may be sent from a user equipment and received
35 by a network node.

[0036] The re-establishment request message, in other embodiments, can include the nextHopChainingCount that the UE used to derive the new key used in the eNB (K_{eNB}) for data reception after the message. The nextHopChainingCount is a security algorithm used to generate security keys used by the UE. This new K_{eNB} can then be used to generate K_{RRCint} , K_{RRCenc} , and/or

5 K_{UPenc} . This embodiment may permit networks to use multiple ciphering algorithms. In some embodiments, therefore, a re-establishment request message that includes a nextHopChainingCount, which the user equipment used in deriving the new K_{eNB} , can be sent from a user equipment and received by a network node.

[0037] In certain embodiments, the re-establishment request message can also include new short

10 message authentication code for integrity (shortMAC-I) or a modified calculation of an existing shortMAC-I. These embodiments permit the network to verify the integrity of the buffer status, default configuration ID, and security parameters that are included in the message. Such a feature may be needed in some embodiments in which the re-establishment requesting message may not be ciphered because the network needs to immediately provide uplink and/or downlink scheduling.

15 In these embodiments, a false UE cannot request uplink and/or downlink capacity by replaying other UEs RRC re-establishment request messages. In certain embodiments, therefore, a re-establishment request message that includes new shortMAC-I or a modified calculation of an existing shortMAC-I may be sent from a user equipment and received by a network node.

[0038] In certain other embodiments, the re-establishment request message can include the

20 ciphering algorithm that was used by the UE. This permits the networks to use multiple ciphering algorithms. In some embodiments, therefore, a re-establishment request message that includes a used ciphering algorithm used by the UE may be sent from a user equipment and received by a network node.

[0039] The re-establishment request message can also include, in certain embodiments, selected

25 uplink configuration for transmitting CQI, PMI, and/or hybrid automatic repeat request (HARQ) feedback information. In certain embodiments, therefore, a re-establishment request message that includes selected uplink configuration for transmitting CQI, PMI, and/or hybrid automatic repeat request (HARQ) feedback information may be sent from a user equipment and received by a network node.

[0040] Any of the above configuration information elements, or any combination thereof, may

30 be included in the re-establishment request message. In some embodiments, any of the above configuration information elements, or any combination thereof, may be included as part of the radio link default configuration.

[0041] In certain embodiments, after sending a single re-establishment request message,

35 including at least one default configuration, all or some of the RBs in the uplink and downlink

direction can be re-established with new ciphering keys derived from the new K_{eNB} . The K_{eNB} may be derived in various ways, including by the process defined in 3GPP TS 33.401. Re-establishment may also include packet data convergence protocol (PDCP) and radio link control (RLC).

[0042] Upon receiving the re-establishment request message including at least one radio link default configuration from a UE, the network node may begin to schedule downlink and uplink for the UE based on the default configurations and/or other information received.

[0043] In certain embodiments, in which the re-establishment request message contained uplink resources for sending physical layer CQI and PMI information, the UE may start sending CQI and PMI information based on the specific configuration. In addition, the UE may configure uplink HARQ feedback transmission based on the configuration information. The resources for CQI, PMI, transmission and HARQ feedback may be randomly selected from a resource pool reserved for URC communication. If so, the UE may indicate the resource pool selection in an uplink message. In other embodiments, the resources can be selected based on UE identification from the resource pool e.g. Modulo (C-RNTI, X) where X is the number of resources in the pool. Further, in some embodiments, new medium access control (MAC) packet format, which may contains CQI and PMI, can be defined for uplink transmission. The new MAC packet format may then be used until RRC reconfiguration is performed.

[0044] After the re-establishment request message has been sent, the UE may wait for the downlink data transmission based on at least the default configuration. In other embodiments, the UE may wait for uplink grants for uplink transmission based on at least the default configuration, such as scheduled uplink access.

[0045] If the UE does not receive either an RRC message from the network, downlink data with at least default configuration, and/or uplink grant after a predetermined amount of time, the UE, in certain embodiments, may consider that the RRC Connection Re-establishment message was not correctly received and may re-transmit the message. In some embodiments, therefore, the UE resends the re-establishment request message if at least one radio link default configuration is not received.

[0046] As seen in the embodiment illustrated in Figure 2, at the point when the network receives RRC re-establishment request message, the eNB may immediately start downlink and uplink scheduling for the UE with the default configuration. In the embodiment of Figure 2, only a single RRC re-establishment message having at least one default configuration is needed to re-establish the RBs, as shown in step 230.

[0047] In certain embodiments, as shown in Figure 2, the network may perform context fetch from the source eNB in step 240. The context fetch response message, as shown in step 250, may contain piggy backed data of the UE. In other embodiments, the source eNB can start forwarding

data to a target eNB by using the tunnel end point given by the target eNB in the context fetch request message.

[0048] In certain embodiments, the network can perform normal RRC connection reconfiguration procedure in a later point in time to normalize connection. In this embodiment, the uplink resources
5 may be re-allocated so that they are not using the resource pool during the time when the UE enters the cell and connection re-establishment is performed. In such an embodiment, the network can clear the UE from the pool, minimizing the pool size reserved for improved RRC connection re-establishment for URC communication.

[0049] In the embodiment shown in Figure 2, a UE may detect radio link failure in step 210,
10 select a suitable cell in step 220, and determine which default configurations are needed for URC in step 230. A single RRC re-establishment message containing the at least one default configuration can then be sent to a first network node (eNB₁) in step 230. eNB₁ may then send a context fetch message to a source network node (eNB₂) in step 240, and eNB₂ can respond with a context fetch response message which may contain piggy backed data of the UE in step 250. The
15 RBs are then re-established in step 260, and downlink and or uplink scheduling may begin based on at least the default configurations in step 270. Downlink and/or uplink data transmission on RB may then begin. Upon receiving the RRC re-establishment message, eNB₁ can immediately begin to the downlink/uplink scheduling based on at least the default configurations in step 280.

[0050] In certain embodiments, in step 290 the UE may derive new keys for ciphering K_c and
20 integrity K_i, and ready for data transmission or reception using old ciphering keys in step 291.

[0051] Figure 3 illustrates a system according to certain embodiments. It should be understood that each block of the flowchart of Figures 1 or 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. In one embodiment, a system may include several
25 devices, such as, for example, network node 320 and UE or user device 310. The system may include more than one UE 310 and more than one network node 320, although only one of each is shown for the purposes of illustration. A network node can be an access point, a base station, an eNB, server, host or any of the other network nodes discussed herein. Each of these devices may include at least one processor or control unit or module, respectively indicated as 321 and
30 311. At least one memory may be provided in each device, and indicated as 322 and 312, respectively. The memory may include computer program instructions or computer code contained therein. One or more transceiver 323 and 313 may be provided, and each device may also include an antenna, respectively illustrated as 324 and 314. Although only one antenna each is shown, many antennas and multiple antenna elements may be provided to each of the
35 devices. Other configurations of these devices, for example, may be provided. For example,

network node 320 and UE 310 may be additionally configured for wired communication, in addition to wireless communication, and in such a case antennas 324 and 314 may illustrate any form of communication hardware, without being limited to merely an antenna.

[0052] Transceivers 323 and 313 may each, independently, be a transmitter, a receiver, or both
5 a transmitter and a receiver, or a unit or device that may be configured both for transmission and reception. The transmitter and/or receiver (as far as radio parts are concerned) may also be implemented as a remote radio head which is not located in the device itself, but in a mast, for example. The operations and functionalities may be performed in different entities, such as nodes, hosts or servers, in a flexible manner. In other words, division of labor may vary case
10 by case. One possible use is to make a network node deliver local content. One or more functionalities may also be implemented as virtual application(s) in software that can run on a server.

[0053] A user device or user equipment 310 may be a mobile station (MS) such as a mobile phone or smart phone or multimedia device, a computer, such as a tablet, provided with wireless
15 communication capabilities, personal data or digital assistant (PDA) provided with wireless communication capabilities, portable media player, digital camera, pocket video camera, navigation unit provided with wireless communication capabilities or any combinations thereof.

[0054] In an exemplary embodiment, an apparatus, such as a node or user device, may include
20 means for carrying out embodiments described above in relation to Figures 1 or 2. In certain embodiments, at least one memory including computer program code can be configured to, with the at least one processor, cause the apparatus at least to perform any of the processes described herein.

[0055] In certain embodiments, the at least one memory and a computer program code are
25 configured to, with the at least one processor, cause the UE to prepare a re-establishment request message. The re-establishment request message includes at least one radio link default configuration. The at least one memory and a computer program code are configured to, with the at least one processor, also cause the user equipment to send the re-establishment request message from a user equipment to a network node.

[0056] In certain other embodiments, the at least one memory and the computer program code
30 are configured to, with the at least one processor, cause the network node to receive a re-establishment request message. The re-establishment request message includes at least one radio link default configuration. The at least one memory and the computer program code are configured to, with the at least one processor, also cause the network node to schedule at least
35 one of downlink and uplink for the user equipment based on the at least one radio link default

configuration.

[0057] Processors 311 and 321 may be embodied by any computational or data processing device, such as a central processing unit (CPU), digital signal processor (DSP), application specific integrated circuit (ASIC), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), digitally enhanced circuits, or comparable device or a combination thereof. The processors may be implemented as a single controller, or a plurality of controllers or processors.

[0058] For firmware or software, the implementation may include modules or unit of at least one chip set (for example, procedures, functions, and so on). Memories 312 and 322 may independently be any suitable storage device, such as a non-transitory computer-readable medium. A hard disk drive (HDD), random access memory (RAM), flash memory, or other suitable memory may be used. The memories may be combined on a single integrated circuit as the processor, or may be separate therefrom. Furthermore, the computer program instructions may be stored in the memory and which may be processed by the processors can be any suitable form of computer program code, for example, a compiled or interpreted computer program written in any suitable programming language. The memory or data storage entity is typically internal but may also be external or a combination thereof, such as in the case when additional memory capacity is obtained from a service provider. The memory may be fixed or removable.

[0059] The memory and the computer program instructions may be configured, with the processor for the particular device, to cause a hardware apparatus such as network node 320 and/or UE 310, to perform any of the processes described above (see, for example, Figures 1 and 2). Therefore, in certain embodiments, a non-transitory computer-readable medium may be encoded with computer instructions or one or more computer program (such as added or updated software routine, applet or macro) that, when executed in hardware, may perform a process such as one of the processes described herein. Computer programs may be coded by a programming language, which may be a high-level programming language, such as objective-C, C, C++, C#, Java, etc., or a low-level programming language, such as a machine language, or assembler. Alternatively, certain embodiments of the invention may be performed entirely in hardware.

[0060] Furthermore, although Figure 3 illustrates a system including a network node 320 and a UE 310, embodiments of the invention may be applicable to other configurations, and configurations involving additional elements, as illustrated and discussed herein. For example, multiple user equipment devices and multiple network nodes may be present, or other nodes providing similar functionality, such as nodes that combine the functionality of a user equipment and an access point, such as a relay node. The UE 310 may likewise be provided

with a variety of configurations for communication other than communication network node 320. For example, the UE 310 may be configured for device-to-device communication.

[0061] Figure 4 illustrates additional apparatuses according to certain embodiments. The user equipment 401 includes means for detecting radio link failure 410, means for performing cell selection or reselection 420, and means for preparing a re-establishment request message including at least one radio link default configuration 430. The user equipment 401 also includes means for sending the re-establishment request message including the default configurations. The network node 402 then includes means for uplink and downlink scheduling 450 based on the default configuration the network node 402 received with the re-establishment request message. The apparatus then includes means for download and/or uplink data transmission on the radio bearers 460.

[0062] The features, structures, or characteristics of certain embodiments described throughout this specification may be combined in any suitable manner in one or more embodiments. For example, the usage of the phrases “certain embodiments,” “some embodiments,” or other similar language, throughout this specification refers to the fact that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of the present invention. Thus, appearance of the phrases “in certain embodiments,” “in some embodiments,” “in other embodiments,” or other similar language, throughout this specification does not necessarily refer to the same group of embodiments, and the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0063] One having ordinary skill in the art will readily understand that the invention as discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although the invention has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention.

[0064] Partial Glossary

[0065]	LTE	Long-Term Evolution
30 [0066]	UE	User Equipment
[0067]	RRC	Radio Resource Control
[0068]	HO	handover
[0069]	eNB	E-UTRAN Node B/evolved Node B
[0070]	UMTS	Universal Mobile Telecommunication System
35 [0071]	UTRAN	Universal Terrestrial Radio Access

	[0072]	SRB	Signalling Radio Bearers
	[0073]	RB	Radio Bearers
	[0074]	HSPA	High Speed Packet Access
	[0075]	HSDPA	High Speed Downlink Packet Access
5	[0076]	HS-SCCH	The High Speed-Shared Control Channel
	[0077]	URC	Ultra-Reliable Communication
	[0078]	MAC-I	Message Authentication Code for Integrity
	[0079]	CQI	Channel Quality Indicator
	[0080]	PMI	Precoding Matrix Indicator
10	[0081]	ASN.1	Abstract Syntax Notation One
	[0082]	PHY	Physical (layer)
	[0083]	HARQ	Hybrid Automatic Repeat Request
	[0084]	PDCP	Packet Data Convergence Protocol
	[0085]	RLC	Radio Link Control
15	[0086]	MAC	Medium Access Control

WE CLAIM:

1. A method, comprising:
preparing a re-establishment request message, wherein the re-establishment request message includes at least one radio link default configuration; and
sending the re-establishment request message from a user equipment to a network node.
2. The method according to claim 1, further comprising re-establishing at least one radio bearer in an uplink and/or a downlink direction between the user equipment and the network node.
3. The method according to claims 1 or 2, further comprising communicating user plane data from at least one radio bearer in an uplink and/or a downlink direction between the user equipment and the network node based on a network scheduling decision.
4. The method according to claims 1-3, wherein the re-establishment request message includes new ciphering keys for at least one of the network node and the user equipment.
5. The method according to claims 1-4, wherein the re-establishment request message includes information as to at least one of a radio bearer and a set of radio bearers carrying ultra-reliable communication data.
6. The method according to claim 2, wherein the at least one radio bearer includes identification of radio bearer that requires ultra-reliable communication.
7. The method according to claims 1-6, wherein the default configuration is preconfigured by the network in the connection establishment phase.
8. The method according to claims 1-7, wherein the re-establishment request message includes a status of a user equipment uplink buffer.
9. The method according to claims 1-8, wherein the re-establishment request message includes channel quality indicator and precoding matrix indicator information of the channel.
10. The method according to claim 9, wherein the channel quality indicator and precoding matrix indicator information is coded separately in a physical layer part of the re-

establishment request message.

11. The method according to claim 9, wherein the channel quality indicator and the precoding matrix indicator information are separate from an Abstract Syntax Notation One coding.

12. The method according to claims 1-11, wherein the re-establishment request message includes new message authentication code for integrity or a modified calculation of an existing message authentication code for integrity.

13. The method according to claims 1-12, wherein the re-establishment request message includes selected uplink configuration for transmitting at least one of channel quality indicator, precoding matrix indicator, and hybrid automatic repeat request feedback.

14. A method, comprising:
receiving a re-establishment request message from a user equipment, wherein the re-establishment request message includes at least one radio link default configuration, and
scheduling downlink and/or uplink for the user equipment based on the at least one radio link default configuration.

15. The method according to claim 14, further comprising re-establishing at least one radio bearer in an uplink and/or a downlink direction between the user equipment and a network node.

16. The method according to claims 14 or 15, further comprising communicating user plane data from at least one radio bearer in an uplink and/or a downlink direction between the user equipment and a network node based on a network scheduling decision.

17. The method according to claims 14-16, wherein the re-establishing request message includes new ciphering keys for at least one of a network node and the user equipment.

18. The method according to claims 14-17, wherein the re-establishment request message includes information as to at least one of a radio bearer and a set of radio bearers carrying ultra-reliable communication data.

19. The method according to claim 15, wherein the at least one radio bearer includes identification radio bearer that requires ultra-reliable communication.

20. The method according to claims 14-19, wherein the default configuration is preconfigured by the network in the connection establishment phase.

21. The method according to claims 14-20, wherein the re-establishment request message includes a status of a user equipment uplink buffer.

22. The method according to claims 14-21, wherein the re-establishment request message includes channel quality indicator and precoding matrix indicator information of the channel.

23. The method according to claim 22, wherein the channel quality indicator and precoding matrix indicator information is coded separately in a physical layer part of the re-establishment request message.

24. The method according to claim 22, wherein the channel quality indicator and the precoding matrix indicator information are separate from an Abstract Syntax Notation One coding.

25. The method according to claims 14-24, wherein the re-establishment request message includes new message authentication code for integrity or a modified calculation of an existing message authentication code for integrity.

26. The method according to claims 14-25, wherein the re-establishment request message includes selected uplink configuration for transmitting at least one of channel quality indicator, precoding matrix indicator, and hybrid automatic repeat request feedback.

27. An apparatus, comprising:
at least one processor; and
at least one memory including computer program code,
wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform a process according to any of claims 1-26.

28. A non-transitory computer-readable medium encoding instructions that, when executed in hardware, perform a process according to any of claims 1-26.

29. An apparatus comprising means for performing a process according to any of claims 1-26.

30. A computer program product encoding instructions for performing a process according to any of claims 1-26.

Figure 1

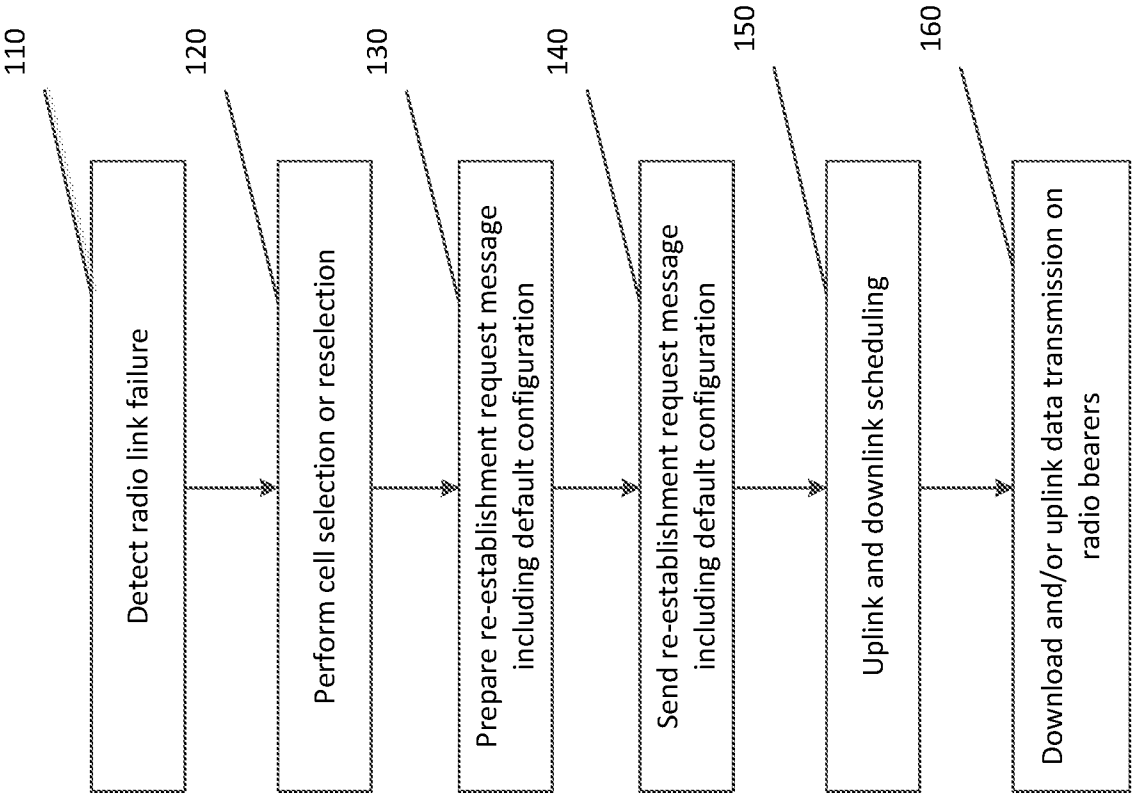


Figure 2

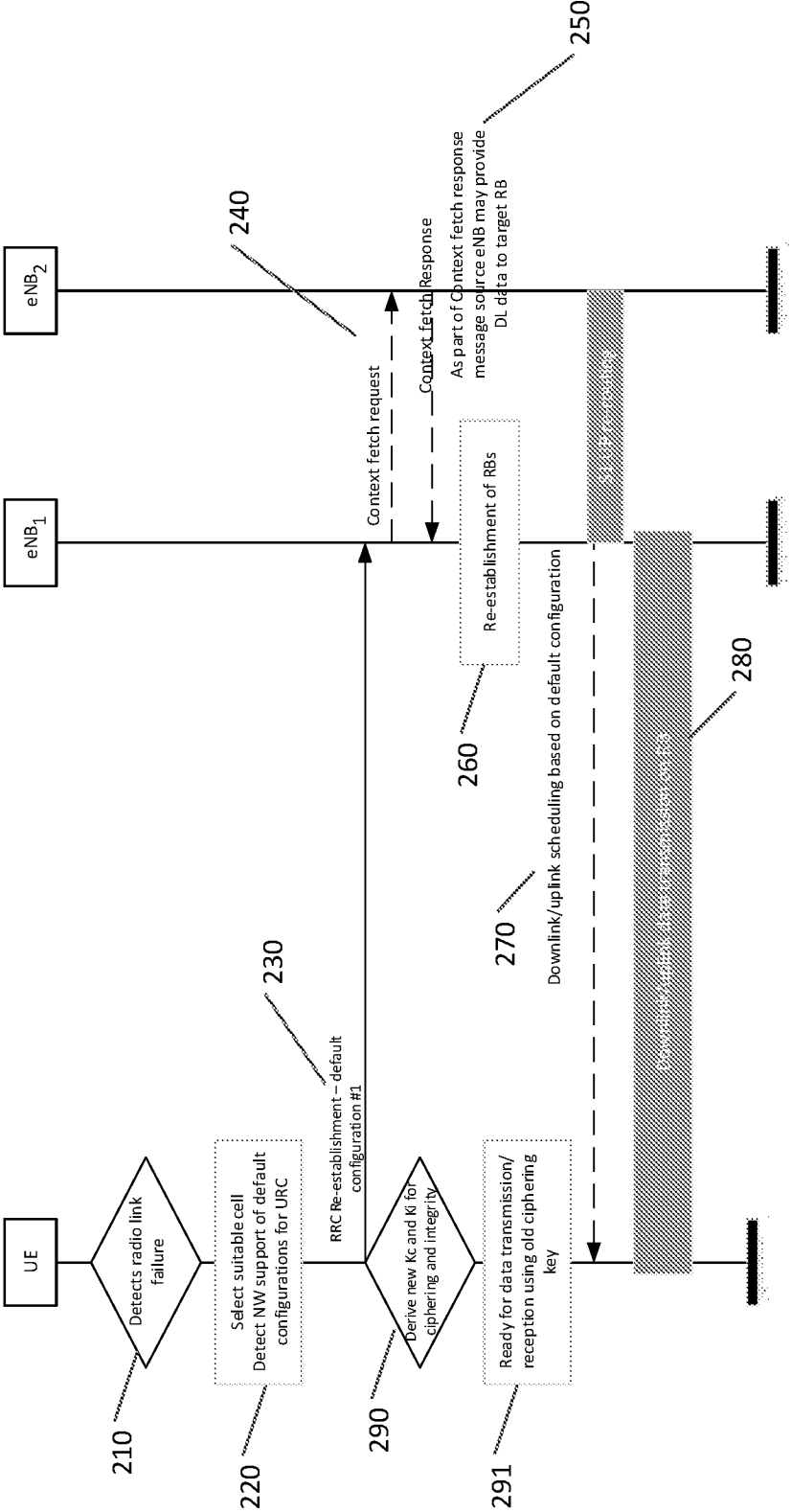


Figure 3

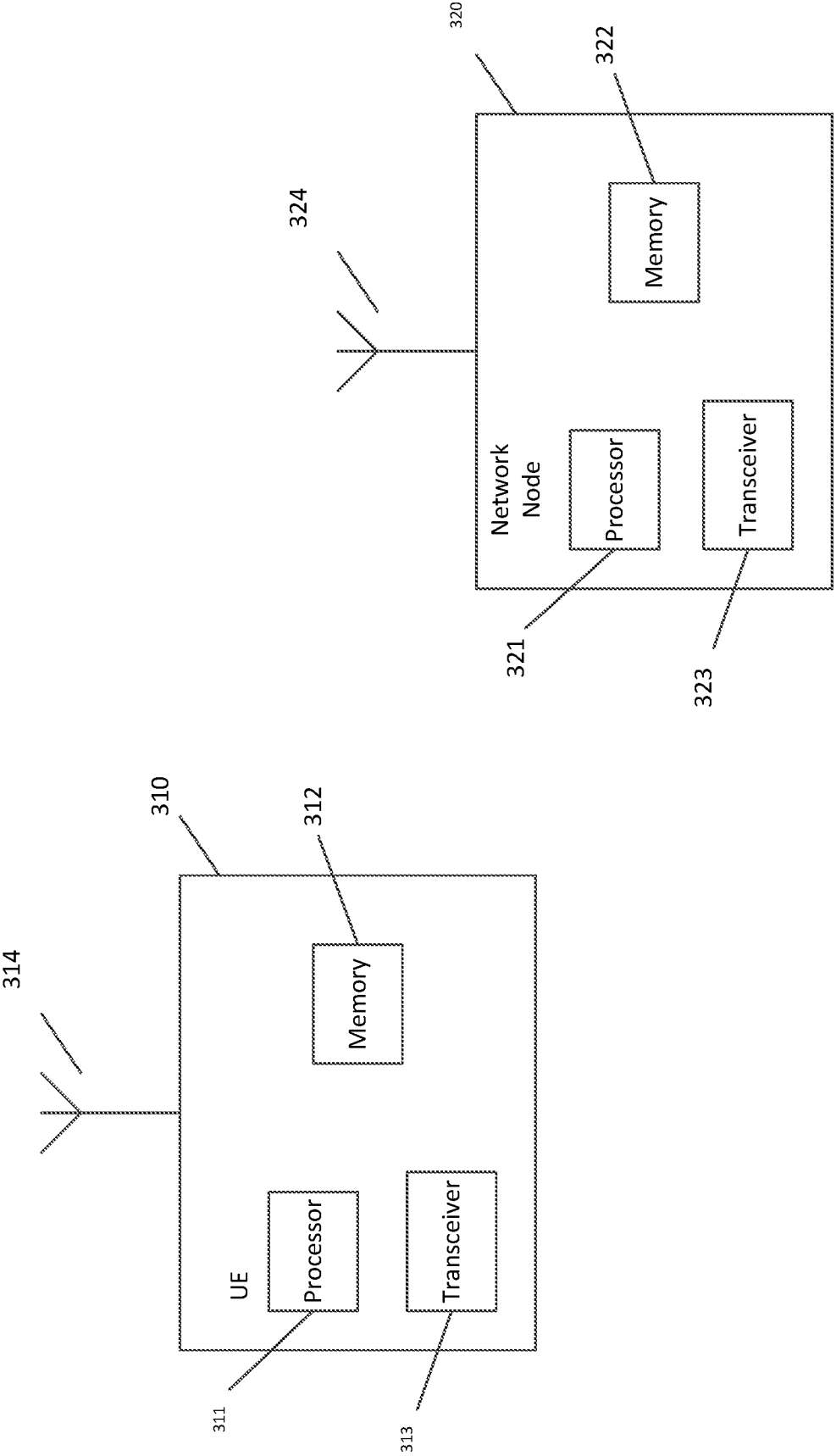
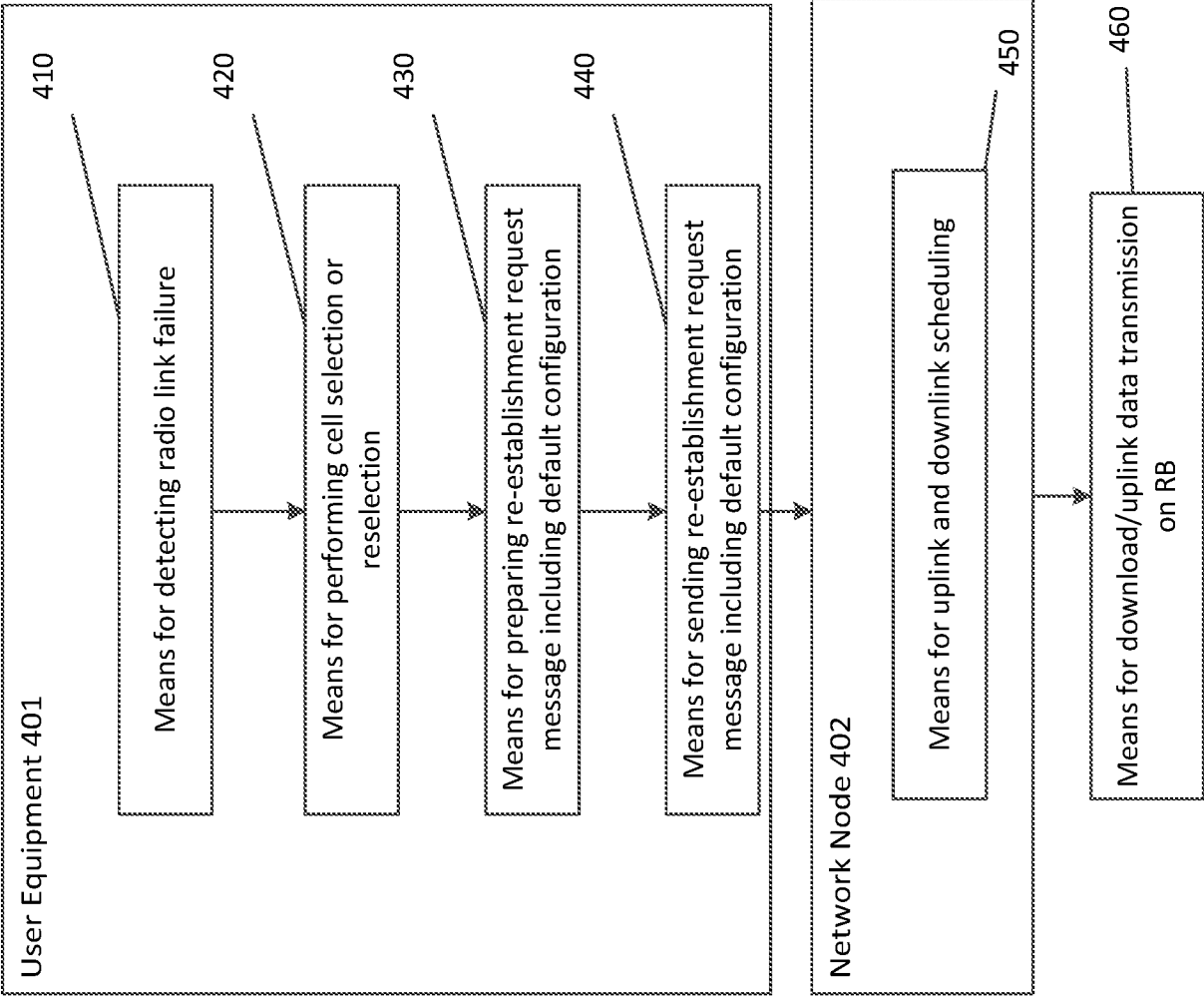


Figure 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2016/052459

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: H04W

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20140056243 A1 (PELLETIER GHYSLAIN ET AL), 27 February 2014 (2014-02-27); paragraphs [0073], [0189], [0199], [0202], [0217], [0219], [0236], [0245], [0258], [0269], [0299]-[0301]	1-4, 7-17, 20-30
Y	--	5-6, 18-19



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

05-07-2016

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

 International application No.
 PCT/IB2016/052459

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Y	P. Popovski, "Ultra-reliable communication in 5G wireless systems," 5G for Ubiquitous Connectivity (5GU), 2014 1st International Conference on, Akaslompolo, 2014, pp. 146-151. doi: 10.4108/icst.5gu.2014.258154 keywords: {5G mobile communication;telecommunication network reliability;5G wireless systems;communication reliability;metadata;reliable service composition;ultrareliable communication;Robustness}, URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7041045&isnumber=7041014; whole document --	5-6, 18-19
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A	US 20120281566 A1 (PELLETIER GHYSLAIN ET AL), 8 November 2012 (2012-11-08); paragraphs [0125]-[0135], [0198]-[0200] --	1-30
A	WO 2014025141 A1 (LG ELECTRONICS INC), 13 February 2014 (2014-02-13); paragraphs [0079]-[0082], [0104]-[0110]; figures 6a-6b --	1-30
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P, Y	GB 2528913 A (SAMSUNG ELECTRONICS CO LTD), 10 February 2016 (2016-02-10); paragraphs [0022]-[0140] --	1-30
P, Y	WO 2015133991 A1 (NOKIA TECHNOLOGIES OY ET AL), 11 September 2015 (2015-09-11); paragraphs [0001]-[0061] --	1-30
P, Y	WO 2016022314 A1 (QUALCOMM INC), 11 February 2016 (2016-02-11); paragraphs [0001]-[0114] -- -----	1-30

Continuation of: second sheet

International Patent Classification (IPC)

H04W 36/00 (2009.01)

H04W 72/00 (2009.01)

H04W 74/04 (2009.01)

H04W 76/02 (2009.01)

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