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(71) Applicant: **NOKIA SOLUTIONS AND NETWORKS OY** [FI/FI]; Karaportti 3, FI-02610 Espoo (FI).

(72) Inventors: **PANEK, Michal**; Lubinska 20/5 street, PL-54-624 Wroclaw (PL). **WIGARD, Jeroen**; Septembervej 1 A, DK-9270 Klarup (DK). **FREDERIKSEN, Frank**; Hornbækvej 4, DK-9270 Klarup (DK). **RANTA-AHO, Karri, Markus**; Leirikaari 26A/7, FI-02600 Espoo (FI).

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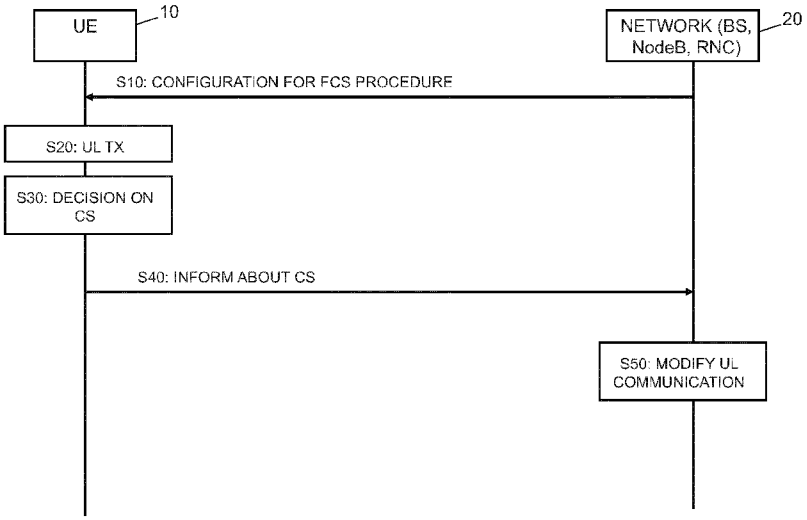
Fig. 2



(57) Abstract: There is provided a mechanism for controlling an uplink communication. After conducting a configuration related to a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, it is decided on the UE side to switch a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier. When the carrier switching is decided to be conducted, the network is informed about the carrier switching.

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DESCRIPTION

TITLE

MECHANISM FOR CONTROLLING AN UPLINK COMMUNICATION

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to a mechanism for controlling a communication. Specifically, the present invention is related to an apparatus, a method, a system and a computer program product which allow, for example, a control of a communication in uplink direction with measures providing a fast load balancing in situations where there is a high load e.g. in the uplink direction.

The following meanings for the abbreviations used in this specification apply:

ACK:	acknowledgement
BLER:	block error rate
BS:	base station
CPU:	central processing unit
CQI:	channel quality indication
CS:	carrier switch
DL:	downlink
DPCCH:	dedicated physical control channel
eNB:	evolved node B
E-AGCH:	E-DCH absolute grant channel
E-DCH:	enhanced dedicated channel
E-DPDCH:	enhanced dedicated physical data channel
E-RNTI:	E-DCH radio network identifier
FCS:	fast carrier switching
FDD:	frequency division duplex

H-ARQ: hybrid automatic repeat request
HSPA: high speed packet access
HSUPA: high-speed uplink packet access
ILPC: inner loop power control
LTE: Long Term Evolution
LTE-A: LTE Advanced
Node B: base station in 3GPP, with a Serving Node B as a base station that the UE is associated to, and a Non-serving Node B as a base station that is included in the active set of the UE for soft-HO operation but is not the serving Node B
OLPC: outer loop power control
P-CCPCH: primary common control channel
RNC: radio network controller
RX: receiver, receive
SG: scheduling grant
SFR: system frame number
SINR: signal-to-interference-and-noise ratio
TB: transport block
TDD: time division duplex
TTI: transmission timing interval
TX: transmitter, transmit
WCDMA : wideband code division multiple access
UE: user equipment
UL: uplink
UMTS: Universal Mobile Telecommunication Services
UTRA: UMTS terrestrial radio access
UTRAN: UMTS terrestrial radio access network

In the last years, an increasing extension of communication networks, e.g. of wire based communication networks, such as the Integrated Services Digital Network (ISDN), DSL, or wireless communication networks, such as the cdma2000 (code division multiple access) system, cellular 3rd generation (3G) and fourth generation (4G) communication networks like the Universal Mobile Telecommunications System (UMTS), enhanced communication networks based e.g. on LTE or LTE-A, cellular 2nd generation (2G) communication networks like the Global System for Mobile

communications (GSM), the General Packet Radio System (GPRS), the Enhanced Data Rates for Global Evolution (EDGE), or other wireless communication system, such as the Wireless Local Area Network (WLAN), Bluetooth or Worldwide Interoperability for Microwave Access (WiMAX), took place all over the world. Various organizations, such as the 3rd Generation Partnership Project (3GPP), Telecoms & Internet converged Services & Protocols for Advanced Networks (TISPAN), the International Telecommunication Union (ITU), 3rd Generation Partnership Project 2 (3GPP2), Internet Engineering Task Force (IETF), the IEEE (Institute of Electrical and Electronics Engineers), the WiMAX Forum and the like are working on standards for telecommunication network and access environments.

Generally, for properly establishing and handling a communication connection between terminal devices such as a user equipment (UE) and another communication network element or user equipment, a database, a server, etc., one or more intermediate network elements such as communication network control elements, such as base stations, control nodes, support nodes or service nodes are involved which may belong to different communication network.

Communications between a communication element such as a UE and a communication network control element such as a BS or NodeB in the UL and DL direction are conducted via one or more carriers. The increasing demand for wireless broadband access leads to an ongoing development of enhanced radio network systems, wherein the 3GPP WCDMA-based UTRA is one example. As one approach for increasing the performance of the communication systems, measures like HSPA are further employed, both in the UL and DL direction. Specifically, HSUPA is aimed at efficiently supporting packet traffic in the UL direction, wherein for an error correction a H-ARQ process is used.

The physical channel structure of HSUPA uses for example the DPCCH pilot channel as a reference channel for channel estimation and transmit power control processing. Also other channels are used, such as an E-DPCCH (enhanced DPCCH) which can be used for carrying HSUPA-related control information and also as an additional reference channel for improved channel estimation, or an E-DPDCH which is used for

data transmission. In a conventional HSUPA implementation, all of these channels are spread by orthogonal spreading codes.

Two power control loops can be used to control the BLER experienced by the transport blocks originating from the UE. A first one, referred to as OLPC, is used to adjust the target SINR of the reference channel (DPCCH). Furthermore, as a second one, an inner loop power control (ILPC) is used to adjust the radiated power in the UE, so that the target SIR is met.

However, in systems such as a HSUPA system, all users share the same physical resource (time and frequency), but are separated in the code domain (through WCDMA). That is, the users are transmitting on top of each other with different codes which causes interferences with regard to each other. In a conventional HSUPA system, the user is fixed on the carrier configured or selected during the initial access for the duration of the packet call (or the entire session). However, in case there is a relative high load in the UL direction, the system performance is degraded, and it may become necessary to take measures against this, for example to do some load balancing or the like.

SUMMARY OF THE INVENTION

It is an object of the invention to overcome at least some of the above described problems and to provide an enhanced mechanism for controlling a communication. Specifically, it is an object of the present invention to provide an improved apparatus, method, system and computer program product which allow, for example, to control a communication in the UL direction wherein measures are taken for providing a fast load balancing in high load situations in the UL direction.

These objects are achieved by the measures defined in the attached claims.

According to an example of an embodiment of the proposed solution, there is provided, for example, an apparatus comprising at least one processor, at least one interface to at least one other network element, and at least one memory for storing instructions to be executed by the processor, wherein the at least one memory and the instructions

are configured to, with the at least one processor, cause the apparatus at least to perform: a carrier switching configuration function configured to receive and process configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, a carrier switching deciding function configured to decide to switch a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information, and a carrier switching information function configured to inform a communication network control element about the carrier switching.

Furthermore, according to an example of an embodiment of the proposed solution, there is provided, for example, a method comprising receiving and processing configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, deciding to switch a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information, and informing a communication network control element about the carrier switching.

According to further refinements, these examples may comprise one or more of the following features:

- the communication may be conducted on the at least one first uplink frequency carrier before the carrier switching, and the communication may be conducted on the at least one second uplink frequency carrier after the carrier switching;
- the configuration information may comprise at least one of a definition of uplink frequency carriers to and from which a carrier switching is executable, a selection probability value for the respective uplink frequency carriers, policy information related to the carrier switching, and information on volumes and timing parameters related to the policy information;
- it may be determined whether a retransmission of data is to be conducted for a communication on the at least one first frequency carrier, and when it is determined that a retransmission of data is to be conducted, the carrier switching may be stopped;
- it may be determined that the retransmission of data is to be conducted when at least one of the following is valid: an acknowledgement for a successful transmission in a preceding transmission cycle in one hybrid automatic repeat request process is not

determined to be received, and an incorrect transmission or decoding of a transport block in a preceding transmission cycle is detected;

- information indicating a time window in which a carrier switching is allowed to be executed may be received and processed, it may be determined, when the time window begins, whether a persistence time has elapsed since a preceding carrier switching executed before a carrier switching to be executed at the present time, and a carrier switching may be allowed in case the persistence time is elapsed, or a carrier switching may be not allowed in case the persistence time is not elapsed;

- in case the carrier switching is allowed and a current time is in the time window, a stop of a transmission of data units on the current carrier may be initiated, it may be checked whether an acknowledgement for already transmitted data units is received, and in case the acknowledgement for the already transmitted data units is received, the carrier switching may be initiated;

- the persistence time may be based on one of a time period required for stabilizing a power control after executing a carrier switching, which may be provided by a communication network control element, and a randomly set time period within a predetermined time window;

- it may be determined whether a maximum retransmission time period is expired since a first retransmission of data on the at least one first frequency carrier, and when it is determined that the maximum retransmission time period is expired, a not-completed retransmission may be discarded, and the carrier switching may be allowed;

- a retransmission of data units comprised in the discarded retransmission in another retransmission process may be initiated;

- channel quality information on an uplink frequency carrier used for the communication may be determined and transmitted, wherein, when it is decided to switch the current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, a transmission of channel quality information on the currently used uplink frequency carrier may be stopped at a predetermined timing before the carrier switching, and a transmission of channel quality information on the uplink frequency carrier to which the carrier switching will switch the communication may be started, at the predetermined timing before the carrier switching;

- a simultaneous scanning and decoding of control channels transmitted via plural downlink carriers corresponding to the uplink frequency carriers usable in the

carrier switching on the basis of the configuration information may be conducted, and a carrier switching processing may be initiated when a switching indication is received and decoded on one of the plural control channels, wherein the carrier switching may be executed to an uplink frequency carrier corresponding to the downlink carrier where the control channel bearing the switching indication is received;

- the control channel may be a grant channel, wherein the grant channel may be an enhanced dedicated channel absolute grant channel, wherein the switching indication may be derived on the basis of a mapping of a transmitted value to an absolute grant by means of a table, wherein the switching indication may be indicated at predefined locations in the table;

- a switching timing parameter which is usable for determining a timing of executing the carrier switching may be received and processed, and the timing of executing the carrier switching may be calculated on the basis of the switching timing parameter and a persistence time;

- the switching timing parameter may be one of a parameter based on a common cell or network specific parameter, or a parameter based on a combination of a common cell or network specific parameter and a communication element specific parameter related to a communication element from which the communication in the uplink direction originates; here, the common cell or network specific parameter may include a system frame number, and the communication element specific parameter may include a radio network identifier, wherein the combination of the common cell or network specific parameter and the communication element specific parameter may be based on an arithmetic operation;

- the timing of executing the carrier switching may be calculated on the basis of the relation “switching timing parameter modulo persistence time = 0”;

- the communication may be a high speed packet access based communication, wherein the carrier switching may be conducted for switching the communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier in a same cell or in a different cell of a communication network, on the basis of the configuration information;

- the above described measures may be implemented in a communication element comprising at least one of a terminal device or user equipment communicating with a communication network control element, wherein the communication may be

conducted with the communication network control element which may comprise at least one of a base station or an access node of a cellular communication network.

According to a further example of an embodiment of the proposed solution, there is provided, for example, an apparatus comprising at least one processor, at least one interface to at least one other network element, and at least one memory for storing instructions to be executed by the processor, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform: a carrier switching configuration setting function configured to set and transmit configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, and a carrier switching information processing function configured to receive and process an information from a communication element about a switching of a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information.

Furthermore, according to a further example of an embodiment of the proposed solution, there is provided, for example, a method comprising setting and transmitting configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, and receiving and processing information from a communication element about a switching of a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information.

According to further refinements, these examples may comprise one or more of the following features:

- an uplink communication chain may be modified according to the information regarding the carrier switching;
- the configuration information may comprise at least one of a definition of uplink frequency carriers to and from which a carrier switching is executable, a selection probability value for the respective uplink frequency carriers, policy information related to the carrier switching, and information on volumes and timing parameters related to the policy information;

- the policy information may comprise a rule that a carrier switching is not allowed at least for a predetermined time when a retransmission of data is to be conducted for a communication on the at least one first frequency carrier;

- the information on volumes and timing parameters related to the policy information may comprise at least one value being set to an amount inhibiting a carrier switch until no retransmission is to be conducted;

- a time window in which a carrier switching is allowed to be executed may be defined, and information indicating the time window may be transmitted;

- an indication of a persistence time may be provided, wherein the persistence time may be based on one of a time period required for stabilizing a power control after executing a carrier switching, and a randomly set time period within a predetermined time window;

- a switching indication may be transmitted on one of plural control channels transmitted via plural downlink carriers corresponding to the uplink frequency carriers usable in the carrier switching on the basis of the configuration information, the switching indication being configured to initiate a carrier switching to an uplink frequency carrier corresponding to the downlink carrier where the control channel bearing the switching indication is transmitted; here, the control channel may be a grant channel; the grant channel may be an enhanced dedicated channel absolute grant channel, wherein the switching indication may be derived on the basis of a mapping of a transmitted value to an absolute grant by means of a table, wherein the switching indication may be indicated at predefined locations in the table;

- a timing of executing the carrier switching may be determined, a switching timing parameter indicating the determined timing of executing the carrier switching may be provided, an the timing of executing the carrier switching may be calculated on the basis of the switching timing parameter and a persistence time; here, the persistence time may be based on one of a time period required for stabilizing a power control after executing a carrier switching, which is provided by a communication network control element, and a randomly set time period within a predetermined time window, and the switching timing parameter may be one of a parameter based on a common cell or network specific parameter, or a parameter based on a combination of a common cell or network specific parameter and a communication element specific parameter related to a communication element from which the communication in the uplink direction originates;

- the common cell or network specific parameter may include a system frame number, and the communication element specific parameter may include a radio network identifier, wherein the combination of the common cell or network specific parameter and the communication element specific parameter may be based on an arithmetic operation;

- the timing of executing the carrier switching may be calculated on the basis of the relation “switching timing parameter modulo persistence time = 0”.

- at least one of a simultaneous carrier switching of plural or all communication elements in a cell, wherein the used switching timing parameter is a parameter based on a common cell or network specific parameter, and a distributed carrier switching of one or plural communication elements in a cell, wherein the used switching timing parameter is based on a combination of a common cell or network specific parameter and a communication element specific parameter related to the respective communication element from which the communication in the uplink direction originates, may be selected;

- the communication may be a high speed packet access based communication, wherein the carrier switching may be conducted switching for switching the communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier in a same cell or in a different cell of a communication network, on the basis of the configuration information;

- the above mentioned measures may be implemented in a communication network control element comprising at least one of a base station or an access node of a cellular communication network, wherein the communication may be conducted with a communication element comprising at least one of a terminal device or user equipment communicating with the communication network control element.

In addition, according to examples of the proposed solution, there is provided, for example, a computer program product for a computer, comprising software code portions for performing the steps of the above defined methods, when said product is run on the computer. The computer program product may comprise a computer-readable medium on which said software code portions are stored. Furthermore, the computer program product may be directly loadable into the internal memory of the computer and/or transmittable via a network by means of at least one of upload, download and push procedures.

By virtue of the proposed solutions, it is possible to provide an enhanced mechanism for controlling a communication e.g. in the UL direction wherein measures are taken for providing a fast load balancing in high load situations in the UL direction. Furthermore, it is possible to avoid that interferences are caused for users communicating on a carrier to which the carrier switching targets. Moreover, the communication and the system in which the communication is conducted can be kept stable when conducting a load balancing measure including carrier switching procedure. In addition, a flexible control of the timing for conducting the carrier switching is possible.

The above and still further objects, features and advantages of the invention will become more apparent upon referring to the description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a diagram illustrating a communication network configuration where some examples of embodiments of the invention are implemented.

Fig. 2 shows a signaling diagram illustrating a processing for controlling a communication in the UL direction according to an example of an embodiment of the invention.

Fig. 3 shows a signaling diagram illustrating a processing for controlling a communication in the UL direction according to a further example of an embodiment of the invention.

Fig. 4 shows a diagram illustrating a result of a processing for controlling a communication in the UL direction according to the example of Fig. 3.

Fig. 5 shows a signaling diagram illustrating a processing for controlling a communication in the UL direction according to a further example of an embodiment of the invention.

Fig. 6 shows a signaling diagram illustrating a processing for controlling a communication in the UL direction according to a still further example of an embodiment of the invention.

Fig. 7 shows a flowchart illustrating a processing executed in a communication network control element for controlling a communication in the UL direction according to examples of embodiments of the invention.

Fig. 8 shows a flowchart illustrating a processing executed in a communication element for controlling a communication in the UL direction according to examples of embodiments of the invention.

Fig. 9 shows a block circuit diagram of a communication network control element including processing portions conducting functions according to examples of embodiments of the invention.

Fig. 10 shows a block circuit diagram of a communication element including processing portions conducting functions according to examples of embodiments of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

In the following, examples and embodiments of the present invention are described with reference to the drawings. For illustrating the present invention, the examples and embodiments will be described in connection with a cellular communication network based on a 3GPP based communication system using WCDMA FDD technology, for example an UTRAN based system. However, it is to be noted that the present invention is not limited to an application using such types of communication system, but is also applicable in other types of communication systems and the like, for example an LTE or LTE-A based communication system, in TDD based systems and the like, as long as load balancing mechanisms like carrier switching are applicable in a communication conducted therein.

A basic system architecture of a communication network where examples of embodiments of the invention are applicable may comprise a commonly known architecture of one or more communication systems comprising a wired or wireless

access network subsystem and a core network. Such an architecture may comprise one or more access network control elements, radio access network elements, access service network gateways or base transceiver stations, such as a base station, a NodeB etc., which control a coverage area also referred to as a cell and with which one or more communication elements or terminal devices such as a UE or another device having a similar function, such as a modem chipset, a chip, a module etc., which can also be part of a UE or attached as a separate element to a UE, or the like, are capable to communicate via one or more channels for transmitting several types of data. Furthermore, core network elements such as gateway network elements, policy and charging control network elements, mobility management entities and the like may be comprised.

The general functions and interconnections of the described elements, which also depend on the actual network type, are known to those skilled in the art and described in corresponding specifications, so that a detailed description thereof is omitted herein. However, it is to be noted that several additional network elements and signaling links may be employed for a communication to or from a communication element or terminal device like a UE and a communication network control element like a BS or NodeB, besides those described in detail herein below.

Furthermore, the described network elements, such as terminal devices like UEs, communication network control elements, like an BS, a NodeB and the like, as well as corresponding functions as described herein may be implemented by software, e.g. by a computer program product for a computer, and/or by hardware. In any case, for executing their respective functions, correspondingly used devices, nodes or network elements may comprise several means and components (not shown) which are required for control, processing and communication/signaling functionality. Such means may comprise, for example, one or more processor units including one or more processing portions for executing instructions, programs and for processing data, memory means for storing instructions, programs and data, for serving as a work area of the processor or processing portion and the like (e.g. ROM, RAM, EEPROM, and the like), input means for inputting data and instructions by software (e.g. floppy disc, CD-ROM, EEPROM, and the like), user interface means for providing monitor and manipulation possibilities to a user (e.g. a screen, a keyboard and the like), interface means for establishing links and/or connections under the control of the processor unit

or portion (e.g. wired and wireless interface means, an antenna, etc.) and the like. It is to be noted that in the present specification processing portions should not be only considered to represent physical portions of one or more processors, but may also be considered as a logical division of the referred processing tasks performed by one or more processors.

As indicated above, examples of embodiments of the invention are related to a communication control where load balancing measures are taken e.g. in an UL communication. For example, such a load balancing measure is based on a carrier switching procedure, which is referred to hereinafter as a FCS operation (FCS: fast carrier switching or fast cell switching or fast carrier selection). According to examples of embodiments of the invention, a case is considered where multiple UL carriers are provided from a system for communications from the UE to the network, wherein it is assumed that one UE is capable to use one carrier frequency at a time.

FCS is usable as an extension of e.g. existing 3GPP WCDMA FDD technology (but is also applicable in other FDD or TDD based communication systems), and in particular in connection with HSUPA. As indicated above, HSUPA is usually related to an operation mode where all users are sharing the same physical resource, but are separated in the code domain (e.g. through WCDMA). Carrier switching, such as FCS, is considered to provide a technique which makes it possible to introduce fast load balancing operation for situations where there is a relative high load in the uplink direction, which is achieved by switching the communication from e.g. the UE to the NodeB (UL direction) from one frequency carrier to another frequency carrier while maintaining the communication (session) as such. The frequency carrier on which the UE is transmitting after the carrier switching is also referred to as “current carrier” (wherein parameters related to the communication on this current carrier are also referred to as „current“ parameters), while the carrier on which the transmission took place before the carrier switching is referred to as hereinafter as “previous carrier” (wherein parameters related to the communication on this previous carrier are referred to as „previous“ or „former“ parameters).

Carrier switching such as an FCS operation is generally related to retransmission procedures, such as a HARQ operation, and carrier operation control. For example, in case of a system being based on a concept like HSUPA, there are issues regarding

interference control as well as UE autonomous operation (that is, the network, such as the BS or NodeB, does not have a tight centralized control of UL transmission timing and formats).

Consequently, according to some examples of embodiments of the invention, when conducting a carrier switching, i.e. when a UE is switching to another cell or carrier, the switching is controlled in such a manner that it is executed at a suitable time and under suitable conditions.

With regard to Fig. 1, a diagram illustrating a general configuration of a communication network is shown where some examples of embodiments of the invention are implemented. It is to be noted that the configuration shown in Fig. 1 shows only those devices, network elements and parts which are useful for understanding principles underlying the examples of embodiments of the invention. As also known by those skilled in the art there may be several other network elements or devices involved in a communication between the communication device (UE) and the network which are omitted here for the sake of simplicity. It is to be noted that the general functions of the elements described in connection with Fig. 1 as well as of reference points/interfaces therebetween are known to those skilled in the art so that a detailed description thereof is omitted here for the sake of simplicity.

As shown in Fig. 1, in the exemplary communication network configuration, a communication network control element 20, such as a NodeB, is provided which establishes, for example, a connection to the core network of the communication network (not shown). Reference sign 10 denotes a communication element such as a UE which communicates with the NodeB 20 via plural channels. As indicated in Fig. 1, in the UL direction, plural carriers are provided for the communication between the UE 10 and the NodeB 20 (one DL carrier is also shown, wherein more than this one DL carrier is also possible to be provided).

According to some examples of embodiments of the invention, in a situation as indicated in Fig. 1, when conducting a carrier switching such as an FCS operation, that there is a risk of breaking a retransmission procedure, such as a HARQ loop. A HARQ loop introduces the possibility to have automatic repeat requests when an UL transmission fails. In such a case, the UE will retransmit its data packet. However, in

case a carrier switching is conducted, the UE is operating on another carrier and can cause impacts on stability and interference situations on the new carrier.

Hence, according to some examples of embodiments of the invention, measures are provided so as to avoid such impacts. For example, according to some examples of embodiments, it is ensured that correct SINR conditions are present, and that impacts on the communication of other users on the new carrier are not caused. Such impacts happen, for example, when transmitting with high power on a new carrier, which in turn leads to a high interference contribution by a retransmission. That is, for example, according to some examples of embodiments of the invention, a mechanism is provided which allows to avoid a HARQ retransmission problem when carrier switching is conducted e.g. in an HSUPA system.

Fig. 2 shows a signaling diagram illustrating a processing for controlling a communication in the UL direction according to an example of an embodiment of the invention.

According to some examples of embodiments of the invention to which the processing described in connection with Fig. 2 is related, at least a part of the control of the carrier switching for selecting a new carrier for UL transmission is done on the UE side. That is, the UE 10 is mandated, when certain conditions are met, to autonomously switch to another carrier (or cell) and to continue UL transmissions on the new carrier. When doing this switching, the UE informs or notifies the communication network control, such as the NodeB 20 of the action in a suitable manner. For example, according to some examples of embodiments of the invention, the information or notification is directly signaled by means of a corresponding message or the like to the network. Alternatively or additionally, according to some examples of embodiments of the invention, the information is provided to the network by means of suitable implicit actions.

Fig. 2 shows an example of embodiments of the invention where a corresponding processing is implemented in a system as shown in Fig. 1. That is, Fig. 2 is related to an example where a communication in the UL direction is controlled when HSUPA is used, wherein a carrier switching for load balancing is to be conducted.

In step S10, the UE 10 executes a configuration for conducting a carrier switching procedure (FCS operation). For this purpose, the network provides corresponding configuration information to the UE 10. According to some examples of embodiments of the invention, the configuration information comprise at least one of the following parameters/information:

(a) a definition which UL carriers are possible to do FCS within, i.e. corresponding information about frequencies etc. of the UL carriers being usable for the carrier switching;

(b) selection probabilities for different carriers, i.e. information allowing to set a probability that a specific UE selects a specific carrier when conducting the carrier switching;

(c) policies for switching, i.e. information regarding policies or rules how the carrier switching procedure is to be conducted; and

(d) setting indications of volumes and/or timer values to be used for the policies, such as time thresholds, indication of time durations or periods, etc..

The configuration information is provided, for example, from a network controller, such as an RNC or the NodeB 20.

In step S20, the UE 10 starts an UL communication by transmitting data by using one of the UL carriers.

During the UL transmission, it is assumed that the UE 10 decides in step S30 at some point of time during the UL transmission that a carrier switch is to be conducted, e.g. for load balancing purpose or connection quality reasons.

In step S40, the UE informs the NodeB 20 of the carrier switching, e.g. by a corresponding signaling. For example, the signaling indicates the new carrier resulting from the carrier switching for the (kept) UL transmission.

In step S50, the NodeB 20, triggered by the signaling in step S40, modifies UL reception chains related to the communication, according to the information received from the UE 10 in step S40.

Concerning the decision made in step S30 regarding a carrier switching, according to examples of embodiments of the invention, the UE 10 decides only to switch to another carrier in case it is determined that there are no pending retransmissions. For example, it is determined whether there is a HARQ process with a potential pending HARQ retransmission. For example, this is determined by checking whether an ACK is received for previously transmitted data packets. In case there is a potential retransmission, the decision to conduct the carrier switching is not made, while otherwise a carrier switching is decided to be executed, for example.

By means of this measure, it is possible to alleviate the problem of high interference to other users on the new carrier after the switching. It is to be noted that according to examples of embodiments of the invention, in case there is no "natural" break in UL transmissions, the policies (e.g. by using suitably set timer and volume values) are such that the UE is configured to forcedly pause new UL transmissions until there are no potential pending UL HARQ retransmissions.

Fig. 3 shows a signaling diagram illustrating a processing for controlling a communication in the UL direction according to a further example of an embodiment of the invention.

According to some examples of embodiments of the invention to which the processing described in connection with Fig. 3 is related, a further improvement of the communication control example discussed for example in connection with some examples of embodiments of the invention as illustrated in Fig. 2 is provided. Specifically, according to the present examples of embodiments of the invention, the required processing and signaling between the UE 10 and the network (e.g. the NodeB 20) for conducting a carrier switching is improved by measures related to transient management, so as to keep the system stable and to provide rules allowing to further enhance the system.

According to some examples of embodiments of the invention, a control procedure is provided allowing to control the setting of a timing of the carrier switching at the UE 10 from one carrier to another carrier. That is, according to some examples of embodiments of the invention, it is determined in the network that the UE is to be allowed to execute a carrier switching from one UL frequency carrier to another UL

frequency carrier. This determination of the requirement to allow to conduct the carrier switching is coupled, for example, on a certain predetermined interval, or it is triggered by a predefined condition in the communication or by a given command. Based on this determination, according some examples of embodiments of the invention the network (e.g. the NodeB 20) indicates to the UE 10 a predetermined window in time (i.e. a starting time and a duration, for example). On the other hand, based on this time window, the UE 10 is able to determine by itself the actual switching timing which is located in this time window.

According to these examples of embodiments of the invention, it is possible to further improve the carrier switching procedure by means of a suitable transient management, so that e.g. HARQ related issues can be solved and power control stability is further enhanced.

A corresponding example of embodiments of the invention is described in connection with Fig. 3. Similar to Fig. 2, Fig. 3 shows an example of a processing for controlling a communication in the UL direction according to a further example of an embodiment of the invention when HSUPA is used, wherein a carrier switching for load balancing is to be conducted.

In step S110, as in step S10 of Fig. 2, the UE 10 executes a configuration for conducting a carrier switching procedure (FCS operation). For this purpose, the network provides corresponding configuration information to the UE 10, such as a definition which UL carriers are possible to do FCS within, i.e. corresponding information about frequencies etc. of the UL carriers being usable for the carrier switching, selection probabilities for different carriers, i.e. information allowing to set a probability that a specific UE selects a specific carrier when conducting the carrier switching, policies for switching, i.e. information regarding policies or rules how the carrier switching procedure is to be conducted, and setting indications of volumes and/or timer values to be used for the policies, such as time thresholds, indication of time durations or periods, etc.. The configuration information is provided, for example, from a network controller, such as an RNC or the NodeB 20.

In step S120, the UE 10 starts an UL communication by transmitting data by using one of the UL carriers.

During the UL transmission, it is assumed that the network determines that a carrier switching is possibly required at the UE side for UL communication. Hence, in step S130, the network, such as the NodeB 20 (or the RNC etc.), defines a time window in which a respective UE is allowed to execute a carrier switching, and sends corresponding information indicating the time window (e.g. a starting point and a duration, or end point) to the UE 10. The definition of the time window, i.e. the setting of starting point, duration and/or end point is dependent, for example, on corresponding settings for other UEs, on a load situation or the like.

In step S140, the UE 10 decides whether a carrier switching is allowed to be conducted, e.g. in view of a load balancing purpose or connection quality reasons. According to some examples of embodiments of the invention, the decision in step S140 considers, for example, whether or not retransmissions are to be conducted for already transmitted data, whether or not the time window is already reached, whether other timers such as a persistence timer are expired, and the like.

In case the processing in step S140 results in that a carrier switching is allowed, the UE 10 makes in step S150 a decision to conduct a carrier switching. Then, in step S160, the UE 10 informs the NodeB 20 of the carrier switching, e.g. by a corresponding signaling. For example, the signaling indicates the new carrier resulting from the carrier switching for the (kept) UL transmission.

In step S170, the NodeB 20, triggered by the signaling in step S160, modifies UL reception chains related to the communication, according to the information received from the UE 10 in step S160.

Concerning the decision made in step S140 regarding whether or not the carrier switching is allowed, according to examples of embodiments of the invention, the UE 10 decides only that the switching is allowed when certain conditions are fulfilled. The corresponding processing is described below in connection with Fig. 4.

Fig. 4 shows a diagram illustrating a result of a processing for controlling a communication in the UL direction according to the example of Fig. 3. On the time bar shown in Fig. 4, at a time T0, it is assumed that the time window defined by the

network for allowing the carrier switching starts (i.e. T0 is the earliest time the network allows to conduct the carrier switching), and that the time window ends at the time T0 + Tdelta (i.e. this is the last time point where the carrier switching is allowed, so that the duration of the time window corresponds to Tdelta), of which the UE 10 is informed in step S130.

Indicated by a dashed line, a persistence timer is shown in Fig. 4. The meaning of the persistence time is, according to some examples of embodiments of the invention, that the UE 10 only changes a carrier (i.e. executes the carrier switching) when the persistence timer is expired. The purpose of the persistence timer is to provide a sufficient time on a respective carrier so that power control can be stabilized. For instance, without a suitably set persistence time, a carrier switching conducted every 2 ms may lead to a loss due to improper functioning of the power control. In order to avoid this, the persistence time is set to a predetermined duration. For example, according to some examples of embodiments of the invention, a persistence timer value is in the order of at least 10-20 ms.

As indicated in Fig. 4, at a time T1, the persistence timer is expired. Hence, it is determined by the UE 10 at T1 that after the persistence timer is expired and the time window for allowing the carrier switching is reached (T0 is reached or even passed), the UE 10 is configured to transmit no new data (PDUs) on the present carrier. Instead, the carrier switching is awaited. However, according to the policies used in the present examples of embodiments of the invention, the UE 10 executes the carrier switching not before it is assured that no retransmssion is required (no open HARQ loop, for example), i.e. when all transmitted PDUs on the (previous) carrier have positively been acknowledged, for example.

As indicated at time T2, the ACKs for all transmissions are received. Hence, the UE 10 decides at T2 that the carrier switching is allowed (the time window is still valid) and decides to execute the carrier switching (in step S150).

According to the present examples of embodiments of the invention, it is possible to avoid that retransmissions end up on the other (new) carrier, so that corresponding problems can be avoided.

It is to be noted that there may be situations where the last ACK is received not before the end of the time window, i.e. where the system gets locked due to pending retransmissions. For this situation, according to further examples of embodiments of the invention, the processing of e.g. Fig. 3 is modified by at least one of the following measures.

As a first measure, according to further examples of embodiments of the invention, a timer is used on the UE side. By means of this timer, a maximum time to spend on the pending retransmissions can be set. When this timer expires, the UE 10 is configured to conduct the carrier switching (in case the further conditions other than the retransmission related condition are fulfilled) to the new carrier, irrespective of whether pending retransmissions are present or not. In this case, according to examples of embodiments of the invention, not completed HARQ retransmissions (loops) are discarded and subsequently recovered by another transmission, e.g. by RLC retransmissions. Furthermore, according to further examples of embodiments of the invention, the timer for indicating the maximum time for a successful retransmission is replaced by a counter counting a number of retransmissions, until a maximum value is reached.

A second measure, according to further examples of embodiments of the invention, is to conduct retransmissions on other HARQ processes. For example, in the processing shown in Fig. 3, a situation may occur where one of present HARQ processes is related to data (e.g. a PDU) which is being retransmitted for several times without success. Then, the situation occurs where other HARQ processes can not be used or completed, since the switching time has passed. In this case, according to further examples of embodiments of the invention, the same PDU is proactively retransmitted in other HARQ processes. In case a positive ACK for one of the HARQ processes is received, the PDU is correctly received and the carrier switching can be executed since the retransmission condition is fulfilled.

It is to be noted that according to some further examples of embodiments of the invention, control cannel signaling is reduced. For example, according to some further examples of embodiments of the invention, the UE 10 is configured to stop transmission of CQIs on the still active carrier some time before the switching time (T2 in Fig. 4). For example, the time for stopping the CQI transmission can be started at the

latest 2 TTIs before T1, since CQIs are only useful for the NodeB 20 in case they can be used for new transmissions. Moreover, according to further examples of embodiments of the invention, transmission of CQIs on the second (new) carrier to which the carrier switching is to be conducted is started from this time on. By means of this, new transmissions on the second carrier can use CQI information already provided.

Fig. 5 shows a signaling diagram illustrating a processing for controlling a communication in the UL direction according to a further example of an embodiment of the invention.

According to some examples of embodiments of the invention to which the processing described in connection with Fig. 5 is related, a further improvement of the communication control example discussed for example in connection with some examples of embodiments of the invention as illustrated in Figs. 2 and 3 is provided. Specifically, according to the present examples of embodiments of the invention, the required processing and signaling between the UE 10 and the network (e.g. the NodeB 20) for conducting a carrier switching is improved by measures allowing a tighter control from the network side.

According to some examples of embodiments of the invention, a control procedure is provided allowing that the network (e.g. the NodeB 20) is more involved in the controlling of the carrier switching. For example, according to some examples of embodiments of the invention, information provided by specific control channels or the like, such as E-AGCH, is used.

According to the present examples of embodiments of the invention, the UE 10 which is configured to do carrier switching (such as FCS) between a number (two or more) of carriers, listens to control channels such as the E-AGCH channels of these carriers in the downlink simultaneously. In case one of the channels provides information that indicates that the UE 10 is scheduled on a certain frequency, the UE 10 is able to start to transmit on that frequency, i.e. conducts a carrier switching. In this context, according to some examples of embodiments of the invention, the above described measures related to the determination whether carrier switching is allowed (see e.g. step S140 of Fig. 2) are still considered.

That is, according to present examples of embodiments of the invention, the UE 10 is actually decoding the E-AGCHs of all possible carriers (or at least of a plurality of all possible carriers) in parallel (not just one E-AGCH). For example, in case of a HSPA system, an aggregation of 8 carriers in the DL direction is possible, so that all eight E-AGCHs can be listened, leading to 8 UL carriers being possible for FCS operation. As indicted above, according to examples of embodiments of the invention, the network ensures that the UE 10 is scheduled on one carrier at a time.

By means of the measures provided by the present examples of embodiments of the invention, carrier switching over multiple carriers can be controlled more tightly by the network.

A corresponding example of embodiments of the invention is described in connection with Fig. 5. Similar to Fig. 3, Fig. 5 shows an example of a processing for controlling a communication in the UL direction according to a further example of an embodiment of the invention when HSUPA is used, wherein a carrier switching for load balancing is to be conducted.

In step S210, as in step S10 of Fig. 2 or step S110 of Fig. 3, the UE 10 executes a configuration for conducting a carrier switching procedure (FCS operation). For this purpose, the network provides corresponding configuration information to the UE 10, such as a definition which UL carriers are possible to do FCS within, i.e. corresponding information about frequencies etc. of the UL carriers being usable for the carrier switching, selection probabilities for different carriers, i.e. information allowing to set a probability that a specific UE selects a specific carrier when conducting the carrier switching, policies for switching, i.e. information regarding policies or rules how the carrier switching procedure is to be conducted, and setting indications of volumes and/or timer values to be used for the policies, such as time thresholds, indication of time durations or periods, etc.. The configuration information is provided, for example, from a network controller, such as an RNC or the NodeB 20.

In step S220, the UE 10 starts an UL communication by transmitting data by using one of the UL carriers.

During the UL transmission, it is assumed that the network determines that a carrier switching is possibly required at the UE side for UL communication. In step S230, the network, such as the NodeB 20 (or the RNC etc.), sends a switching indication via a channel on a DL carrier. For example, the E-AGCH of the DL carrier which corresponds to an UL carrier to be used as the target for the carrier switching is used for delivering the switching indication. According to examples of embodiments of the invention, the switching indication is provided e.g. by means of a scheduling indication of the UE 10 on a frequency of the UL carrier in question. Also indicated in Fig. 5, dashed arrows are shown, wherein the dashed arrows shall indicate those carriers whose control channel (E-AGCH) does not include the switching indication, but which are listened by the UE 10.

In step S240, the UE 10 decides whether a carrier switching is allowed to be conducted to the carrier indicated in step S230, e.g. in view of a load balancing purpose or connection quality reasons. According to some examples of embodiments of the invention, the decision in step S240 considers, for example, whether or not retransmissions are to be conducted for already transmitted data, whether or not a time window is already reached, whether other timers such as a persistence timer are expired, and the like.

In case the processing in step S240 results in that a carrier switching is allowed, the UE 10 makes in step S250 a decision to conduct a carrier switching. Then, in step S260, the UE 10 informs the NodeB 20 of the carrier switching, e.g. by a corresponding signaling. For example, the signaling indicates the new carrier resulting from the carrier switching for the (kept) UL transmission.

In step S270, the NodeB 20, triggered by the signaling in step S260, modifies UL reception chains related to the communication, according to the information received from the UE 10 in step S260.

Concerning the decision made in step S240 regarding whether or not the carrier switching is allowed, according to examples of embodiments of the invention, the UE 10 makes the decision in accordance with a process described in connection with Figs. 3 and 4, for example, i.e. on the basis of certain conditions.

According to some examples of embodiments of the invention, when using e.g. E-AGCH for delivering the switching indication, an E-AGCH table is used. That is, by means of doing a puncturing of the E-AGCH table, a mapping from the E-AGCH value to the absolute grant is created. With the puncturing, some of the entries in the E-AGCH table are reserved for the indication of the UL carrier on which the UE is to be operating on (i.e. where the carrier switching is conducted to).

Fig. 6 shows a signaling diagram illustrating a processing for controlling a communication in the UL direction according to a still further example of an embodiment of the invention.

According to some examples of embodiments of the invention to which the processing described in connection with Fig. 6 is related, a further improvement of the communication control example discussed for example in connection with some examples of embodiments of the invention as illustrated in Figs. 2, 3 and 5 is provided. Specifically, according to the present examples of embodiments of the invention, the required processing and signaling between the UE 10 and the network (e.g. the NodeB 20) for conducting a carrier switching is improved by measures allowing a coordination of switching times of UEs which shall conduct a carrier switching in e.g. the same cell (controlled by the same communication network control element).

According to some examples of embodiments of the invention, a control procedure is provided allowing that the network (e.g. the NodeB 20) can improve a coordination of carrier switching.

According to the present examples of embodiments of the invention, as described above, the UE 10 which is configured for carrier switching (e.g. FCS operation) is allowed to conduct carrier switching at some point of times. According to the present examples of embodiments of the invention, both the network (e.g. the NodeB 20) and the UE 10 are to be aware of the exact point of time when switching from one carrier to another.

In the following, a situation is considered where in a communication system plural UEs (i.e. a significant fraction of all connected UEs) are configured for the carrier switching procedure (i.e. are in an FCS mode, for example). In this case, the network executes,

according to some examples of embodiments of the invention, a coordination of the carrier switching procedures of the plural UEs.

For example, all UEs (or a subset of UEs) are mandated to switch the carrier within the same time period.

Alternatively or additionally, the respective UEs (or a subset of the UEs) are controlled so that the respective switching times for different UEs are distributed so that to avoid simultaneous switching.

By means of a corresponding coordination, it is possible to mitigate negative impacts of carrier switching on the system performance. For example, sudden changes of Rx power from a given UE immediately after the carrier switch can be avoided.

According to some examples of embodiments of the invention, when coordinating all UEs to change their carrier at the same time, unwanted Rx power fluctuation can be limited to a short period after the switch. On the other hand, according to examples of embodiments of the invention, when following the distributed approach, blurring of the Rx power fluctuations is achieved over time.

According to present examples of embodiments of the invention, a parameter used for indicating the switching timing is determined as one of the following, depending on whether a common carrier switching or a distributed carrier switching is selected by the network.

One set of parameters for the switching timing indication comprises common parameters which are also referred to as cell or network-specific parameters. For example, a SFN transmitted in the DL direction on a P-CCPCH is used. Hence, all UEs within the same cell are informed to conduct a carrier switching approximately at the same time.

Alternatively, as another set of parameters for the switching timing indication, a combination of common (i.e. cell or network-specific) parameters and UE-specific parameter is used. For example, SFN is used as the common parameter, while the UE-

specific parameter is provided in form of e.g. an E-RNTI (i.e. the SFN is a parameter specific for the given cell and the E-RNTI is specific for a given UE), wherein the combination is achieved by an arithmetic operation like summing, multiplying, randomizing etc.).

According to examples of embodiments of the invention, for coordination of the switching time, a formula is employed which uses the switching timing parameter (either for common switching or distributed switching) and a parameter related to a system condition (i.e. a parameter related to a condition whether switching is possible). For example, the persistence timer described above is usable for this further parameter. Then, according to some examples of embodiments of the invention, the switching time is calculated according to the following principle:

If (switching-timing-parameter % PersistenceTime) equals to 0
Switch Carrier ;

where the *switching timing parameter* is e.g. the SFN (or another cell or network-specific parameter), or a combination (based on an arithmetic operation like sum, product, difference, etc.) of the SFN (or another cell or network-specific parameter) and the E-RNTI (or an other UE-specific parameter), combined with a randomization function to ensure randomized operation (including potential fluctuations in the persistence time parameter), % denotes modulo operation, *PersistenceTime* represents a period on which the UE 10 is camping on one carrier (this period can be predefined by the network or also under impact by a randomization function such that the timer is set to varying values within a given window); *Switch Carrier* represents a command allowing the UE 10 to initiate the carrier switching procedure for switching the active UL carrier.

It is to be noted that the UE 10 is, according to examples of embodiments of the invention, not forced to immediately conduct the switch at the switching time, or to conduct a carrier switch at all. That is, the UE 10 is configured to conduct the carrier switching voluntary, e.g. to decide to stay on one carrier for longer than one *PersistenceTimer*.

Hence, according to the present examples of embodiments of the invention, the UEs are enabled to conduct the carrier switching either in a simultaneous manner or in a distributed manner. According to examples of embodiments of the invention, the configuration of the operation is such that it is a network parameter which decides which kind of operation (common or distributed switching) is to be executed. Hence, the network (the NodeB or the like) is able to determine and decide whether the UE UL carrier switching is happening in a synchronized manner or whether it is happening in a time-wise distributed manner.

A corresponding example of embodiments of the invention is described in connection with Fig. 6. Similar to Fig. 3, Fig. 6 shows an example of a processing for controlling a communication in the UL direction according to a further example of an embodiment of the invention when HSUPA is used, wherein a carrier switching for load balancing is to be conducted.

In step S310, the UE 10 executes a configuration for conducting a carrier switching procedure (FCS operation). For this purpose, the network provides corresponding configuration information to the UE 10, such as a definition which UL carriers are possible to do FCS within, i.e. corresponding information about frequencies etc. of the UL carriers being usable for the carrier switching, selection probabilities for different carriers, i.e. information allowing to set a probability that a specific UE selects a specific carrier when conducting the carrier switching, policies for switching, i.e. information regarding policies or rules how the carrier switching procedure is to be conducted, and setting indications of volumes and/or timer values to be used for the policies, such as time thresholds, indication of time durations or periods, etc.. The configuration information is provided, for example, from a network controller, such as an RNC or the NodeB 20.

In step S220, the UE 10 starts an UL communication by transmitting data by using one of the UL carriers.

During the UL transmission, in step S330, it is assumed that the network determines that a carrier switching is possibly required at the UE side for UL communication. In this connection, the network determines also whether the switching is to be conducted in a simultaneous manner or in a distributed manner.

In step S340, the network, such as the NodeB 20 (or the RNC etc.), sends a switching timing parameter to the UE for providing a switching timing parameter to be used for the calculation of the switching time.

In step S350, the UE 10 decides whether a carrier switching is allowed to be conducted, e.g. in view of a load balancing purpose or connection quality reasons. According to some examples of embodiments of the invention, the decision in step S350 considers, for example, whether or not retransmissions are to be conducted for already transmitted data, whether or not a time window is already reached, whether other timers such as a persistence timer are expired, and the like.

In case the processing in step S350 results in that a carrier switching is allowed, the UE 10 calculated the switching time by using the parameters indicated above, and makes in step S360 a decision to conduct the carrier switching.

Then, in step S370, the UE 10 informs the NodeB 20 of the carrier switching, e.g. by a corresponding signaling. For example, the signaling indicates the new carrier resulting from the carrier switching for the (kept) UL transmission.

In step S380, the NodeB 20, triggered by the signaling in step S370, modifies UL reception chains related to the communication, according to the information received from the UE 10 in step S370.

Fig. 7 shows a flowchart illustrating a processing executed in a communication element like the UE 10 of Fig. 1 according to some examples of embodiments of the invention.

In step S400, configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier are received and processed.

For example, the communication is a HSPA based communication, wherein the carrier switching is conducted for switching the communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier in a same cell or in a

different cell of a communication network, on the basis of the configuration information. In this connection, the configuration information comprises at least one of a definition of uplink frequency carriers to and from which a carrier switching is executable, a selection probability value for the respective uplink frequency carriers, policy information related to the carrier switching, and information on volumes and timing parameters related to the policy information.

In step S410, it is decided to switch a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information

For example, in the decision on whether to conduct the carrier switching, it is determined whether a retransmission of data is to be conducted for a communication on the at least one first frequency carrier (based on e.g. a determination that an acknowledgement for a successful transmission in a preceding transmission cycle in one HARQ process is not received, or a detection of an incorrect transmission or decoding of a transport block in a preceding transmission cycle). When it is determined that a retransmission of data is to be conducted, the carrier switching is stopped (at least temporarily).

Furthermore, in the decision on whether to conduct the carrier switching, received information indicating a time window in which a carrier switching is allowed to be executed are processed, wherein it is determined, when the time window begins, whether a persistence time has elapsed since a preceding carrier switching executed before a carrier switching to be executed at the present time (for example, the persistence time is based on a time period required for stabilizing a power control after executing a carrier switching, or a randomly set time period within a predetermined time window). Carrier switching is only allowed in case the persistence time is elapsed. According to further examples, if the carrier switching is allowed and a current time is in the time window, a transmission of data units on the current carrier is stopped, it is checked whether an acknowledgement for already transmitted data units is received, and in case the acknowledgement for the already transmitted data units is received, the carrier switching is decided or initiated.

Furthermore, in connection with the decision of whether the carrier switching is allowed, it is possible to determine whether a maximum retransmission time period is expired since a first retransmission of data on the at least one first frequency carrier. When it is determined that the maximum retransmission time period is expired, a not-completed retransmissions are discarded (which can be completed in another retransmission process), and carrier switching is allowed (despite retransmissions would be pending otherwise).

Furthermore, in connection with the decision of whether the carrier switching is allowed, it is possible to stop to transmit channel quality information on an present UL frequency carrier used for the communication, when it is decided to switch the current communication from at least one first UL frequency carrier to at least one second UL frequency carrier at a predetermined timing before the carrier switching. Instead, the channel quality information is transmitted on the UL uplink frequency carrier to which the carrier switching will switch the communication, at the predetermined timing before the carrier switching.

Moreover, in connection with the decision of whether the carrier switching is allowed, it is possible to scan and decode simultaneously control channels (e.g. grant channels like E-AGCH) transmitted via plural downlink carriers corresponding to the uplink frequency carriers usable in the carrier switching on the basis of the configuration information. A carrier switching processing is initiated when a switching indication is received and decoded on one of the plural control channels. The carrier switching is executed to a UL frequency carrier corresponding to the downlink carrier where the channel bearing the switching indication is received. For example, the switching indication is derived on the basis of a mapping of a transmitted value to an absolute grant by means of a table, wherein the switching indication is indicated at predefined locations in the table.

In addition, in connection with the decision of whether the carrier switching is allowed, it is possible process a received switching timing parameter which is usable for determining a timing of executing the carrier switching. The timing of executing the carrier switching is calculated on the basis of the switching timing parameter and e.g.

the persistence time, wherein the switching timing parameter one of a parameter based on a common cell or network specific parameter, or a parameter based on a combination of a common cell or network specific parameter and a communication element specific parameter related to a communication element from which the communication in the uplink direction originates (e.g. a system frame number as the network specific parameter, and a radio network identifier as the communication element specific parameter, wherein the combination of the network specific parameter and the communication element specific parameter is based on an arithmetic operation). The calculation of the timing of executing the carrier switching is based e.g. on the relation

switching timing parameter modulo persistence time = 0.

In step S420, the network, i.e. a communication network control element like the NodeB 20, is informed about the carrier switching.

In step S430, the communication is conducted according to the carrier switching decision, i.e. still on the at least one first uplink frequency carrier (i.e. before conducting carrier switching), and on the at least one second uplink frequency carrier after the carrier switching.

Fig. 8 shows a flowchart illustrating a processing executed in a communication network control element like the NodeB 20 of Fig. 1 according to some examples of embodiments of the invention.

In step S500, configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier is set and transmitted to the UE 10.

For example, the communication is a HSPA based communication, wherein the carrier switching is conducted for switching the communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier in a same cell or in a different cell of a communication network, on the basis of the configuration information. In this connection, the configuration information comprises at least one of a definition of uplink frequency carriers to and from which a carrier switching is executable, a

selection probability value for the respective uplink frequency carriers, policy information related to the carrier switching, and information on volumes and timing parameters related to the policy information. Furthermore, the policy information can comprise a rule that a carrier switching is not allowed at least for a predetermined time when a retransmission of data is to be conducted for a communication on the at least one first frequency carrier, wherein the information on volumes and timing parameters related to the policy information are used to indicate at least one value being set to an amount inhibiting a carrier switch until no retransmission is to be conducted.

It is to be noted that in connection with step S500, the NodeB 20 can conduct further processings which are related to the control of the carrier switching procedure.

For example, it is possible that a time window in which a carrier switching is allowed to be executed is defined wherein corresponding information is transmitted to the UE 10. In this connection, a persistence time can be indicated (the persistence time is based on a time period required for stabilizing a power control after executing a carrier switching, or a randomly set time period within a predetermined time window).

Furthermore, it is possible that a switching indication on one of plural control channels (e.g. grant channels like E-AGCH) transmitted via plural DL carriers corresponding to the UL frequency carriers usable in the carrier switching is provided. The switching indication is usable to initiate a carrier switching to a UL frequency carrier corresponding to the downlink carrier where the control channel bearing the switching indication is transmitted. The switching indication is derivable, for example, on the basis of a mapping of a transmitted value to an absolute grant by means of a table, wherein the switching indication is indicated at predefined locations in the table.

In addition, it is possible to determining a timing of executing the carrier switching and to provide a corresponding switching timing parameter indicating the determined timing of executing the carrier switching. The timing of executing the carrier switching is calculated on the basis of the switching timing parameter and a parameter such as the persistence time. For example, the switching timing parameter is one of a parameter based on a common cell or network specific parameter, or a parameter based on a combination of a common cell or network specific parameter and a communication

element specific parameter related to a communication element from which the communication in the uplink direction originates (e.g. a system frame number as the network specific parameter, and a radio network identifier as the communication element specific parameter, wherein the combination of the network specific parameter and the communication element specific parameter is based on an arithmetic operation). The calculation of the timing of executing the carrier switching is based e.g. on the relation

switching timing parameter modulo persistence time = 0.

Moreover, it is possible to select at least one of a simultaneous carrier switching of plural or all communication elements in a cell, wherein the used switching timing parameter is a parameter based on a common cell or network specific parameter, and a distributed carrier switching of one or plural communication elements in a cell, wherein the used switching timing parameter is based on a combination of a common cell or network specific parameter and a communication element specific parameter related to the respective communication element from which the communication in the uplink direction originates.

In step S510, information from a communication element about a switching of a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information, is received and processed.

In step S520, an UL communication chain is modified according to the information regarding the carrier switching.

In Fig. 9, a block circuit diagram illustrating a configuration of a communication element, such as of UE 10, is shown, which is configured to implement the control procedure for the UL communication as described in connection with some examples of embodiments of the invention. It is to be noted that the communication element or UE 10 shown in Fig. 9 may comprise several further elements or functions besides those described herein below, which are omitted herein for the sake of simplicity as they are not essential for understanding the invention. Furthermore, even though reference is made to a UE (or terminal device), the communication element 10 may be

also another device having a similar function, such as a chipset, a chip, a module etc., which can also be part of a UE or attached as a separate element to a UE, or the like.

The communication element or UE 10 may comprise a processing function or processor 11, such as a CPU or the like, which executes instructions given by programs or the like related to the control procedure for the UL communication. The processor 11 may comprise one or more processing portions dedicated to specific processing as described below, or the processing may be run in a single processor. Portions for executing such specific processing may be also provided as discrete elements or within one or more further processors or processing portions, such as in one physical processor like a CPU or in several physical entities, for example. Reference sign 12 denotes transceiver or input/output (I/O) units (interfaces) connected to the processor 11. The I/O units 12 are used for communicating with one or more communication network control elements like the NodeB 20. The I/O units 12 may be a combined unit comprising communication equipment towards several network elements, or may comprise a distributed structure with a plurality of different interfaces for different network elements. Reference sign 13 denotes a memory usable, for example, for storing data and programs to be executed by the processor 11 and/or as a working storage of the processor 11.

The processor 11 is configured to execute processing related to the above described control procedure for the UL communication. In particular, the processor 11 comprises a sub-portion 111 as a processing portion which is usable for conducting a configuration for carrier switching. The portion 111 may be configured to perform processing according to step S400 of Fig. 7, for example. Furthermore, the processor 11 comprises a sub-portion 112 usable as a portion for deciding on the switching of the carrier. The portion 112 may be configured to perform processing according to step S410 of Fig. 7, for example. Furthermore, the processor 11 comprises a sub-portion 113 usable as a portion for informing about the carrier switching. The portion 113 may be configured to perform a processing according to steps S420 of Fig. 7, for example. Moreover, the processor 11 comprises a sub-portion 114 usable as a portion for conducting an UL communication. The portion 114 may be configured to perform a processing according to step S430 of Fig. 7, for example. In addition, the processor 11 comprises a sub-portion 115 usable as a retransmission determining function (which is according to some examples of embodiments of the invention e.g. part of step S410 of

Fig. 7), a sub-portion 116 usable as a grant channel signaling processing function (according to the processing described in connection with Fig. 5, for example), and a sub-portion 117 usable as a switching timing indication processing function (according to the processing described in connection with Fig. 6, for example).

In Fig. 10, a block circuit diagram illustrating a configuration of a communication network control element, such as of the NodeB 20, is shown, which is configured to implement the procedure for resource requesting as described in connection with some of the examples of embodiments of the invention. It is to be noted that the communication network control element like the NodeB 20 shown in Fig. 10 may comprise several further elements or functions besides those described herein below, which are omitted herein for the sake of simplicity as they are not essential for understanding the invention. Furthermore, even though reference is made to a NodeB, the communication network control element may be also another device having a similar function, such as a chipset, a chip, a module etc., which can also be part of a communication network control element or attached as a separate element to a communication network control element, or the like.

The communication network control element shown in Fig. 10 may comprise a processing function or processor 21, such as a CPU or the like, which executes instructions given by programs or the like related to control procedure of the UL communication. The processor 21 may comprise one or more processing portions dedicated to specific processing as described below, or the processing may be run in a single processor. Portions for executing such specific processing may be also provided as discrete elements or within one or more further processors or processing portions, such as in one physical processor like a CPU or in several physical entities, for example. Reference signs 22 denote transceiver or input/output (I/O) units (interfaces) connected to the processor 21. The I/O units 22 may be used for communicating with one or more communication elements like UEs. The I/O units 22 may be a combined unit comprising communication equipment towards several network elements, or may comprise a distributed structure with a plurality of different interfaces for different network elements. Reference sign 23 denotes a memory usable, for example, for storing data and programs to be executed by the processor 21 and/or as a working storage of the processor 21.

The processor 21 is configured to execute processing related to the above described control procedure of the UL communication. In particular, the processor 21 comprises a sub-portion 211 processing portion which is usable for setting a configuration for carrier switching. The portion 211 may be configured to perform processing according to step S500 of Fig. 8, for example. Furthermore, the processor 21 comprises a sub-portion 212 usable as a portion for processing an information regarding the switching of the carrier. The portion 212 may be configured to perform processing according to step S510 of Fig. 8, for example. Furthermore, the processor 21 comprises a sub-portion 213 usable as a portion for modifying settings for the communication. The portion 213 may be configured to perform a processing according to steps S520 of Fig. 8, for example. Moreover, the processor 21 comprises a sub-portion 214 usable as a portion for defining a time window for conducting the carrier switching (according to the processing described in connection with Fig. 3, for example), a sub-portion 215 usable as a grant channel signaling function (according to the processing described in connection with Fig. 5, for example), and a sub-portion 216 usable as a switching timing determining function (according to the processing described in connection with Fig. 6, for example).

It is to be noted that the above described examples of embodiments of the invention can be also used in a combined manner. For example, the processings described in connection with Figs. 2 to 6 according to the examples of embodiments of the invention can be combined with each other in a suitable manner.

Furthermore, even though it is described that according to examples of embodiments of the invention a case is considered where multiple UL carriers are provided from a system for communications from the UE to the network, wherein it is assumed that one UE is capable to use one carrier frequency at a time, examples of embodiments of the invention are also applicable in case where multiple UL carriers are provided from a system for communications from the UE to the network, wherein an UE is capable to use more than one carrier frequency at a time.

According to further examples of embodiments of the invention, there is provided, for example, an apparatus comprising carrier switching configuration means for receiving and processing configuration information related to conduct a carrier switching for

switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, carrier switching deciding means for deciding to switch a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information, and carrier switching information means for informing a communication network control element about the carrier switching.

In addition, according to further examples of embodiments of the invention, there is provided, for example, an apparatus comprising carrier switching configuration setting means for setting and transmitting configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, and carrier switching information processing means for receiving and processing an information from a communication element about a switching of a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information.

For the purpose of the present invention as described herein above, it should be noted that

- an access technology via which signaling is transferred to and from a network element may be any technology by means of which a network element or sensor node can access another network element or node (e.g. via a base station or generally an access node). Any present or future technology, such as WLAN (Wireless Local Access Network), WiMAX (Worldwide Interoperability for Microwave Access), LTE, LTE-A, Bluetooth, Infrared, and the like may be used; although the above technologies are mostly wireless access technologies, e.g. in different radio spectra, access technology in the sense of the present invention implies also wired technologies, e.g. IP based access technologies like cable networks or fixed lines but also circuit switched access technologies; access technologies may be distinguishable in at least two categories or access domains such as packet switched and circuit switched, but the existence of more than two access domains does not impede the invention being applied thereto,
- usable communication networks, stations and transmission nodes may be or comprise any device, apparatus, unit or means by which a station, entity or other user equipment may connect to and/or utilize services offered by the access network; such

services include, among others, data and/or (audio-) visual communication, data download etc.;

- a user equipment or communication network element (station) may be any device, apparatus, unit or means by which a system user or subscriber may experience services from an access network, such as a mobile phone or smart phone, a personal digital assistant PDA, or computer, or a device having a corresponding functionality, such as a modem chipset, a chip, a module etc., which can also be part of a UE or attached as a separate element to a UE, or the like;

- method steps likely to be implemented as software code portions and being run using a processor at a network element or terminal (as examples of devices, apparatuses and/or modules thereof, or as examples of entities including apparatuses and/or modules for it), are software code independent and can be specified using any known or future developed programming language as long as the functionality defined by the method steps is preserved;

- generally, any method step is suitable to be implemented as software or by hardware without changing the idea of the invention in terms of the functionality implemented;

- method steps and/or devices, apparatuses, units or means likely to be implemented as hardware components at a terminal or network element, or any module(s) thereof, are hardware independent and can be implemented using any known or future developed hardware technology or any hybrids of these, such as a microprocessor or CPU (Central Processing Unit), MOS (Metal Oxide Semiconductor), CMOS (Complementary MOS), BiMOS (Bipolar MOS), BiCMOS (Bipolar CMOS), ECL (Emitter Coupled Logic), TTL (Transistor-Transistor Logic), etc., using for example ASIC (Application Specific IC (Integrated Circuit)) components, FPGA (Field-programmable Gate Arrays) components, CPLD (Complex Programmable Logic Device) components or DSP (Digital Signal Processor) components; in addition, any method steps and/or devices, units or means likely to be implemented as software components may for example be based on any security architecture capable e.g. of authentication, authorization, keying and/or traffic protection;

- devices, apparatuses, units or means can be implemented as individual devices, apparatuses, units or means, but this does not exclude that they are implemented in a distributed fashion throughout the system, as long as the functionality of the device, apparatus, unit or means is preserved; for example, for executing operations and functions according to examples of embodiments of the invention, one or more

processors may be used or shared in the processing, or one or more processing sections or processing portions may be used and shared in the processing, wherein one physical processor or more than one physical processor may be used for implementing one or more processing portions dedicated to specific processing as described,

- an apparatus may be represented by a semiconductor chip, a chipset, or a (hardware) module comprising such chip or chipset; this, however, does not exclude the possibility that a functionality of an apparatus or module, instead of being hardware implemented, be implemented as software in a (software) module such as a computer program or a computer program product comprising executable software code portions for execution/being run on a processor;
- a device may be regarded as an apparatus or as an assembly of more than one apparatus, whether functionally in cooperation with each other or functionally independently of each other but in a same device housing, for example.

As described above, there is provided a mechanism for controlling an uplink communication. After conducting a configuration related to a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, it is decided on the UE side to switch a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier. When the carrier switching is decided to be conducted, the network is informed about the carrier switching.

Although the present invention has been described herein before with reference to particular embodiments thereof, the present invention is not limited thereto and various modifications can be made thereto.

CLAIMS

1. An apparatus comprising

at least one processor,

at least one interface to at least one other network element, and

at least one memory for storing instructions to be executed by the processor, wherein

the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:

a carrier switching configuration function configured to receive and process configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier,

a carrier switching deciding function configured to decide to switch a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information, and

a carrier switching information function configured to inform a communication network control element about the carrier switching.

2. The apparatus according to claim 1, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a communication function configured to conduct the communication on the at least one first uplink frequency carrier before the carrier switching and to conduct the communication on the at least one second uplink frequency carrier after the carrier switching.

3. The apparatus according to any of claims 1 and 2, wherein

the configuration information comprises at least one of

a definition of uplink frequency carriers to and from which a carrier switching is executable,

a selection probability value for the respective uplink frequency carriers,

policy information related to the carrier switching, and

information on volumes and timing parameters related to the policy information.

4. The apparatus according to any of claims 1 to 3, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a retransmission determining function configured to determine whether a retransmission of data is to be conducted for a communication on the at least one first frequency carrier,

wherein, when the retransmission determining function determines that a retransmission of data is to be conducted, the carrier switching deciding function is further configured to stop the carrier switching.

5. The apparatus according to claim 4, wherein the retransmission determining function is further configured to determine that the retransmission of data is to be conducted when at least one of the following is valid:

an acknowledgement for a successful transmission in a preceding transmission cycle in one hybrid automatic repeat request process is not determined to be received, and

an incorrect transmission or decoding of a transport block in a preceding transmission cycle is detected.

6. The apparatus according to any of claims 1 to 5, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a time window determining function configured to receive and process information indicating a time window in which a carrier switching is allowed to be executed,

wherein the carrier switching deciding function is further configured

to determine, when the time window begins, whether a persistence time has elapsed since a preceding carrier switching executed before a carrier switching to be executed at the present time,

to allow a carrier switching in case the persistence time is elapsed, and

to not allow a carrier switching in case the persistence time is not elapsed.

7. The apparatus according to claim 6, wherein the carrier switching deciding function is further configured, in case the carrier switching is allowed and a current time is in the time window,

to initiate to stop a transmission of data units on the current carrier,

to check whether an acknowledgement for already transmitted data units is received, and

in case the acknowledgement for the already transmitted data units is received, to initiate the carrier switching.

8. The apparatus according to any of claims 6 and 7, wherein the persistence time is based on one of

a time period required for stabilizing a power control after executing a carrier switching, which is provided by a communication network control element, and

a randomly set time period within a predetermined time window.

9. The apparatus according to claim 4, wherein retransmission determining function is further configured to determine whether a maximum retransmission time period is expired since a first retransmission of data on the at least one first frequency carrier,

wherein, when the retransmission determining function determines that the maximum retransmission time period is expired, the retransmission determining function is further configured to discard a not-completed retransmission, and the carrier switching deciding function is further configured to allow the carrier switching.

10. The apparatus according to claim 9, wherein the retransmission determining function is further configured to initiate a retransmission of data units comprised in the discarded retransmission in another retransmission process.

11. The apparatus according to any of claims 1 to 10, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a channel quality indication function configured to transmit channel quality information on an uplink frequency carrier used for the communication, wherein, when the carrier switching deciding function decides to switch the current communication

from at least one first uplink frequency carrier to at least one second uplink frequency carrier, the channel quality indication function is further configured

to stop a transmission of channel quality information on the currently used uplink frequency carrier at a predetermined timing before the carrier switching, and

to start a transmission of channel quality information on the uplink frequency carrier to which the carrier switching will switch the communication, at the predetermined timing before the carrier switching.

12. The apparatus according to any of claims 1 to 11, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a control channel signaling processing function configured to simultaneously scan and decode control channels transmitted via plural downlink carriers corresponding to the uplink frequency carriers usable in the carrier switching on the basis of the configuration information, and to initiate a carrier switching processing by the carrier switching deciding function when a switching indication is received and decoded on one of the plural control channels, wherein the carrier switching deciding function is configured to decide to execute the carrier switching to an uplink frequency carrier corresponding to the downlink carrier where the control channel bearing the switching indication is received.

13. The apparatus according to claim 12, wherein the control channel is a grant channel.

14. The apparatus according to claim 13, wherein the grant channel is an enhanced dedicated channel absolute grant channel, wherein the switching indication is derived on the basis of a mapping of a transmitted value to an absolute grant by means of a table, wherein the switching indication is indicated at predefined locations in the table.

15. The apparatus according to any of claims 1 to 14, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a switching timing receiving and processing function configured to receive and process a switching timing parameter which is usable for determining a timing of executing the carrier switching,

wherein the carrier switching deciding function is further configured

to calculate the timing of executing the carrier switching on the basis of the switching timing parameter and a persistence time.

16. The apparatus according to claim 15, wherein

the persistence time is based on one of

a time period required for stabilizing a power control after executing a carrier switching, which is provided by a communication network control element, and

a randomly set time period within a predetermined time window, and

the switching timing parameter one of

a parameter based on a common cell or network specific parameter, or

a parameter based on a combination of a common cell or network specific parameter and a communication element specific parameter related to a communication element from which the communication in the uplink direction originates.

17. The apparatus according to claim 16, wherein the common cell or network specific parameter includes a system frame number, and the communication element specific parameter includes a radio network identifier, wherein the combination of the common cell or network specific parameter and the communication element specific parameter is based on an arithmetic operation.

18. The apparatus according to any of claims 15 and 17, wherein the carrier switching deciding function is further configured to calculate the timing of executing the carrier switching on the basis of the relation

switching timing parameter modulo persistence time = 0.

19. The apparatus according to any of claims 1 to 18, wherein the communication is a high speed packet access based communication, wherein the carrier switching deciding function is configured to decide on conducting a carrier switching for switching the communication from at least one first uplink frequency carrier to at least one

second uplink frequency carrier in a same cell or in a different cell of a communication network, on the basis of the configuration information.

20. The apparatus according to any of claims 1 to 19, wherein the apparatus is comprised in a communication element comprising at least one of a terminal device or user equipment communicating with a communication network control element, wherein the communication is conducted with the communication network control element which comprises at least one of a base station or an access node of a cellular communication network.

21. A method comprising

receiving and processing configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier,

deciding to switch a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information, and

informing a communication network control element about the carrier switching.

22. The method according to claim 21, further comprising:

conducting the communication on the at least one first uplink frequency carrier before the carrier switching, and

conducting the communication on the at least one second uplink frequency carrier after the carrier switching.

23. The method according to any of claims 21 and 22, wherein

the configuration information comprises at least one of

a definition of uplink frequency carriers to and from which a carrier switching is executable,

a selection probability value for the respective uplink frequency carriers,

policy information related to the carrier switching, and

information on volumes and timing parameters related to the policy information.

24. The method according to any of claims 21 to 23, further comprising:

determining whether a retransmission of data is to be conducted for a communication on the at least one first frequency carrier, and

when it is determined that a retransmission of data is to be conducted, stopping the carrier switching.

25. The method according to claim 24, further comprising determining that the retransmission of data is to be conducted when at least one of the following is valid:

an acknowledgement for a successful transmission in a preceding transmission cycle in one hybrid automatic repeat request process is not determined to be received, and

an incorrect transmission or decoding of a transport block in a preceding transmission cycle is detected.

26. The method according to any of claims 21 to 25, further comprising:

receiving and processing information indicating a time window in which a carrier switching is allowed to be executed,

determining, when the time window begins, whether a persistence time has elapsed since a preceding carrier switching executed before a carrier switching to be executed at the present time, and

allowing a carrier switching in case the persistence time is elapsed, or

not allowing a carrier switching in case the persistence time is not elapsed.

27. The method according to claim 26, further comprising, in case the carrier switching is allowed and a current time is in the time window,

initiating to stop a transmission of data units on the current carrier,

checking whether an acknowledgement for already transmitted data units is received, and in case the acknowledgement for the already transmitted data units is received,

initiating the carrier switching.

28. The method according to any of claims 26 and 27, wherein the persistence time is based on one of

a time period required for stabilizing a power control after executing a carrier switching, which is provided by a communication network control element, and

a randomly set time period within a predetermined time window.

29. The method according to claim 24, further comprising

determining whether a maximum retransmission time period is expired since a first retransmission of data on the at least one first frequency carrier, and when it is determined that the maximum retransmission time period is expired,

discarding a not-completed retransmission, and

allowing the carrier switching.

30. The method according to claim 29, further comprising initiating a retransmission of data units comprised in the discarded retransmission in another retransmission process.

31. The method according to any of claims 21 to 30, further comprising:

determining and transmitting channel quality information on an uplink frequency carrier used for the communication, wherein, when it is decided to switch the current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, a transmission of channel quality information on the currently used uplink frequency carrier is stopped at a predetermined timing before the carrier switching, and a transmission of channel quality information on the uplink frequency carrier to which the carrier switching will switch the communication is started, at the predetermined timing before the carrier switching.

32. The method according to any of claims 21 to 31, further comprising:

scanning and decoding simultaneously control channels transmitted via plural downlink carriers corresponding to the uplink frequency carriers usable in the carrier switching on the basis of the configuration information, and

initiating a carrier switching processing when a switching indication is received and decoded on one of the plural control channels,

wherein the carrier switching is executed to an uplink frequency carrier corresponding to the downlink carrier where the control channel bearing the switching indication is received.

33. The method according to claim 32, wherein the control channel is a grant channel.

34. The method according to claim 33, wherein the grant channel is an enhanced dedicated channel absolute grant channel, wherein the switching indication is derived on the basis of a mapping of a transmitted value to an absolute grant by means of a table, wherein the switching indication is indicated at predefined locations in the table.

35. The method according to any of claims 21 to 34, further comprising:

receiving and processing a switching timing parameter which is usable for determining a timing of executing the carrier switching, and

calculating the timing of executing the carrier switching on the basis of the switching timing parameter and a persistence time.

36. The method according to claim 35, wherein

the persistence time is based on one of

a time period required for stabilizing a power control after executing a carrier switching, which is provided by a communication network control element, and

a randomly set time period within a predetermined time window, and

the switching timing parameter one of

a parameter based on a common cell or network specific parameter, or

a parameter based on a combination of a common cell or network specific parameter and a communication element specific parameter related to a communication element from which the communication in the uplink direction originates.

37. The method according to claim 36, wherein the common cell or network specific parameter includes a system frame number, and the communication element specific parameter includes a radio network identifier, wherein the combination of the common cell or network specific parameter and the communication element specific parameter is based on an arithmetic operation.

38. The method according to any of claims 35 and 37, further comprising

calculating the timing of executing the carrier switching on the basis of the relation

switching timing parameter modulo persistence time = 0.

39. The method according to any of claims 21 to 38, wherein the communication is a high speed packet access based communication, wherein the carrier switching is conducted for switching the communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier in a same cell or in a different cell of a communication network, on the basis of the configuration information.

40. The method according to any of claims 21 to 39, wherein the method is implemented in a communication element comprising at least one of a terminal device or user equipment communicating with a communication network control element, wherein the communication is conducted with the communication network control element which comprises at least one of a base station or an access node of a cellular communication network.

41. An apparatus comprising

at least one processor,

at least one interface to at least one other network element, and

at least one memory for storing instructions to be executed by the processor, wherein

the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:

a carrier switching configuration setting function configured to set and transmit configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, and

a carrier switching information processing function configured to receive and process an information from a communication element about a switching of a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information.

42. The apparatus according to claim 41, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a communication modification function configured to modify an uplink communication chain according to the information regarding the carrier switching.

43. The apparatus according to any of claims 41 and 42, wherein

the configuration information comprises at least one of

a definition of uplink frequency carriers to and from which a carrier switching is executable,

a selection probability value for the respective uplink frequency carriers,

policy information related to the carrier switching, and

information on volumes and timing parameters related to the policy information.

44. The apparatus according to any of claims 41 to 43, wherein the policy information comprises a rule that a carrier switching is not allowed at least for a predetermined time when a retransmission of data is to be conducted for a communication on the at least one first frequency carrier.

45. The apparatus according to claim 44, wherein the information on volumes and timing parameters related to the policy information comprises at least one value being set to an amount inhibiting a carrier switch until no retransmission is to be conducted.

46. The apparatus according to any of claims 41 to 45, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a time window defining function configured to define and transmit information indicating a time window in which a carrier switching is allowed to be executed.

47. The apparatus according to claim 46, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a persistence time providing function configured to provide an indication of a persistence time, wherein the persistence time is based on one of

a time period required for stabilizing a power control after executing a carrier switching, and

a randomly set time period within a predetermined time window.

48. The apparatus according to any of claims 41 to 47, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a control channel signaling function configured to send a switching indication on one of plural control channels transmitted via plural downlink carriers corresponding to the uplink frequency carriers usable in the carrier switching on the basis of the configuration information, the switching indication being configured to initiate a carrier switching to an uplink frequency carrier corresponding to the downlink carrier where the control channel bearing the switching indication is transmitted.

49. The apparatus according to claim 48, wherein the control channel is a grant channel.

50. The apparatus according to claim 49, wherein the grant channel is an enhanced dedicated channel absolute grant channel, wherein the switching indication is derived on the basis of a mapping of a transmitted value to an absolute grant by means of a table, wherein the switching indication is indicated at predefined locations in the table.

51. The apparatus according to any of claims 41 to 50, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to further perform:

a switching timing determining function configured to determine a timing of executing the carrier switching,

a switching timing parameter providing function configured to transmit a switching timing parameter indicating the determined timing of executing the carrier switching,

wherein the switching timing determining function is further configured

to calculate the timing of executing the carrier switching on the basis of the switching timing parameter and a persistence time.

52. The apparatus according to claim 51, wherein

the persistence time is based on one of

a time period required for stabilizing a power control after executing a carrier switching, which is provided by a communication network control element, and

a randomly set time period within a predetermined time window, and

the switching timing parameter one of

a parameter based on a common cell or network specific parameter, or

a parameter based on a combination of a common cell or network specific parameter and a communication element specific parameter related to a communication element from which the communication in the uplink direction originates.

53. The apparatus according to claim 52, wherein the common cell or network specific parameter includes a system frame number, and the communication element specific parameter includes a radio network identifier, wherein the combination of the common cell or network specific parameter and the communication element specific parameter is based on an arithmetic operation.

54. The apparatus according to any of claims 51 to 53, wherein the switching timing determining function is further configured to calculate the timing of executing the carrier switching on the basis of the relation

switching timing parameter modulo persistence time = 0.

55. The apparatus according to any of claims 51 to 54, wherein the switching timing determining function is further configured to select at least one of

a simultaneous carrier switching of plural or all communication elements in a cell, wherein the used switching timing parameter is a parameter based on a common cell or network specific parameter, and

a distributed carrier switching of one or plural communication elements in a cell, wherein the used switching timing parameter is based on a combination of a common cell or network specific parameter and a communication element specific parameter related to the respective communication element from which the communication in the uplink direction originates.

56. The apparatus according to any of claims 41 to 55, wherein the communication is a high speed packet access based communication, wherein the carrier switching is

conducted switching for switching the communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier in a same cell or in a different cell of a communication network, on the basis of the configuration information.

57. The apparatus according to any of claims 41 to 56, wherein the apparatus is comprised in a communication network control element comprising at least one of a base station or an access node of a cellular communication network, wherein the communication is conducted with a communication element comprising at least one of a terminal device or user equipment communicating with the communication network control element.

58. A method comprising

setting and transmitting configuration information related to conduct a carrier switching for switching a communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, and

receiving and processing information from a communication element about a switching of a current communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier, on the basis of the configuration information.

59. The method according to claim 58, further comprising

modifying an uplink communication chain according to the information regarding the carrier switching.

60. The method according to any of claims 58 and 59, wherein

the configuration information comprises at least one of

a definition of uplink frequency carriers to and from which a carrier switching is executable,

a selection probability value for the respective uplink frequency carriers,

policy information related to the carrier switching, and

information on volumes and timing parameters related to the policy information.

61. The method according to any of claims 58 to 60, wherein the policy information comprises a rule that a carrier switching is not allowed at least for a predetermined time

when a retransmission of data is to be conducted for a communication on the at least one first frequency carrier.

62. The method according to claim 61, wherein the information on volumes and timing parameters related to the policy information comprises at least one value being set to an amount inhibiting a carrier switch until no retransmission is to be conducted.

63. The method according to any of claims 58 to 62, further comprising:

defining a time window in which a carrier switching is allowed to be executed, and

transmitting information indicating the time window.

64. The method according to claim 63, further comprising:

providing an indication of a persistence time, wherein the persistence time is based on one of

a time period required for stabilizing a power control after executing a carrier switching, and

a randomly set time period within a predetermined time window.

65. The method according to any of claims 58 to 64, further comprising:

transmitting a switching indication on one of plural control channels transmitted via plural downlink carriers corresponding to the uplink frequency carriers usable in the carrier switching on the basis of the configuration information, the switching indication being configured to initiate a carrier switching to an uplink frequency carrier corresponding to the downlink carrier where the control channel bearing the switching indication is transmitted.

66. The method according to claim 65, wherein the control channel is a grant channel.

67. The method according to claim 66, wherein the grant channel is an enhanced dedicated channel absolute grant channel, wherein the switching indication is derived on the basis of a mapping of a transmitted value to an absolute grant by means of a table, wherein the switching indication is indicated at predefined locations in the table.

68. The method according to any of claims 58 to 67, further comprising:

determining a timing of executing the carrier switching,

providing a switching timing parameter indicating the determined timing of executing the carrier switching, and

calculating the timing of executing the carrier switching on the basis of the switching timing parameter and a persistence time.

69. The method according to claim 68, wherein

the persistence time is based on one of

a time period required for stabilizing a power control after executing a carrier switching, which is provided by a communication network control element, and

a randomly set time period within a predetermined time window, and

the switching timing parameter one of

a parameter based on a common cell or network specific parameter, or

a parameter based on a combination of a common cell or network specific parameter and a communication element specific parameter related to a communication element from which the communication in the uplink direction originates.

70. The method according to claim 69, wherein the common cell or network specific parameter includes a system frame number, and the communication element specific parameter includes a radio network identifier, wherein the combination of the common cell or network specific parameter and the communication element specific parameter is based on an arithmetic operation.

71. The method according to any of claims 68 to 70, further comprising calculating the timing of executing the carrier switching on the basis of the relation

switching timing parameter modulo persistence time = 0.

72. The method according to any of claims 68 to 71, further comprising

selecting at least one of a simultaneous carrier switching of plural or all communication elements in a cell, wherein the used switching timing parameter is a parameter based on a common cell or network specific parameter, and a distributed carrier switching of one or plural communication elements in a cell, wherein the used

switching timing parameter is based on a combination of a common cell or network specific parameter and a communication element specific parameter related to the respective communication element from which the communication in the uplink direction originates.

73. The method according to any of claims 58 to 72, wherein the communication is a high speed packet access based communication, wherein the carrier switching is conducted switching for switching the communication from at least one first uplink frequency carrier to at least one second uplink frequency carrier in a same cell or in a different cell of a communication network, on the basis of the configuration information.

74. The method according to any of claims 58 to 73, wherein the method is implemented in a communication network control element comprising at least one of a base station or an access node of a cellular communication network, wherein the communication is conducted with a communication element comprising at least one of a terminal device or user equipment communicating with the communication network control element.

75. A computer program product for a computer, comprising software code portions for performing the steps of any of claims 21 to 40 or any of claims 58 to 74 when said product is run on the computer.

76. The computer program product according to claim 75, wherein

the computer program product comprises a computer-readable medium on which said software code portions are stored, and/or

the computer program product is directly loadable into the internal memory of the computer and/or transmittable via a network by means of at least one of upload, download and push procedures.

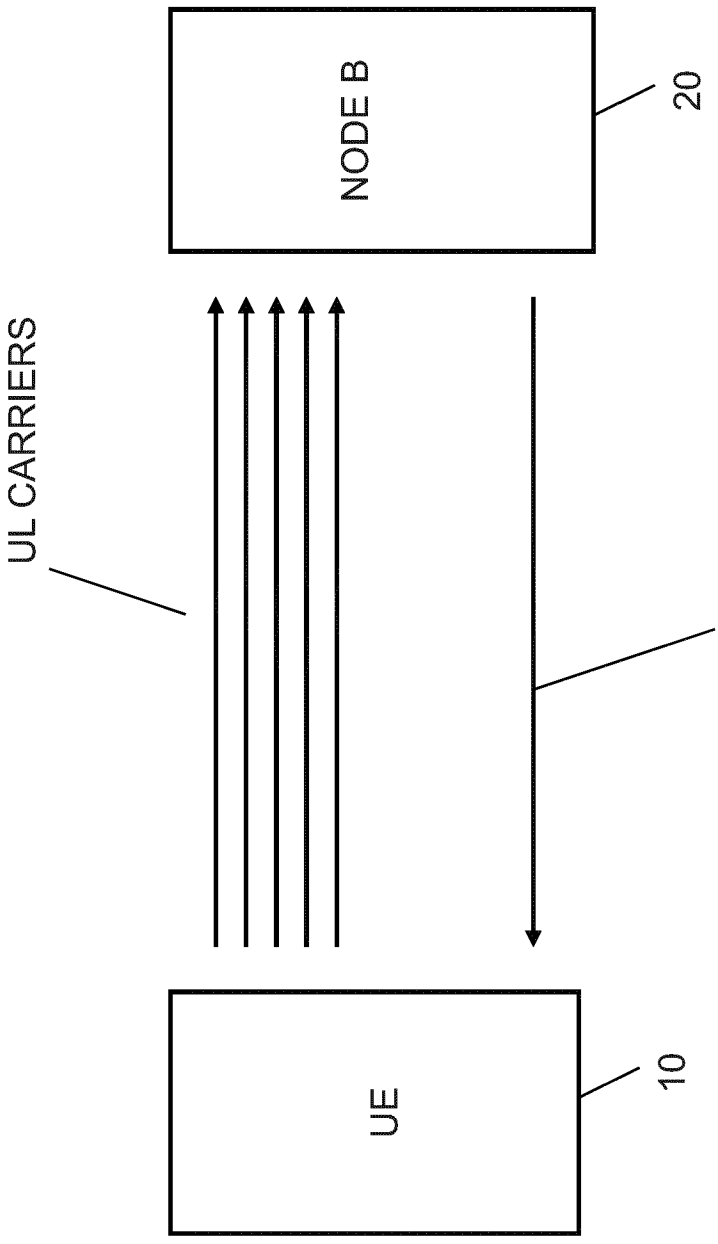


Fig. 1

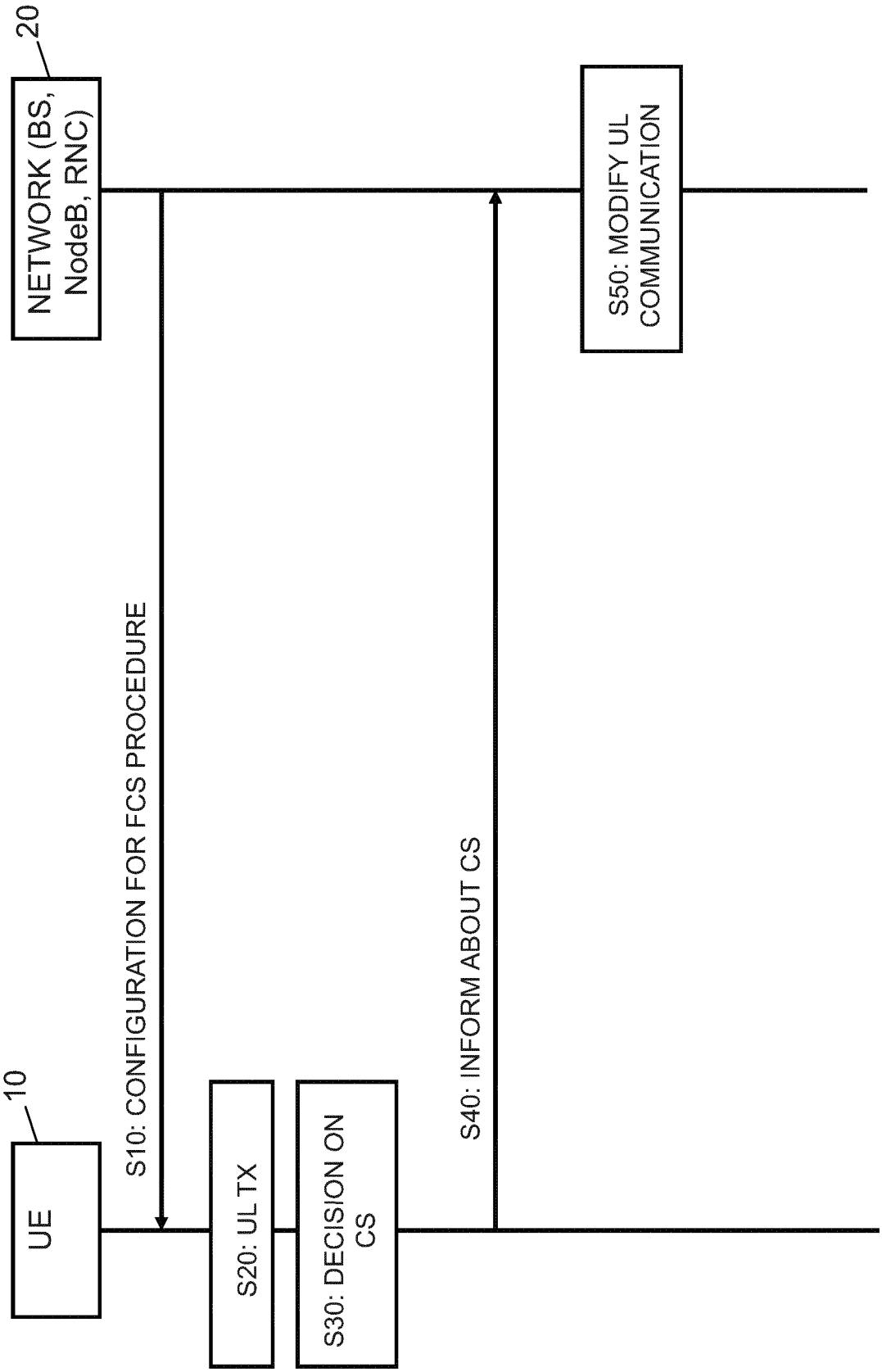
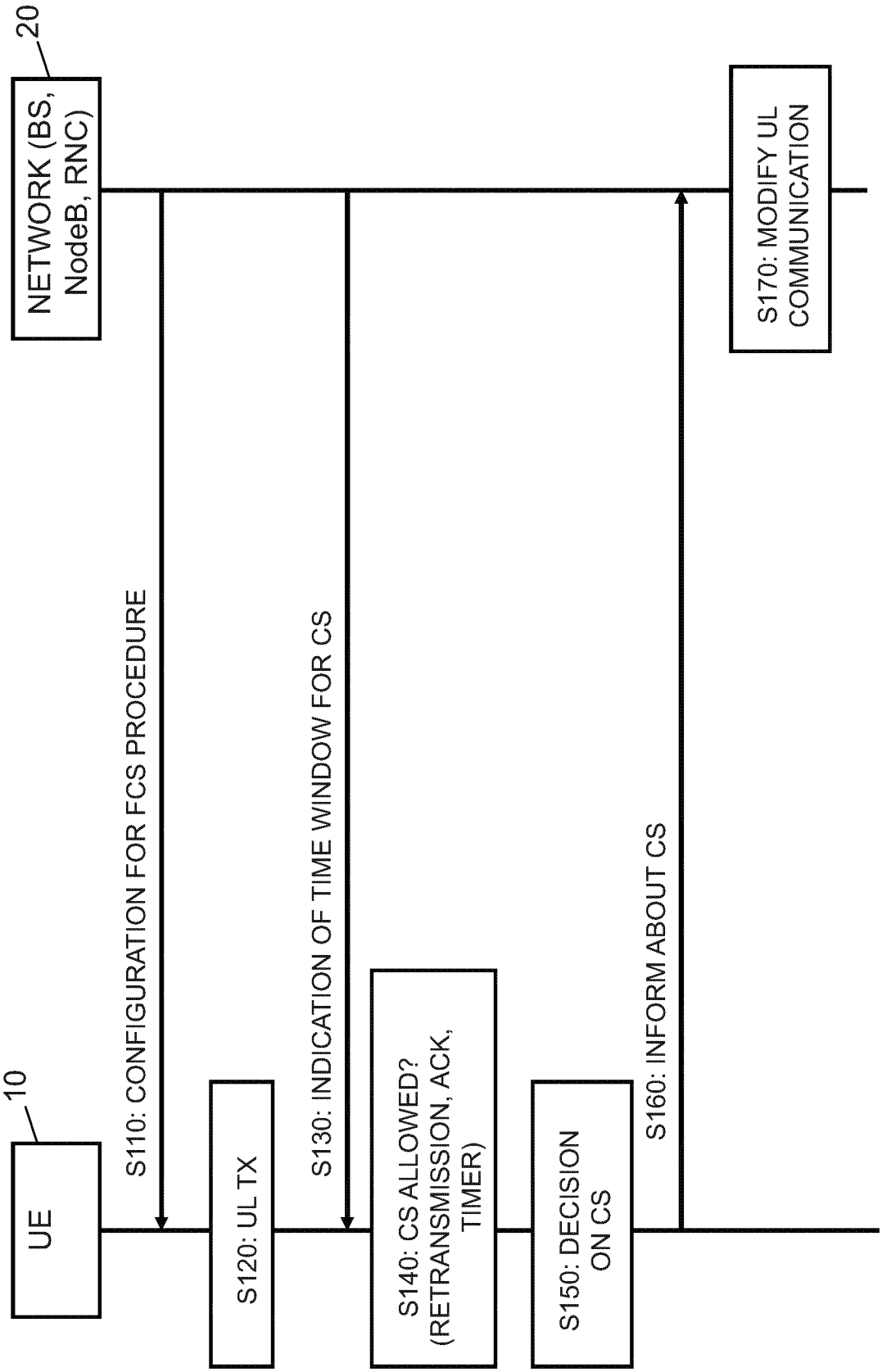

20
NETWORK (BS, NodeB, RNC)
S50: MODIFY UL COMMUNICATION
10
UE
S10: CONFIGURATION FOR FCS PROCEDURE
S20: UL TX
S30: DECISION ON CS
S40: INFORM ABOUT CS

Fig. 2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NETWORK (BS, NodeB, RNC)
S170: MODIFY UL COMMUNICATION
10
UE
S110: CONFIGURATION FOR FCS PROCEDURE
S120: UL TX
S130: INDICATION OF TIME WINDOW FOR CS
S140: CS ALLOWED? (RETRANSMISSION, ACK, TIMER)
S150: DECISION ON CS
S160: INFORM ABOUT CS

Fig. 3

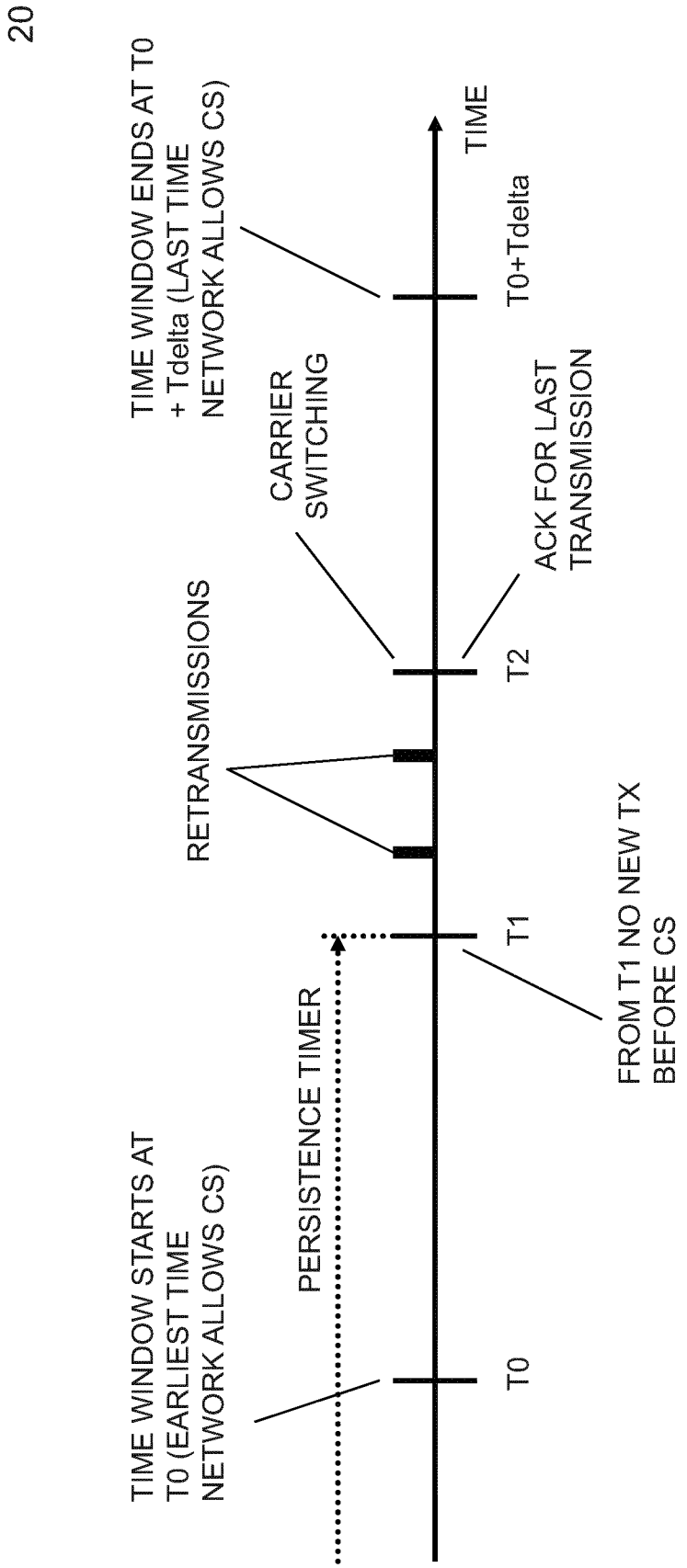
20
TIME WINDOW ENDS AT T0
+ Tdelta (LAST TIME
NETWORK ALLOWS CS)
TIME
T0+Tdelta
CARRIER
SWITCHING
ACK FOR LAST
TRANSMISSION
RETRANSMISSIONS
T2
T1
FROM T1 NO NEW TX
BEFORE CS
PERSISTENCE TIMER
TIME WINDOW STARTS AT
T0 (EARLIEST TIME
NETWORK ALLOWS CS)
T0

Fig. 4

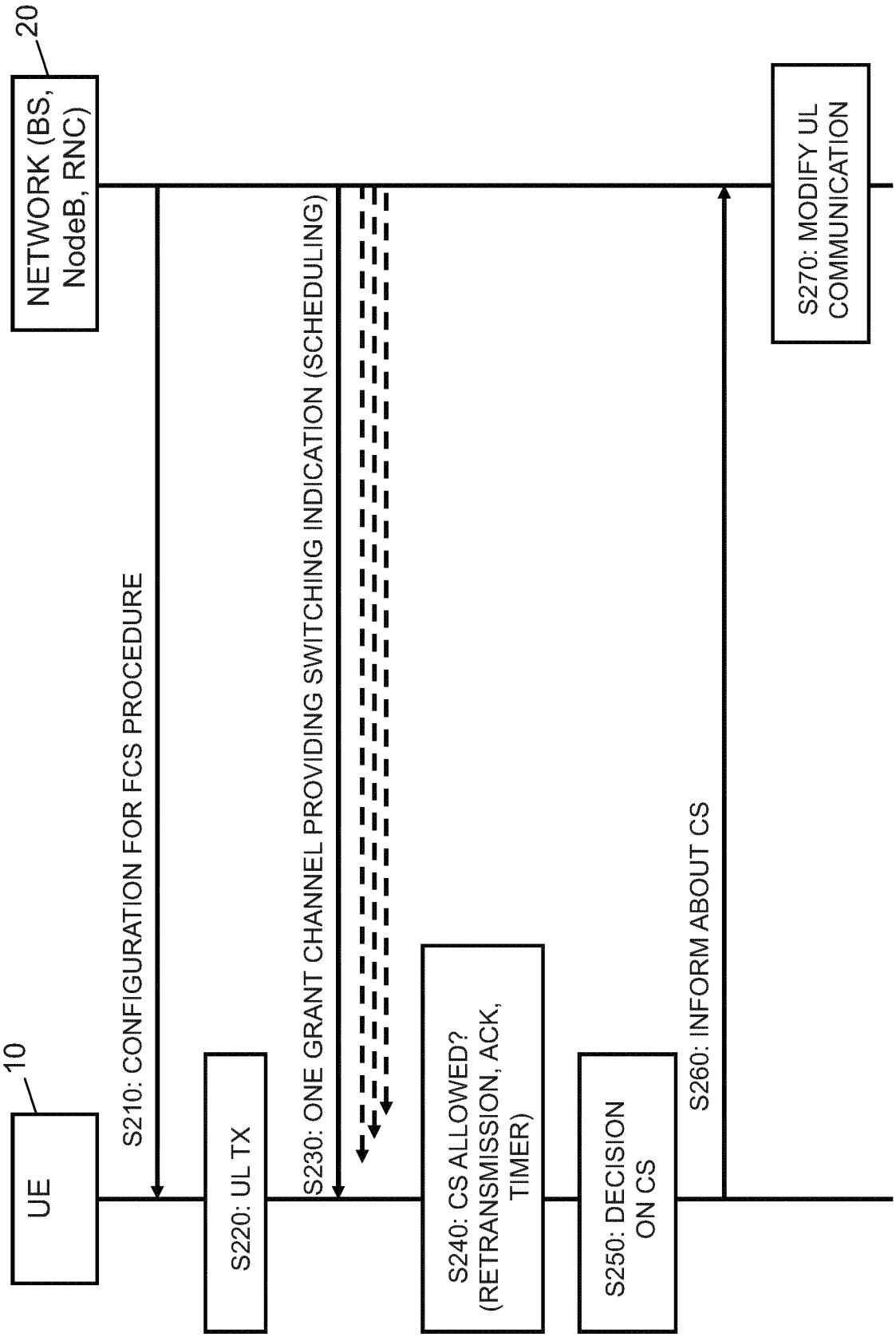
20
NETWORK (BS, NodeB, RNC)
10
UE
S210: CONFIGURATION FOR FCS PROCEDURE
S220: UL TX
S230: ONE GRANT CHANNEL PROVIDING SWITCHING INDICATION (SCHEDULING)
S240: CS ALLOWED? (RETRANSMISSION, ACK, TIMER)
S250: DECISION ON CS
S260: INFORM ABOUT CS
S270: MODIFY UL COMMUNICATION

Fig. 5

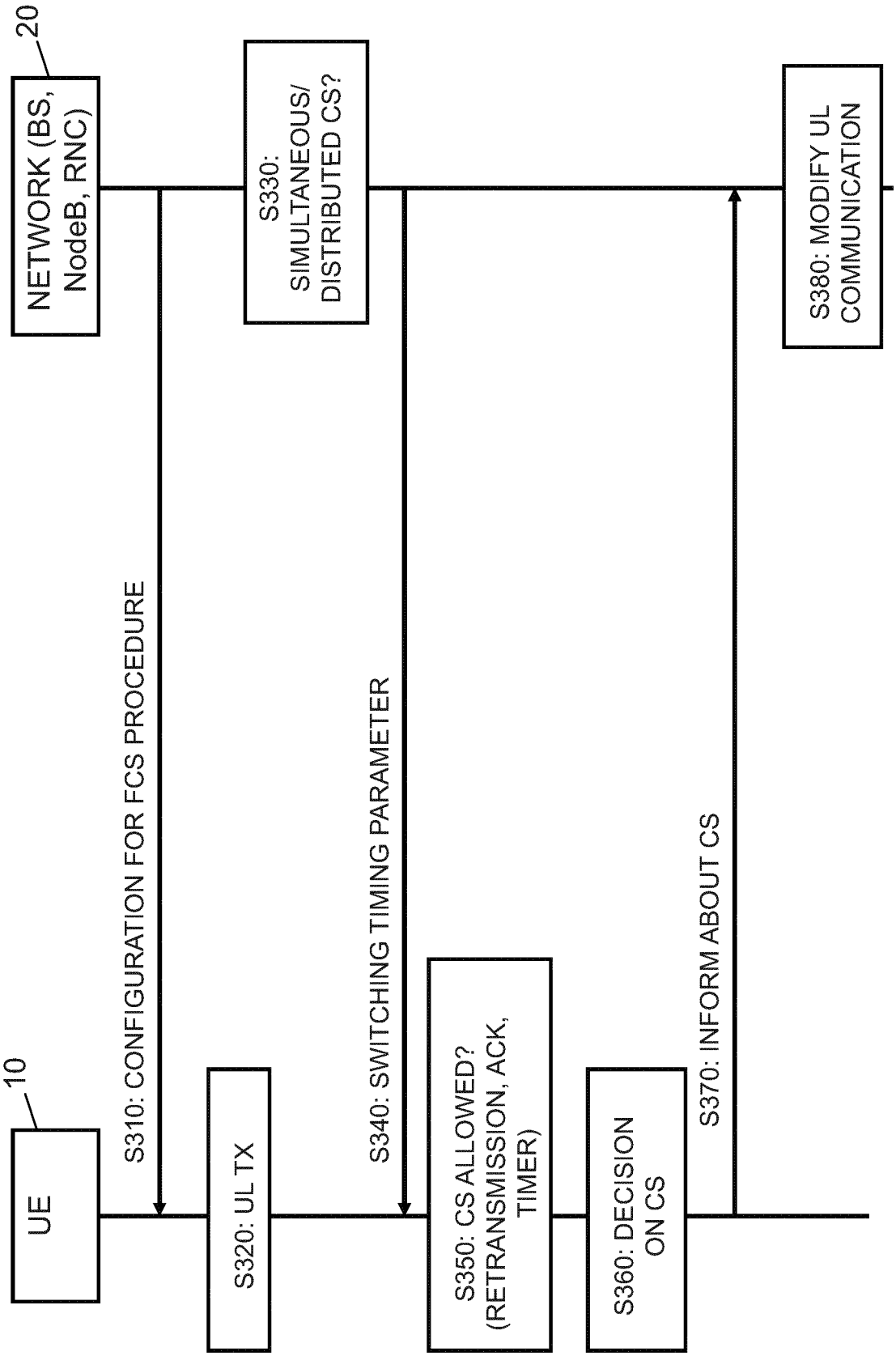
20
NETWORK (BS, NodeB, RNC)
S330: SIMULTANEOUS/ DISTRIBUTED CS?
S380: MODIFY UL COMMUNICATION
10
UE
S310: CONFIGURATION FOR FCS PROCEDURE
S320: UL TX
S340: SWITCHING TIMING PARAMETER
S350: CS ALLOWED? (RETRANSMISSION, ACK, TIMER)
S360: DECISION ON CS
S370: INFORM ABOUT CS

Fig. 6

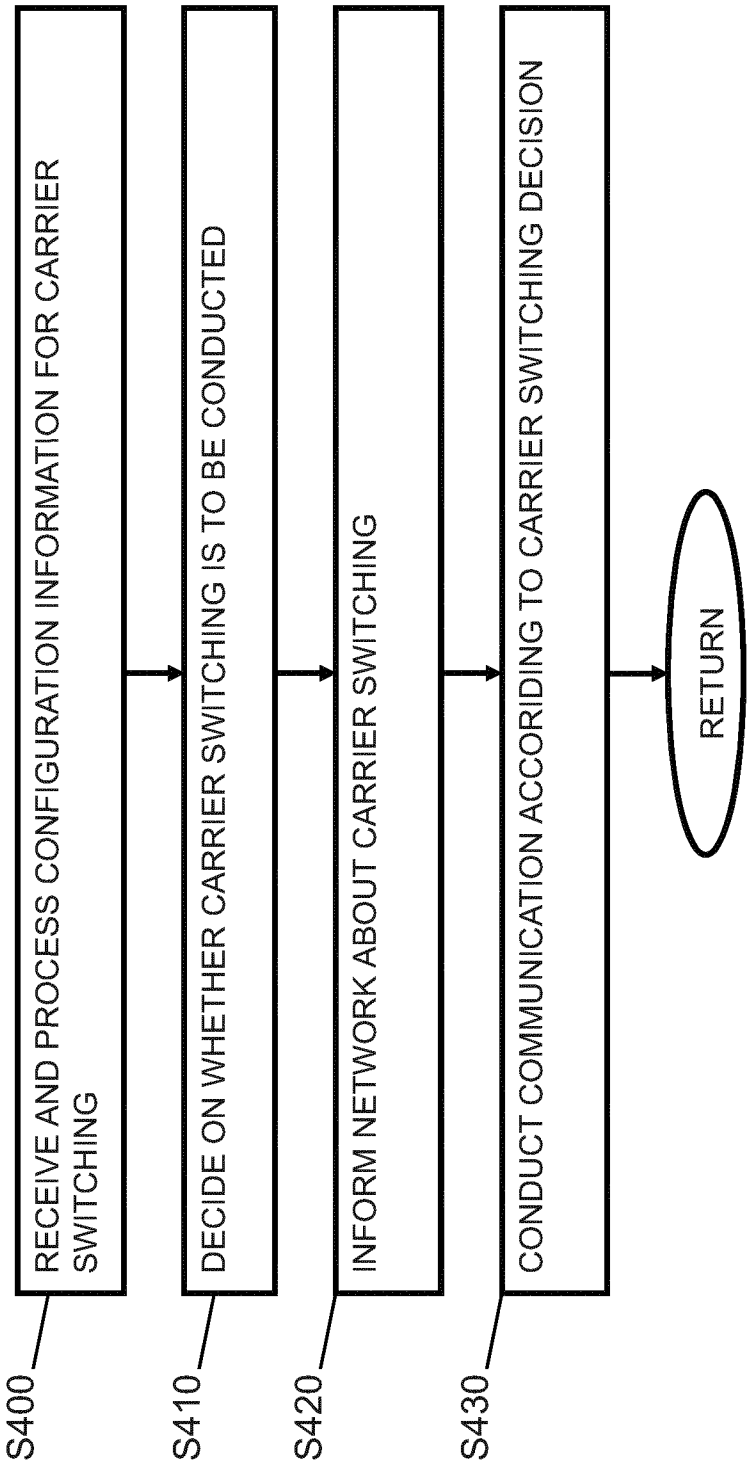
S400
RECEIVE AND PROCESS CONFIGURATION INFORMATION FOR CARRIER SWITCHING
S410
DECIDE ON WHETHER CARRIER SWITCHING IS TO BE CONDUCTED
S420
INFORM NETWORK ABOUT CARRIER SWITCHING
S430
CONDUCT COMMUNICATION ACCORIDING TO CARRIER SWITCHING DECISION
RETURN

Fig. 7

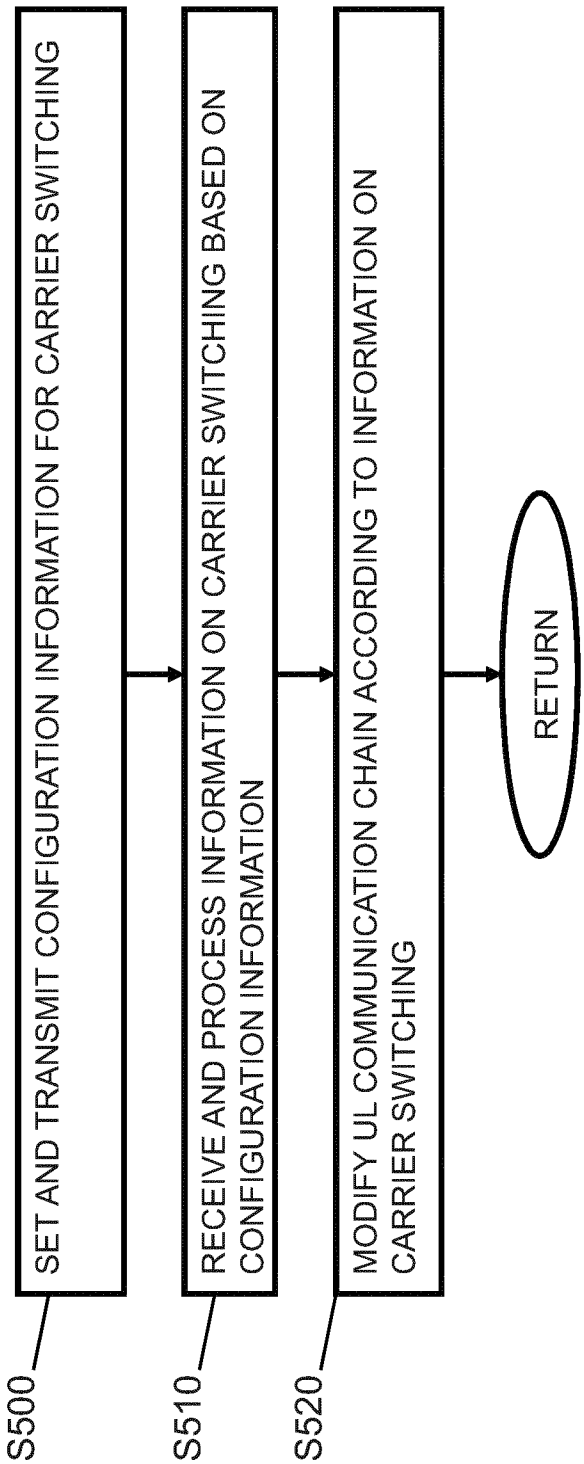
S500
SET AND TRANSMIT CONFIGURATION INFORMATION FOR CARRIER SWITCHING
S510
RECEIVE AND PROCESS INFORMATION ON CARRIER SWITCHING BASED ON CONFIGURATION INFORMATION
S520
MODIFY UL COMMUNICATION CHAIN ACCORDING TO INFORMATION ON CARRIER SWITCHING
RETURN

Fig. 8

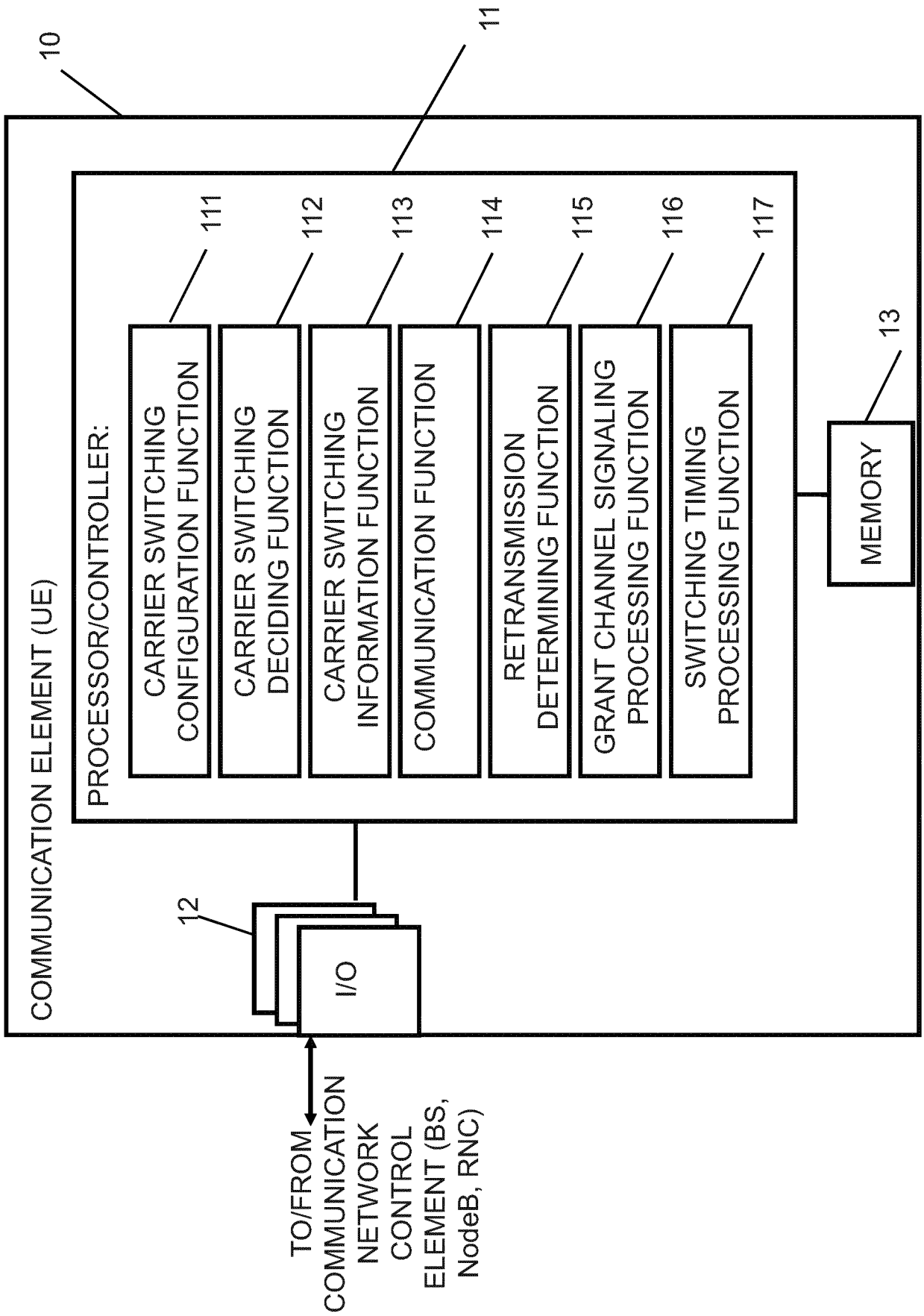
10
11
COMMUNICATION ELEMENT (UE)
PROCESSOR/CONTROLLER:
111
CARRIER SWITCHING CONFIGURATION FUNCTION
112
CARRIER SWITCHING DECIDING FUNCTION
113
CARRIER SWITCHING INFORMATION FUNCTION
114
COMMUNICATION FUNCTION
115
RETRANSMISSION DETERMINING FUNCTION
116
GRANT CHANNEL SIGNALING PROCESSING FUNCTION
117
SWITCHING TIMING PROCESSING FUNCTION
13
MEMORY
12
I/O
TO/FROM COMMUNICATION NETWORK CONTROL ELEMENT (BS, NodeB, RNC)

Fig. 9

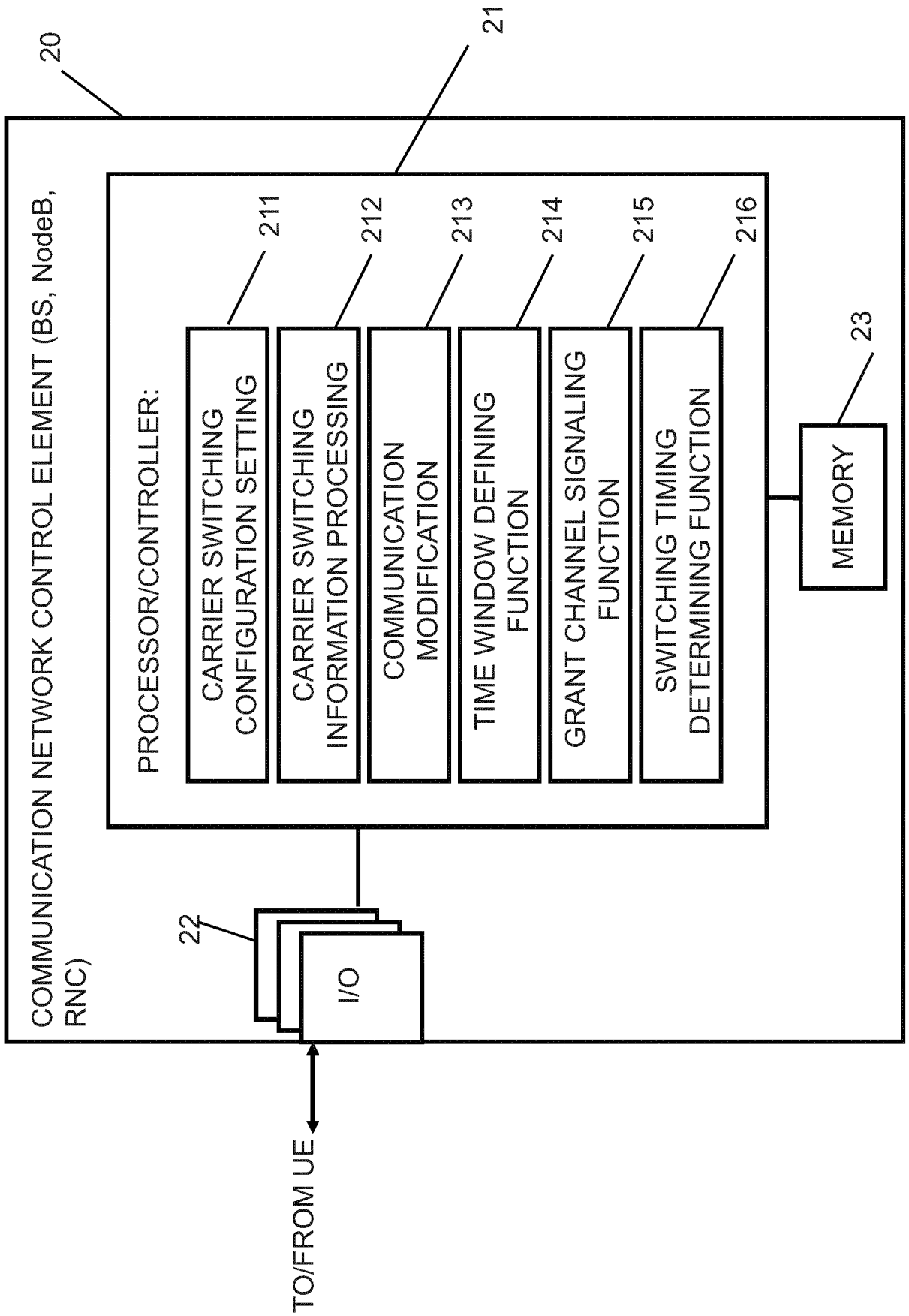
20
21
COMMUNICATION NETWORK CONTROL ELEMENT (BS, NodeB, RNC)
PROCESSOR/CONTROLLER:
211
CARRIER SWITCHING CONFIGURATION SETTING
212
CARRIER SWITCHING INFORMATION PROCESSING
213
COMMUNICATION MODIFICATION
214
TIME WINDOW DEFINING FUNCTION
215
GRANT CHANNEL SIGNALING FUNCTION
216
SWITCHING TIMING DETERMINING FUNCTION
23
MEMORY
22
I/O
TO/FROM UE

Fig. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/050979

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W36/06
ADD. H04W36/36 H04W36/22

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

B. FIELDS SEARCHED

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

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	TELECOM ITALIA ET AL: "Load balancing use case involving cell reselection and handover parameters self optimization", 3GPP DRAFT; R3-072249, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG3, no. Jeju Island; 20071031, 31 October 2007 (2007-10-31), XP050163031, [retrieved on 2007-10-31] paragraph [0002] - paragraph [0003]	1-76

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[X] 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
30 July 2013	06/08/2013

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/050979

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	QUALCOMM EUROPE: "Intra-System Mobility", 3GPP DRAFT; R2-060013 INTRA-SYSTEM MOBILITY, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Sophia Antipolis, France; 20060113, 13 January 2006 (2006-01-13), XP050130182, [retrieved on 2006-01-13] paragraph [0002] - paragraph [0003]	1-76
A	JUSSI TURKKA ET AL: "Performance of LTE SON uplink load balancing in non-regular network", PERSONAL INDOOR AND MOBILE RADIO COMMUNICATIONS (PIMRC), 2011 IEEE 22ND INTERNATIONAL SYMPOSIUM ON, IEEE, 11 September 2011 (2011-09-11), pages 162-166, XP032102180, DOI: 10.1109/PIMRC.2011.6139780 ISBN: 978-1-4577-1346-0 paragraph [000I] - paragraph [00II]	1-76