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(54) Title: A USER EQUIPMENT, A NETWORK NODE AND RESPECTIVE METHOD THEREIN FOR TRANSMITTING SOUNDING REFERENCE SIGNALS

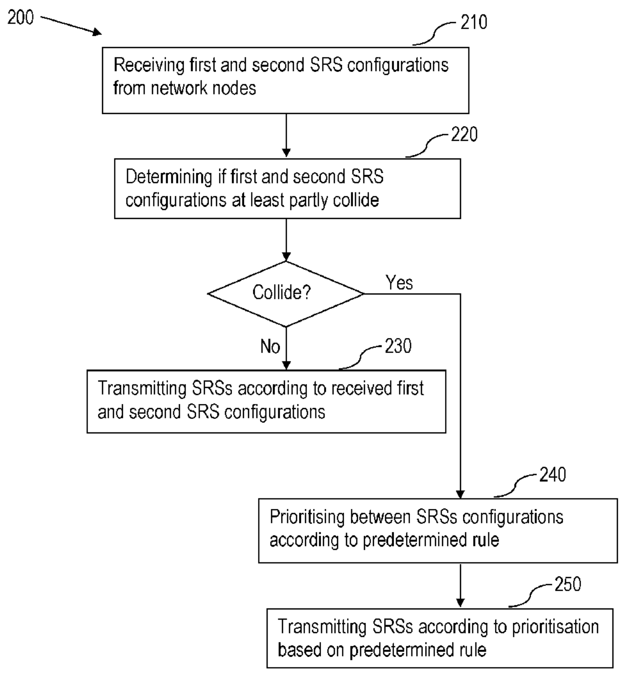

Fig. 2a

(57) Abstract: A UE and a method performed by the UE for transmitting SRSs, the UE being in dual connectivity mode to at least a first network node and a second network node are provided. A first network node and a method performed by the first network node for enabling transmission of SRSs from a UE being connected in dual connectivity mode to at least the first network node and a second network node are also provided. The method performed by the UE comprises receiving (210), from the network nodes, a first and a second SRS configuration; and determining (220) if the received first and the second SRS configurations at least partly collide. If the received first and the second SRS configuration collide, the method comprises prioritising (240) between which SRSs to transmit of the received first and second SRS configuration according to a predetermined rule; and transmitting (250) SRSs according to the predetermined rule

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A USER EQUIPMENT, A NETWORK NODE AND RESPECTIVE METHOD THEREIN FOR TRANSMITTING SOUNDING REFERENCE SIGNALS

Technical field

[0001] The present disclosure relates to telecommunications, and particularly to the transmission of Sounding Reference Signals SRSs.

Background

[0002] In a typical cellular radio system, wireless terminals (also known as mobile stations and/or User Equipments, UEs) communicate via a Radio Access Network, RAN, to one or more core networks. The RAN covers a geographical area which is divided into cell areas, with each cell area being served by a base station, e.g., a Radio Base Station, RBS, which in some networks may also be called, for example, a “NodeB” (UMTS) or “eNodeB” (LTE). A cell is a geographical area where radio coverage is provided by the RBS equipment at a base station site. Each cell is identified by an identity within the local radio area, which is broadcast in the cell. The base stations communicate over the air interface operating on radio frequencies with the user UEs within range of the base stations.

[0003] In some versions of the RAN, several base stations are typically connected (e.g., by landlines or microwave) to a controller node (such as a Radio Network Controller, RNC, or a Base Station Controller ,BSC) which supervises and coordinates various activities of the plural base stations connected thereto. The radio network controllers are typically connected to one or more core networks.

[0004] The UMTS is a third generation mobile communication system, which evolved from the second generation (2G) Global System for Mobile Communications, GSM. UMTS Terrestrial Radio Access Network, UTRAN, is essentially a radio access network using Wideband Code Division Multiple Access, WCDMA, for UEs. In a forum known as the Third Generation Partnership Project, 3GPP, telecommunications suppliers propose and agree upon standards for third generation networks and UTRAN specifically, and investigate enhanced data rate and radio capacity. The 3GPP has developed specifications for the Evolved Universal Terrestrial Radio Access Network, E-UTRAN. The E-UTRAN comprises the LTE and System Architecture Evolution, SAE. LTE is a variant of a 3GPP radio access technology wherein the radio base station nodes are connected to a core network (via Access Gateways, or AGWs) rather than to RNC nodes. In general, in LTE the functions of an RNC node are distributed between the RBS nodes (eNodeBs in LTE) and AGWs. As such, the RAN of an LTE system has an essentially “flat” architecture comprising radio base station nodes without reporting to RNC nodes.

[0005] LTE uses Orthogonal Frequency-Division Multiplexing, OFDM, in the downlink and Discrete Fourier Transform, DFT,-spread OFDM in the uplink. Figure 1a illustrates a basic LTE downlink physical resource in terms of a time-frequency grid, where each resource element corresponds to one OFDM subcarrier during one OFDM symbol interval. In the time domain, LTE downlink transmissions are organized into radio frames of 10 ms, each radio frame consisting of ten equally-sized subframes of length $T_{subframe}$ = 1 ms, as illustrated in figure 1b.

[0006] The resource allocation in LTE is typically described in terms of resource blocks, RB, where an RB corresponds to one slot (0.5 ms) in the time domain and 12 contiguous subcarriers in the frequency domain. A pair of two adjacent RBs in time direction (1.0 ms) is known as a RB pair. RBs are numbered in the frequency domain, starting with 0 from one end of the system bandwidth.

[0007] In the Frequency domain, LTE downlink uses a 15 KHz sub-carrier spacing. Thus, an RB corresponds to one slot (0.5 ms) in the time domain and 12 contiguous sub-carriers in the frequency domain. A Resource Element, RE, is then defined as one sub-carrier in the frequency domain, and the duration of one OFDM symbol in the time domain.

[0008] Physical layer channels in the LTE uplink are provided by the Physical Random Access Channel, PRACH; the Physical Uplink Shared Channel, PUSCH); and the Physical Uplink Control Channel, PUCCH. PUCCH transmissions are allocated specific frequency resources at the edges of the uplink bandwidth (e.g. multiples of 180 KHz in LTE depending on the system bandwidth). PUCCH is mainly used by the UE to transmit control information in the uplink, only in sub-frames in which the UE has not been allocated any RBs for PUSCH transmission. The control signalling may consist of Hybrid Automatic Repeat Request, HARQ, feedback as a response to a downlink transmission, Channel Status Reports, CSRs, scheduling requests, Channel Quality Indicators, CQIs, etc.

[0009] On the other hand, PUSCH is mainly used for data transmissions. However, this channel is also used for data-associated control signalling (e.g. transport format indications, Multiple Input Multiple Output, MIMO, parameters, etc.). This control information is crucial for processing the uplink data and is therefore transmitted together with that data.

[00010] The notion of Virtual Resource Blocks, VRBs and Physical RBs, PRBs has been introduced in LTE. The actual resource allocation to a UE is made in terms of VRB pairs. There are two types of resource allocations, localised and distributed. In the localised resource allocation, a VRB pair is directly mapped to a PRB pair, hence two consecutive and localised VRB are also placed as consecutive PRBs in the frequency domain. On the other hand, the distributed VRBs are not mapped to consecutive PRBs in the frequency domain, thereby providing frequency diversity for data channel transmitted using these distributed VRBs.

[00011] Downlink transmissions are dynamically scheduled, e.g., in each subframe the base station transmits control information about to which terminals data is transmitted and upon which resource blocks the data is transmitted, in the current downlink subframe. This control signalling is typically transmitted in the first 1, 2, 3 or 4 OFDM symbols in each subframe and the number n=1,2,3 or 4 is known as the Control Format Indicator, CFI, indicated by the physical CFI channel, PCFICH, transmitted in the first symbol of the control region. The control region also contains Physical Downlink Control CHannels, PDCCH and possibly also Physical HARQ Indication Channels, PHICH, carrying ACK/NACK for the uplink transmission.

[00012] The downlink subframe also comprises Common Reference Symbols, CRS, which are known to the receiver and used for coherent demodulation of e.g. the control information. A downlink system with CFI=3 OFDM symbols as control is illustrated in figure 1c.

[00013] Figure 1d shows an example uplink transmission subframe. In terms of the uplink, UL, Sounding Reference Signals, SRSs, are known signals that are transmitted by UEs so that the eNodeB may estimate different uplink-channel properties. The RSRs have time duration of a single OFDM symbol. These estimates may be used for uplink scheduling and link adaptation but also for downlink multiple antenna transmission, especially in case of Time Division Duplex, TDD, where the uplink and downlink use the same frequencies. The SRSs are defined in 3GPP TS 36.211 "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation", incorporated herein by reference in its entirety.

[00014] The SRSs may be transmitted in the last symbol of a 1ms uplink subframe. For the case of TDD, the SRSs may also be transmitted in the special slot, Uplink Pilot Time Slot, UpPTS. The length of UpPTS may be configured to be one or two symbols. Figure 1e shows an example 10ms radio frame for TDD, wherein in each of the two 5-slot subframes the ratio of downlink, DL, slots to UL slots is 3DL:2UL, and wherein up to eight symbols may be set aside for SRSs.

[00015] The configuration of SRS symbols, such as SRS bandwidth, SRS frequency domain position, SRS hopping pattern and SRS subframe configuration are set semi-statically as a part of Radio Resource Control, RRC, information element, as explained by 3GPP TS 36.331 "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification", incorporated herein by reference in its entirety. Therein it is explained that the Information Element, IE, *SoundingRS-UL-Config* is used to specify the uplink Sounding RS configuration for periodic and aperiodic sounding.

[00016] There are two types of SRS transmission in LTE UL: periodic and aperiodic. Periodic SRS is transmitted at regular time instances as configured by

means of RRC signalling. Aperiodic SRS is one shot transmission that is triggered by signalling in the Physical Downlink Control Channel (PDCCH).

[00017] There are two different configurations related to SRS: Cell specific SRS configuration and UE specific configuration. The cell specific configuration in essence indicates which subframes may be used for SRS transmissions within the cell as illustrated in figure 1e. The UE specific configuration indicates to the terminal (e.g. the UE) a pattern of subframes (among the subframes reserved for SRS transmission within the cell) and frequency domain resources to be used for SRS transmission of that specific UE. It also includes other parameters that the UE shall use when transmitting the signal, such as frequency domain comb and cyclic shift.

[00018] This means that SRSs from different UEs may be multiplexed in the time domain, by using UE-specific configurations such that the SRS of the two UEs are transmitted in different subframes. Furthermore, within the same symbol, SRSs may be multiplexed in the frequency domain. A set of subcarriers is divided into two sets of subcarriers, or combs with the even and odd subcarriers respectively in each such set. Additionally, UEs may have different bandwidths to get additional Frequency Division Multiplexing, FDM. The comb enables frequency domain multiplexing of signals with different bandwidths and also overlapping. Additionally, Code Division Multiplexing, CDM, may be used. Then different users (or UEs) may use exactly the same time and frequency domain resources by using different shifts of a basic base sequence.

[00019] Dual connectivity is a feature defined from the UE perspective wherein the UE may simultaneously receive and transmit to at least two different network points. For example, figure 1f illustrates a dual connectivity scenario wherein a wireless terminal (e.g. a UE) participates both in a connection with a macro RBS node and a Low Power Node, LPN, node. Dual connectivity is one of the features that are considered for standardisation within the umbrella work of small cell enhancements for LTE within 3GPP Rel-12.

[00020] Dual connectivity is defined for the case when the aggregated network points operate on the same or separate frequency. Each network point that the UE is aggregating may define a stand-alone cell or it may not define a stand-alone cell (or RBS). It is further foreseen that from the UE perspective, the UE may apply some form of Time Division Multiplexing, TDM, scheme between the different network points that the UE is aggregating. This implies that the communication on the physical layer to and from the different aggregated network points may not be truly simultaneous.

[00021] Dual connectivity as a feature bears many similarities with carrier aggregation and Coordinated Multi Point, CoMP. A differentiating factor is that dual connectivity is designed considering a relaxed backhaul and less stringent requirements on synchronisation requirements between the network points, and thus is in contrast to carrier aggregation and CoMP wherein tight synchronisation and a low-delay backhaul are assumed between connected network points.

[00022] When a UE is operating in UL dual connection mode, different SRS transmissions from the same UE may be needed to estimate channel properties for each of the two uplinks (to the two network nodes to which the UE is in dual-connectivity). The current configuration of SRS transmissions does not provide sufficient flexibility to effectively utilise the SRS transmissions at separate nodes.

[00023] Furthermore, if the SRS triggering collides, the UE is not able to transmit the expected SRS. SRS triggering collision may refer to any two or more SRS triggering that configure SRSs in same resources, overlapping resources, similar bases sequence or cyclic shift, etc.

Summary

[00024] The object is to obviate at least some of the problems outlined above. In particular, it is an object to provide a UE and a method performed by the UE for transmitting SRSs, the UE being in dual connectivity mode to at least a first network node and a second network node. It is a further object to provide a first network node and a method performed by the first network node for enabling transmission of SRSs from a UE being connected in dual connectivity mode to at

least the first network node and a second network node. These objects and others may be obtained by providing a UE and a first network node and a method performed by a UE and a first network node according to the independent claims attached below.

[00025] According to an aspect a method performed by a UE for transmitting SRSs, the UE being in dual connectivity mode to at least a first network node and a second network node is provided. The method comprises receiving, from the network nodes, a first and a second SRS configuration; and determining if the received first and the second SRS configurations at least partly collide. If the received first and the second SRS configuration collide, the method comprises prioritising between which SRSs to transmit of the received first and second SRS configuration according to a predetermined rule; and transmitting SRSs according to the predetermined rule.

[00026] According to an aspect, a UE adapted for transmitting SRSs, the UE being in dual connectivity mode to at least a first network node and a second network node is provided. The UE comprises a receiving unit adapted for receiving, from the network nodes, a first and a second SRS configuration; and a determining unit adapted for determining if the received first and the second SRS configurations at least partly collide. The UE further comprises a prioritising unit adapted for, if the first and the second SRS configurations collide, prioritising between which SRSs to transmit of the received first and second SRS configuration according to a predetermined rule; and a transmitting unit adapted for transmitting SRSs according to the predetermined rule.

[00027] The UE and the method performed by the UE may have several advantages. One possible advantage is that at least one SRS transmission has a higher chance of being successfully received due to the prioritisation. Another possible advantage is that ambiguity of the network nodes and the UE may be removed. Colliding or partial colliding SRS may be permitted depending on the prioritisation. Further, SRS configuration constraint may be reduced and also the allocated resources for SRS thus improving SRS resource utilisation efficiency.

[00028] According to an aspect, a method performed by a first network node for enabling transmission of SRSs from a UE being connected in dual connectivity mode to at least the first network node and a second network node is provided. The method comprises coordinating, with the second network node, SRS configurations to be used by the UE for transmitting SRSs to both the first and the second network node; and determining at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node based on the coordination with the second network node. The method further comprises transmitting, to the UE, at least the determined first SRS configuration to be used by the UE for transmitting SRSs to the first network node.

[00029] According to an aspect, a first network node adapted for enabling transmission of SRSs from a UE being connected in dual connectivity mode to at least the first network node and a second network node is provided. The first network node comprises a coordinating unit adapted for coordinating, with the second network node, SRS configurations to be used by the UE for transmitting SRSs to both the first and the second network node; and a determining unit adapted for determining at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node based on the coordination with the second network node. The first network node further comprises a transmitting unit adapted for transmitting, to the UE, at least the determined first SRS configuration to be used by the UE for transmitting SRSs to the first network node.

[00030] The first network and the method performed by the first network node may have several advantages. One possible advantage is that the UE may not need to check if the first and the second SRS configuration collide. Another possible advantage is that the first and the second SRS configuration may be optimised for their purpose without colliding at least not more than to a minimum. Still another possible advantage is that ambiguity of the network nodes and the UE may be removed. Colliding or partial colliding SRS may be permitted depending on the prioritisation. Further, SRS configuration constraint may be reduced and also the allocated resources for SRS thus improving SRS resource utilisation efficiency.

Brief description of drawings

[00031] Embodiments will now be described in more detail in relation to the accompanying drawings, in which:

[00032] Figure 1a illustrates a basic LTE downlink physical resource in terms of a time-frequency grid.

[00033] Figure 1b illustrates LTE downlink transmissions organised into radio frames of 10 ms, each radio frame consisting of ten equally-sized subframes.

[00034] Figure 1c illustrates a downlink subframe wherein the three first OFDM symbols are reserved for control signalling.

[00035] Figure 1d illustrates an example uplink transmission subframe.

[00036] Figure 1e shows an example 10ms radio frame for TDD, wherein in each of the two 5-slot subframes the ratio of DL slots to UL slots is 3DL:2UL, and wherein up to eight symbols may be set aside for sounding reference signals.

[00037] Figure 1f illustrates a dual connectivity scenario wherein a wireless terminal participates both in a connection with a macro RBS node and an LPN node.

[00038] Figure 2a is a flowchart of a method performed by a UE for transmitting SRSs, the UE being in dual connectivity mode, according to an exemplifying embodiment.

[00039] Figure 2b is a flowchart of a method performed by a UE for transmitting SRSs, the UE being in dual connectivity mode, according to still an exemplifying embodiment.

[00040] Figure 3a is a flowchart of a method performed by a first network node for enabling transmission of SRSs from a UE being in dual connectivity mode, according to an exemplifying embodiment.

[00041] Figure 3b is a flowchart of a method performed by a first network node for enabling transmission of SRSs from a UE being in dual connectivity mode, according to still an exemplifying embodiment.

[00042] Figure 4 is a block diagram of a UE adapted for transmitting SRSs, the UE being in dual connectivity mode, according to an exemplifying embodiment.

[00043] Figure 5 is a block diagram of a first network node adapted for enabling transmission of SRSs from a UE being in dual connectivity mode, according to an exemplifying embodiment.

[00044] Figure 6a is a block diagram of a UE adapted for transmitting SRSs, the UE being in dual connectivity mode, according to an exemplifying embodiment.

[00045] Figure 6b is block diagram of a UE adapted for transmitting SRSs, the UE being in dual connectivity mode, according to still an exemplifying embodiment.

[00046] Figure 6c is a block diagram of a UE adapted for transmitting SRSs, the UE being in dual connectivity mode, according to yet an exemplifying embodiment.

[00047] Figure 6d is block diagram of a UE adapted for transmitting SRSs, the UE being in dual connectivity mode, according to another exemplifying embodiment.

[00048] Figure 6e is a block diagram of a first network node and a second network node and a UE adapted for transmitting SRSs, the UE being in dual connectivity mode with the first and the second network node, according to an exemplifying embodiment.

[00049] Figure 6f is block diagram of a first network node adapted for enabling transmission of SRSs from a UE being in dual connectivity mode, according to an exemplifying embodiment.

[00050] Figure 6g is a block diagram of a first network node adapted for enabling transmission of SRSs from a UE being in dual connectivity mode, according to an exemplifying embodiment.

[00051] Figure 6h is block diagram of a first network node adapted for enabling transmission of SRSs from a UE being in dual connectivity mode, according to another exemplifying embodiment.

[00052] Figure 6k is block diagram of a first network node adapted for enabling transmission of SRSs from a UE being in dual connectivity mode, according to yet another exemplifying embodiment.

[00053] Figure 7 is a block diagram of an arrangement in a UE adapted for transmitting SRSs, the UE being in dual connectivity mode, according to an exemplifying embodiment.

[00054] Figure 8 is a block diagram of an arrangement in a first network node adapted for enabling transmission of SRSs from a UE being in dual connectivity mode, according to an exemplifying embodiment.

Detailed description

[00055] Briefly described, a UE and a method performed by the UE for transmitting SRSs when the UE is in dual connectivity mode are provided. Further, a first network node and a method performed by the first network node for enabling transmission of SRSs from a UE being in dual connectivity mode with the first network node and a second network node are provided.

[00056] The UE considers transmissions to both the first and the second network node when the UE determines which respective SRS configurations to transmit.

[00057] In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular architectures, interfaces, techniques, etc. in order to provide a thorough understanding of the technology disclosed herein. However, it will be apparent to those skilled in the art that the technology disclosed herein may be practiced in other embodiments that depart

from these specific details. That is, those skilled in the art will be able to devise various arrangements which, although not explicitly described or shown herein, embody the principles of the technology disclosed herein and are included within its spirit and scope. In some instances, detailed descriptions of well-known devices, circuits, and methods are omitted so as not to obscure the description of the technology disclosed herein with unnecessary detail. All statements herein reciting principles, aspects, and embodiments of the technology disclosed herein, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of structure.

[00058] Thus, for example, it will be appreciated by those skilled in the art that block diagrams herein can represent conceptual views of illustrative circuitry or other functional units embodying the principles of the technology. Similarly, it will be appreciated that any flow charts, state transition diagrams, pseudo-code, and the like represent various processes which may be substantially represented in computer readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

[00059] The functions of the various elements including functional blocks, including but not limited to those labelled or described as “computer”, “processor” or “controller”, may be provided through the use of hardware such as circuit hardware and/or hardware capable of executing software in the form of coded instructions stored on computer readable medium. Thus, such functions and illustrated functional blocks are to be understood as being either hardware-implemented and/or computer-implemented, and thus machine-implemented.

[00060] In terms of hardware implementation, the functional blocks may include or encompass, without limitation, digital signal processor (DSP) hardware, reduced instruction set processor, hardware (e.g., digital or analogue) circuitry including but not limited to application specific integrated circuit(s) [ASIC], and/or

Field Programmable Gate Array(s), FPGA(s), and (where appropriate) state machines capable of performing such functions.

[00061] In terms of computer implementation, a computer is generally understood to comprise one or more processors or one or more controllers, and the terms computer and processor and controller may be employed interchangeably herein. When provided by a computer or processor or controller, the functions may be provided by a single dedicated computer or processor or controller, by a single shared computer or processor or controller, or by a plurality of individual computers or processors or controllers, some of which may be shared or distributed. Moreover, use of the term “processor” or “controller” shall also be construed to refer to other hardware capable of performing such functions and/or executing software, such as the example hardware recited above.

[00062] The following terminologies may be used in the disclosure for consistency and simplicity. The technology described herein may apply to a heterogeneous networks comprising macro RBSs together with LPNs, and also to homogeneous networks comprising RBSs of similar or the same transmission power.

[00063] As used herein, the term “node” and/or “network node” may encompass nodes using any technology including, e.g., High Speed Packet Access, HSPA, LTE, CDMA2000, GSM, etc. or a mixture of technologies such as with a multi-standard radio (MSR) node (e.g., LTE/HSPA, GSM/HS/LTE, CDMA2000/LTE etc.). Furthermore the technology described herein may apply to different types of nodes e.g., base station, eNode B, Node B, relay, Base Transceiver Station, BTS, donor node serving a relay node (e.g., donor base station, donor Node B, donor eNB), supporting one or more radio access technologies.

[00064] Nodes that communicate using the air interface also have suitable radio communications circuitry. Moreover, the technology can additionally be considered to be embodied entirely within any form of computer-readable memory, such as solid-state memory, magnetic disk, or optical disk containing an

appropriate set of computer instructions that would cause a processor to carry out the techniques described herein.

[00065] Embodiments of a method performed by the UE for transmitting SRSs, the UE being in dual connectivity mode to at least a first network node and a second network node will now be described with reference to figures 2a and 2b. Figure 2a illustrates the method comprising receiving 210, from the network nodes, a first and a second SRS configuration; and determining 220 if the received first and the second SRS configurations at least partly collide. If the received first and the second SRS configuration collide, the method comprises prioritising 240 between which SRSs to transmit of the received first and second SRS configuration according to a predetermined rule; and transmitting 250 SRSs according to the predetermined rule.

[00066] Figure 2a illustrates that if the received first and the second SRS configurations do not collide, then the UE transmit 230 SRSs according to the received first and second SRS configuration. However, if the received first and the second SRS configuration collide, then the UE should prioritise between the at least two configurations. If the UE should transmit colliding SRSs, they may interfere with each other and the first and/or the second network node may not be able to successfully receive the SRSs.

[00067] By colliding SRSs or colliding SRS configurations means that at least one resource element is comprised in both SRS configurations so that at least one resource element needs to carry one sounding reference symbol intended for the first network node and also a second reference symbol intended for the second network node. It shall be pointed out that there may be more than one resource element is comprised in both SRS configurations and hence the SRS configuration may be partly or completely overlapping. An SRS configuration may define at least one of periodicity and offset, transmission comb, frequency start position, sounding bandwidth and frequency hopping of the SRSs.

[00068] The UE receives a first SRS configuration from the first network node and a second SRS configuration from the second network node. In this manner,

the network nodes inform the UE how it should transmit SRSs in order for the respective network node to receive the SRSs. In case the two network nodes do not communicate, they may not be aware of each other's respective SRS configuration. Thus, when the UE receives the first and the second SRS configuration, the UE determines if the SRS configurations at least partly collide, or overlap. If they do not, then the UE may transmit SRSs accordingly. However, if the two SRS configurations at least partly collide, then the UE prioritises between the first and the second SRS configuration according to a predetermined rule. The predetermined rule will be explained in more detail below. The UE may then transmit SRS according to the predetermined rule, or according to the prioritisation govern by the predetermined rule.

[00069] The method performed by the UE may have several advantages. One possible advantage is that at least one SRS transmission has a higher chance of being successfully received due to the prioritisation. Another possible advantage is that ambiguity of the network nodes and the UE may be removed. Colliding or partial colliding SRS may be permitted depending on the prioritisation. Further, SRS configuration constraint may be reduced and also the allocated resources for SRS thus improving SRS resource utilisation efficiency.

[00070] The SRSs may be periodic SRSs or aperiodic SRSs.

[00071] There are two types of SRS transmission, periodic and aperiodic. Periodic SRS is transmitted at regular time instances as configured by means of RRC signalling. Aperiodic SRS is one shot transmission that is triggered by signalling in the Physical Downlink Control Channel, PDCCH.

[00072] A periodic SRS transmission is performed using a specific set of SRS parameters that is associated with an SRS process or configuration. In case the SRS is a periodic SRS the triggering may be given by RRC signalling. This can be done by assigning each SRS processes or configuration with a unique identifier and the identifier is signalled via RRC signalling to invoke the corresponding SRS configuration. The SRS configuration may also be identified by the signalling structure. By detecting the signalling structure, it determines which SRS is

triggered. Each SRS configuration is independently configured from each other, e.g. defined within a unique RRC IE.

[00073] For the case of an aperiodic SRS transmission a basic configuration may be configured through RRC signalling in a similar manner as for the periodic SRS, and which SRS configuration is triggered is dynamically signalled.

[00074] Examples of ways to for the eNB to trigger a specific SRS configuration or processes are as follows:

- Evolved PDCCH, ePDCCH, set that the triggering Downlink Control Information, DCI, message was sent from. Two ePDCCH set may be configured simultaneously for each node. Each ePDCCH set is with independent ePDCCH configuration. In this example, an SRS configuration is associated with the ePDCCH set in a predefined manner. Thus by detecting which ePDCCH set is used for DCI transmission, which SRS configuration shall be triggered is implicitly signalled by the ePDCCH set.
- Radio Network Temporary Identifier, RNTI, that scrambled the DCI messages Cyclic Redundancy Check, CRC. In this example, different SRS configuration is associated with different RNTI. For the same DCI contents but with different SRS configuration, different RNTI may be used for DCI messages scramble. The detected RNTI implicitly indicate which SRS configuration shall be triggered.
- Different types of DCI message that triggers aperiodic SRS. For example, if the SRS trigger is carried in a DCI formats that schedule DL assignments, it may trigger one SRS configuration, and if the SRS trigger is carried in a DCI message that is associated with an UL grant, it may trigger another SRS configuration.
- Bit combination and DCI format that was used to trigger an aperiodic SRS. In this example, which SRS configuration shall be triggered is explicitly signalling in the DCI. A new field shall be added on current DCI to explicitly indicate the SRS configuration.

[00075] The method may further comprise receiving, from the network nodes, a first and a second trigger for transmitting aperiodic SRSs.

[00076] In case of aperiodic SRS, the UE may receive the first and the second trigger for transmitting aperiodic SRSs, e.g. by means of signalling in the PDCCH. In this case, the trigger informs the UE that it shall transmit SRSs according to the first and the second received SRS configuration. The UE determines if the received first and the second SRS configurations at least partly collide and if not, the UE will transmit the aperiodic SRSs according to the received first and second SRS configuration. If the SRS configurations do collide, the UE prioritises according to the predetermined rule as described above.

[00077] In case of periodic SRS, the reception of the first and the second SRS configuration from the first and the second network node, no explicit trigger is needed.

[00078] The predetermined rule may indicate to the UE to prioritise aperiodic SRS transmission over periodic SRS transmission.

[00079] In case one of the SRS transmissions is an aperiodic SRS transmission and the other SRS transmission is a periodic SRS transmission, and in case the SRS configuration for the aperiodic SRS transmission at least partly collide with the SRS configuration for the periodic SRS transmission, then the UE may prioritise the aperiodic SRS transmission over periodic SRS transmission. In other words, the UE may transmit only the aperiodic SRS and refrain from transmitting the periodic SRS configuration. Since the transmission of periodic SRSs will be done periodically and the transmission of the aperiodic SRS is to be done only one, the UE will thus skip the transmission of the periodic SRS and only transmit the aperiodic SRS. The reason may be that the base station expecting to receive a periodic SRS may recover from not receiving an instance of the periodic SRS, whereas the network node expecting to receive one aperiodic SRS may be more severely affected by not receiving the expected aperiodic SRS.

[00080] The predetermined rule may indicate to the UE to prioritise SRS transmission used for estimating the least static uplink channel.

[00081] Different uplink channels may be more or less static. One of the uplinks channels may be relatively static whereas the other is relatively varying or fluctuating. Since the SRSs may be used for estimating the channel, it may be more important to estimate a relatively varying or fluctuating channel than a relatively static channel. Hence, the predetermined rule may indicate to the UE to prioritise SRS transmission used for estimating the least static uplink channel, i.e. the most relatively varying or fluctuating channel.

[00082] Merely as an example, in case the UE and the network nodes are employed in a heterogeneous communication network comprising of macro network nodes and LPN network nodes, an uplink channel to a LPN network node may be more static than the uplink channel to a macro network node. If so, then the SRS transmission to the LPN network node may be prioritised.

[00083] The predetermined rule may indicate to the UE, in case of Time division Duplex, TDD, operations, to prioritise SRS transmission to one of the two network nodes in the last symbol of a subframe and to the other network node in an Uplink Pilot Time Slot, UpPTS.

[00084] In TDD the uplink and downlink channels are separated in the time domain and sharing the same frequency. The duration of one LTE radio frame is 10 ms. One frame is divided into 10 subframes of 1 ms each, and each subframe is divided into two slots of 0.5 ms each. Each slot contains either six or seven OFDM symbols, depending on the Cyclic Prefix, CP, length. Subframes 0 and 5 are downlink subframes as they contain synchronisation signal and broadcast information necessary for the UE to perform synchronisation and obtain relevant system information. Subframe 1 is a special subframe that serves as a switching point between downlink to uplink transmission. It contains three fields - Downlink Pilot Time Slot, DwPTS, Guard Period, GP, and UpPTS. The predetermined rule may thus indicate to the UE to prioritise SRS transmission to one of the two network nodes in the last symbol of a subframe and to the other network node in an Uplink Pilot Time Slot, UpPTS. Thus both network nodes may receive SRSs, one of the network nodes receives the SRS in the last symbol of a subframe and the other node receives the SRS in a UpPTS.

[00085] In an example for TDD, when two Single Carrier Frequency Division Multiple Access, SC-FDMA, symbols exist in UpPTS, either two SC-FDMA symbols may be used for one SRS transmission as in above example or each SC-FDMA symbol may be used separately for SRS transmission intended for different network nodes.

[00086] The method may further comprise receiving signalling from the network nodes indicating an intended purpose of the respective SRS transmissions, wherein the predetermined rule indicates to the UE which SRS transmission to prioritise based on the intended purpose of the respective SRS transmissions.

[00087] Merely as an example, the network nodes may signal to the UE the purpose of SRSs and the UE may then prioritise according to the predetermined rule. The rule may be that transmissions of SRSs for frequency selective scheduling must take precedence over transmissions of SRSs for downlink beamforming. In case of dual connectivity with UL/DL split in Frequency Division Duplex, FDD, the purpose of SRS transmission may be clear. In an UL data link, the SRS is likely to be used for UL scheduling, but not for DL beamforming. In the case of TDD, the UL SRS may be used for beamforming in DL, thus the decision may be reversed.

[00088] The predetermined rule may indicate to the UE to prioritise SRS transmission autonomously.

[00089] In such a case, the UE may determine which SRS to prioritise at its own volition, i.e. selecting for itself which SRS to prioritise. For example, the UE may, in the event of colliding SRS transmission, select to transmit one SRS and deny another one.

[00090] The selection which SRS to prioritise may be based on quality of the link or the ongoing UL traffic, etc. The UE may inform the relevant network node about a denied SRS transmission. In another embodiment, the UE may select to which network node the SRS is to be transmitted to, based on its previous SRS transmission, thus finding a fair SRS transmission between the network nodes. For

example, if the UE has transmitted an aperiodic SRS to one network node, then the other network node may be prioritised when the UE transmits the next SRS.

[00091] The method may further comprise the UE informing 250 at least one of the first and the second network node about the determined collision between the first and the second SRS configuration.

[00092] Since the collision may result in that at least one of the network nodes may not receive SRS according to the SRS configuration it has previously sent to the UE. Hence, the UE informs at least one of the first and the second network node, for example the network node which will not receive an expected SRS, about the collision and optionally also about the prioritisation between the first and the second SRS configuration. In this manner, a network node having sent an SRS configuration to the UE and thus is expecting to receive an SRS accordingly is informed that it will not receive the expected SRS. By doing so, the network node is enabled to send a new SRS configuration, or optionally also a new trigger, to the UE in order to receive SRS at a later stage. If the UE send information indicating collision to the first network node, the information may comprise the second SRS configuration. If the UE received the second SRS configuration from the second network node, the first network node may be unaware of the second SRS configuration. Likewise, the UE may send the first SRS configuration to the second network node when informing the second network node of the collision.

[00093] According to an embodiment, the first and second SRS configuration are associated with a respective SRS process defining at least one of periodicity and offset, transmission comb, frequency start position, sounding bandwidth and frequency hopping of the SRSs.

[00094] Thus, instead of sending all information of an SRS configuration, the network node may simply send an indicator to identify which SRS configuration the network node requests the UE to use for transmitting SRSs. The indicator may in an example be an index of an SRS-book of SRS configurations. Thus each SRS configuration of the SRS-book may be identified by an indicator. In this manner, the network nodes need not send all information pertaining to the respective SRS

configuration, but merely an indicator, which saves downlink signalling resources. An advantage of having the UE being configured with (or comprising) a plurality of e.g. cell-specific SRS configurations may be that a dual connected UE may be configured to respect SRS regions of two different network nodes.

[00095] As described above, the first and a second SRS trigger may be received by means of evolved ePDCCH set that a DCI was sent from, or RNTI that was used to scramble the CRC of the DCI message, or the type of the DCI message, or a bit combination and DCI format that was used to trigger an aperiodic SRS.

[00096] Embodiments herein also relate to a method performed by a first network node for enabling transmission of SRSs from a UE being connected in dual connectivity mode to at least the first network node and a second network node. Embodiments of such a method will now be described with reference to figures 3a and 3b.

[00097] Figure 3a illustrates the method comprising coordinating 310, with the second network node, SRS configurations to be used by the UE for transmitting SRSs to both the first and the second network node; and determining 320 at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node based on the coordination with the second network node. The method further comprises transmitting 330, to the UE, at least the determined first SRS configuration to be used by the UE for transmitting SRSs to the first network node.

[00098] The first network node may communicate with the second network node, e.g. by means of an X2-interface if the two network nodes are employed in an LTE based communication system. In case the communication system is e.g. GSM or UMTS, the two network nodes may possibly not communicate directly but instead via e.g. BSC or an RNC. Independently of how the communication between the network nodes is performed, the first and the second network node coordinate with each other which SRS configurations they would like to use. Different uplink radio conditions such as e.g. interference level and bit or block error rate may require a specific SRS configuration. Further, the purpose for the SRSs may require another

specific SRS configuration. Hence, the first and the second network node coordinate which SRS configuration the first network node should request and which SRS configuration the second network node should request. In this manner, the first and the second network node may ensure that the two SRS configurations, i.e. the first and the second SRS configuration, do not collide/overlap or only partly collide to a minimum.

[00099] The coordination may in an example be a sort of negotiation between the first and the second network node. For example, they may compare their respective desired SRS configurations in order to find two SRS configurations (one desired by the first network node and one desired by the second network node) that does not collide or only collide to a minimum with each other. Then the first network node may determine one of them to be the first SRS configuration, and optionally also determine the other SRS configuration to be the second SRS configuration.

[000100] The first network node may alternatively be in control of both SRS configurations so that it is the first network node that determines both the first and the second SRS configuration, based on the coordination with the second network node. In such a scenario, the coordination is more controlled by the first network node such that the first network node receives at least one desired SRS configuration from the second network node. For example, the first network node may receive a couple of different SRS configurations from the second network node and the first network node may compare the received SRS configurations with the SRS configuration(s) it desires itself. Possibly at least one of the SRS configurations desired by the second network node does not collide or only collide to a minimum with an SRS configuration desired by the first network node. Then the first network node may simply determine both the first and the second SRS configuration based on the at least one of the SRS configurations desired by the second network node that does not collide or only collide to a minimum with the SRS configuration desired by the first network node.

[000101] It may further be that the first network node receives one or more SRS configurations from the second network node but that all of the received SRS

configurations do collide with SRS configurations desired by the first network node. If so, the first network node may determine the first network node to be any of the SRS configurations desired by the first network node. The first network node may identify an SRS configuration that is somewhat similar to the received one or more SRS configurations but that does not collide with the determined first SRS configuration. Thus the first network node determines the second SRS configuration to be the identified SRS configuration hat does not collide with the determined first SRS configuration.

[000102] Once the first network node has coordinated SRS configurations with the second network node and determined at least the first SRS configuration to be used by the UE for transmitting SRSs to the first network node, the first network node transmits at least the determined first SRS configuration to be used by the UE for transmitting SRSs to the first network node.

[000103] Merely as an example, in case the first network node is a macro network node and the second network node is a low power network node, then the first network node may be in control of the second network node and hence may determine both the first and the second SRS configuration and optionally also send both the first and the second SRS configuration to the UE.

[000104] The method performed by the first network node may have several advantages. One possible advantage is that the UE may not need to check if the first and the second SRS configuration collide. Another possible advantage is that the first and the second SRS configuration may be optimised for their purpose without colliding at least not more than to a minimum. Still another possible advantage is that ambiguity of the network nodes and the UE may be removed. Colliding or partial colliding SRS may be permitted depending on the prioritisation. Further, SRS configuration constraint may be reduced and also the allocated resources for SRS thus improving SRS resource utilisation efficiency.

[000105] The SRS configurations may be intended for aperiodic SRS transmission, wherein the method further comprises transmitting a trigger for the transmission of aperiodic SRS to the UE.

[000106] In case the SRS configurations are intended for periodic SRS transmission, no trigger is needed but the first and the second SRS configuration can be seen as a trigger themselves. If the SRS configurations are intended for aperiodic SRS transmission, then the first network node may transmit at least a trigger for the first SRS configuration, meaning that the first network node sends at least a first trigger for triggering the UE to send at least an SRS transmission to the first network node according to the first SRS configuration. The first network node may optionally also send a second trigger to the UE for triggering the UE to send an SRS transmission to the second network node according to the second SRS configuration.

[000107] Coordinating 310 SRS configurations may comprise determining to multiplex the SRS resources in time or frequency the first SRS configuration associated with the first network node and a second SRS configuration associated with the second network node.

[000108] By multiplexing the SRS resources in time or frequency, it may be possible to avoid collision of SRS transmissions when transmitted according to the first and the second SRS configuration. If both the first and the second network node are aware of how the UE will multiplex the SRS resources when transmitting SRSs according to the first and the second SRS configuration, both the first and the second network node will be able to receive their respective SRS transmission accordingly.

[000109] As described above, coordinating 310 SRS configurations may comprise exchanging cell specific SRS configurations between the first and the second network node.

[000110] The method may further comprise receiving 305 information from the UE indicating collision between the first SRS configuration and a second SRS configuration associated with the second network node, wherein determining 320 at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node further is based on the received information indicating collision between the first SRS configuration and the second SRS configuration.

[000111] In such a scenario, the first network node has transmitted at least the first SRS configuration to the UE. If the first network node has not also transmitted the second SRS configuration to the UE, then the second network node has transmitted the second SRS configuration to the UE. The UE has determined that the first and the second SRS configuration at least partly collide, meaning that a transmission of SRS according the first SRS configuration would at least partly collide with a transmission of SRS according the second SRS configuration. Thus the UE informs at least the first network node about the detected collision between the first SRS configuration and the second SRS configuration.

[000112] The first network node may take this information into account when determining a new first SRS configuration and/or a new second SRS configuration. In other words, the first network node may itself, or by coordinating with the second network node, modify one or both of the first and the second SRS configuration in order to find two individual SRS configurations that do not collide.

[000113] Merely as an example, in case the first network node may choose another first SRS configuration, there is no need to coordinate with the second network node in order to determine the new first network node. In case the first network node wants to change, or find a new, second SRS configuration then the first network node may coordinate with the second network node since the second SRS configuration is relevant for the second network node.

[000114] Embodiments herein also relate to a UE adapted for transmitting SRSs the UE being connected in dual connectivity mode to at least a first network node and a second network node. The UE has the same technical features, objects and advantages as the method performed by the UE. The UE will only be described in brief in order to avoid unnecessary repetition.

[000115] Figure 4 is a block diagram of a UE adapted for transmitting SRSs the UE being connected in dual connectivity mode to at least a first network node and a second network node, according to an exemplifying embodiment.

[000116] Figure 4 illustrates the UE 400 comprising a receiving unit 402 adapted for receiving, from the network nodes, a first and a second SRS configuration; and a determining unit 403 adapted for determining if the received first and the second SRS configurations at least partly collide. The UE 400 further comprises a prioritising unit 404 adapted for, if the first and the second SRS configurations collide, prioritising between which SRSs to transmit of the received first and second SRS configuration according to a predetermined rule; and a transmitting unit 405 adapted for transmitting SRSs according to the predetermined rule.

[000117] The UE has the same possible advantages as the method performed by the UE. One possible advantage is that at least one SRS transmission has a higher chance of being successfully received due to the prioritisation. Another possible advantage is that ambiguity of the network nodes and the UE may be removed. Colliding or partial colliding SRS may be permitted depending on the prioritisation. Further, SRS configuration constraint may be reduced and also the allocated resources for SRS thus improving SRS resource utilisation efficiency.

[000118] The SRSs may be periodic SRSs or aperiodic SRSs.

[000119] The receiving unit 402 may further be adapted for receiving, from the network nodes, a first and a second trigger for transmitting aperiodic SRSs.

[000120] Further, the predetermined rule may indicate to the UE to prioritise aperiodic SRS transmission over periodic SRS transmission.

[000121] Additionally or alternatively, the predetermined rule may indicate to the UE to prioritise SRS transmission used for estimating the least static uplink channel.

[000122] Further, the predetermined rule may indicate to the UE to, in case of TDD, operations, to prioritise SRS transmission to one of the two network nodes in the last symbol of a subframe and to the other network node in an UpPTS.

[000123] The receiving unit 402 may further be adapted for receiving signalling from the network nodes indicating an intended purpose of the respective SRS transmissions, wherein the predetermined rule indicates to the UE which SRS transmission to prioritise based on the intended purpose of the respective SRS transmissions.

[000124] Still further, the predetermined rule may indicate to the UE to prioritise SRS transmission autonomously.

[000125] The UE may further comprise an informing unit 406 adapted for informing at least one of the first and the second network node about the determined collision between the first and the second SRS configuration.

[000126] According to an embodiment, the first and second SRS configuration are associated with a respective SRS process defining at least one of periodicity and offset, transmission comb, frequency start position, sounding bandwidth and frequency hopping of the SRSs.

[000127] The receiving unit 402 may further be adapted for receiving the first and a second SRS trigger by means of ePDCCH, set that a DCI was sent from, or RNTI that was used to scramble the CRC of the DCI message, or the type of the DCI message, or a bit combination and DCI format that was used to trigger an aperiodic SRS.

[000128] Embodiments herein also relate to a first network node adapted for enabling transmission of SRSs from a UE being connected in dual connectivity mode to at least the first network node and a second network node. The first network node has the same technical features, objects and advantages as the method performed by the first network node. The first network node will only be described in brief in order to avoid unnecessary repetition.

[000129] Figure 5 is a block diagram of a first network node adapted for enabling transmission of SRSs from a UE being connected in dual connectivity mode to at least the first network node and the second network node, according to an exemplifying embodiment.

[000130] Figure 5 illustrates the first network node 500 comprising a coordinating unit 502 adapted for coordinating, with the second network node, SRS configurations to be used by the UE for transmitting SRSs to both the first and the second network node; and a determining unit 503 adapted for determining at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node based on the coordination with the second network node. The first network node further comprises a transmitting unit 504 adapted for transmitting, to the UE, at least the determined first SRS configuration to be used by the UE for transmitting SRSs to the first network node.

[000131] The first network node has the same possible advantages as the method performed by the first network node. One possible advantage is that the UE may not need to check if the first and the second SRS configuration collide. Another possible advantage is that the first and the second SRS configuration may be optimised for their purpose without colliding at least not more than to a minimum. Still another possible advantage is that ambiguity of the network nodes and the UE may be removed. Colliding or partial colliding SRS may be permitted depending on the prioritisation. Further, SRS configuration constraint may be reduced and also the allocated resources for SRS thus improving SRS resource utilisation efficiency.

[000132] The SRS configurations may be intended for aperiodic SRS transmission, wherein the transmitting unit 504 further is adapted for transmitting a trigger for the transmission of aperiodic SRS to the UE.

[000133] The coordinating unit 502 may be adapted for coordinating SRS configurations by determining to multiplex the SRS resources in time or frequency the first SRS configuration associated with the first network node and a second SRS configuration associated with the second network node.

[000134] The coordinating unit 502 may further be adapted for coordinating SRS configurations by exchanging cell specific SRS configurations between the first and the second network node.

[000135] The first network node may further comprise a receiving unit 505 adapted for receiving information from the UE indicating collision between the first SRS configuration and a second SRS configuration associated with the second network node, wherein the determining unit 503 further is adapted for determining at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node further is based on the received information indicating collision between the first SRS configuration and the second SRS configuration.

[000136] Figure 6a is a block diagram of a UE adapted for transmitting SRSs, the UE being in dual connectivity mode, according to an exemplifying embodiment. Figure 6a illustrates a network including a wireless terminal, i.e. the UE, comprising plural SRS processes and configured for dual connectivity with two network nodes.

[000137] Figure 6a shows portions of an example telecommunications network, and particularly two network nodes, e.g., first network node 630 and second network node 640 and a UE 600. The first network node 630 and second network node 640 may or may not be members of a same RAN. In an LTE context the first network node and the second network node may be base station nodes. In other contexts or other types of RANs, the first network node and the second network node may be a base station node or other type of node, such as an RNC node, for example.

[000138] Figure 6a further also shows a UE 600 which communicates over a radio or air interface (indicated by the dotted-dashed line) with the two network nodes 630 and 640. The UE 600 comprises a communications interface 601 configured to facilitate communications over the radio interface between the UE and the network nodes, including dual connectivity wireless communications utilising a radio frame structure. In the dual connectivity wireless communications transmissions occur essentially concurrently between the UE and the plural network nodes.

[000139] The UE also comprises a processor 602, also known as a frame processor. The processor 602 is configured to handle both uplink and downlink

transmissions which are scheduled in the radio frame structure. For uplink purposes the radio frame structure may be described, at least in part, with reference to figure 1d and/or figure 1e. As such the organisation of the frame structure may be specified by one or more network nodes and expressed in one or more control channels of the radio frame, as previously explained. In accordance with such frame organisation the frame processor of the UE receives signals and data in downlink transmissions of the frame structure and transmits appropriate signals and data in uplink transmissions of the frame structure, and does so for both network nodes when participating in dual connectivity operations.

[000140] The frame processor 602 includes an SRS processor 603 which executes plural SRS processes 604 and 605 when engaging in the dual connectivity wireless communications. When the UE 600 is in dual connectivity wireless communications, each of the SRS processes 604 and 605 are configured to provide SRSs in the frame structure to a respective one of the plural network nodes 630 and 640.

[000141] In an example, the concept of SRS transmissions is defined in terms of SRS processes. An SRS process may be defined by a set of specific, unique parameters that define the possibility to transmit SRS in a set of subframes. Such parameters may be, for example, separate SRS configurations such as sounding subframe configuration (periodicity and offset), transmission comb [SRS transmissions from two terminals can be frequency multiplexed by assigning them to different frequency shifts or “combs”], frequency start position, sounding bandwidth, frequency hopping etc.. For the UE with dual connectivity, each set of SRS configurations is associated (implicitly or explicitly) with one node.

[000142] In a further example, the UE can be configured so that one periodic SRS transmission is performed using a specific set of SRS parameters that is associated with the SRS process. This is illustrated in simplified, representative fashion in figure 6b, where a particular SRS process (SRS process 1 having reference sign 604) is shown as being configured with a specific set of SRS parameters that is to be associated with the SRS process. Figure 6b shows that the configuration of the SRS process may occur via higher layer signalling. As

used herein, “higher layer signalling” includes any signalling that is out-of-band of the radio frame structure, e.g., that is transmitted or received outside of the radio frame structure. As such, “higher layer signalling” may include RRC signalling, for example. The source of the higher layer signalling that configures the SRS process of the UE is not explicitly illustrated in figure 6b, it being understood that such higher layer signalling may originate at either the network first node or the network second node.

[000143] Figure 6b further indicates that the signalling which configures the SRS process, e.g. provides SRS parameters to the SRS process, may also provide other parameters for the UE. Such other parameters may comprise, for example, pathloss reference, timing advance and power control commands associated with a specific reference cell or reference node.

[000144] Figure 6c illustrates that the SRS processor 603 may have access to a bank of SRS processes 607, one or more of which may be configured, e.g. in the manner of figure 6b. For example, figure 6c illustrates that the SRS processes 604-606 available to the UE may be SRS process 1, SRS process 2, up to and including SRS process n, having reference signs 604, 605 and 606.

[000145] Figure 6d illustrates that the SRS processor 603 may receive an execution signal or the like which specifies which of the SRS processes 604-606 is to be executed by the UE when the UE is in dual connectivity. The SRS processor 603 comprises an execution trigger detector 607which detects an indication of which of the SRS processes is to be triggered for execution by the UE. In this further example, which SRS processes that are triggered to be transmitted may be given in different ways. In case the SRS is a periodic SRS the triggering may be given by RRC configuration. This may be done by assigning each SRS processes with a unique identifier, and the identifier is signalled via RRC signalling to invoke the corresponding SRS process. The SRS process can also be identified by the signalling structure. By detecting the signalling structure, it determines which SRS is triggered. Each SRS process is independently configured from each other, e.g. defined within a unique RRC IE.

[000146] For the case of an aperiodic SRS transmission a basic configuration may be configured through RRC signalling in a similar manner as for the periodic SRS, and which SRS process is triggered may be dynamically signalled. Examples of ways for a network node to trigger a specific SRS process are given above.

[000147] According to another example, the two network nodes may coordinate the SRS configurations for the two uplinks such that the two SRS transmissions do not collide or overlap or interfere with each other. For example the SRS for the two network nodes may be multiplexed in time, or multiplexed in frequency by using different subcarriers for the two SRS transmissions.

[000148] The foregoing is illustrated in an exemplifying representative manner by figure 6e. Figure 6e shows each of the network nodes 630 and 640 as comprising a communications interface 631 and 641 respectively for communicating over the radio interface with the UE 600; a communications interface 632 and 642 for communicating with the other network node via e.g. an X2 interface or other new interface; and, a frame processor 633 and 643 respectively. The node frame processor 633 and 643 respectively includes an SRS scheduler 634 and 644 respectively, which in turn comprises a dual connectivity SRS coordinator 635 and 645 respectively. In this example, pre-configured cell specific SRS configurations may be exchanged between (or made available at) the at least two network nodes 630 and 640 participating in a dual connection to the UE 600. Moreover, an eNodeB (or network node) could be informed (or determine), which (if not all) of these cell-specific SRS configurations are configured for a specific UE.

[000149] When a UE transmits uplink channels not mapped onto resource elements reserved for SRS transmissions (such as PUSCH and PUCCH), the UE will respect all (or at least a plurality) of the cell specific SRS configurations configured for the UE. For an eNodeB (e.g. a network node) to decode the channel (e.g., PUSCH or PUCCH), it can derive the used resource element mapping from the cell specific SRS configurations received from the other nodes.

Moreover, each eNodeB may schedule and configure SRS transmissions, for a UE, in a particular associated cell-specific SRS configuration.

[000150] In an example, at least two configured cell-specific SRS configurations are non-overlapping, in which case the SRS transmissions for the two network nodes may be uncoordinated, since the SRS transmissions cannot collide. In another embodiment the cell-specific configurations at least partially overlap or collide, in which case a collision handling mechanism as outlined herein could be applied. One example of identifying at least two non-colliding SRS configurations is the coordination between the network nodes as illustrated in figure 6e.

[000151] Figure 6f shows the dual connectivity SRS coordinator 635 of one network node, e.g. the first network node, 630 as comprising selection logic 636. The function of selection logic in the figure 6f example is to select between time multiplexing 637 of the SRSs for the two connections or frequency multiplexing 638 of the SRSs for the two connections. As indicated in figure 6f, the selection performed by the logic 636 may be either predefined or autonomous (e.g., not predefined, but based on other criteria within the discretion of the network node). The selection logic of figure 6g differs in that the selection pertains to which of the network nodes will be allocated its SRS in a normal uplink subframe and which will be allocated its SRS in UpPTS. Figure 6g thus reflects a special embodiment for TDD, wherein the SRS transmission may be configured for one node in UpPTS and the SRS transmission to another node in a normal uplink subframe. The attachment of the SRS transmission to the network nodes either with UpPTS or with normal uplink subframes may either be predefined, or it can be decided by one network node which can also inform the other network node in dual connectivity about this arrangement. In a second version of the same example, the UpPTS is configured with two OFDM symbols wherein each network node is using a specific OFDM symbol for its transmissions of SRS, for a UE being connected to both nodes.

[000152] In another example, illustrated by figure 6h, when a UE receives colliding SRS configurations either in time or in frequency, the UE may prioritise according to a predetermined rule. Figure 6h shows that the SRS processor 603

may include a SRS conflict prioritiser 608. The SRS conflict prioritiser 608 is configured to operate based on certain conflict rules. Example conflict rules are described above.

[000153] In another example, illustrated by way of example in figure 6k, in the event of colliding SRS transmission, the UE 600 may select to transmit one SRS and deny another one autonomously. Figure 6k particularly shows the SRS processor 603 as comprising a SRS selector 609. The SRS selector 609 operates on the basis of selection criteria.

[000154] The selection can be based on quality of the link or the ongoing uplink traffic, etc. The UE may inform the relevant network node about a denied SRS transmission. In another example, the UE may select to which network node the SRS is to be transmitted to, based on its previous SRS transmission, thus finding a fair SRS transmission between the network nodes. For example, if a UE has transmitted an aperiodic SRS to one network node, then the other network node may be prioritised when the UE transmits the next SRS.

[000155] All periodic SRS configurations, for both nodes, may be constrained to the same cell specific SRS configuration. In a further such example, the cell specific SRS configuration of a first network node is transmitted to a second network node, which will respect the cell specific SRS configuration when configuring any periodic SRS or when scheduling dynamic SRS transmissions.

[000156] In example embodiments described herein or otherwise encompassed hereby, various elements or units which are bounded or enclosed by broken lines, such as the frame processors described herein, may be realised by a machine platform. The terminology “machine platform” is a way of describing how the functional units may be implemented or realised by machine. The machine platform can take any of several forms, such as (for example) electronic circuitry in the form of a computer implementation platform or a hardware circuit platform. A computer implementation of the machine platform may be realised by or implemented as one or more computer processors or controllers as those terms are herein expansively defined, and which may execute instructions stored on

non-transient computer-readable storage media. In such a computer implementation the machine platform may comprise, in addition to a processor(s), a memory section (which in turn can comprise random access memory; read only memory; an application memory (a non-transitory computer readable medium which stores, e.g. coded non instructions which can be executed by the processor to perform acts described herein); and any other memory such as cache memory, for example). Another example platform suitable is that of a hardware circuit, e.g. an Application Specific Integrated Circuit, ASIC, wherein circuit elements are structured and operated to perform the various acts described herein.

[000157] In figure 4, the UE 400 is also illustrated comprising a receiving interface 411 and a transmitting interface 412. Through these two interfaces, the UE 400 is adapted to communicate with other nodes and/or entities in the wireless communication network. The receiving interface 411 may comprise more than one receiving arrangement. For example, the receiving interface may be connected to both a wire and an antenna, by means of which the UE 400 is enabled to communicate with other nodes and/or entities in the wireless communication network. Similarly, the transmitting interface 412 may comprise more than one transmitting arrangement, which in turn are connected to both a wire and an antenna, by means of which the UE 400 is enabled to communicate with other nodes and/or entities in the wireless communication network. The UE 400 further comprises a memory 401 for storing data. Further, the UE 400 is illustrated comprising a control or processing unit 406 which in turns is connected to the different units 402-405. It shall be pointed out that this is merely an illustrative example and the UE 400 may comprise more, less or other units or modules which execute the functions of the UE 400 in the same manner as the units illustrated in figure 4.

[000158] It should be noted that figure 4 merely illustrates various functional units in the UE 400 in a logical sense. The functions in practice may be implemented using any suitable software and hardware means/circuits etc. Thus, the embodiments are generally not limited to the shown structures of the UE 400 and the functional units. Hence, the previously described exemplary embodiments

may be realised in many ways. For example, one embodiment includes a computer-readable medium having instructions stored thereon that are executable by the control or processing unit 406 for executing the method steps in the UE 400. The instructions executable by the computing system and stored on the computer-readable medium perform the method steps of the UE 400 as set forth in the claims.

[000159] In figure 5, the Network Node 500 is also illustrated comprising a receiving interface 511 and a transmitting interface 512. Through these two interfaces, the Network Node 500 is adapted to communicate with other nodes and/or entities in the wireless communication network. The receiving interface 511 may comprise more than one receiving arrangement. For example, the receiving unit may be connected to both a wire and an antenna, by means of which the Network Node 500 is enabled to communicate with other nodes and/or entities in the wireless communication network. Similarly, the transmitting interface 512 may comprise more than one transmitting arrangement, which in turn are connected to both a wire and an antenna, by means of which the Network Node 500 is enabled to communicate with other nodes and/or entities in the wireless communication network. The Network Node 500 further comprises a memory 501 for storing data. Further, the Network Node 500 is illustrated comprising a control or processing unit 506 which in turns is connected to the different units 502-505. It shall be pointed out that this is merely an illustrative example and the Network Node 500 may comprise more, less or other units or modules which execute the functions of the Network Node 500 in the same manner as the units illustrated in figure 5.

[000160] It should be noted that figure 5 merely illustrates various functional units in the Network Node 500 in a logical sense. The functions in practice may be implemented using any suitable software and hardware means/circuits etc. Thus, the embodiments are generally not limited to the shown structures of the Network Node 500 and the functional units. Hence, the previously described exemplary embodiments may be realised in many ways. For example, one embodiment includes a computer-readable medium having instructions stored thereon that are executable by the control or processing unit 506 for executing the method steps in

the Network Node 500. The instructions executable by the computing system and stored on the computer-readable medium perform the method steps of the Network Node 500 as set forth in the claims.

[000161] Figure 7 schematically shows an embodiment of an arrangement in a UE 700. Comprised in the UE 700 are here a processing unit 706, e.g. with a DSP (Digital Signal Processor). The processing unit 706 may be a single unit or a plurality of units to perform different actions of procedures described herein. The UE 700 may also comprise an input unit 702 for receiving signals from other entities, and an output unit 704 for providing signal(s) to other entities. The input unit and the output unit may be arranged as an integrated entity or as illustrated in the example of figure 4, as one or more interfaces 411/412.

[000162] Furthermore, the UE 700 comprises at least one computer program product 708 in the form of a non-volatile memory, e.g. an EEPROM (Electrically Erasable Programmable Read-Only Memory), a flash memory and a hard drive. The computer program product 708 comprises a computer program 710, which comprises code means, which when executed in the processing unit 706 in the UE 700 causes the UE 700 to perform the actions e.g. of the procedure described earlier in conjunction with figures 2a and 2b.

[000163] The computer program 710 may be configured as a computer program code structured in computer program modules 710a-710e. Hence, in an exemplifying embodiment, the code means in the computer program of the UE 700 comprises a receiving unit, or module, for receiving, from the network nodes, a first and a second SRS configuration. The computer program further comprises a determining unit, or module, for determining, if the received first and the second SRS configurations at least partly collide. The computer program further comprises a prioritising unit, or module, for prioritising between which SRSs to transmit of the received first and second SRS configuration according to a predetermined rule if the first and the second SRS configurations collide. The computer program still further comprises a transmitting unit, or module, for transmitting, SRSs according to the predetermined rule.

[000164] The computer program modules could essentially perform the actions of the flow illustrated in figures 2a and 2b, to emulate the UE 400, 700. In other words, when the different computer program modules are executed in the processing unit 706, they may correspond to the units 402-405 of figure 4.

[000165] Figure 8 schematically shows an embodiment of an arrangement in a network node 800. Comprised in the network node 800 are here a processing unit 806, e.g. with a DSP (Digital Signal Processor). The processing unit 806 may be a single unit or a plurality of units to perform different actions of procedures described herein. The network node 800 may also comprise an input unit 802 for receiving signals from other entities, and an output unit 804 for providing signal(s) to other entities. The input unit and the output unit may be arranged as an integrated entity or as illustrated in the example of figure 5, as one or more interfaces 511/512.

[000166] Furthermore, the network node 800 comprises at least one computer program product 808 in the form of a non-volatile memory, e.g. an EEPROM (Electrically Erasable Programmable Read-Only Memory), a flash memory and a hard drive. The computer program product 808 comprises a computer program 810, which comprises code means, which when executed in the processing unit 806 in the network node 800 causes the network node 800 to perform the actions e.g. of the procedure described earlier in conjunction with figures 3a and 3b.

[000167] The computer program 810 may be configured as a computer program code structured in computer program modules 810a-810e. Hence, in an exemplifying embodiment, the code means in the computer program of the network node 800 comprises a coordinating unit, or module, for coordinating, with the second network node, SRS configurations to be used by the UE for transmitting SRSs to both the first and the second network node. The computer program further comprises a determining unit, or module, for determining at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node based on the coordination with the second network node. The computer program further comprises a transmitting unit, or module, for

transmitting, to the UE, at least the determined first SRS configuration to be used by the UE for transmitting SRSs to the first network node.

[000168] The computer program modules could essentially perform the actions of the flow illustrated in figures 3a and 3b, to emulate the network node 500, 800. In other words, when the different computer program modules are executed in the processing unit 806, they may correspond to the units 502-5058 of figure 5.

[000169] Although the code means in the respective embodiments disclosed above in conjunction with figures 4 and 5 are implemented as computer program modules which when executed in the respective processing unit causes the UE and the network node respectively to perform the actions described above in the conjunction with figures mentioned above, at least one of the code means may in alternative embodiments be implemented at least partly as hardware circuits.

[000170] The processor may be a single CPU (Central processing unit), but could also comprise two or more processing units. For example, the processor may include general purpose microprocessors; instruction set processors and/or related chips sets and/or special purpose microprocessors such as ASICs (Application Specific Integrated Circuit). The processor may also comprise board memory for caching purposes. The computer program may be carried by a computer program product connected to the processor. The computer program product may comprise a computer readable medium on which the computer program is stored. For example, the computer program product may be a flash memory, a RAM (Random-access memory) ROM (Read-Only Memory) or an EEPROM, and the computer program modules described above could in alternative embodiments be distributed on different computer program products in the form of memories within the UE and the network node respectively.

[000171] It is to be understood that the choice of interacting units, as well as the naming of the units within this disclosure are only for exemplifying purpose, and nodes suitable to execute any of the methods described above may be configured in a plurality of alternative ways in order to be able to execute the suggested procedure actions.

[000172] It should also be noted that the units described in this disclosure are to be regarded as logical entities and not with necessity as separate physical entities.

[000173] Although terminology from 3GPP LTE has been used herein for example, such terminology should not be seen as limiting the scope to only the aforementioned system. Other wireless systems, including WCDMA, WiMax, UMB and GSM, may also benefit from exploiting the ideas covered within the technology disclosed herein.

[000174] Also note that terminology such as eNodeB, wireless terminal ("UE") should be considering non-limiting and does in particular not imply a certain hierarchical relation between the two. In general, "eNodeB" could be considered as device 1 and "wireless terminal" or "UE" considered as device 2, and these two devices communicate with each other over some radio channel. Aspects of the technology disclosed herein may be equally applicable in the uplink and the downlink.

[000175] The exemplary embodiments described herein are not mutually exclusive. Rather, concepts and components from one embodiment may be combined with other example embodiments.

[000176] While the embodiments have been described in terms of several embodiments, it is contemplated that alternatives, modifications, permutations and equivalents thereof will become apparent upon reading of the specifications and study of the drawings. It is therefore intended that the following appended claims include such alternatives, modifications, permutations and equivalents as fall within the scope of the embodiments and defined by the pending claims.

CLAIMS

1. A method (200) performed by a User Equipment, UE, for transmitting Sounding Reference Signals, SRSs, the UE being connected in dual connectivity mode to at least a first network node and a second network node, the method comprising:

- receiving (210), from the network nodes, a first and a second SRS configuration,
- determining (220) if the received first and the second SRS configurations at least partly collide,

and if the first and the second SRS configurations collide:

- prioritising (240) between which SRSs to transmit of the received first and second SRS configuration according to a predetermined rule, and
- transmitting (250) SRSs according to the predetermined rule.

2. A method (200) according to claim 1, wherein the SRSs are periodic SRSs or aperiodic SRSs.

3. A method (200) according to claim 1 or 2, further comprising receiving from the network nodes, a first and a second trigger for transmitting aperiodic SRSs.

4. A method (200) according to any of claims 1-3, wherein the predetermined rule indicates to the UE to prioritise aperiodic SRS transmission over periodic SRS transmission.

5. A method (200) according to any of claims 1-3, wherein the predetermined rule indicates to the UE to prioritise SRS transmission used for estimating the least static uplink channel.

6. A method (200) according to any of claim 1-3, wherein the predetermined rule indicates to the UE, in case of Time division Duplex, TDD, operations, to prioritise SRS transmission to one of the two network nodes in the last symbol of a subframe and to the other network node in an Uplink Pilot Time Slot, UpPTS.

7. A method (200) according to any of claim 1-3, the method further comprising receiving signalling from the network nodes indicating an intended purpose of the respective SRS transmissions, wherein the predetermined rule indicates to the UE which SRS transmission to prioritise based on the intended purpose of the respective SRS transmissions.

8. A method (200) according to any of claim 1-3, wherein the predetermined rule indicates to the UE to prioritise SRS transmission autonomously.

9. A method (200) according to any of claims 1-8, further comprising informing (250) at least one of the first and the second network node about the determined collision between the first and the second SRS configuration.

10. A method (200) according to any of claims 1-8, wherein the first and second SRS configuration are associated with a respective SRS process defining at least one of periodicity and offset, transmission comb, frequency start position, sounding bandwidth and frequency hopping of the SRSs.

11. A method (200) according to any of claims 1-10, wherein the first and a second SRS trigger are received by means of evolved Physical Downlink Control Channel, ePDCCH, set that a Downlink Control Information, DCI, was sent from, or Radio Network Temporary Identifier, RNTI that was used to scramble the Cyclic Redundancy Check, CRC, of the DCI message, or the type of the DCI message, or a bit combination and DCI format that was used to trigger an aperiodic SRS.

12. A method (300) performed by a first network node for enabling transmission of Sounding Reference Signals, SRSs, from a User Equipment, UE, being connected in dual connectivity mode to at least the first network node and a second network node, the method comprising:

- coordinating (310), with the second network node, SRS configurations to be used by the UE for transmitting SRSs to both the first and the second network node,

- determining (320) at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node based on the coordination with the second network node, and
- transmitting (330), to the UE, at least the determined first SRS configuration to be used by the UE for transmitting SRSs to the first network node.

13. A method (300) according to claim 12, wherein the SRS configurations are intended for aperiodic SRS transmission, the method further comprises transmitting, to the UE, a trigger for the transmission of aperiodic SRS.

14. A method (300) according to claim 12 or 13, wherein coordinating (310) SRS configurations comprises determining to multiplex the SRS resources in time or frequency the first SRS configuration associated with the first network node and a second SRS configuration associated with the second network node.

15. A method (300) according to claim 12 or 13, wherein coordinating (310) SRS configurations comprises exchanging cell specific SRS configurations between the first and the second network node.

16. A method (300) according to any of claims 12-15, further comprising receiving (305) information from the UE indicating collision between the first SRS configuration and a second SRS configuration associated with the second network node, wherein determining (320) at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node further is based on the received information indicating collision between the first SRS configuration and the second SRS configuration.

17. A User Equipment, UE, (400) adapted for transmitting Sounding Reference Signals, SRSs, the UE being connected in dual connectivity mode to at least a first network node and a second network node, the UE comprising:

- a receiving unit (402) adapted for receiving, from the network nodes, a first and a second SRS configuration,
- a determining unit (403) adapted for determining if the received first and the second SRS configurations at least partly collide,

- a prioritising unit (404) adapted for, if the first and the second SRS configurations collide, prioritising between which SRSs to transmit of the received first and second SRS configuration according to a predetermined rule, and
- a transmitting unit (405) adapted for transmitting SRSs according to the predetermined rule.

18. A UE (400) according to claim 17, wherein the SRSs are periodic SRSs or aperiodic SRSs.

19. A UE (400) according to claim 17 or 18, wherein the receiving unit (402) further is adapted for receiving, from the network nodes, a first and a second trigger for transmitting aperiodic SRSs.

20. A UE (400) according to any of claims 17-19, wherein the predetermined rule indicates to the UE to prioritise aperiodic SRS transmission over periodic SRS transmission.

21. A UE (400) according to any of claims 17-19, wherein the predetermined rule indicates to the UE to prioritise SRS transmission used for estimating the least static uplink channel.

22. A UE (400) according to any of claim 17-19, wherein the predetermined rule indicates to the UE, in case of Time division Duplex, TDD, operations, to prioritise SRS transmission to one of the two network nodes in the last symbol of a subframe and to the other network node in an Uplink Pilot Time Slot, UpPTS.

23. A UE (400) according to any of claim 17-19, wherein the receiving unit (402) further is adapted for receiving signalling from the network nodes indicating an intended purpose of the respective SRS transmissions, wherein the predetermined rule indicates to the UE which SRS transmission to prioritise based on the intended purpose of the respective SRS transmissions.

24. A UE (400) according to any of claim 17-19, wherein the predetermined rule indicates to the UE to prioritise SRS transmission autonomously.

25. A UE (400) according to any of claims 17-24, further comprising an informing unit (406) adapted for informing at least one of the first and the second network node about the determined collision between the first and the second SRS configuration.

26. A UE (400) according to any of claims 17-25, wherein the first and second SRS configuration are associated with a respective SRS process defining at least one of periodicity and offset, transmission comb, frequency start position, sounding bandwidth and frequency hopping of the SRSs.

27. A UE (400) according to any of claims 17-26, wherein the receiving unit (402) further is adapted for receiving the first and a second SRS trigger by means of evolved Physical Downlink Control Channel, ePDCCH, set that a Downlink Control Information, DCI, was sent from, or Radio Network Temporary Identifier, RNTI that was used to scramble the Cyclic Redundancy Check, CRC, of the DCI message, or the type of the DCI message, or a bit combination and DCI format that was used to trigger an aperiodic SRS.

28. A first network node (500) adapted for enabling transmission of Sounding Reference Signals, SRSs, from a User Equipment, UE, being connected in dual connectivity mode to at least the first network node and a second network node, the first network node (500) comprising:

- a coordinating unit (502) adapted for coordinating, with the second network node, SRS configurations to be used by the UE for transmitting SRSs to both the first and the second network node,
- a determining unit (503) adapted for determining at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node based on the coordination with the second network node, and
- a transmitting unit (504) adapted for transmitting, to the UE, at least the determined first SRS configuration to be used by the UE for transmitting SRSs to the first network node.

29. A first network node (500) according to claim 28, wherein the SRS configurations are intended for aperiodic SRS transmission, wherein the

transmitting unit (504) further is adapted for transmitting, to the UE, a trigger for the transmission of aperiodic SRS.

30. A first network node (500) according to claim 28 or 29, wherein the coordinating unit (502) is adapted for coordinating SRS configurations by determining to multiplex the SRS resources in time or frequency the first SRS configuration associated with the first network node and a second SRS configuration associated with the second network node.

31. A first network node (500) according to claim 28 or 29, wherein the coordinating unit (502) is adapted for coordinating SRS configurations by exchanging cell specific SRS configurations between the first and the second network node.

32. A first network node (500) according to any of claims 28-31, further comprising a receiving unit (505) adapted for receiving information from the UE indicating collision between the first SRS configuration and a second SRS configuration associated with the second network node, wherein the determining unit (503) further is adapted for determining at least a first SRS configuration to be used by the UE for transmitting SRSs to the first network node further is based on the received information indicating collision between the first SRS configuration and the second SRS configuration.

33. A Computer program (710), comprising computer readable code means, which when run in a processing unit (706) comprised in an arrangement in a User Equipment (400, 700) according to claims 17-27 causes the User Equipment (400, 700) to perform the corresponding method according to claim 1-11.

34. A Computer program product (708) comprising computer program (710) according to claim 33.

35. A Computer program (810), comprising computer readable code means, which when run in a processing unit (806) comprised in an arrangement in a first network node (500, 800) according to claims 28-32 causes the first network node (500, 800) to perform the corresponding method according to claim 12-16.

36. A Computer program product (808) comprising computer program (810) according to claim 33.

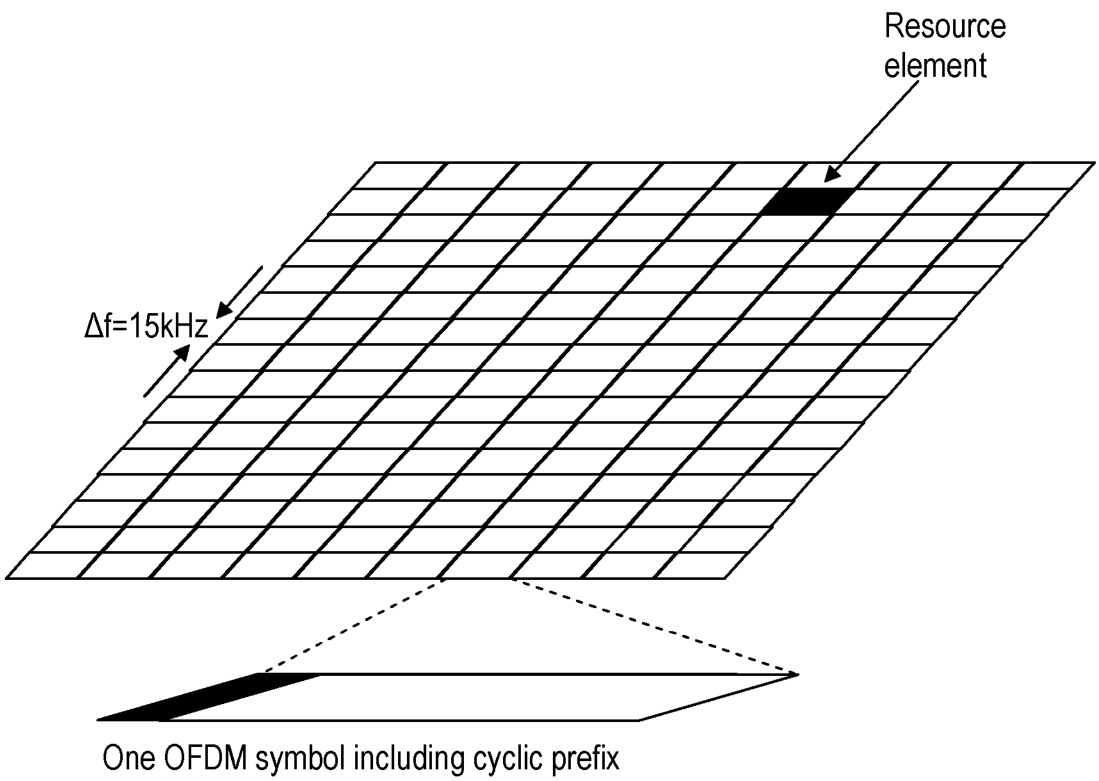

Resource
element
Δf=15kHz
One OFDM symbol including cyclic prefix

Fig. 1a

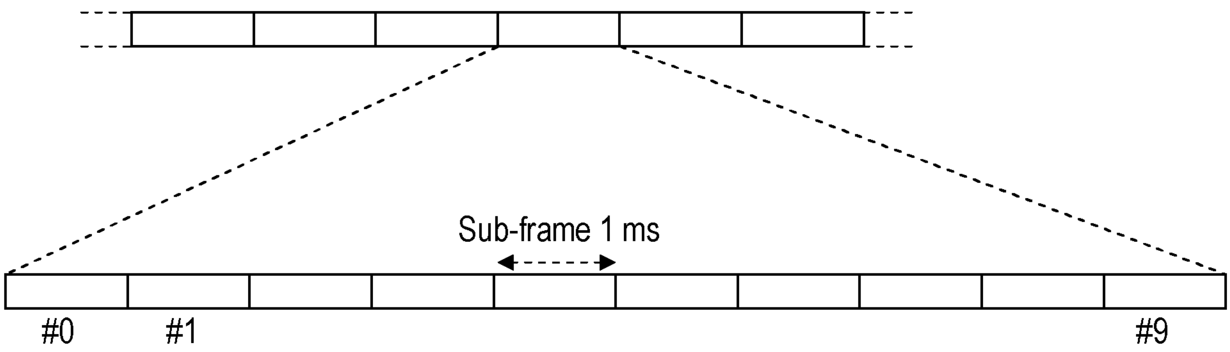

Sub-frame 1 ms
#0
#1
#9

Fig. 1b

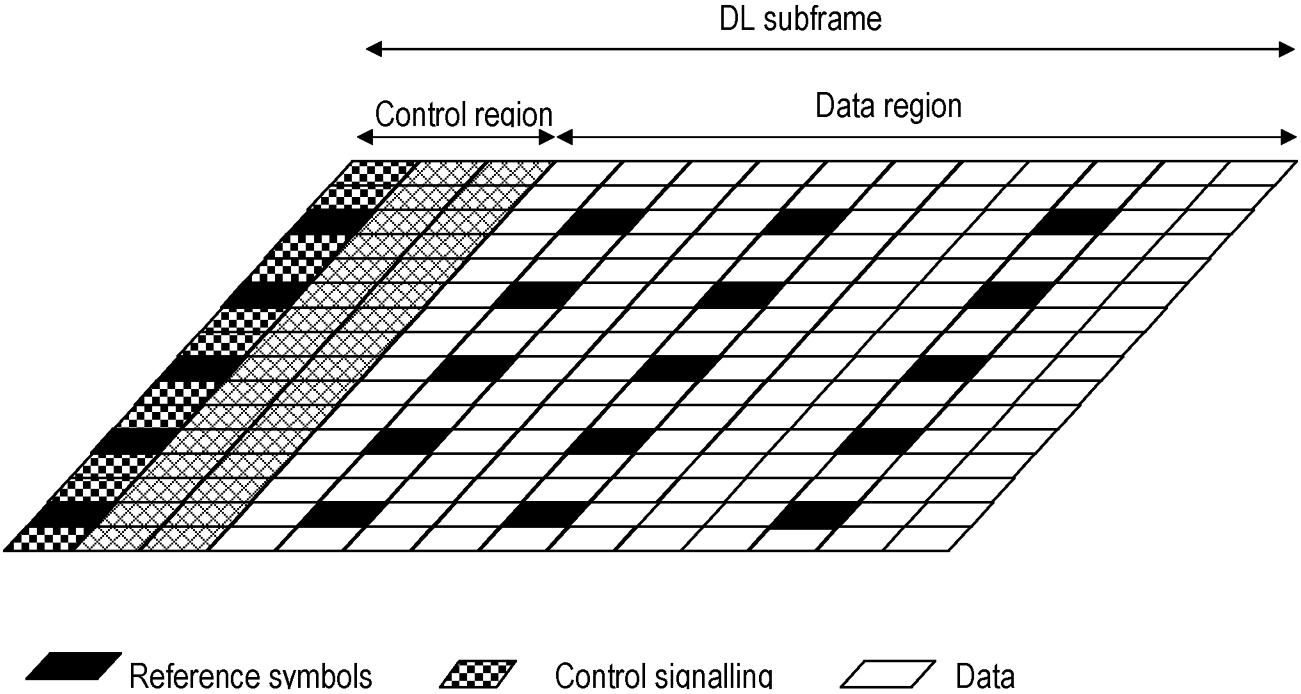

DL subframe
Control region
Data region
Reference symbols
Control signalling
Data

Fig. 1c

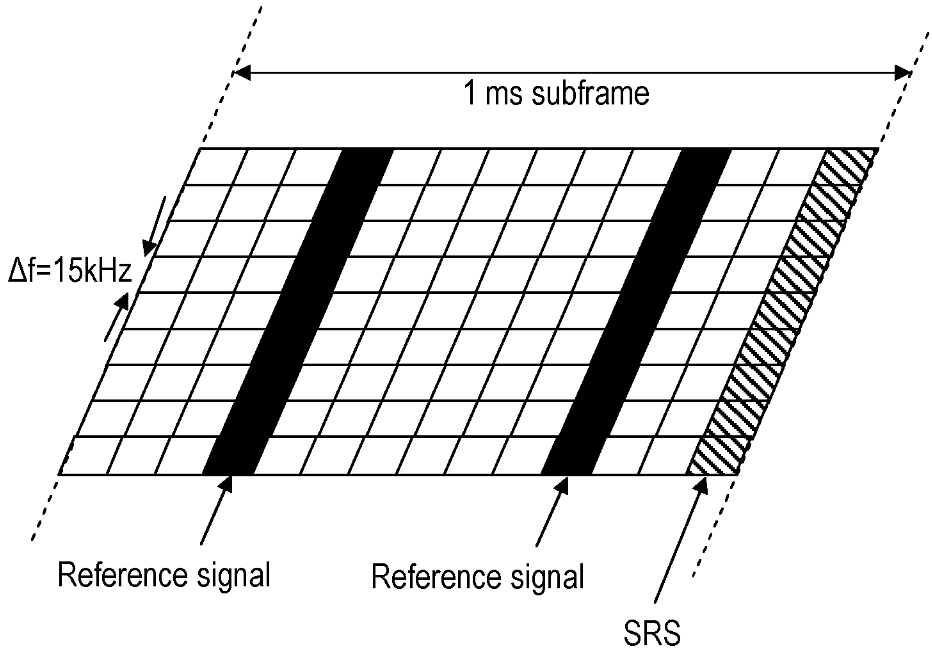

1 ms subframe
Δf=15kHz
Reference signal
Reference signal
SRS

Fig. 1d

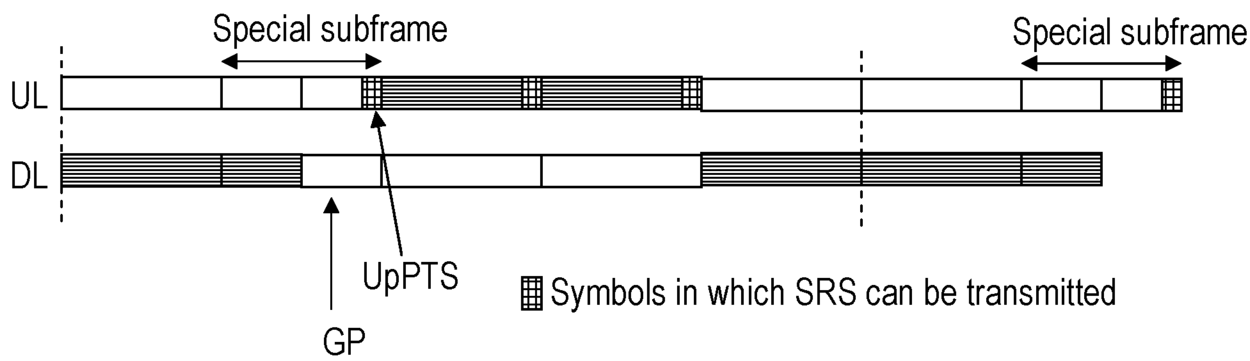

Special subframe
Special subframe
UL
DL
UpPTS
GP
Symbols in which SRS can be transmitted

Fig. 1e

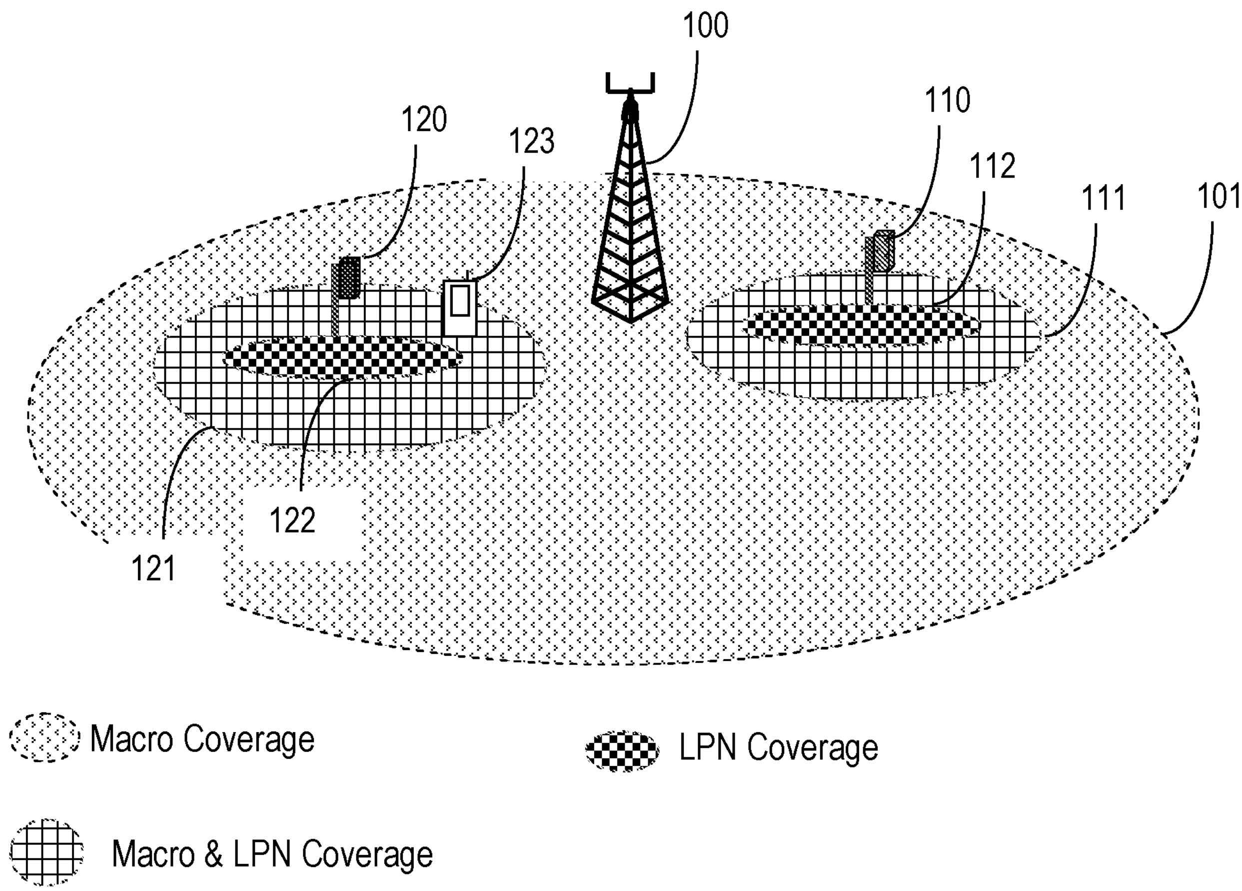

100
120
123
110
112
111
101
121
122
Macro Coverage
LPN Coverage
Macro & LPN Coverage

Fig. 1f

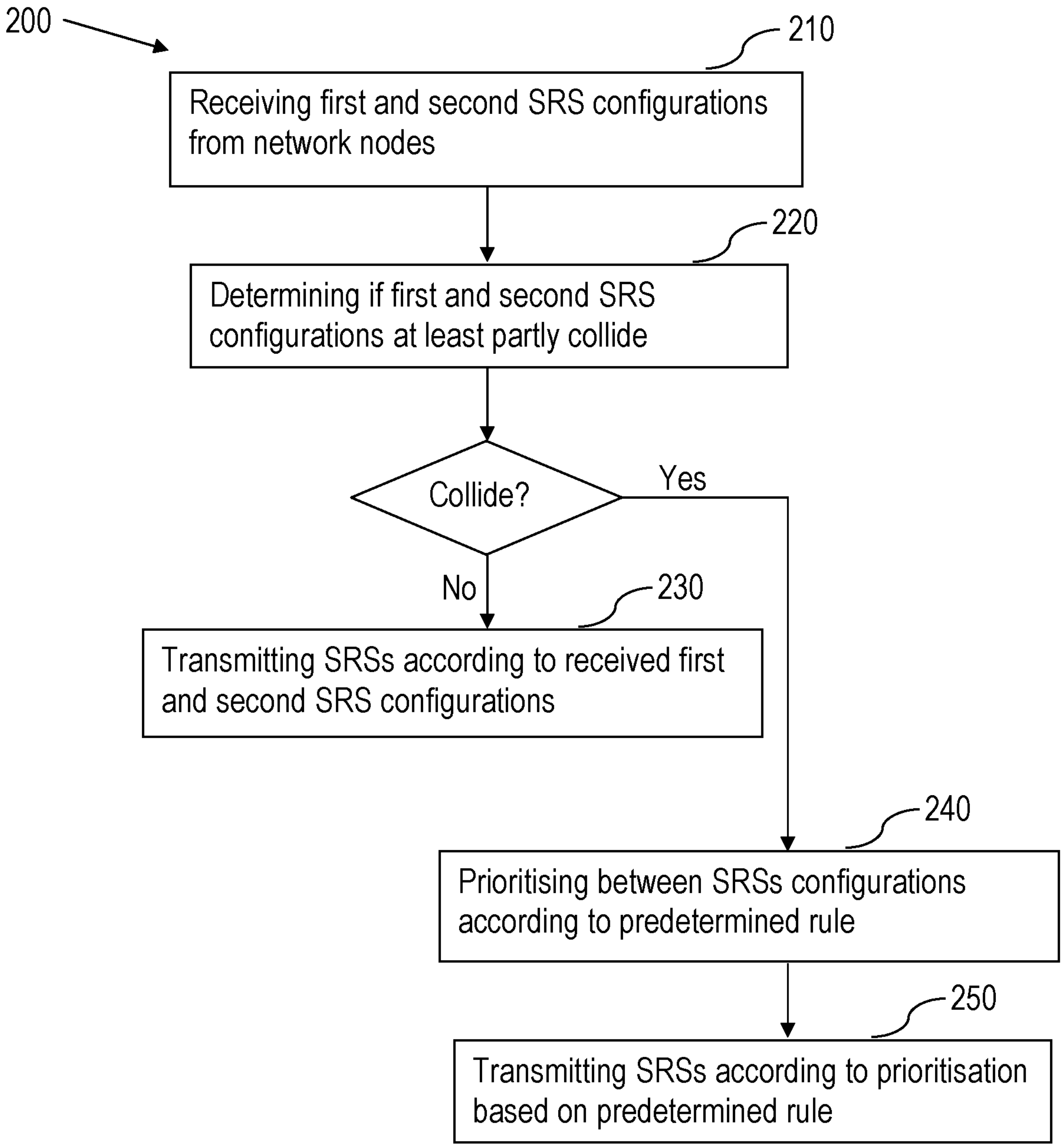

200
210
Receiving first and second SRS configurations from network nodes
220
Determining if first and second SRS configurations at least partly collide
Collide?
Yes
No
230
Transmitting SRSs according to received first and second SRS configurations
240
Prioritising between SRSs configurations according to predetermined rule
250
Transmitting SRSs according to prioritisation based on predetermined rule

Fig. 2a

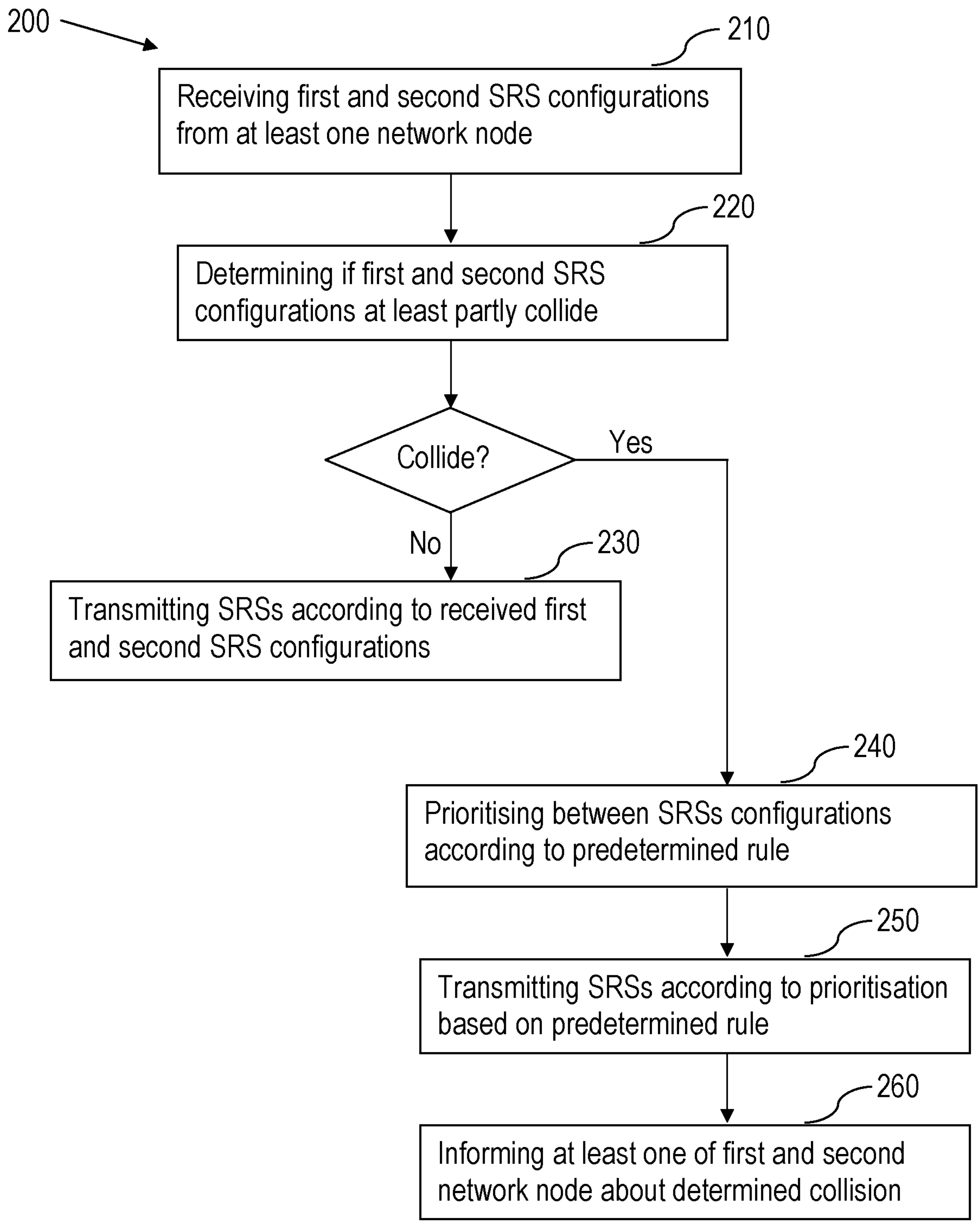

200
210
Receiving first and second SRS configurations from at least one network node
220
Determining if first and second SRS configurations at least partly collide
Collide?
Yes
No
230
Transmitting SRSs according to received first and second SRS configurations
240
Prioritising between SRSs configurations according to predetermined rule
250
Transmitting SRSs according to prioritisation based on predetermined rule
260
Informing at least one of first and second network node about determined collision

Fig. 2b

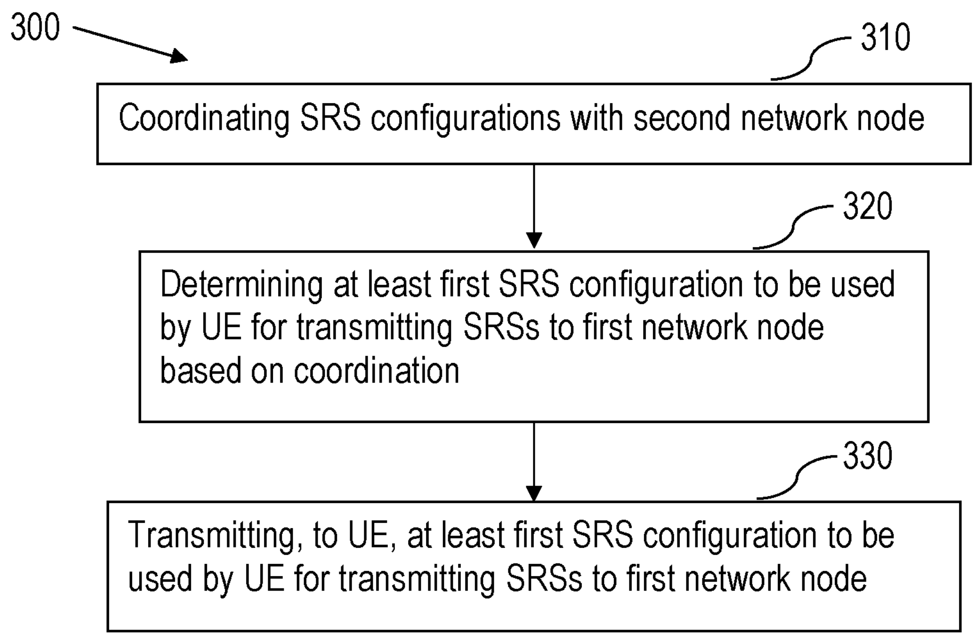

300
310
Coordinating SRS configurations with second network node
320
Determining at least first SRS configuration to be used by UE for transmitting SRSs to first network node based on coordination
330
Transmitting, to UE, at least first SRS configuration to be used by UE for transmitting SRSs to first network node

Fig. 3a

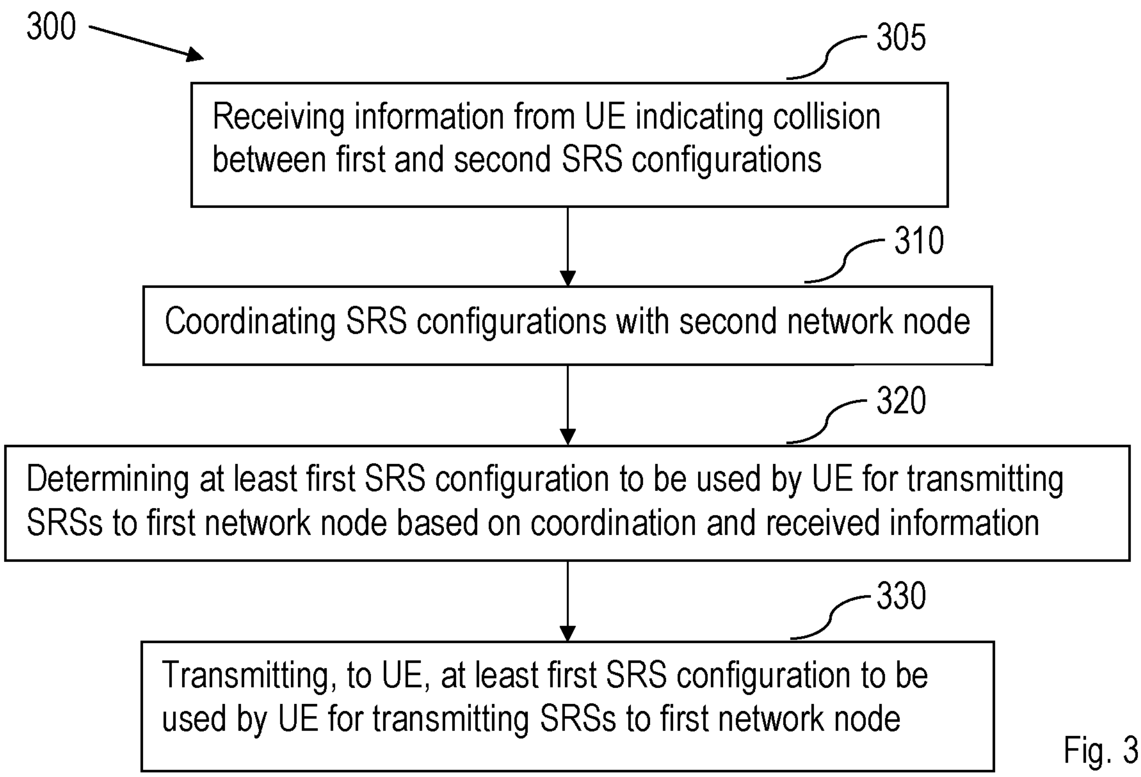

300
305
Receiving information from UE indicating collision between first and second SRS configurations
310
Coordinating SRS configurations with second network node
320
Determining at least first SRS configuration to be used by UE for transmitting SRSs to first network node based on coordination and received information
330
Transmitting, to UE, at least first SRS configuration to be used by UE for transmitting SRSs to first network node

Fig. 3b

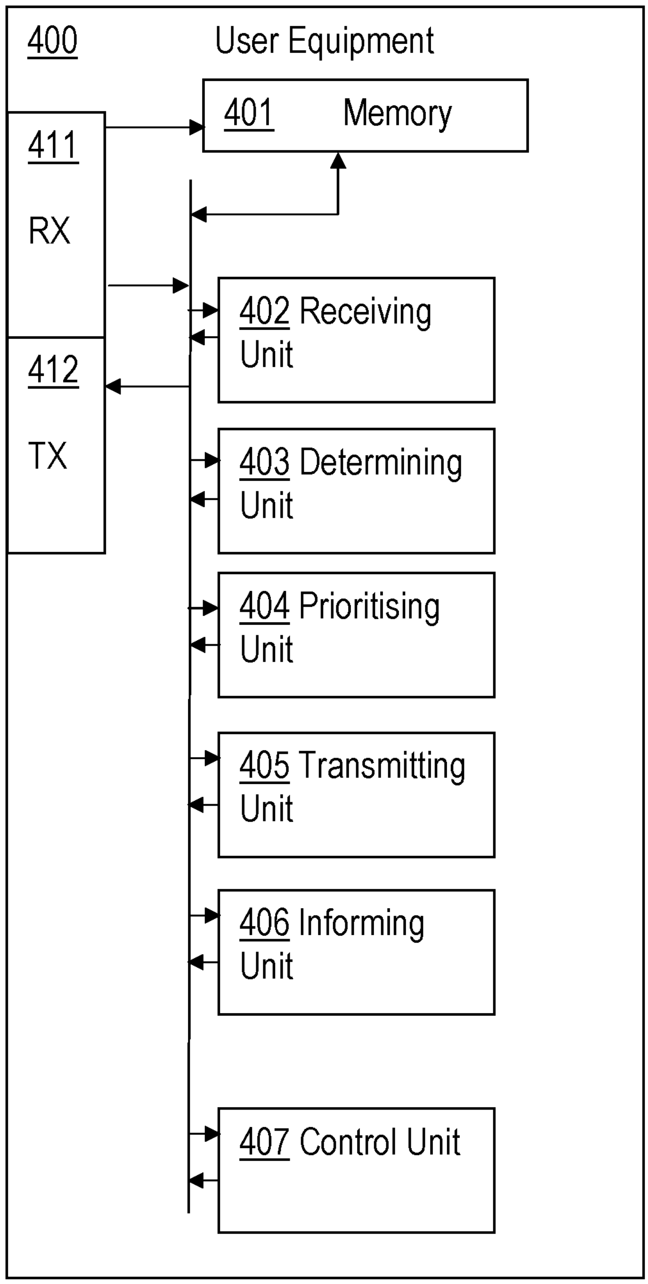

400
User Equipment
401 Memory
411
RX
412
TX
402 Receiving Unit
403 Determining Unit
404 Prioritising Unit
405 Transmitting Unit
406 Informing Unit
407 Control Unit

Fig. 4

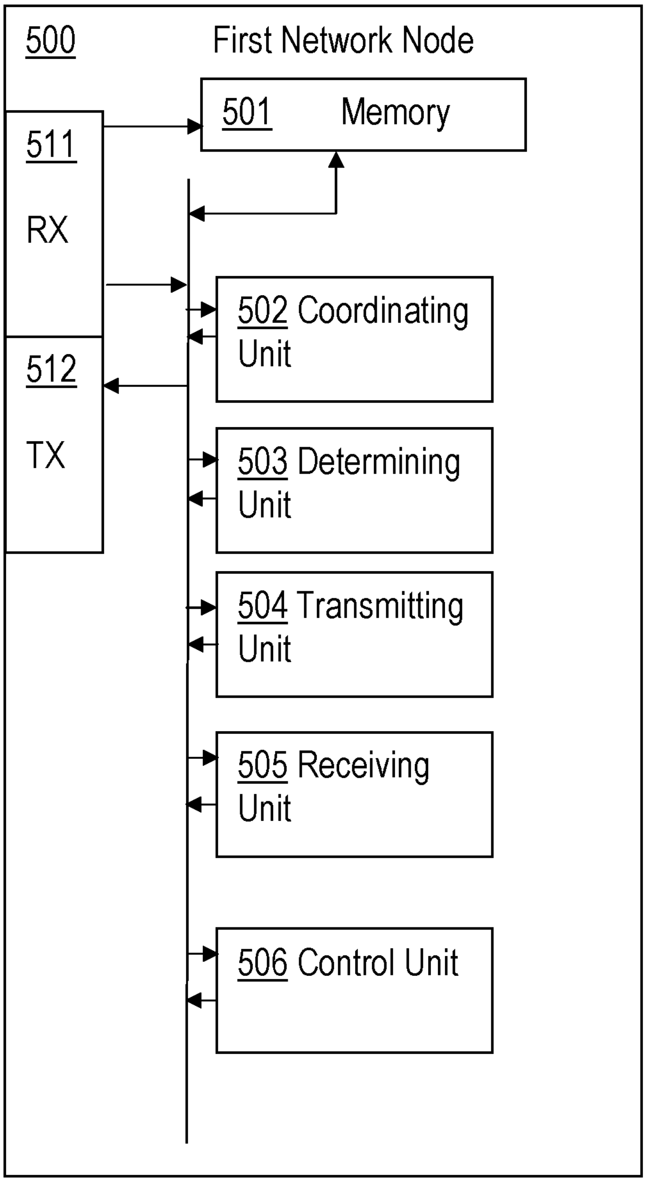

500 First Network Node
501 Memory
511
RX
512
TX
502 Coordinating Unit
503 Determining Unit
504 Transmitting Unit
505 Receiving Unit
506 Control Unit

Fig. 5

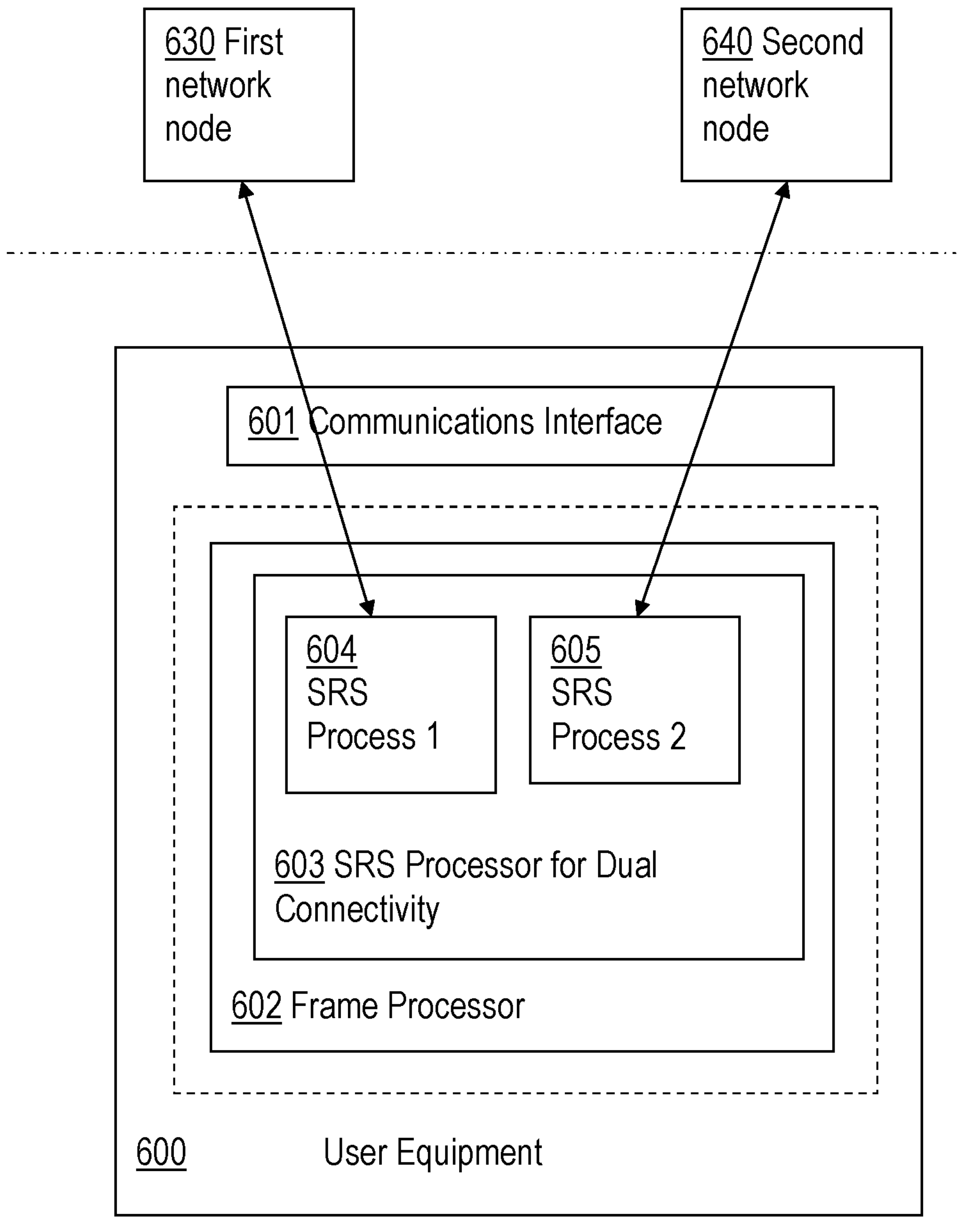

630 First network node
640 Second network node
601 Communications Interface
604 SRS Process 1
605 SRS Process 2
603 SRS Processor for Dual Connectivity
602 Frame Processor
600 User Equipment

Fig. 6a

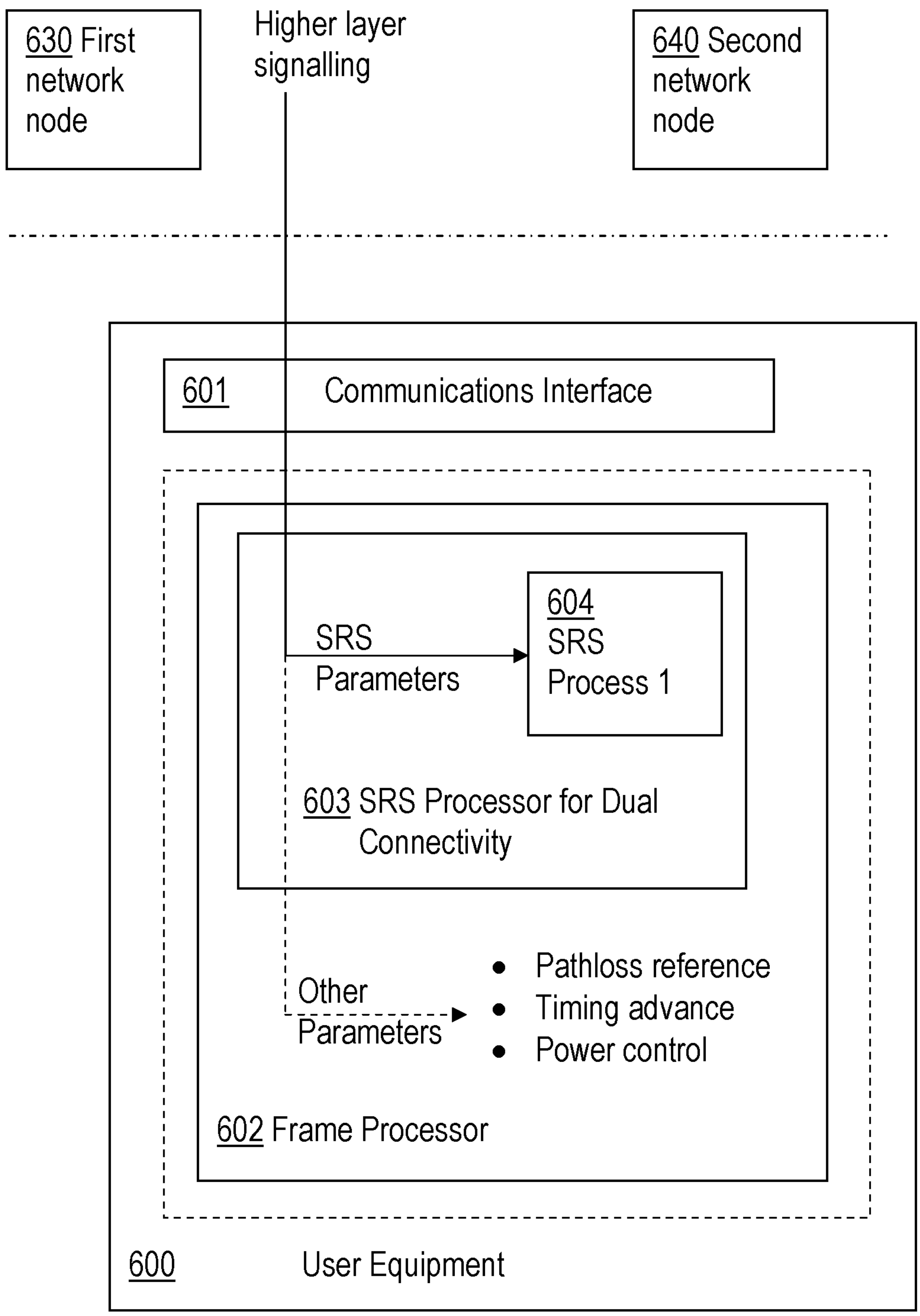

630 First network node
Higher layer signalling
640 Second network node
601 Communications Interface
SRS Parameters
604 SRS Process 1
603 SRS Processor for Dual Connectivity
Other Parameters
Pathloss reference
Timing advance
Power control
602 Frame Processor
600 User Equipment

Fig. 6b

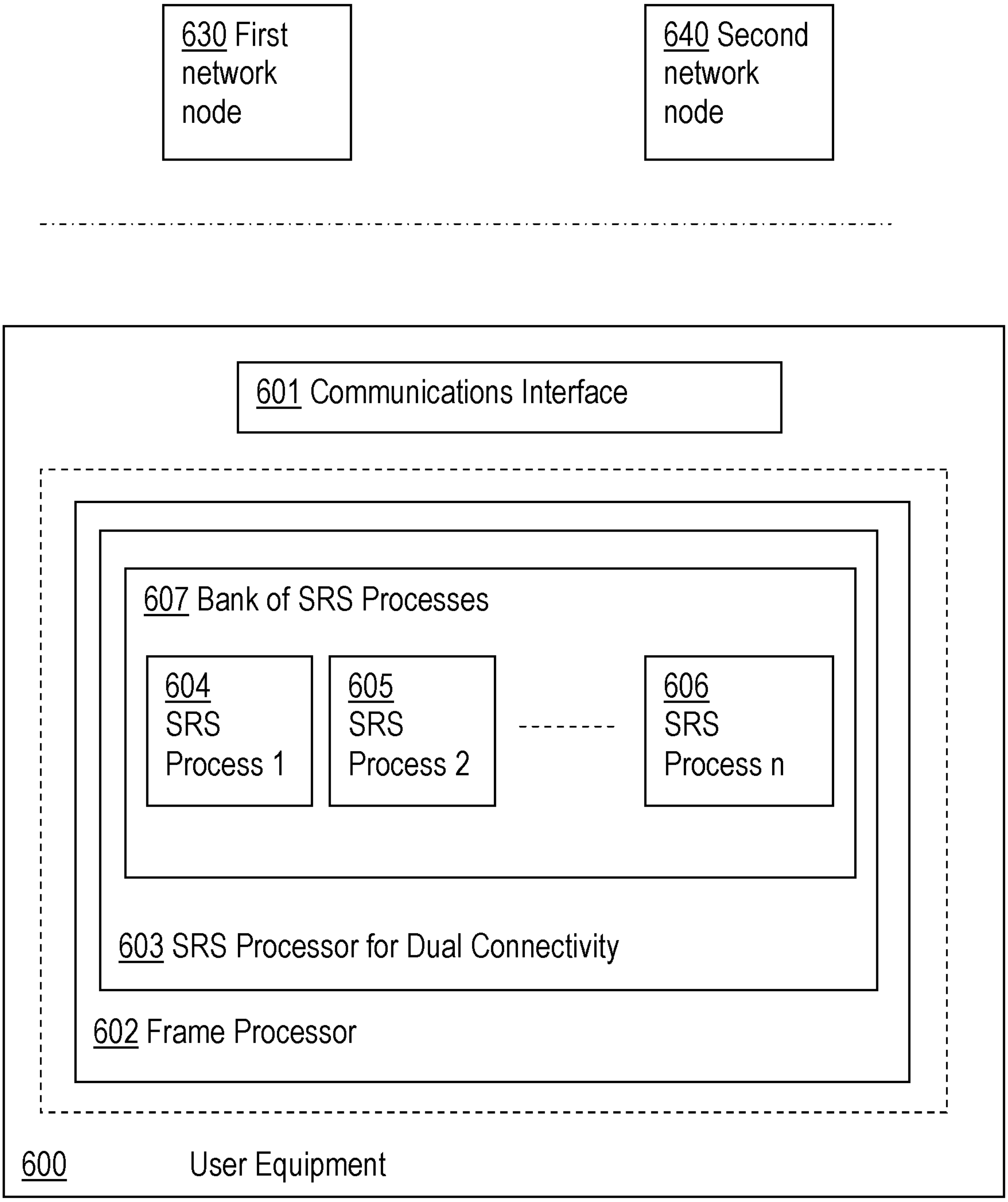

630 First network node
640 Second network node
601 Communications Interface
607 Bank of SRS Processes
604 SRS Process 1
605 SRS Process 2
606 SRS Process n
603 SRS Processor for Dual Connectivity
602 Frame Processor
600 User Equipment

Fig. 6c

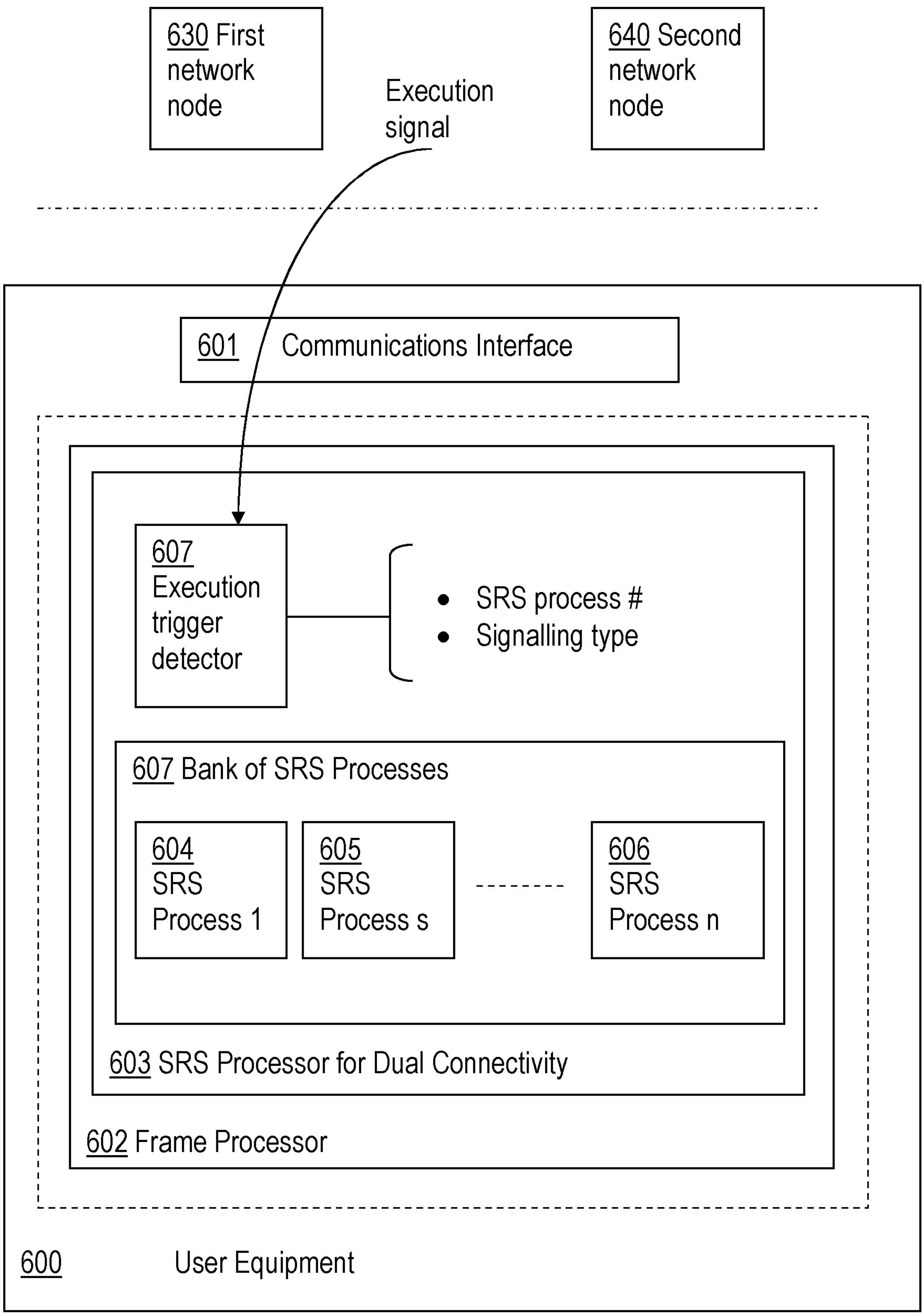
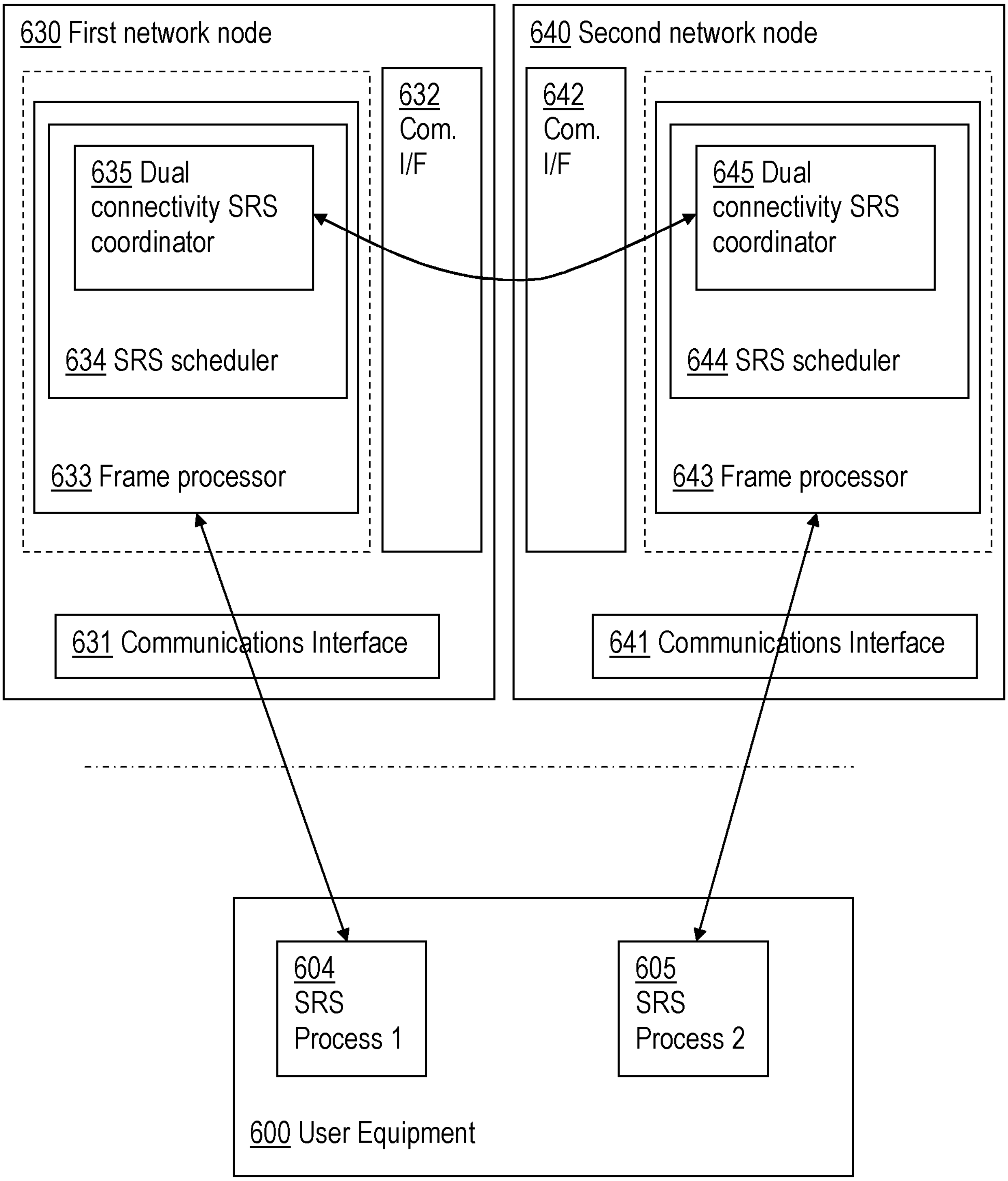

630 First network node
640 Second network node
Execution signal
601 Communications Interface
607 Execution trigger detector
SRS process #
Signalling type
607 Bank of SRS Processes
604 SRS Process 1
605 SRS Process s
606 SRS Process n
603 SRS Processor for Dual Connectivity
602 Frame Processor
600 User Equipment

Fig. 6d



630 First network node
632 Com. I/F
635 Dual connectivity SRS coordinator
634 SRS scheduler
633 Frame processor
631 Communications Interface
640 Second network node
642 Com. I/F
645 Dual connectivity SRS coordinator
644 SRS scheduler
643 Frame processor
641 Communications Interface
604 SRS Process 1
605 SRS Process 2
600 User Equipment

Fig. 6e

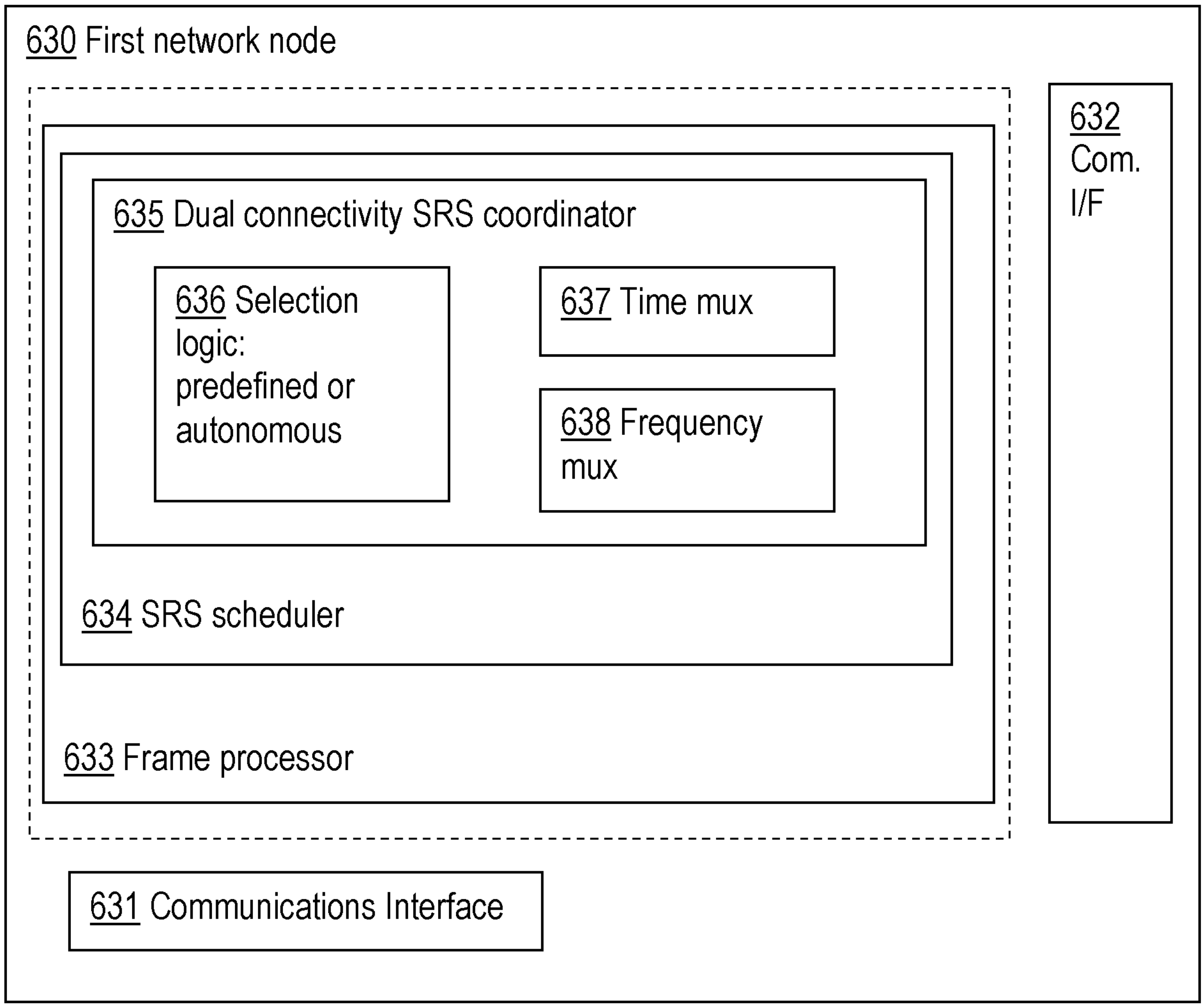

630 First network node
635 Dual connectivity SRS coordinator
636 Selection logic: predefined or autonomous
637 Time mux
638 Frequency mux
634 SRS scheduler
633 Frame processor
632 Com. I/F
631 Communications Interface

Fig. 6f

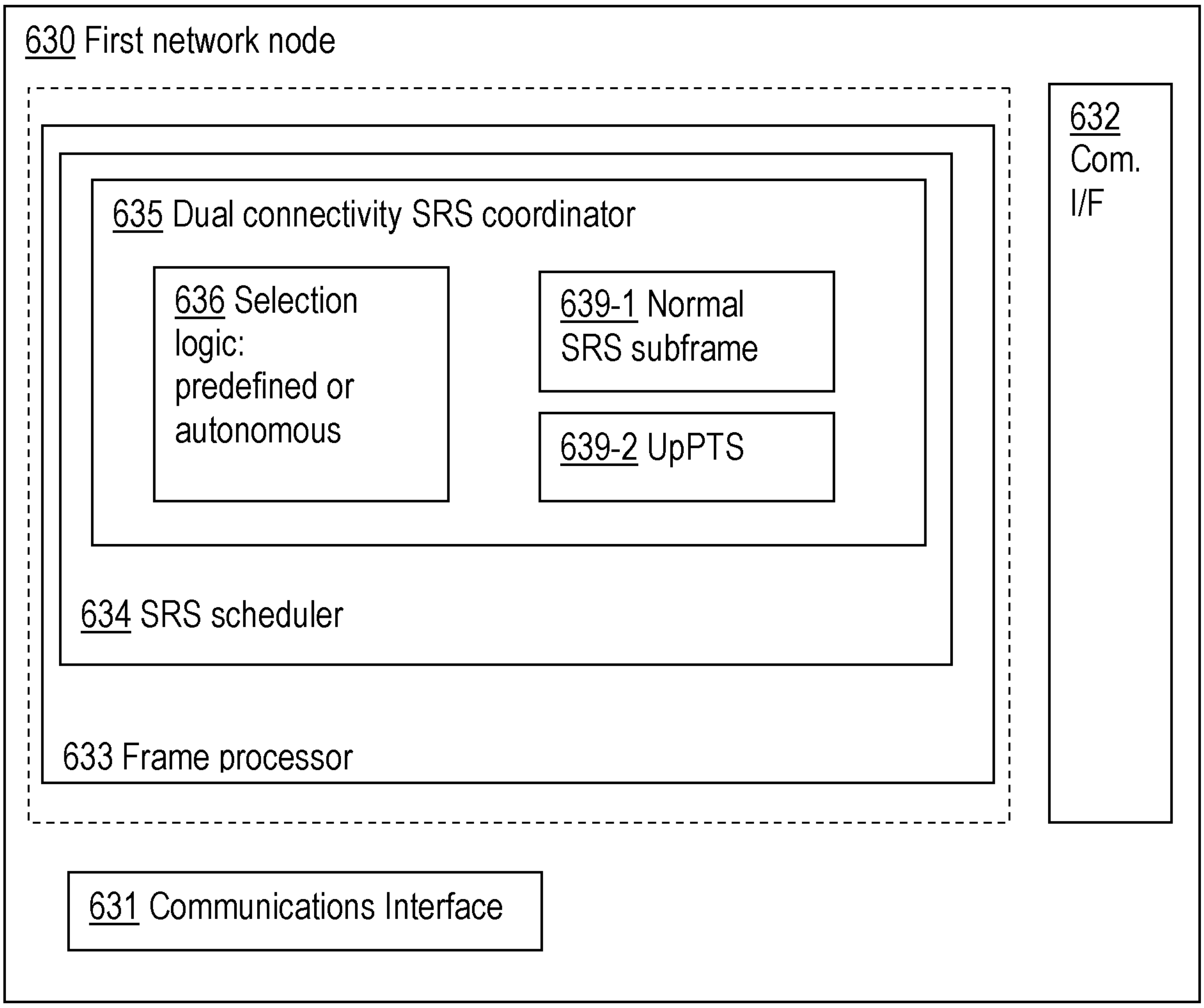

630 First network node
632 Com. I/F
635 Dual connectivity SRS coordinator
636 Selection logic: predefined or autonomous
639-1 Normal SRS subframe
639-2 UpPTS
634 SRS scheduler
633 Frame processor
631 Communications Interface

Fig. 6g

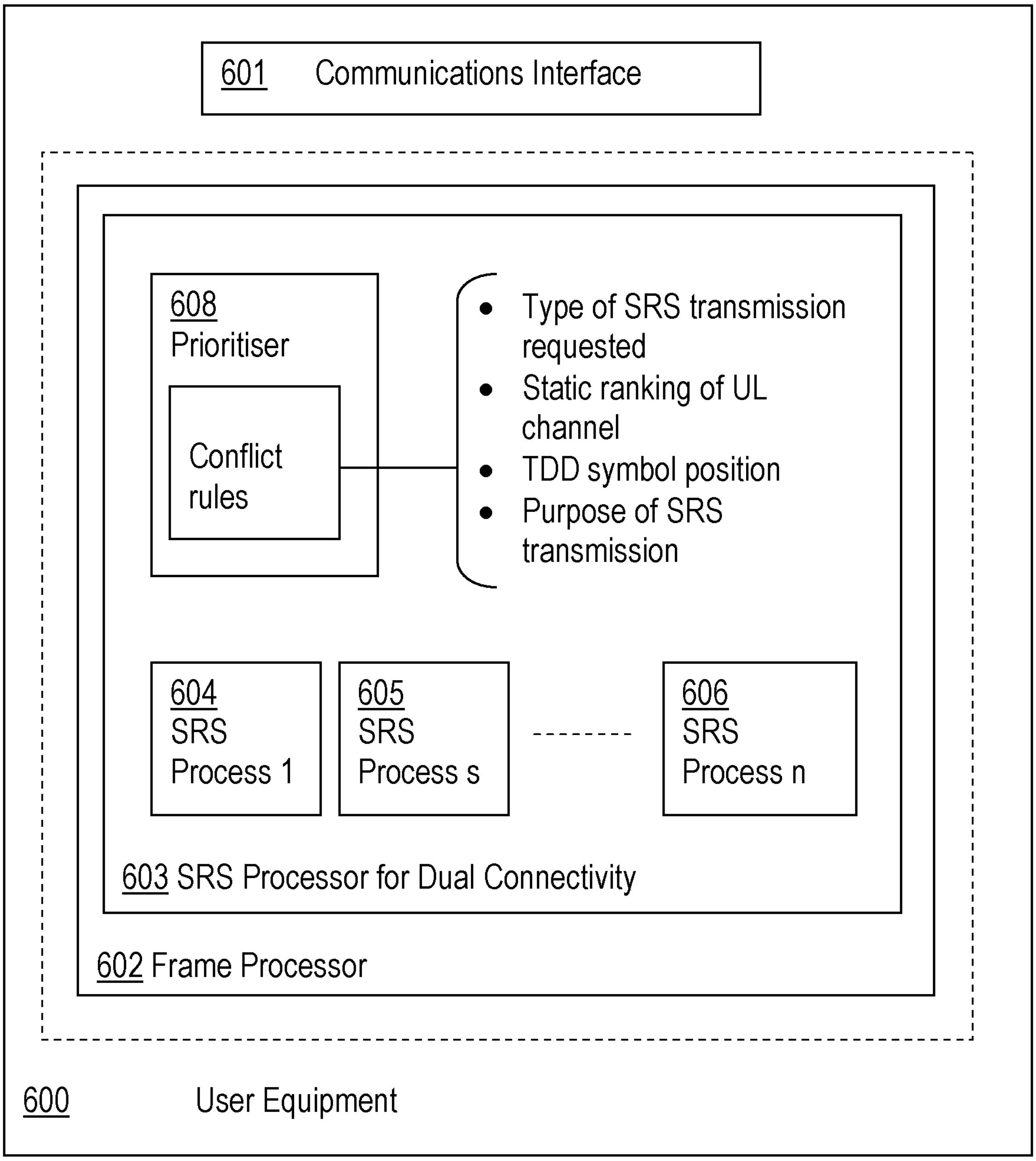

601 Communications Interface
608
Prioritiser
Conflict rules
Type of SRS transmission requested
Static ranking of UL channel
TDD symbol position
Purpose of SRS transmission
604
SRS
Process 1
605
SRS
Process s
606
SRS
Process n
603 SRS Processor for Dual Connectivity
602 Frame Processor
600 User Equipment

Fig. 6h

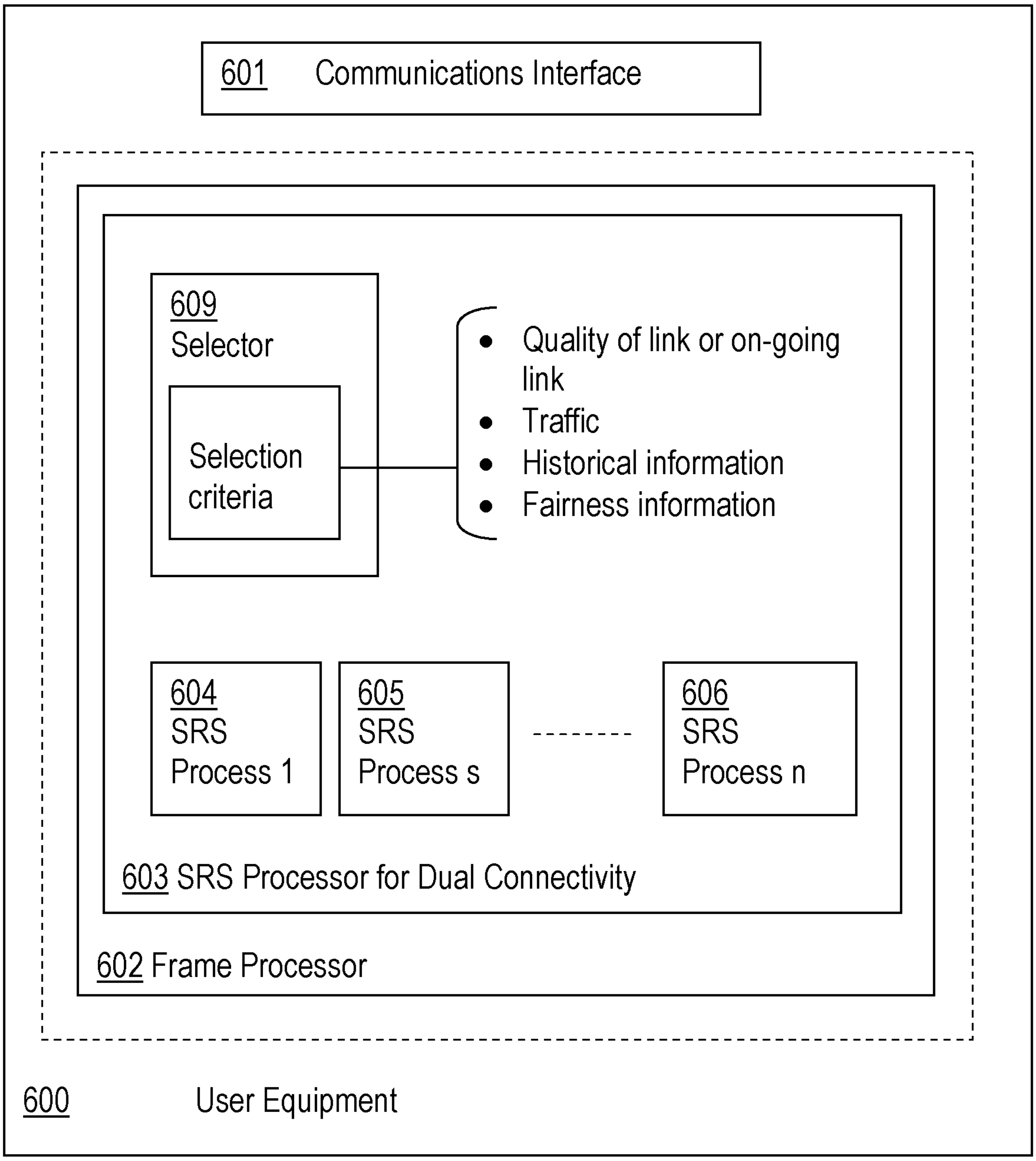

601 Communications Interface
609
Selector
Selection criteria
Quality of link or on-going link
Traffic
Historical information
Fairness information
604
SRS
Process 1
605
SRS
Process s
606
SRS
Process n
603 SRS Processor for Dual Connectivity
602 Frame Processor
600 User Equipment

Fig. 6k

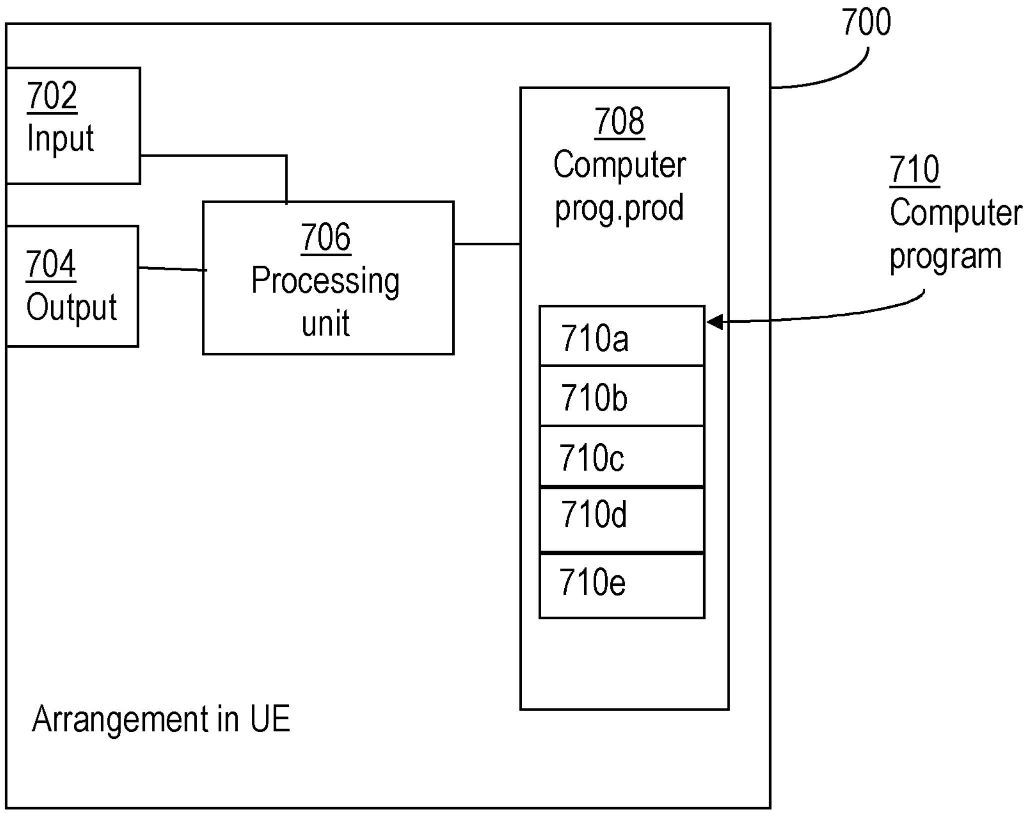

700
702
Input
704
Output
706
Processing
unit
708
Computer
prog.prod
710
Computer
program
710a
710b
710c
710d
710e
Arrangement in UE

Fig. 7

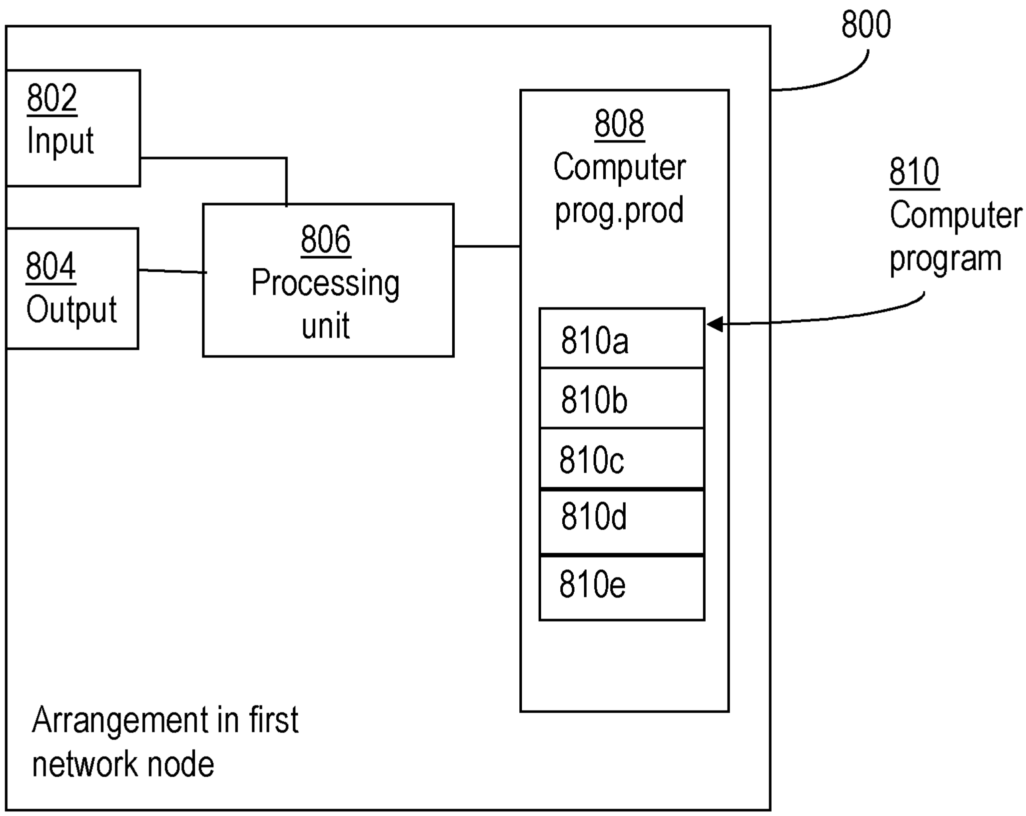

800
802
Input
804
Output
806
Processing
unit
808
Computer
prog.prod
810
Computer
program
810a
810b
810c
810d
810e
Arrangement in first
network node

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2013/050888

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

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

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

EPO-Internal, WPI Data, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/268028 A1 (STERN-BERKOWITZ JANET A [US] ET AL) 3 November 2011 (2011-11-03) paragraphs [0003] - [0005], [0048] - [0066], [0259], [0292] - [0295]; figure 1; tables 1-2 -----	1-3, 5-11, 17-19, 21-27, 33,34,36
X	US 2013/010659 A1 (CHEN WANSHI [US] ET AL) 10 January 2013 (2013-01-10) paragraphs [0056], [0074], [0075] figure 1 ----- -/--	1,2,17, 18,33, 34,36

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

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 October 2013	07/11/2013

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	Barrientos Lezcano

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2012/108643 A2 (PANTECH CO LTD [KR]; KWON KI BUM [KR]; KIM JONG NAM [KR]; AHN JAE HYUN) 16 August 2012 (2012-08-16) paragraphs [0005] - [0016], [181196] -----	1-4,10, 17-20, 26,33, 34,36
X	EP 2 485 555 A1 (ERICSSON TELEFON AB L M [SE]) 8 August 2012 (2012-08-08) paragraphs [0009], [0011], [0035], [0048] - [0052] figures 4,9 -----	12-16, 28-32,35

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/SE2013/050888

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		CN 103069739 A	24-04-2013
		EP 2553860 A1	06-02-2013
		JP 2013528016 A	04-07-2013
		KR 20130019415 A	26-02-2013
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		WO 2011123805 A1	06-10-2011
US 2013010659 A1	10-01-2013	US 2013010659 A1	10-01-2013
		WO 2013009464 A1	17-01-2013
WO 2012108643 A2	16-08-2012	NONE	
EP 2485555 A1	08-08-2012	EP 2485555 A1	08-08-2012
		US 2012201149 A1	09-08-2012