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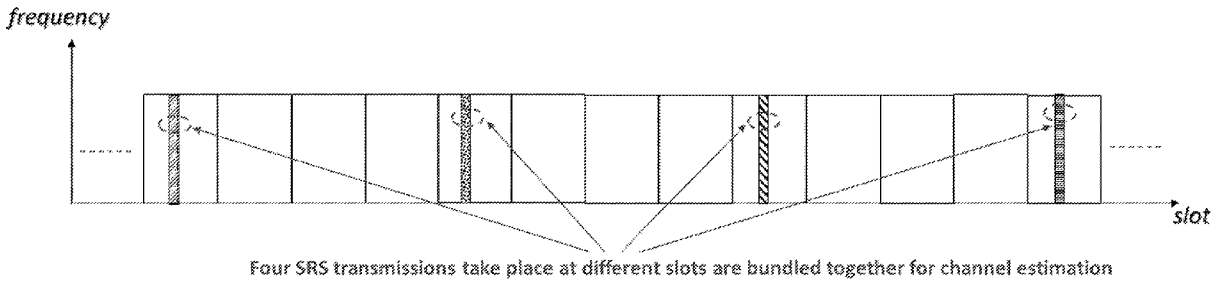


FIG. 3

(57) Abstract: A terminal that performs SRS resource time bundling for SRS coverage may include a receiver that receives information relating to multiple SRS resources. The information may include an indication related to considering the plurality of SRS resources for time bundling. The receiver may receive index information for each SRS resource out of the multiple SRS resources. The terminal may include a processor that considers whether the information relating to the plurality of SRS resources is equal or different with respect to each SRS resource. The processor may time bundle SRS resources based on similarities in the information.

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TERMINAL AND METHOD FOR PERFORMING SRS RESOURCES TIME BUNDLING FOR SRS COVERAGE ENHANCEMENTS

TECHNICAL FIELD

[0001] One or more embodiments disclosed herein relate to a terminal and a method for performing SRS resources time bundling for sounding reference signal (SRS) coverage enhancements.

BACKGROUND

[0002] Rel. 15 of New Radio (NR) includes a number of Multiple Input-Multiple Output (MIMO) features that facilitate utilization of a large number of antenna elements at a base station for both sub-6GHz and over-6GHz frequency bands. Rel. 16 of NR enhances Rel. 15 by introducing enhanced Type II codebook with Discrete Fourier Transform (DFT)-based compression, support for multi-Tx/Rx Point (TRP) transmission for enhanced Mobile Broadband (eMBB) and Physical Data Shared Channel (PDSCH), enhancements for multi-beam operation including reduction in latency and/or overhead for various reconfigurations (Quasi Co Location (QCL)-related, measurements), SCell beam failure recovery (BFR), and L1- signal-to-noise and interference ratio (SINR). In addition, Rel. 16 of NR also introduces low peak-to-average-power ratio (PAPR) reference signals and features enabling uplink full-power transmission.

CITATION LIST

NON-PATENT REFERENCE

[0003]

[Non-Patent Reference 1] 3GPP RP 193133, “New WID: Further enhancements on MIMO for NR”, Dec., 2019.

[Non-Patent Reference 2] 3GPP TS 38.211, "NR; Physical channels and modulation (Release 16)".

SUMMARY

[0004] In general, in one aspect, embodiments disclosed herein relate to a terminal that performs SRS resource time bundling for SRS coverage. The terminal includes a receiver that receives information relating to multiple SRS resources. The information includes an indication related to considering the plurality of SRS resources for time bundling. The receiver receives index information for each SRS resource out of the multiple SRS resources. The terminal includes a processor that considers whether the information relating to the plurality of SRS resources is equal or different with respect to each SRS resource. The processor time bundles SRS resources based on similarities in the information.

[0005] In general, in one aspect, embodiments disclosed herein relate to a terminal that performs SRS resource time bundling for SRS coverage. The terminal includes a receiver that receives information relating to SRS resources from same or different SRS resource sets with different usages. The terminal includes a processor that considers whether the information relating to each SRS resource out of the plurality of SRS resources is equal or different. The processor time bundles some of the SRS resources based on similarities in their respective information.

[0006] In general, in one aspect, embodiments disclosed herein relate to a method for performing SRS resource time bundling for SRS coverage. The method includes obtaining information relating to multiple SRS resources. The information includes an indication related to considering the plurality of SRS resources for time bundling. The method includes obtaining index information for each SRS resource out of the multiple SRS resources. The method includes considering whether the information relating to the plurality of SRS resources is equal or different with respect to each SRS resource. The method includes time bundling SRS resources based on similarities in the information.

[0007] In general, in one aspect, embodiments disclosed herein relate to a method for performing SRS resource time bundling for SRS coverage. The method includes obtaining information relating to SRS resources from same or different SRS resource sets with different usages. The method includes considering whether the information relating to each SRS resource out of the various SRS resources is equal or different. The method includes considering whether the information relating to the plurality of SRS resources is equal or different with respect to each SRS resource. The method includes time bundling some of the SRS resources based on similarities in their respective information. The method includes assigning the SRS resources to a same antenna port.

[0008] Other aspects of the disclosure will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 shows a diagram showing a configuration of a wireless communication system according to one or more embodiments of the present invention.

[0010] FIG. 2 shows a diagram showing a configuration of a wireless communication system according to one or more embodiments of the present invention.

[0011] FIG. 3 shows an example in accordance with one or more embodiments.

[0012] FIG. 4 shows an example in accordance with one or more embodiments.

[0013] FIG. 5A and FIG. 5B show examples in accordance with one or more embodiments.

[0014] FIG. 6 shows an example in accordance with one or more embodiments.

[0015] FIG. 7A and FIG. 7B show examples in accordance with one or more embodiments.

[0016] FIG. 8 shows an example in accordance with one or more embodiments.

[0017] FIG. 9 shows an example in accordance with one or more embodiments.

[0018] FIG. 10 shows an example in accordance with one or more embodiments.

[0019] FIG. 11 shows an example configuration instruction in accordance with one or more embodiments.

[0020] FIG. 12 shows an example configuration instruction in accordance with one or more embodiments.

[0021] FIG. 13 shows a block diagram of an assembly in accordance with one or more embodiments.

[0022] FIG. 14 shows a block diagram of an assembly in accordance with one or more embodiments.

[0023] FIG. 15 shows a block diagram of an assembly in accordance with one or more embodiments.

DETAILED DESCRIPTION

[0024] Specific embodiments of the invention will now be described in detail with reference to the accompanying figures. Like elements in the various figures are denoted by like reference numerals for consistency.

[0025] In the following detailed description of embodiments of the invention, numerous specific details are set forth in order to provide a more thorough understanding of the invention. However, it will be apparent to one of ordinary skill in the art that the invention may be practiced without these specific details. In other instances, well-known features have not been described in detail to avoid unnecessarily complicating the description.

[0026] Throughout the application, ordinal numbers (*e.g.*, first, second, third, etc.) may be used as an adjective for an element (*i.e.*, any noun in the application). The use of ordinal numbers is not to imply or create any particular ordering of the elements nor to limit any element to being a single element unless expressly disclosed, such as by the use of the terms “before,” “after,” “single,” and other such terminology. Rather,

the use of ordinal numbers is to distinguish between the elements. By way of an example, a first element is distinct from a second element, and the first element may encompass more than one element and succeed (or precede) the second element in an ordering of elements.

[0027] In one or more embodiments, enhancements in NR may include one or more areas of technological advancement. A technological advancement may be to aggressively reduce latency and/or overhead in high-speed vehicular scenarios (*e.g.*, a UE traveling at high speed on highways) at FR2 - not only for intra-cell, but also for L1/L2 centric inter-cell mobility. This also includes reducing occurrences of beam failure events. A technological advancement may enable further panel-specific UL beam selection. This offers some potential for increasing UL coverage including mitigating the UL coverage loss due to meeting the MPE (maximum permissible exposure) regulation. In one or more embodiments, a technological advancement

[0028] A technological advancement may be implementing channels other than PDSCH that benefit from multi-TRP transmission (as well as multi-panel reception), which also includes multi-TRP for inter-cell operations. This includes some cases for multi-TRP such as UL dense deployment within a macro-cell and/or heterogeneous-network-type deployment scenarios. A technological advancement may be to enhance capacity and coverage of SRS for various scenarios. A technological advancement may be to support enhanced Type II CSI. This includes CSI designed for multi-TRP/panel for NC-JT use case and the utilization of partial reciprocity on channel statistics such as angles and delays mainly targeting FR1 FDD deployments.

[0029] In one or more embodiments, requirements for enhancing SRS transmissions targeting both FR1 and FR2 may include: (1) identifying and specifying enhancements on aperiodic SRS triggering to facilitate more flexible triggering and/or DCI overhead/usage reduction; (2) specifying SRS switching for up to 8 antennas (*e.g.*, xTyR, x = {1, 2, 4}, and y = {6, 8}); and (3) evaluating and, if needed, specifying mechanism(s) to enhance SRS capacity and/or coverage. In some embodiments SRS

capacity and/or coverage includes SRS time bundling, increased SRS repetition, and partial sounding across frequency.

[0030] In one or more embodiments, SRS time bundling may be introduced to enhance SRS coverage in a wireless communication system while focusing on lowering overhead.

[0031] A wireless communication system 100 according to one or more embodiments of the present invention will be described below with reference to FIG. 1.

[0032] As shown in FIG. 1, the wireless communication system 100 includes a User Equipment (UE) 10, a Base Station (BS) 20, and a core network 30. The wireless communication system 100 may be a New Radio (NR) system or a Long-Term Evolution (LTE)/LTE-Advanced (LTE-A) system.

[0033] The BS 20 communicates with the UE 10 via multiple antenna ports using a multiple-input and multiple-output (MIMO) technology. The BS 20 may be a gNodeB (gNB) or an Evolved NodeB (eNB). The BS 20 receives downlink packets from a network equipment such as upper nodes or servers connected on the core network 30 via the access gateway apparatus and transmits the downlink packets to the UE 10 via the multiple antenna ports. The BS 20 receives uplink packets from the UE 10 and transmits the uplink packets to the network equipment via the multiple antenna ports.

[0034] The BS 20 includes antennas for MIMO to transmit radio signals between the UE 10, a communication interface to communicate with an adjacent BS 20 (for example, X2 interface), a communication interface to communicate with the core network (for example, S1 interface), and a CPU (Central Processing Unit) such as a processor or a circuit to process transmitted and received signals with the UE 10. Functions and processing of the BS 20 described below may be implemented by the processor processing or executing data and programs stored in a memory. However, the BS 20 is not limited to the hardware configuration set forth above and may include any appropriate hardware configurations. Generally, a plurality of the BSs 20 may be disposed so as to cover a broader service area of the wireless communication system 1. Furthermore, in some embodiments a BS may also be a terminal.

[0035] The UE 10 communicates with the BS 20 using the MIMO technology. The UE 10 transmits and receives radio signals such as data signals and control signals between the BS 20 and the UE 10. The UE 10 may be a mobile station, a smartphone, a cellular phone, a tablet, a radio terminal, a terminal, a mobile router, or information processing apparatus having a radio communication function such as a wearable device.

[0036] The UE 10 includes a CPU such as a processor, a RAM (Random Access Memory), a flash memory, and a radio communication device to transmit/receive radio signals to/from the BS 20 and the UE 10. For example, functions and processing of the UE 10 described below may be implemented by the CPU processing or executing data and programs stored in a memory. The UE 10 is not limited to the hardware configuration set forth above and may be configured with, e.g., a circuit to achieve the processing described below.

[0037] The wireless communication 1 supports Type II CSI feedback. As shown in FIG. 1, at step S1, the BS 20 transmits CSI-Reference Signals (RSs). When the UE 10 receives the CSI-RSs from the BS 20, the UE 10 performs measurements of the received CSI-RSs. Then, at step S2, the UE 10 performs CSI reporting to notify the BS 20 of the CSI as CSI feedback. For example, the CSI includes at least one of rank indicator (RI), precoding matrix indicator (PMI), channel quality information (CQI), CSI-RS resource indicator (CRI), a wideband (WB) amplitude, and a subband (SB) amplitude. In one or more embodiments of the present invention, the CSI reporting that reports the SB amplitude may be referred to as SB amplitude reporting. For example, rather than reporting the SB amplitude every time when the CSI reporting takes place, the periodicity of reporting the SB amplitude may be dynamically adjusted using higher layer signaling from the BS 20.

[0038] Based on the above, as shown in FIG. 2, SRS time bundling may be used enhance SRS coverage in a wireless communication system 2000. The communication system 400 includes the UE 10 and the BS 20. In communication system 2000, a UL SRS transmission 2010 is transmitted from the UE 10 to the BS 10. In response, the BS 20 may exchange beamformed CSI-RS 2020 to the UE 10, which causes the UE 10

to report at least UL CSI. The reporting provided by the UE 10 may be transmitted in UL CSI reporting 2030.

[0039] FIG. 3 shows an example of SRS time bundling configured for SRS coverage enhancement in the communication systems 100 and 2000. In particular, FIG. 3 shows an example of four SRS transmissions taking place at different slots. In one or more embodiments, the SRS transmissions are bundled together for channel estimation. In 5G NR, SRS repetition for a given SRS resource is used for enhancing the SRS coverage. However, with multiple symbols assigned for SRS transmission within a slot with repetition, the UL capacity may be negatively affected.

[0040] In NR, intra-slot and inter-slot time bundling may be applied between the same or different SRS resources. In this regard, time bundling utilizes a relationship among two or more occasions of one or more SRS resources or occasions to enable joint processing within time domain, without changing legacy SRS pattern in one resource. To this point, SRS time bundling may be introduced so that multiple SRS resources are time bundled together to enhance the SRS coverage while reducing the impact on the UL capacity. As shown in FIG. 3, inter-slot time bundling may be performed to enhance SRS coverage.

[0041] FIG. 4 shows an example of intra-slot time bundling configured for coverage enhancement in the communication systems 100 and 2000. In one or more embodiments, multiple SRS resources from the same or different SRS resource sets are time bundled together within a slot for estimating the channel associated with a particular antenna port. In communication systems 100 and 2000, the UE 10 may receive information relating to various SRS resources. To this point, the information may include an indication related to considering the SRS resources for time bundling. Further, the UE 20 may receive index information for each SRS resource out of the SRS resources. Once the various information has been received, the UE 20 may consider whether the information relating to the SRS resources is equal or different with respect to each SRS resource such that the UE 20 may time bundle SRS resources based on similarities in the information.

[0042] In one or more embodiments, time bundled SRS resources may be assigned to a same SRS antenna port. In this case, periodicities of different time-bundled SRS resources within a slot may be same or different. As shown in FIG. 4, two SRS resources from two SRS resource sets may be time bundled together to estimate the channel associated with an antenna port AP_1. In some embodiments, a NW may trigger an aperiodic SRS resource to be transmitted within a particular UL slot while bundling it with already configured for transmission of periodic SRS resources, SP resources, or aperiodic SRS resources transmitting within the same slot.

[0043] In one or more embodiments, information is needed for configuring one or more SRS resources from SRS resource sets that are time bundled. In some embodiments, the information may indicate explicitly, or implicitly, SRS resources/SRS resource sets which need to be considered for time bundling. Further, the information may indicate some index per SRS resource/SRS resource set. Then the SRS resources/SRS resource sets corresponding to the same index may be time bundled. In this case, the information may be configured using higher layer or DCI signaling. To this end, the information relating to the SRS resources may include parameter *transmissionComb*. Configurations of time-bundled SRS resources for the parameter may be the same or different. In this case, different time bundled SRS resources can be assigned to different SRS antenna ports for estimating channels associated with the respective antenna ports.

[0044] FIG. 5A and FIG. 5B show examples of intra-slot time bundling configured for coverage enhancement in the communication systems 100 and 2000. In one or more embodiments, multiple SRS resources from the same or different SRS resource sets with different usages may be time-bundled together within a slot for estimating the channel associated with a particular antenna port. In particular, same slot bundling may be performed because time bundled SRS resources may be assigned to a same SRS antenna port.

[0045] In some embodiments, the periodicities of different SRS resources time bundled within a slot can be the same or different. As shown in FIG. 5A, two SRS

resources from two SRS resource sets with different usages are time bundled together to estimate the channel associated with the antenna port AP_1. In some embodiments, the NW triggers an aperiodic SRS resource to be transmitted within a particular UL slot while time bundling it with already configured periodic/SP/aperiodic SRS resource transmission takes place within the same slot. As shown FIG. 5B, in some embodiments, the NW configures time bundling of different periodic/SP SRS resources with different periodicities, whenever they fall into the same UL slot. The time bundled SRS resources are transmitted from the same SRS antenna port.

[0046] In accordance with the above, the examples of FIG. 5A and FIG. 5B may be implemented for time bundles of more than 2 SRS resources as well as time bundling of 4 or 8 SRS resources. The bundle size (explained in more detail below) is 2 in these examples.

[0047] FIG. 6 shows an example of inter-slot time bundling configured for coverage enhancement in the communication systems 100 and 2000. In one or more embodiments, single or multiple SRS resource(s) from the same slot, or different SRS resource sets occurring at different slots, may be time-bundled together for estimating channel associated with a particular antenna port. To this end, time bundled SRS resources may be assigned to a same SRS antenna port. As shown in FIG. 6, periodic/SP SRS resource with single SRS symbol may be time-bundled considering bundle sizes of $x \in \{1, 2, 4\}$ symbols.

[0048] As shown in FIG. 6, there may be three parameters to be configured using higher layer or DCI signaling for inter-slot time bundling of periodic/SP SRS resource. These parameters may be a starting slot, a bundle size, and a separation of consecutive time bundled symbols.

[0049] In some embodiments, the slot carrying the first SRS symbol/resource of time-bundle may be configured using higher layer or DCI signaling. In this case, the NW triggers a time bundled SRS transmission using higher layer signaling or DCI. Then, the UE may transmit a first symbol based on a pre-configured offset in the specification. Further, the NW triggers a time bundled SRS transmission using higher

layer signaling or DCI. Then, the UE may transmit the first symbol based on an offset configured using higher layer signaling.

[0050] In some embodiments, the bundle size x may be 1, 2, 4, 8, or other values. This value may be configured using higher layer or DCI signaling. In this case, a set of values for x is pre-defined in the specification. Then, one value out of those pre-defined values (*e.g.*, let $x \in \{1, 2, 4, 8\}$) may be selected using higher layer signaling or using m-bits in DCI. Then, using m=2 bits in DCI, the NW may select the value of x.

[0051] In some embodiments, the separation between two consecutive time bundled SRS symbols is configured using higher layer or DCI signaling. In this case, the set of values for y may be pre-defined in the specification. Then, one value out of those pre-defined values may be selected using higher layer signaling or using m-bits in DCI (*e.g.*, let $y \in \{3, 6\}$ and using m=1 bit in DCI, the NW selects value of y). Further, the separation may be pre-configured in the specification. The separation may be defined in terms of number of UL slots.

[0052] If time bundled SRS resources are from different SRS resource sets, the NW configures which SRS resources from SRS resource sets are time bundled using higher layer or DCI signaling. In some embodiments, time bundling is performed considering explicit/implicit indication of SRS resources/SRS resource sets for time bundling; indication of some index per SRS resource/SRS resource set. At this stage, the SRS resources/SRS resource sets corresponding to the same index may be time bundled.

[0053] In one or more embodiments, separate indication of SRS resources may not need to be considered for time-bundling. Further, as noted above, different time bundled SRS resources may be assigned to different SRS antenna ports for channel estimation.

[0054] FIG. 7A and FIG. 7B show examples of inter-slot time bundling configured for coverage enhancement in the communication systems 100 and 2000. In one or more embodiments, if time bundled SRS resources are from different SRS

resource sets, using higher layer or DCI signaling, the NW configures which SRS resources from SRS resource sets are time bundled. In some embodiments, explicit/implicit indication of SRS resources/SRS resource sets are considered for time bundling. Further, indication of some index per SRS resource/SRS resource set are considered for time bundling. As such, the SRS resources/SRS resource sets corresponding to the same index may be time bundled.

[0055] In one or more embodiments, separate indication of SRS resources may not need to be considered for time-bundling. Further, as noted above, different time bundled SRS resources may be assigned to different SRS antenna ports for channel estimation. As shown in FIG. 7A, the NW time bundles aperiodic SRS resources with already configured periodic/semi-periodic (SP)/aperiodic SRS resources in different slots. In some embodiments, time bundling may be done between the nearest SRS transmission of a periodic/SP SRS resource with an aperiodic SRS resource. In this case, a periodic/SP SRS resource with a single SRS symbol is time bundled with an aperiodic SRS resource. The bundle size is 2 in this example.

[0056] As shown in FIG. 7B, the NW configures/triggers a starting slot of a time-bundle using an aperiodic SRS resource. In this case, a periodic/SP SRS resource may be time bundled with an aperiodic SRS resource such that the starting slot of the time bundle is the slot transmitting an aperiodic SRS resource. The bundle size is 4 this example. In some embodiments, the bundle size and the symbol separation may be configured as discussed with respect to FIG. 6. Further, the aperiodic SRS transmission and periodic/SP SRS resource transmission within the time bundle may be done using the same SRS antenna port. Further, instead of aperiodic SRS resource, the NW may time bundle SRS symbols in different slots from another periodic/SP SRS resource. The SRS resource indication may be done as discussed above.

[0057] FIG. 8 shows an example of inter-slot time bundling in the communication systems 100 and 2000. In one or more embodiments, inter-slot time bundling may be considered for estimating and tracking spatial covariance of the channel. In particular, periodic/SP SRS may be configured with larger periodicity for

estimating spatial covariance. In this case, if there is a sudden change in consecutive covariance estimations, the NW may trigger an aperiodic SRS transmission. As such, time bundling may be configured for periodic/SP SRS transmission in covariance estimation. As shown in FIG. 8, periodic/SP SRS transmission is time-bundled with an aperiodic SRS transmission for covariance estimation.

[0058] FIG. 9 shows an example of intra-slot time bundling and inter-slot time bundling configured for coverage enhancement in the communication systems 100 and 2000. In one or more embodiments, multiple SRS resource transmissions may take place within a same slot and among different slots. In this case, multiple SRS resource transmissions may be time bundled together for estimating the channel associated with a particular antenna port. Time bundled SRS resources may be assigned to the same SRS antenna port. As shown in FIG. 9, three SRS resources with a single SRS symbol may be time bundled considering a bundle size of 3 symbols. The time bundling may consider intra-slot and inter-slot bundling jointly. To this point, SRS resource indication of the bundle may be done as discussed above.

[0059] FIG. 10 shows an example of repetition and inter-slot time bundling configured for coverage enhancement in the communication systems 100 and 2000. In one or more embodiments, SRS resource transmissions may be configured with symbol repetition and that SRS resource transmissions may be time bundled together with an SRS resource transmission takes place in a different slot, for estimating the channel associated with a particular antenna port. Time bundled SRS resources may be assigned to the same SRS antenna port. As shown in FIG. 10, an SRS resource with *repetitionFactor* may be configured to 2 such that time-bundling may be performed with an SRS resource with or without repetition. In this case, the bundle size is equal to 3. In some embodiments, all or some of the time bundled SRS resources may be configured with different values for *repetitionFactor*. To this point, SRS resource indication of the bundle may be done as discussed above.

[0060] FIG. 11 shows possible updates for implementing a number of antenna ports such that antenna ports per SRS resource may be changed to include sizes 6 and

8. In this case, $N_{ap}^{SRS} \epsilon \{1, 2, 4, 6, 8\}$ antenna ports $\{p_i\}_{i=0}^{N_{ap}^{SRS}-1}$, where the number of antenna ports may be given by the higher layer parameter *nrofSRS-Ports* if configured, otherwise $N_{ap}^{SRS} = 1$, and $p_i = 100 + i$ when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* not set to *nonCodebook*, or determined according to the specification when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* set to *nonCodebook*.

[0061] FIG. 12 shows an example of intra-slot time bundling configured for coverage enhancement in the communication systems 100 and 2000. In one or more embodiments, a parameter *SRS-Config* IE may be used to configure SRS transmissions. In some embodiments, a list of *SRS-ResourceSets* and SRS-Resources may be defined in *SRS-Config*. Each *SRS-ResourceSets* may be configured with a set of SRS-Resources. In one or more embodiments, *SRS-ResourceSets* may be configured by the parameter *usage* for applicability. In some embodiments, when PUSCH and SRS are transmitted in the same slot, the UE may only be configured to transmit SRS after the transmission of the PUSCH and the corresponding DM-RS.

[0062] FIG. 13 shows possible updates for implementing an SRS resource configured by *SRS-Resource* IE and consists. In this case, the update includes supporting multiple antenna ports, time domain allocation, frequency domain allocation, related indication of hopping, and SRS characteristics for periodic SRS.

[0063] The BS 20 according to one or more embodiments of the present invention will be described below with reference to the FIG. 14.

[0064] As shown in FIG. 14, the BS 20 may include an antenna 201 for 3D MIMO, an amplifier 202, a transmitter/receiver circuit 203 (hereinafter referred as including a CSI-RS scheduler), a baseband signal processor 204 (hereinafter referred as including a CS-RS generator), a call processor 205, and a transmission path interface 206. The transmitter/receiver 202 includes a transmitter and a receiver.

[0065] The antenna 201 may comprise a multi-dimensional antenna that includes multiple antenna elements such as a 2D antenna (planar antenna) or a 3D antenna such

as antennas arranged in a cylindrical shape or antennas arranged in a cube. The antenna 201 includes antenna ports having one or more antenna elements. The beam transmitted from each of the antenna ports is controlled to perform 3D MIMO communication with the UE 10.

[0066] The antenna 201 allows the number of antenna elements to be easily increased compared with linear array antenna. MIMO transmission using a large number of antenna elements is expected to further improve system performance. For example, with the 3D beamforming, high beamforming gain is also expected according to an increase in the number of antennas. Furthermore, MIMO transmission is also advantageous in terms of interference reduction, for example, by null point control of beams, and effects such as interference rejection among users in multi-user MIMO can be expected.

[0067] The amplifier 202 generates input signals to the antenna 201 and performs reception processing of output signals from the antenna 201.

[0068] The transmitter included in the transmitter/receiver circuit 203 transmits data signals (e.g., reference signals and precoded data signals) via the antenna 201 to the UE 10. The transmitter transmits CSI-RS resource information that indicates a state of the determined CSI-RS resources (e.g., subframe configuration ID and mapping information) to the UE 20 via higher layer signaling or lower layer signaling. The transmitter transmits the CSI-RS allocated to the determined CSI-RS resources to the UE 10.

[0069] The receiver included in the transmitter/receiver circuit 203 receives data signals (i.e., reference signals and the CSI feedback information) via the antenna 201 from the UE 10.

[0070] The CSI-RS scheduler 203 determines CSI-RS resources allocated to the CSI-RS. For example, the CSI-RS scheduler 203 determines a CSI-RS subframe that includes the CSI-RS in subframes. The CSI-RS scheduler 203 determines at least an RE that is mapped to the CSI-RS.

[0071] The CSI-RS generator 204 generates CSI-RS for estimating the downlink channel states. The CSI-RS generator 204 may generate reference signals defined by the LTE standard, dedicated reference signal (DRS) and Cell-specific Reference Signal (CRS), synchronized signals such as Primary synchronization signal (PSS) and Secondary synchronization signal (SSS), and newly defined signals in addition to CSI-RS.

[0072] The call processor 205 determines a precoder applied to the downlink data signals and the downlink reference signals. The precoder is called a precoding vector or more generally a precoding matrix. The call processor 205 determines the precoding vector (precoding matrix) of the downlink based on the CSI indicating the estimated downlink channel states and the decoded CSI feedback information inputted.

[0073] The transmission path interface 206 multiplexes CSI-RS on REs based on the determined CSI-RS resources by the CSI-RS scheduler 203.

[0074] The transmitted reference signals may be Cell-specific or UE-specific. For example, the reference signals may be multiplexed on the signal such as PDSCH, and the reference signal may be precoded. Here, by notifying a transmission rank of reference signals to the UE 10, estimation for the channel states may be realized at the suitable rank according to the channel states.

[0075] The BS 20 further, in one or more embodiments, comprising hardware configured for reducing feedback overhead associated with bitmap reporting between a user equipment and a base station. For example, the BS 20 may include the capabilities described above for reducing feedback overhead when communicating with the UE 10.

[0076] The UE 10 according to one or more embodiments of the present invention will be described below with reference to the FIG. 15.

[0077] As shown in FIG. 15, the UE 10 may comprise a UE antenna 101 used for communicating with the BS 20, an amplifier 102, a transmitter/receiver circuit 103, a controller 104, the controller including a CSI feedback controller and a codeword

generator, and a CSI-RS controller. The transmitter/receiver circuit 103 includes a transmitter and a receiver 1031.

[0078] The transmitter included in the transmitter/receiver circuit 103 transmits data signals (for example, reference signals and the CSI feedback information) via the UE antenna 101 to the BS 20.

[0079] The receiver included in the transmitter/receiver circuit 103 receives data signals (for example, reference signals such as CSI-RS) via the UE antenna 101 from the BS 20.

[0080] The amplifier 102 separates a PDCCH signal from a signal received from the BS 20.

[0081] The controller 104 estimates downlink channel states based on the CSI-RS transmitted from the BS 20, and then outputs a CSI feedback controller.

[0082] The CSI feedback controller generates the CSI feedback information based on the estimated downlink channel states using the reference signals for estimating downlink channel states. The CSI feedback controller outputs the generated CSI feedback information to the transmitter, and then the transmitter transmits the CSI feedback information to the BS 20. The CSI feedback information may include at least one of Rank Indicator (RI), PMI, CQI, BI and the like.

[0083] The CSI-RS controller determines whether the specific user equipment is the user equipment itself based on the CSI-RS resource information when CSI-RS is transmitted from the BS 20. When the CSI-RS controller 16 determines that the specific user equipment is the user equipment itself, the transmitter that CSI feedback based on the CSI-RS to the BS 20.

[0084] The UE 10 further, in one or more embodiments, comprising hardware configured for reducing feedback overhead associated with bitmap reporting between a user equipment and a base station. For example, the UE 10 may include the capabilities described above for reducing feedback overhead when communicating with the BS 20.

[0085] The above examples and modified examples may be combined with each other, and various features of these examples can be combined with each other in various combinations. The invention is not limited to the specific combinations disclosed herein.

[0086] Although the disclosure has been described with respect to only a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that various other embodiments may be devised without departing from the scope of the present invention. Accordingly, the scope of the invention should be limited only by the attached claims.

CLAIMS

What is claimed is:

1. A terminal that performs Sounding Reference Signal (SRS) resource time bundling for SRS coverage, the terminal comprising:
   a receiver that:
      receives information relating to a plurality of SRS resources, the information including an indication related to considering the plurality of SRS resources for time bundling, and
      receives index information for each SRS resource out of the plurality of SRS resources; and
   a processor that:
      determines whether the information relating to the plurality of SRS resources is equal or different with respect to each SRS resource of the plurality of SRS resources; and
      time bundles SRS resources based on similarities in the information.

2. The terminal according to claim 1,
   wherein the information relating to the SRS resources comprises a parameter transmissionComb.

3. The terminal according to claim 1, the terminal further comprising:
   a transmitter coupled to the processor that assigns time bundled SRS resources comprising different information to different SRS antenna ports for estimating channels associated with respective antenna ports.

4. A terminal that performs Sounding Reference Signal (SRS) resource time bundling for SRS coverage, the terminal comprising:
   a receiver that receives information relating to a plurality of SRS resources from same or different SRS resource sets with different usages;
   a processor that:

determines whether the information relating to each SRS resource out of the plurality of SRS resources is equal or different, and

time bundles some of the SRS resources based on similarities in their respective information; and

a transmitter coupled to the processor that assigns the SRS resources to a same antenna port.

5. The terminal according to claim 4,

wherein periodicities of different SRS resources are time bundled within a same slot.

6. The terminal according to claim 4,

wherein an aperiodic SRS resource is transmitted within a particular UL slot while time bundling it with already configured periodic/semi-periodic/aperiodic SRS resource transmission takes place within a same slot.

7. The terminal according to claim 4,

wherein a slot carrying a first SRS resource that is time-bundled is configured using higher layer or DCI signaling.

8. The terminal according to claim 7,

wherein the transmitter transmits the first SRS resource based on an offset configured using higher layer signaling.

9. The terminal according to claim 7,

wherein the transmitter transmits the first SRS resource based on a pre-determined offset.

10. The terminal according to claim 4,

wherein a bundle size is a number of SRS resources used for time bundling,

wherein the bundle size is 1, 2, 4, or 8, and

wherein the bundle size is configured using higher layer signaling or DCI signaling.

11. The terminal according to claim 4,

wherein separation between any two consecutive time bundled SRS resources is configured using higher layer signaling or DCI signaling.

12. The terminal according to claim 4,

wherein a plurality of SRS resource transmissions take place within a same slot or among different slots are time bundled together for estimating a channel associated with a particular antenna port.

13. The terminal according to claim 4,

wherein SRS resource transmissions configured with symbol repetition are time bundled together with an SRS resource transmission that takes place in a different slot for estimating a channel associated with a particular antenna port.

14. A method for performing Sounding Reference Signal (SRS) resource time bundling for SRS coverage, the method comprising:

obtaining information relating to a plurality of SRS resources, the information including an indication related to considering the plurality of SRS resources for time bundling;

obtaining index information for each SRS resource out of the plurality of SRS resources;

determining whether the information relating to the plurality of SRS resources is equal or different with respect to each SRS resource; and

time bundling SRS resources based on similarities in the information.

15. The method according to claim 14,

wherein the information relating to the SRS resources include a parameter transmissionComb.

16. The method according to claim 14, the method further comprising:

assigning SRS resources comprising different information to different SRS antenna ports for estimating channels associated with respective antenna ports.

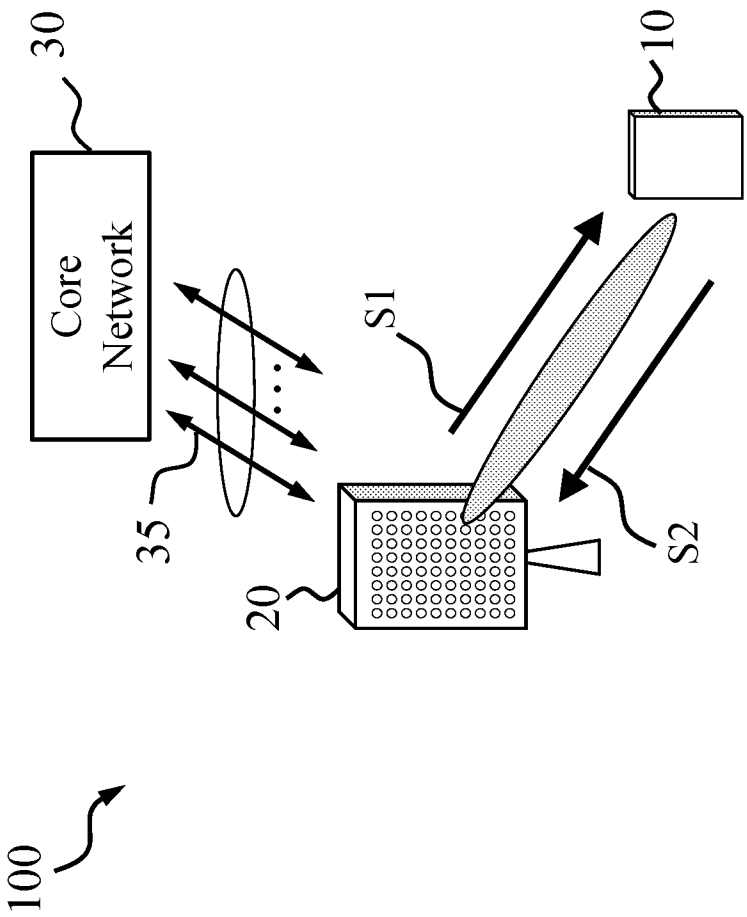


FIG. 1

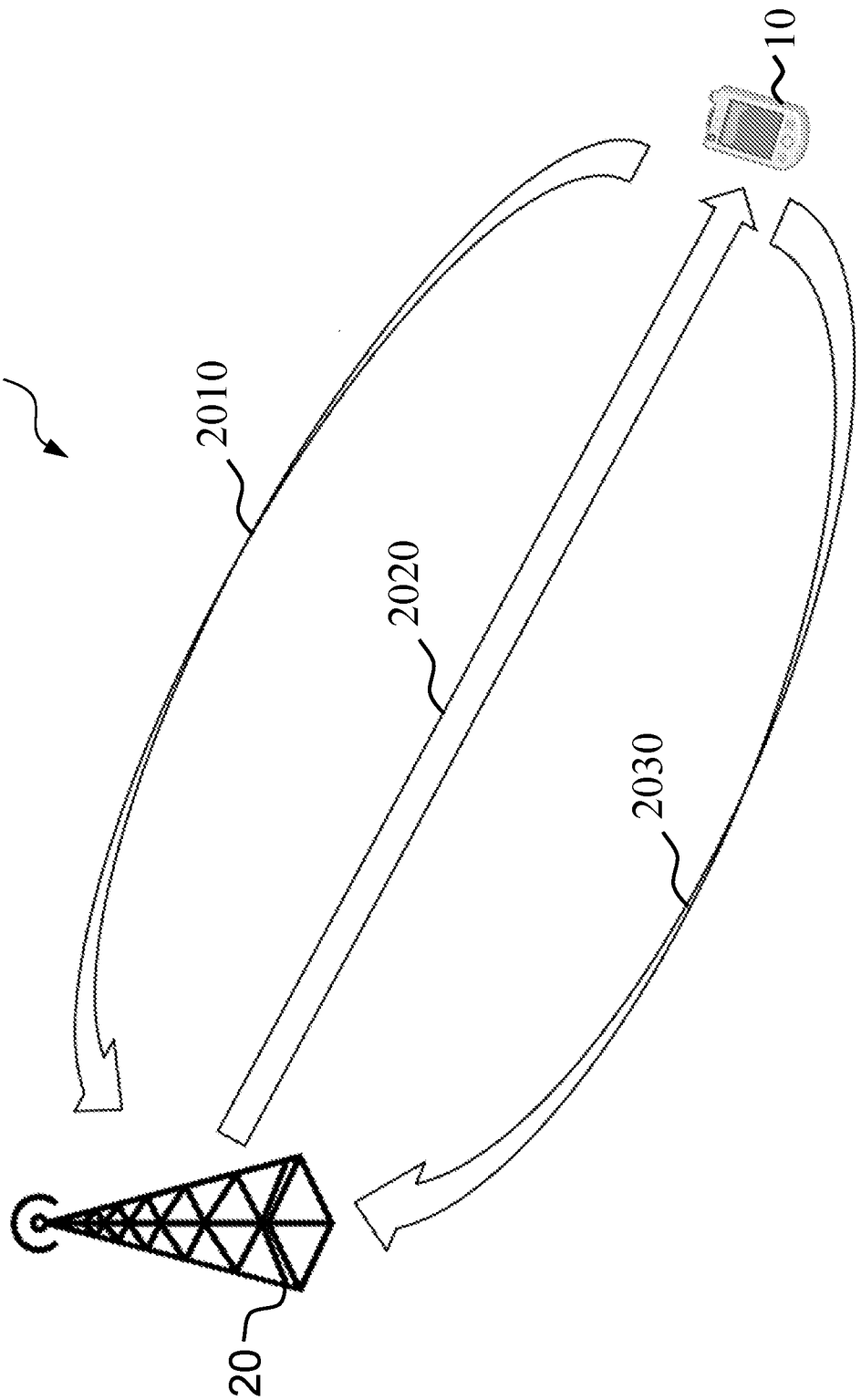


FIG. 2

FIG. 3

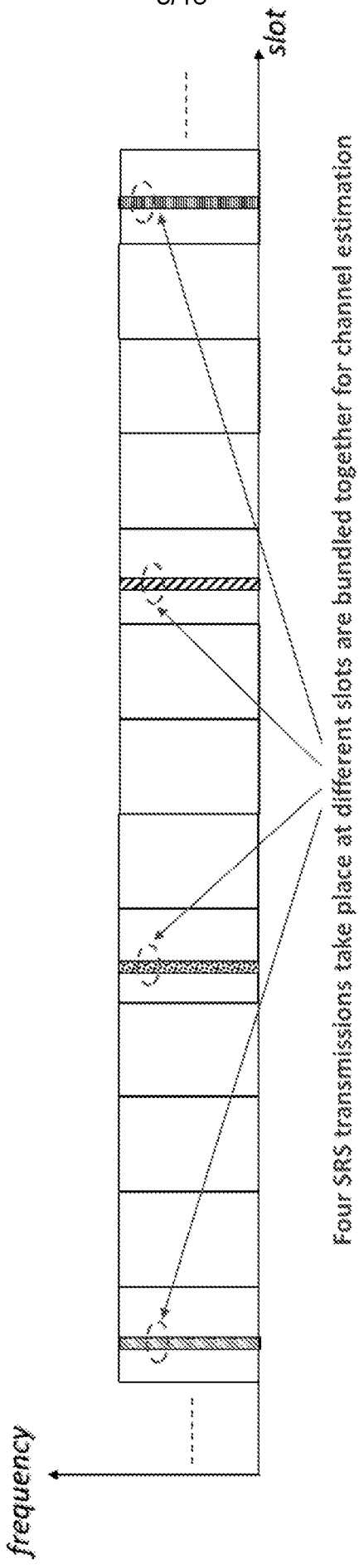

slot
frequency
Four SRS transmissions take place at different slots are bundled together for channel estimation

FIG. 4

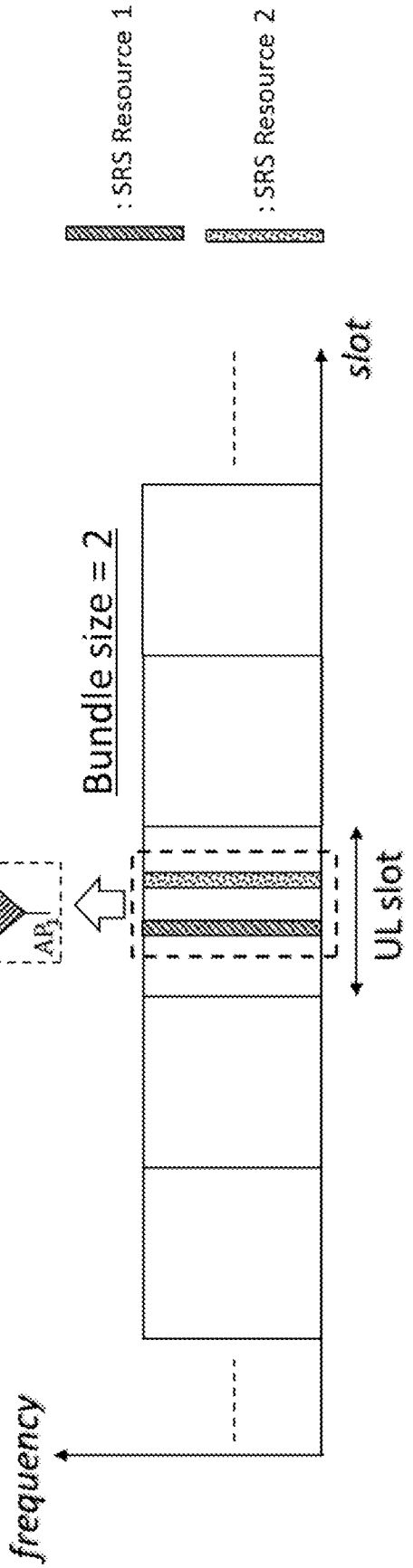

: SRS Resource 1
: SRS Resource 2
slot
Bundle size = 2
AP1
UL slot
frequency

FIG. 5A

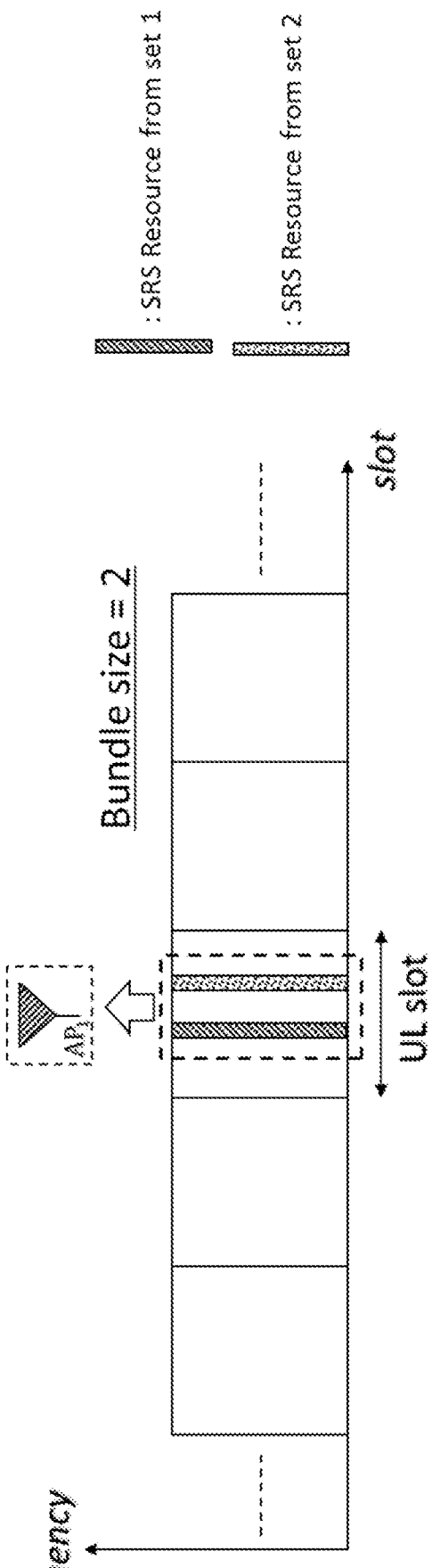

: SRS Resource from set 1
: SRS Resource from set 2
slot
Bundle size = 2
UL slot
frequency

FIG. 5B

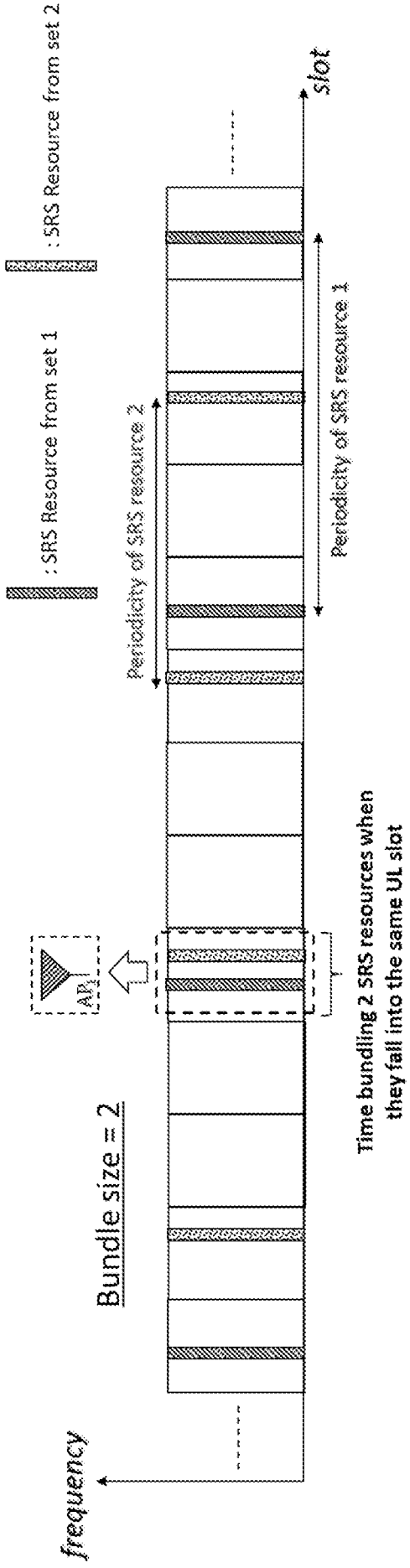

: SRS Resource from set 2
: SRS Resource from set 1
slot
Periodicity of SRS resource 2
Periodicity of SRS resource 1
Bundle size = 2
Time bundling 2 SRS resources when they fall into the same UL slot
frequency

FIG. 6

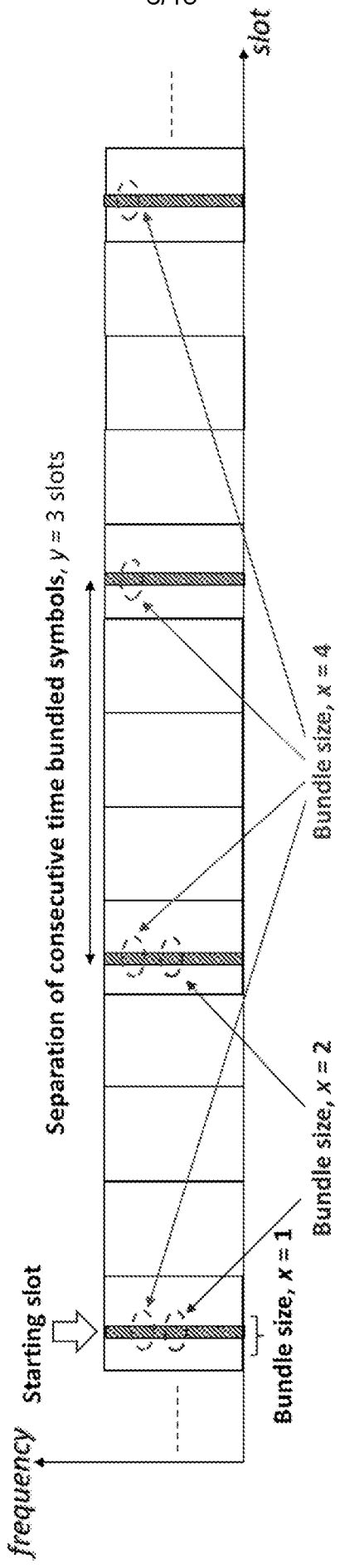

slot
frequency
Starting slot
Separation of consecutive time bundled symbols, y = 3 slots
Bundle size, x = 4
Bundle size, x = 2
Bundle size, x = 1

FIG. 7A

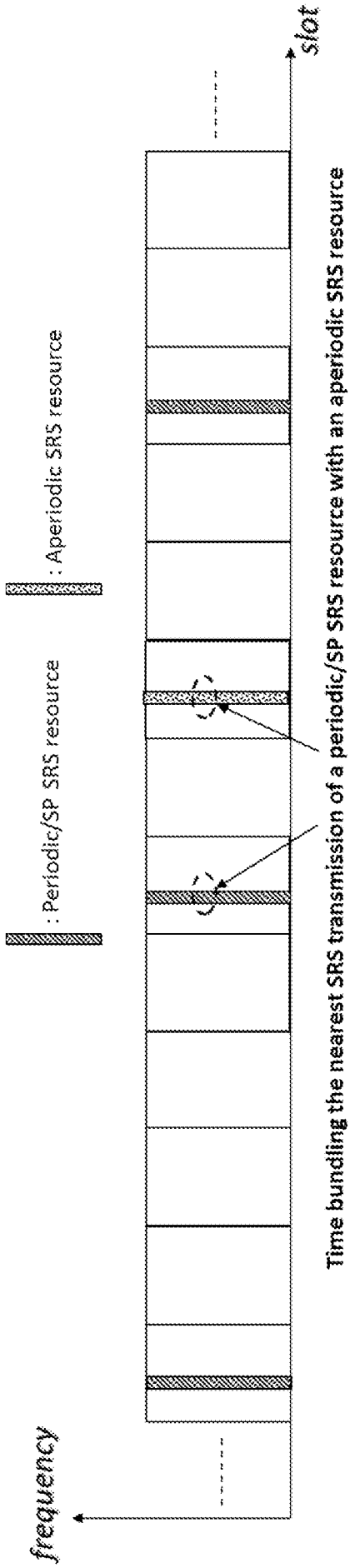

slot
: Aperiodic SRS resource
: Periodic/SP SRS resource
Time bundling the nearest SRS transmission of a periodic/SP SRS resource with an aperiodic SRS resource
frequency

FIG. 7B

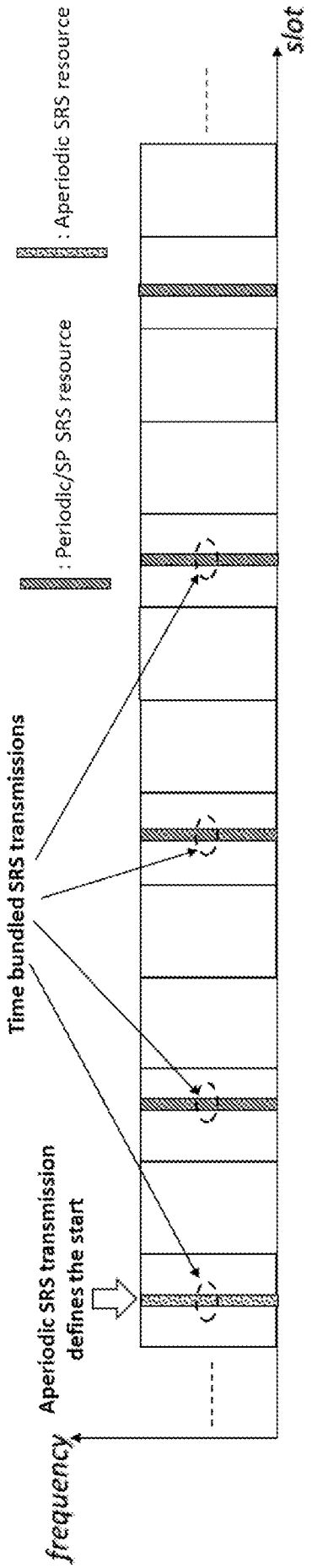

slot
: Aperiodic SRS resource
: Periodic/SP SRS resource
Time bundled SRS transmissions
Aperiodic SRS transmission defines the start
frequency

FIG. 8

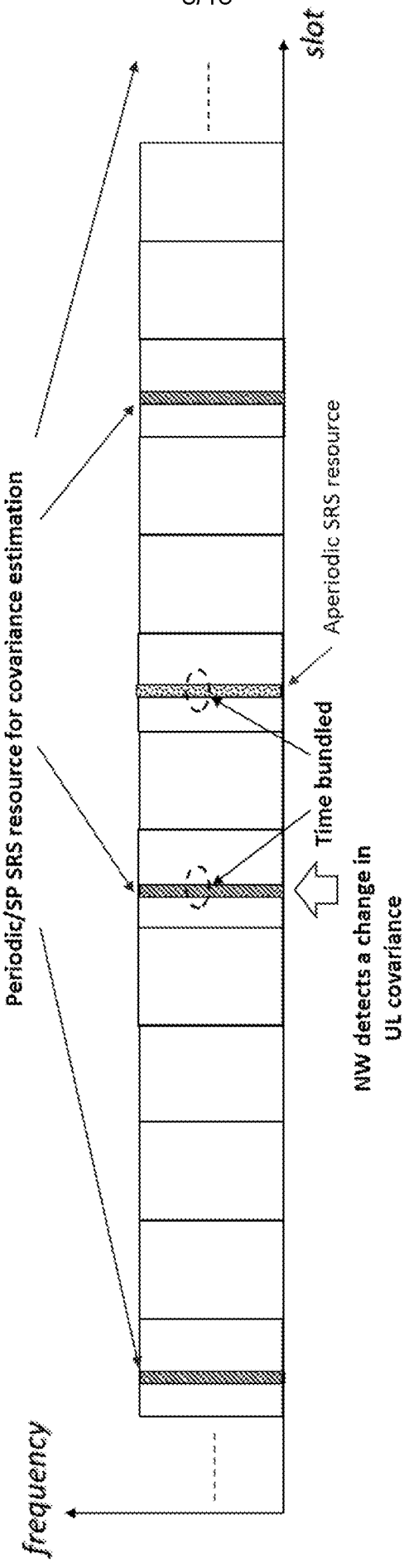

slot
frequency
Periodic/SP SRS resource for covariance estimation
Aperiodic SRS resource
Time bundled
NW detects a change in UL covariance

FIG. 9

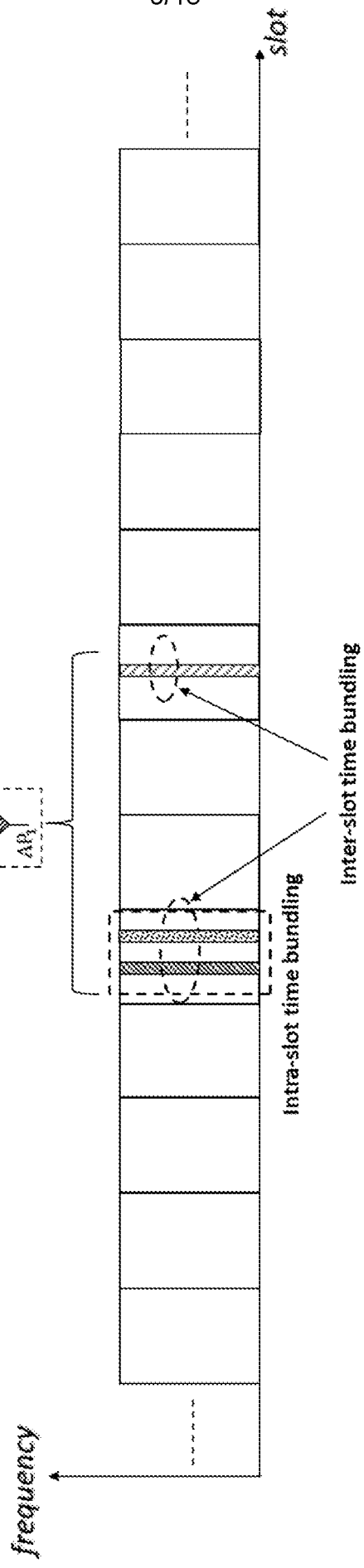

slot
frequency
Inter-slot time bundling
Intra-slot time bundling
ΔP_3

FIG. 10

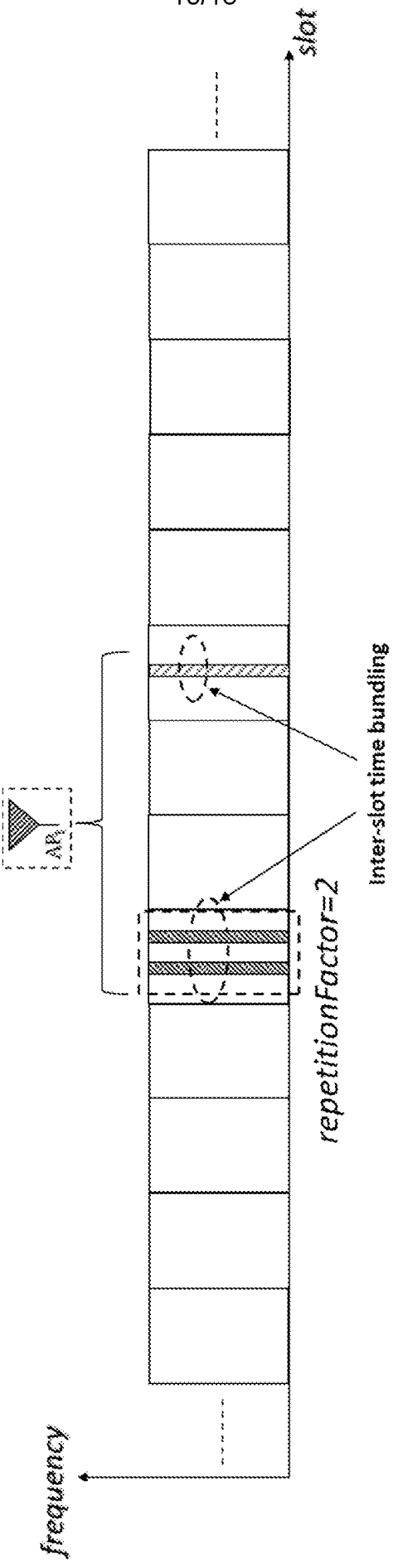
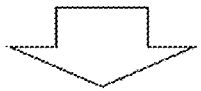

slot
frequency
repetitionFactor=2
Inter-slot time bundling
AP

FIG. 11

$N_{ap}^{SRS} \in \{1,2,4\}$ antenna ports $\{p_i\}_{i=0}^{N_{ap}^{SRS}-1}$, where the number of antenna ports is given by the higher layer parameter *nrofSRS-Ports* if configured, otherwise $N_{ap}^{SRS} = 1$, and $p_i = 1000 + i$ when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* not set to 'nonCodebook', or determined according to [6, TS 38.214] when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook' [4]



Required Update

$N_{ap}^{SRS} \in \{1,2,4,6,8\}$ antenna ports $\{p_i\}_{i=0}^{N_{ap}^{SRS}-1}$, where the number of antenna ports is given by the higher layer parameter *nrofSRS-Ports* if configured, otherwise $N_{ap}^{SRS} = 1$, and $p_i = 1000 + i$ when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* not set to 'nonCodebook', or determined according to [6, TS 38.214] when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook' [4]

FIG. 12

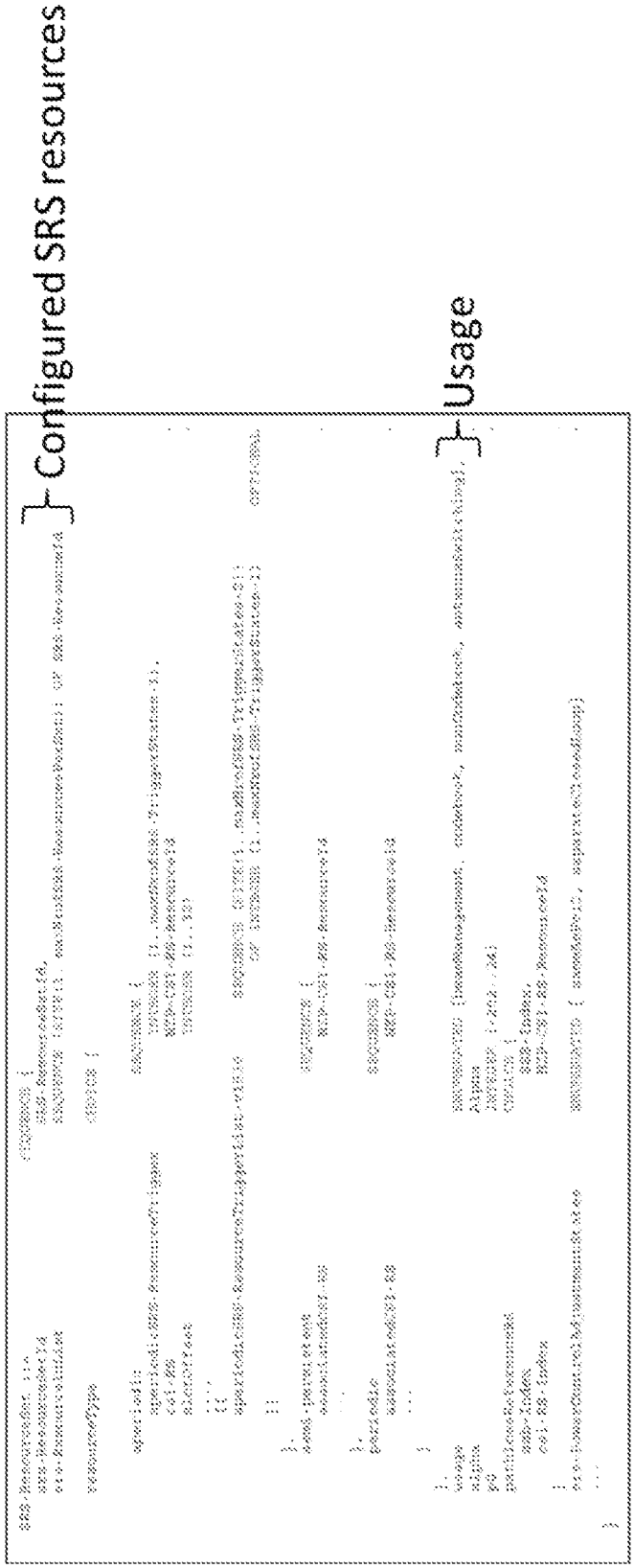
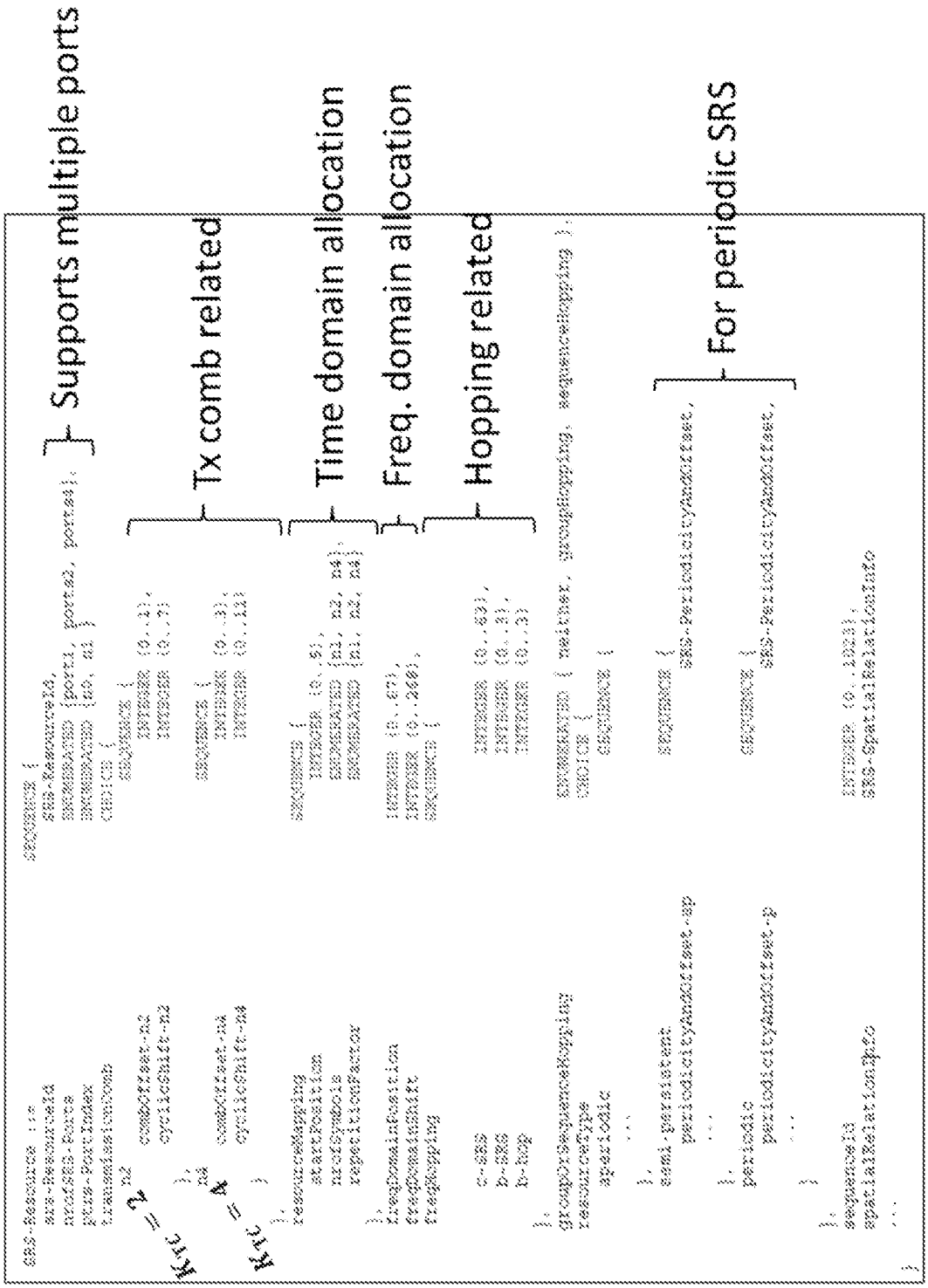


FIG. 13


Supports multiple ports
Tx comb related
Time domain allocation
Freq. domain allocation
Hopping related
For periodic SRS

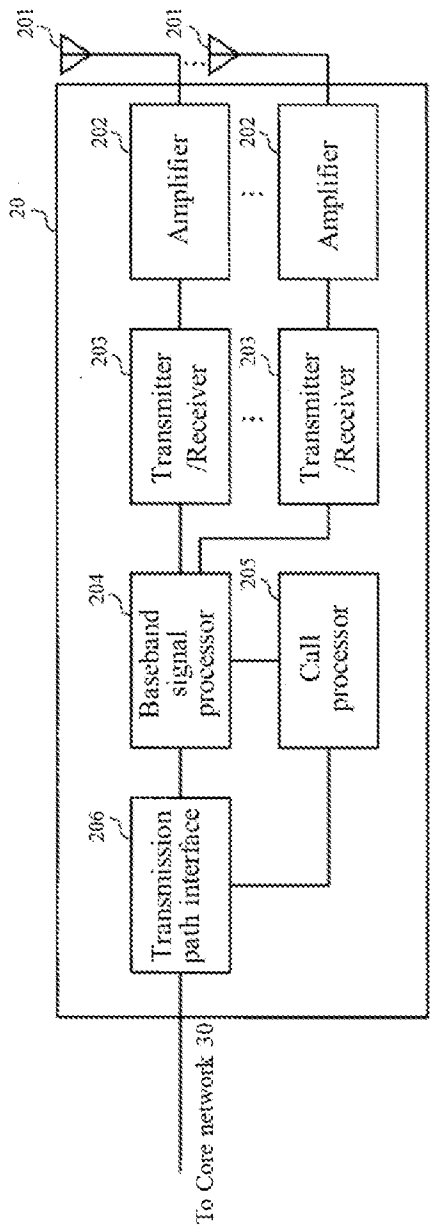

20
201
201
202
Amplifier
202
Amplifier
203
Transmitter /Receiver
203
Transmitter /Receiver
204
Baseband signal processor
205
Call processor
206
Transmission path interface
To Core network 30

FIG. 14

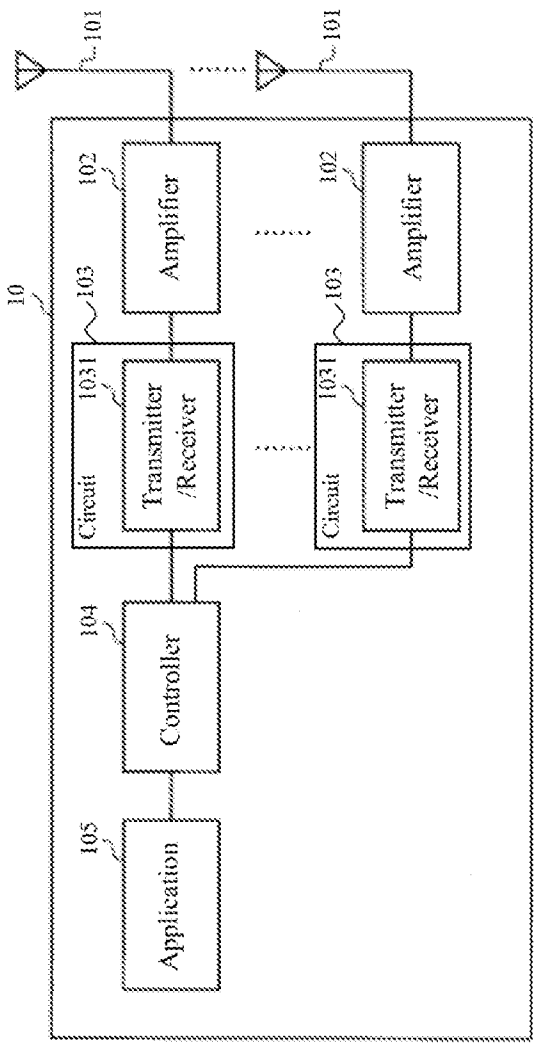

10
101
101
102
Amplifier
102
Amplifier
103
103
1031
Circuit
Transmitter /Receiver
1031
Circuit
Transmitter /Receiver
104
Controller
105
Application

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/055213

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00 H04L25/02
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HUAWEI ET AL: "Enhancements on SRS for Rel-17", 3GPP DRAFT; R1-2005247, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. E-meeting; 20200817 - 20200828 8 August 2020 (2020-08-08), XP051917295, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005247.zip R1-2005247.docx [retrieved on 2020-08-08] page 3 ----- -/--	1-16

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

[x] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 January 2022	03/02/2022

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	Gimmler-Dumont, C

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/055213

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 111 224 766 A (BEIJING UNISOC COMMUNICATION TECH CO LTD) 2 June 2020 (2020-06-02) paragraph [0077] - paragraph [0078] paragraph [0081] - paragraph [0083] -----	1-16
E	WO 2021/229539 A1 (ERICSSON TELEFON AB L M [SE]) 18 November 2021 (2021-11-18) page 37, line 23 - line 32 page 40, line 16 - line 29 page 45, line 14 - line 31 page 46, line 27 - line 32 page 50, line 16 - line 26 -----	1,4,14
A,P	NTT DOCOMO ET AL: "Discussion on SRS enhancement", 3GPP DRAFT; R1-2009179, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. e-Meeting; 20201026 - 20201113 23 October 2020 (2020-10-23), XP051946884, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2009179.zip R1-2009179.docx [retrieved on 2020-10-23] page 5 - page 7 -----	1-16

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2021/055213

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 111224766 A	02-06-2020	CN 111224766 A	02-06-2020
		WO 2021139831 A1	15-07-2021
WO 2021229539 A1	18-11-2021	NONE	