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(71) **Applicant: NOKIA TECHNOLOGIES OY** [FI/FI]; Karakaari 7, 02610 Espoo (FI).

(72) **Inventors: ROSA, Claudio**; Alfred Nobels Vej 27, 9220 Aalborg (DK). **PARIS, Stefano**; 12 rue Jean Bart, 91300 Massy (FR). **YANAKIEV, Boyan**; Alfred Nobels Vej 27, 9220 Aalborg (DK). **KASHYAP, Bharath Ramesh**; Manyata Embassy Business Park, Bangalore 560045 (IN). **LI, Zexian**; Karakaari 13, 02610 Espoo (FI).

(74) **Agent: NOKIA EPO REPRESENTATIVES**; Nokia Technologies Oy, Karakaari 7, 02610 ESPOO (FI).

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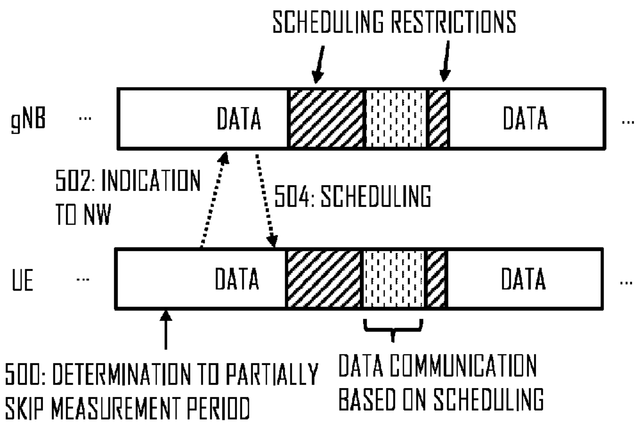

FIG. 5

(57) **Abstract:** There is provided a method, comprising: acquiring a measurement configuration for a preconfigured measurement period dedicated for performing radio signal measurements; determine to partially skip the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed and one or more second parts during which radio signal measurements are not performed; prioritize data communication on the one or more second parts of the preconfigured measurement period; and end the radio signal measurements associated with the preconfigured measurement period at latest at the end of the preconfigured measurement period.

WO 2025/103641 A1

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PARTIAL SKIPPING OF MEASUREMENTS

TECHNICAL FIELD

Various example embodiments relate generally to enhancement of transmission-reception of delay-critical data.

BACKGROUND

Sometimes a user equipment (UE) needs to communicate delay critical data. Other tasks of the UE, such as performing measurements of neighboring cell(s), may prohibit or complicate the communication.

BRIEF DESCRIPTION

According to some aspects, there is provided the subject matter of the independent claims. Some further aspects are provided in the dependent claims. The embodiments that do not fall under the scope of the claims are to be interpreted as examples useful for understanding the disclosure.

LIST OF THE DRAWINGS

In the following, the invention will be described in greater detail with reference to the embodiments and the accompanying drawings, in which

Figure 1 presents a network to which one or more embodiments are applicable;

Figure 2 shows a method, according to an embodiment;

Figures 3A, 3B and 3C show example divisions of a measurement period into one or more first parts and one or more second parts, according to some embodiment;

Figure 4 shows a method, according to an embodiment;

Figure 5 illustrates an example of UE centric approach related to partial skipping;

Figures 6A, 6B and 7 show some embodiments on how to select which part(s) of a measurement period to use for measurements and which for data communication;

Figures 8 and 9 show some examples of network centric approach related to partial skipping;

Figures 10A and 10B show example bitmaps, according to some embodiments;

Figure 11 shows a signaling flow diagram, according to some embodiments; and

Figures 12 and 13 illustrate apparatuses, according to some embodiments.

DESCRIPTION OF EMBODIMENTS

The following embodiments are exemplary. Although the specification may refer to “an”, “one”, or “some” embodiment(s) in several locations of the text, this does not necessarily mean that each reference is made to the same embodiment(s), or that a particular feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments. For the purposes of the present disclosure, the phrases “at least one of A or B”, “at least one of A and B”, “A and/or B” means (A), (B), or (A and B). For the purposes of the present disclosure, the phrases “A or B” and “A and/or B” means (A), (B), or (A and B). For the purposes of the present disclosure, the phrase “A, B, and/or C” means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B, and C).

It shall be understood that although the terms “first” and “second” etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and similarly, a second element could be termed a first element, without departing from the scope of example embodiments.

Embodiments described may be implemented in a radio system, such as one comprising at least one of the following radio access technologies (RATs): Worldwide Interoperability for Micro-wave Access (WiMAX), Global System for Mobile communications (GSM, 2G), GSM EDGE radio access Network (GERAN), General Packet Radio Service (GRPS), Universal Mobile Telecommunication System (UMTS, 3G) based on basic wideband-code division multiple access (W-CDMA), high-speed packet access (HSPA), Long Term Evolution (LTE), LTE-Advanced, and enhanced LTE (eLTE). Term ‘eLTE’ here denotes the LTE evolution that connects to a 5G core. LTE is also known as evolved UMTS terrestrial radio access (EUTRA) or as evolved UMTS terrestrial radio access network (EUTRAN). A term “resource” may refer to radio resources, such as a physical resource block (PRB), a radio frame, a subframe, a time slot, a subband, a frequency region, a sub-carrier, a beam, etc. The term “transmission” and/or “reception” may refer to wirelessly transmitting and/or receiving via a wireless propagation channel on radio resources

The embodiments are not, however, restricted to the systems/RATs given as an example but a person skilled in the art may apply the solution to other communication systems/networks provided with necessary properties. Some examples of a suitable communication networks include a 5G network and/or a 6G network. The 3GPP solution to 5G is referred to as New Radio (NR). 6G is envisaged to be a further development of 5G. NR has been envisaged to use multiple-input-multiple-output (MIMO) multi-antenna transmission techniques, more base stations or nodes than the current network deployments of LTE (a so-called small cell concept), including macro sites operating in co-operation with smaller local area access nodes and perhaps also employing a variety of radio technologies for better coverage and enhanced data rates. 5G will likely be comprised of more than one radio access technology / radio access network (RAT/RAN), each optimized for certain use cases and/or spectrum. 5G mobile communications may have a wider range of use cases and related applications including video streaming, augmented reality, different ways of data sharing and various forms of machine type applications, including vehicular safety, different sensors and real-time control. 5G is expected to have multiple radio interfaces, namely below 6GHz, cmWave and mmWave, and being integrable with existing legacy radio access technologies, such as the LTE.

The current architecture in LTE networks is distributed in the radio and centralized in the core network. The low latency applications and services in 5G may require to bring the content close to the radio which leads to local break out and multi-access edge computing (MEC). 5G enables analytics and knowledge generation to occur at the source of the data. This approach requires leveraging resources that may not be continuously connected to a network such as laptops, smartphones, tablets and sensors. MEC provides a distributed computing environment for application and service hosting. It also has the ability to store and process content in close proximity to cellular subscribers for faster response time. Edge computing covers a wide range of technologies such as wireless sensor networks, mobile data acquisition, mobile signature analysis, cooperative distributed peer-to-peer ad hoc networking and processing also classifiable as local cloud/fog computing and grid/mesh computing, dew computing, mobile edge computing, cloudlet, distributed data storage and retrieval, autonomic self-healing networks, remote cloud services, augmented and virtual reality, data caching, Internet of Things (massive connectivity and/or latency critical), critical communications (autonomous vehicles, traffic safety, real-time analytics, time-critical control, healthcare applications). Edge cloud may be brought into RAN by utilizing network function virtualization (NVF) and software defined networking (SDN). Using edge cloud may mean access node operations to be carried out, at least partly, in a server, host or node operationally coupled to a remote radio head or base station comprising radio parts. Network slicing allows multiple virtual networks to be created on top of a common shared physical infrastructure. The virtual networks are then customised to meet the specific needs of applications, services, devices, customers or operators.

In radio communications, node operations may in be carried out, at least partly, in a central/centralized unit, CU, (e.g. server, host or node) operationally coupled to distributed unit, DU, (e.g. a radio head/node). It is also possible that node operations will be distributed among a plurality of servers, nodes or hosts. It should also be understood that the distribution of work between core network operations and base station operations may vary depending on implementation. Thus, 5G networks architecture may be based on a so-called CU-DU split. One gNB-CU may control one or more gNB-DUs. The term ‘gNB’ may correspond in 5G to the eNB in LTE. The gNBs (one or more) may communicate with one or more UEs. The gNB-CU (central node) may control a plurality of spatially separated gNB-DUs, acting at least as transmit/receive (Tx/Rx) nodes. In some embodiments, however, the gNB-DUs (also called DU) may comprise e.g. a radio link control (RLC), medium access control (MAC) layer and a physical (PHY) layer, whereas the gNB-CU (also called a CU) may comprise the layers above RLC layer, such as a packet data convergence protocol (PDCP) layer, a radio resource control (RRC) and an internet protocol (IP) layers. Other functional splits are possible too. It is considered that skilled person is familiar with the OSI model and the functionalities within each layer.

In an embodiment, the server or CU may generate a virtual network through which the server communicates with the radio node. In general, virtual networking may involve a process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a virtual network. Such virtual network may provide flexible distribution of operations between the server and the radio head/node. In practice, any digital signal processing task may be performed in either the CU or the DU and the boundary where the responsibility is shifted between the CU and the DU may be selected according to implementation.

Some other possible technology advancements to be used are Software-Defined Networking (SDN), Big Data, and all-IP, to mention only a few non-limiting examples. For example, network slicing may be a form of virtual network architecture using the same principles behind software defined networking (SDN) and network functions virtualisation (NFV) in fixed networks. SDN and NFV may deliver greater network flexibility by allowing traditional network architectures to be partitioned into virtual elements that can be linked (also through software). Network slicing allows multiple virtual networks to be created on top of a common shared physical infrastructure. The virtual networks are then customised to meet the specific needs of applications, services, devices, customers or operators.

The plurality of gNBs (access points/nodes), each comprising the CU and one or more DUs, may be connected to each other via the Xn interface over which the gNBs may negotiate. The gNBs may also be connected over next generation (NG) interfaces to a 5G core network (5GC), which may be a 5G equivalent for the core network of LTE. Such 5G CU-DU split architecture may be implemented using cloud/server so that the CU having higher layers locates in the cloud and the DU is closer to or comprises actual radio and antenna unit. There are similar plans ongoing for LTE/LTE-A/eLTE as well. When both eLTE and 5G will use similar architecture in a same cloud hardware (HW), the next step may be to combine software (SW) so that one common SW controls both radio access networks/technologies (RAN/RAT). This may allow then new ways to control radio resources of both RANs. Furthermore, it may be possible to have configurations where the full protocol stack is controlled by the same HW and handled by the same radio unit as the CU.

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

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

The embodiments may be also applicable to narrow-band (NB) Internet-of-things (IoT) systems which may enable a wide range of devices and services to be connected using cellular telecommunications bands. NB-IoT is a narrowband radio technology designed for the Internet of Things (IoT) and is one of technologies standardized by the 3rd Generation Partnership Project (3GPP). Other 3GPP IoT technologies also suitable to implement the embodiments include machine type communication (MTC) and eMTC (enhanced Machine-Type Communication). NB-IoT focuses specifically on low cost, long battery life, and enabling a large number of connected devices. The NB-IoT technology is deployed “in-band” in spectrum allocated to Long Term Evolution (LTE) - using resource blocks within a normal LTE carrier, or in the unused resource blocks within a LTE carrier’s guard-band - or “standalone” for deployments in dedicated spectrum.

The embodiments may be also applicable to device-to-device (D2D), machine-to-machine, peer-to-peer (P2P) communications. The embodiments may be also applicable to vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), infrastructure-to-vehicle (I2V), or in general to V2X or X2V communications.

Figure 1 illustrates an example of a communication system to which embodiments of the invention may be applied. The system may comprise a control node 110 providing one or more cells, such as cell 100, and a control node 112 providing one or more other cells, such as cell 102. Each cell may be, e.g., a macro cell, a micro cell, femto, or a pico cell, for example. In another point of view, the cell may define a coverage area or a service area of the corresponding access node. The control node 110, 112 may be an evolved Node B (eNB) as in the LTE and LTE-A, ng-eNB as in eLTE, gNB of 5G, or any other apparatus capable of controlling radio communication and managing radio resources within a cell. The control node 110, 112 may be called a base station, network node, or an access node.

The system may be a cellular communication system composed of a radio access network of access nodes, each controlling a respective cell or cells. The access node 110 may provide user equipment (UE) 120 (one or more UEs) with wireless access to other networks such as the Internet. The wireless access may comprise downlink (DL) communication from the control node to the UE 120 and uplink (UL) communication from the UE 120 to the control node.

Additionally, although not shown, one or more local area access nodes may be arranged such that a cell provided by the local area access node at least partially overlaps the cell of the access node 110 and/or 112. The local area access node may provide wireless access within a sub-cell. Examples of the sub-cell may include a micro, pico and/or femto cell. Typically, the sub-cell provides a hot spot within a macro cell. The operation of the local area access node may be controlled by an access node under whose control area the sub-cell is provided. In general, the control node for the small cell may be likewise called a base station, network node, or an access node.

There may be a plurality of UEs 120, 122 in the system. Each of them may be served by the same or by different control nodes 110, 112. The UEs 120, 122 may communicate with each other, in case D2D communication interface is established between them.

The term “terminal device” or “UE” refers to any end device that may be capable of wireless communication. By way of example rather than limitation, a terminal device may also be referred to as a communication device, user equipment (UE), a Subscriber Station (SS), a Portable Subscriber Station, a Mobile Station (MS), or an Access Terminal (AT). The terminal device may include, but not limited to, a mobile phone, a cellular phone, a smart phone, voice over IP (VoIP) phones, wireless local loop phones, a tablet, a wearable terminal device, a personal digital assistant (PDA), portable computers, desktop computer, image capture terminal devices such as digital cameras, gaming terminal devices, music storage and playback appliances, vehicle-mounted wireless terminal devices, wireless endpoints, mobile stations, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), USB dongles, smart devices, wireless customer-premises equipment (CPE), an Internet of Things (loT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. In the following description, the terms “terminal device”, “communication device”, “terminal”, “user equipment” and “UE” may be used interchangeably.

In the case of multiple access nodes in the communication network, the access nodes may be connected to each other with an interface. LTE specifications call such an interface as X2 interface. For IEEE 802.11 network (i.e. wireless local area network, WLAN, WiFi), a similar interface may be provided between access points. An interface between an LTE access point and a 5G access point, or between two 5G access points may be called Xn. Other communication methods between the access nodes may also be possible. The access nodes 110 and 112 may be further connected via another interface to a core network 116 of the cellular communication system. The LTE specifications specify the core network as an evolved packet core (EPC), and the core network may comprise a mobility management entity (MME) and a gateway node. The MME may handle mobility of terminal devices in a tracking area encompassing a plurality of cells and handle signalling connections between the terminal devices and the core network. The gateway node may handle data routing in the core network and to/from the terminal devices. The 5G specifications specify the core network as a 5G core (5GC), and there the core network may comprise e.g. an access and mobility management function (AMF) and a user plane function/gateway (UPF), to mention only a few. The AMF may handle termination of non-access stratum (NAS) signalling, NAS ciphering & integrity protection, registration management, connection management, mobility management, access authentication and authorization, security context management. The UPF node may support packet routing & forwarding, packet inspection and QoS handling, for example.

As said, a UE may be required to perform measurements of a serving cell and or neighboring cell(s). However, UE performing radio resource management (RRM) measurements may impose scheduling restrictions, either due to potential measurement gaps for inter-frequency RRM measurements, or restrictions for frequency range 2 (FR2) intra-frequency RRM measurements. This may be cumbersome for communication of delay critical data for use cases due to the UE prioritizing RRM measurements during network-configured measurement windows as currently specified in 3GPP. Examples of such measurement windows/periods are a synchronization signal block (SSB) -based measurement timing configuration (SMTC) window and a measurement gap (MG).

As per the current new radio (NR) specifications, the network configures the UE when to measure reference signal received power (RSRP) or other reference signal power or quality metrics from e.g. SSBs by means of SMTC. The time-resolution of SMTC may be on a subframe level, corresponding to 1 ms intervals. It should be noted that the

SMTC only instruct the UE when (in time domain) it could/should measure RSRP, while it is left for UE implementation exactly when to measure, and which antenna panel to be used for conducting such measurement during those measurement windows.

Scheduling restrictions may apply to the UE during time-intervals where it may be performing RSRP measurements, e.g. as per the SMTC configuration. As an example, for FR2 and L1-RSRP on SSB, NR specifications read "*The UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/CSI-RS...*".

A typical network configuration may use a setting with SMTC windows of 5 ms every 20 ms (aligned to the SSB periodicity), meaning that 25% of the time the UE cannot be scheduled and its transmissions get delayed by up to 5ms, which may correspond to half the time of the packet delay budget (PDB) of augmented reality (AR) / virtual reality (VR) services, commonly called XR. This poses serious scheduling restrictions that likely challenge the networks capability to efficiently schedule and serve its XR users according to their QoS constraints, severely limiting the XR capacity.

For example, assume that the SMTC induced scheduling restrictions come every 20 ms, while the average XR frame inter-arrival time is 16.6 ms (assuming 60 fps). On top of that, each XR frame arrival may be subject to +/-4 ms jitter. As such, the SMTC windows with scheduling restrictions may collide with time periods where the gNB would have preferred to schedule the XR transmissions. This will negatively impact XR Quality of Experience (QoE), as well as the corresponding network capacity.

In NR, the UE determines the neighbor cell measurements (RSRP, RSRQ (=reference signal received quality), etc.) e.g. based on SSB(s) by measuring either the best beam or the best *N* (*N* = *nrofSS-BlocksToAverage*) beams above a threshold. These measurements may take place during MGs or SMTCs. In NR, the SMTC duration can take the values of 1, 2 ,3, 4, or 5 ms, while the MG duration can take values of 1.5, 3, 3.5, 4, 5.5 and 6 ms.

Given the range of possible SMTC and MG durations, example configurations could be as follows:

- For inter-frequency measurements in FR1 (SCS=30 kHz, 8 SSBs), the network may configure the UE with 3ms measurement gap to allow the UE to perform measurements on all the SSBs. The Measurement Gap Length (MGL) also include 2 x 0.5ms RF switching time (2 x 0.25ms in FR2). In some examples of SSB transmissions in time domain, the time between the first OFDM symbol of the first SSB and the last OFDM symbol of the last SSB is approximately 1.71ms. Additional 1ms (2 x 0.5ms RF switching time) is needed, resulting in MGL configuration of 3ms.
- Similarly, when considering intra-frequency or inter-frequency measurements in FR2 (SCS=120 kHz, 64 SSBs), the network may need to

configure SMTC (with scheduling restrictions) of 5 ms, or measurement gap of 5.5ms. An example with SMTC duration of 5ms for FR2 intra-frequency measurements (i.e. no RF switching needed) results in time between the first OFDM symbol of the first SSB and the last OFDM symbol of the last SSB being approximately 4.68 ms, requiring an SMTC duration of 5 ms to enable the UE to measure all the 64 SSBs within the SSB burst.

To tackle such problems related to scheduling restrictions for delay critical data, NW-centric solutions are proposed which mainly consist of methods that rely on the gNB informing the UE to skip a certain pattern of SMTC windows or measurement gaps for RRM measurements, and instead prioritize PDCCH/PDSCH reception and/or PUSCH/PUCCH transmissions. UE centric solutions, on the other hand, rely on UE autonomously determining, based on gNB configuration, whether to prioritize PDCCH/PDSCH reception and/or PUCCH/ PUSCH transmission over RRM measurements (or vice versa) during one or more SMTC and/or MG.

There are drawbacks related to such solutions. For example, NW-centric solutions may have the problem that if the gNB schedules a new DL transmission with XR (delay-critical) data, or the UE sends a scheduling request (SR) for XR (delay-critical) data just shortly before a MG/SMTC window is starting, then scheduling a HARQ retransmission or an UL transmission may need to be postponed after the MG/SMTC window, if the gNB and/or UE processing time(s) do not allow scheduling in DL and/or UL. This may result in unacceptable latencies that will in many cases violate the PDB constraint of XR traffic.

Further, in these solutions, the UE either prioritizes measurements or data transmission/reception during a MG or SMTC. In situations where both data transmission/reception and RRM measurements are critical, prior art solutions may not allow to meet the latency requirements while providing the baseline mobility performance. More specifically, if communication is prioritized over measurements, the UE may experience degraded mobility performance. Hence, in mobile scenarios, the XR QoE and corresponding XR capacity would still be negatively impacted. This naturally results in a trade-off between transmission/reception and measurement prioritization that has not been considered in earlier solutions.

To at least partially tackle these problems, there is proposed a solution with finer granularity that allows skipping portions of the MG and/or SMTC window(s). For example, in some embodiments, the skipping can be performed at the granularity of SSBs.

Figure 2 depicts an example method. The method may be computer-implemented. The method may be performed by a UE, such as UE 120 of Figure 1.

As shown in Figure 2, the UE 120 in step 200, acquires a measurement configuration for a preconfigured measurement period dedicated for performing radio signal measurements. Based on the configuration, the UE 120 knows where the measurement period(s) are placed in time domain.

In an embodiment, this configuration configures the UE with at least one measurement gap (MG). In another embodiment, the configuration configures the UE with SMTC. In this way, the preconfigured measurement period is at least one of a MG or a time widow that is based on SMTC. In an embodiment, the configuration comprises MeasGapConfig of standard specifications. In an embodiment, the configuration comprises SSB-MTC configuration of standard specifications. The configuration may configure one or more measurement periods for the UE.

In an embodiment, the at least one radio signal measurement (also called simply measurements) comprises a measurement of at least one SSB or at least one channel state information reference signal (CSI-RS), or measurements of both.

In step 202, the UE determines to partially skip the preconfigured measurement period. By partial skipping it is meant that the measurements are performed only at part(s) of the measurement period but performing the measurements do not take the whole time domain length of the measurement period. As such, the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed and one or more second parts during which radio signal measurements are not performed.

Some examples of such divisions of the measurement period are shown in Figure 3A-3C, where the 1st part(s) reserved for performing measurements are shown with boxes having right leaning diagonal lines, whereas 2nd part(s) during which radio signal measurements do not need to be performed are shown with boxes having vertical dashed lines. Each box may be understood to represent one part. That is, the parts need not be of same size in time domain. As can be seen from the Figures, the division of the measurement period into the first and second parts may vary. In some cases, there is only one 1st part and one 2nd part, while in some other embodiments there are more of these parts within one measurement period. Moreover, the division of the measurement period need not be the same for all of the configured measurement periods (in case there are many). As an example, in Figure 3A the two configured measurement periods (e.g. MGs) are divided in the same manner, while in Figures 3B and 3C the two configured measurement periods are divided differently. How a given measurement period is divided may be up to the UE or the gNB, and may be based on e.g. the need of delay critical data communication (transmission and/or reception) and/or the need to perform radio signal measurements. As one example, UE being close to cell edge may be in a need to perform more intercell measurements than a UE in the centre of a cell.

In an embodiment, the second parts (which are partially skipped and can be used for data) can be contiguous or be at different parts of the measurement period. In an embodiment, the first parts (which are measured) can be contiguous or be at different parts of the measurement period.

In an embodiment, the one or more second parts comprise at least two second parts within the preconfigured measurement period, wherein each two second parts are separated by one (or at least one) of the one or more first parts. In an embodiment, the one or more first parts comprise at least two first parts within the preconfigured measurement period, wherein each two first parts are separated by one (or at least one) of the one or more second parts.

Although not shown in Figure 2, step 202 may comprise the UE 120 sending a partial skipping indication to the gNB 110, e.g. to inform the gNB 110 about the partial skipping possibility and/or to inform the gNB 110 about a desired division of the measurement period into first and second parts.

In step 204, the UE 120 prioritizes data communication on the one or more second parts of the preconfigured measurement period. In this manner, the gNB may schedule data communication of e.g. delay critical XR data, for the UE to take place during the one or more second parts of the measurement period.

In step 206, the UE 120 ends the radio signal measurements associated with the preconfigured measurement period at latest at the end of the preconfigured measurement period. That is, the UE does not extend the measurement gap over the preconfigured length, in order not to complicate scheduling between the preconfigured measurement gaps. As shown in Figures 3A-3C, data communication may take place directly after the preconfigured measurement gap(s). This is possible because only such measurement periods are used for the proposed partial skipping during which the UE need not utilize the whole length of the measurement period for measurements. If the whole time domain length needs to be used for measurements, then it may be better to not skip the measurement period.

Looking from network's point of view, Figure 4 depicts an example method. The method may be computer-implemented. The method may be performed by a network node, such as the gNB 110 of Figure 1.

In step 400, the gNB 110 determines the configuration for the preconfigured measurement period, which is dedicated for performing radio signal measurements by the configured UE, such as UE 120. The gNB 110 may additionally send the configuration to the UE 120.

In step 402, the gNB 110 receives, from the user equipment, a partial skipping indication indicating partial skipping of the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into the first and second parts.

In step 404, the gNB 110 determines, based on the partial skipping indication, that the user equipment prioritizes data communication on the one or more second parts of the preconfigured measurement period. This allows the gNB 110 to determine that it can e.g. schedule data communication for the UE to take place during the one or more second parts.

In step 406, the gNB 110 determines that further data communication with the user equipment can be scheduled to take place directly after the end of the preconfigured measurement period.

Let us then take a look at some more specific embodiments.

In an embodiment, as shown in Figure 5, which may be called a UE-centric approach, the UE 120 determines the division of the preconfigured measurement period into the first and second parts in step 500. Then, the UE 120 transmit in step 502 a first indication (serving as the partial skipping indication) of partial skipping of the preconfigured measurement period to a network node (such as the gNB 110). In this embodiment, the partial skipping indication indicates the determined division. In other words, prior to the SMTC/MG (=measurement period), the UE 120 transmits indication that radio signal measurements (e.g. RRM measurements) are or can be limited to a specific part of the at least one upcoming SMTC/MG.

Then, the gNB 110 assumes the UE prioritizes data transmissions/receptions over RRM measurements in the corresponding part(s) of the at least one upcoming SMTC/MG. Thereafter, based the first indication, the gNB 110 may in step 504 schedule data communication for the UE so that the data communication can take place during the second parts of the measurement period, and also directly after the preconfigured measurement period.

For example, upon receiving the first indication of "partial skipping" (i.e. partial skipping indication), the gNB 110 may e.g. schedule DL and/or UL transmissions to take place during the portion of the at least one upcoming measurement period where the UE has indicated it will not perform RRM measurements. Similarly, the gNB 110 shall assume the UE will perform RRM measurements in the remaining part of the at least one upcoming measurement period, i.e. gNB 110 may determine that scheduling restrictions with respect to data communication may only apply to the remaining part of the at least one upcoming measurement period (i.e. apply for the user equipment on any of the one or more first parts).

In an embodiment, each of the one or more first parts comprise one or more synchronization signal blocks (SSBs) to be measured, and the indication of the division of the preconfigured measurement period into the first and second parts comprises identification of the one or more SSBs to measure. Therefore, this embodiment provides SSB-level granularity for dividing the measurement period. In one implementation, the UE 120 determines a subset of the SSBs in an SSB burst it needs to measure and/or that it will not measure in at least one upcoming SMTC window and/or measurement gap (MG). There may be one SSB burst (comprising many SSBs) within each measurement period.

The determination of step 202 (where the UE 120 determines that it may only need to perform RRM measurement on a subset of the SSBs that are overlapping with at least one upcoming SMTC/MG) may be based on network (NW) -configuration or may be UE implementation specific. For example, the UE may determine the SSB(s) to be measured based on previously performed measurements in both its serving cell as well as in neighbor cells.

If it is determined to divide the measurement period (i.e. to partially skip) in step 202, then in an embodiment, the determination of the subset of SSBs to be measured, e.g. in step 500, can be based by comparing the received signal strength (e.g., RSRP) in correspondence of an SSB, measured during previous one or more SMTC windows and/or MGs, with a threshold value T. This way the one or more first parts comprises a subset of those one or more SSBs within the preconfigured measurement period for which a previous radio signal measurement exceeded a predetermined signal strength threshold T.

For example, only the SSBs whose received signal strength has been measured earlier (e.g. within a predetermined time period) to be above the threshold value T may be considered for measurements in the at least one upcoming SMTC/MG. The threshold value T could be an absolute signal power level (e.g., it could be the same as absThreshSS-BlocksConsolidation of NR standard specifications), or a value relative to e.g. the received signal strength of the strongest SSB. In an embodiment, threshold T is preconfigured to the UE or it may be configured by the network, or could be determined at the UE based on UE implementation specific method. In one additional or alternative embodiment, at most N = nrofSS-BlocksToAverage SSBs within the measurement period may be selected to be measured.

This is shown in Figure 6A, where only N (=4) strongest SSBs (marked with dots) within 8 SSBs of the measurement period are measured during the preconfigured measurement period. If N was 5, then also the SSB marked with horizontal dashed lines would have been selected, as its signal strength is over threshold T.

Figure 6B shows another example where only M < N (=4) SSBs are measured, because only M (=2 in this example) are above the threshold T.

Note that when the threshold value T is used to measure M < N SSBs (e.g., the M SSBs whose signal strength or any other metric is above the threshold value T), the number of measurable SSBs can decrease over time. For example, let $M(0) \subseteq \aleph$ be the set of SSBs selected at time t=0 ($\aleph$ is the set of all SSBs) and assume that at any time t the UE is moving towards the SSBs that were excluded at time 0, namely $\aleph \setminus M(0)$. The sequence of sets of SSBs may monotonically decrease over time $\emptyset\subseteq\ldots\subseteq M(t)\subseteq\cdots\subseteq M(1)\subseteq M(0)\subseteq\aleph$, since at each SMTC window (or MG) the UE may know only the SSBs measured in the previous SMTC window (or MG), and the UE may forget the rest of the SSBs that are skipped. Therefore, the UE may not know that the best SSBs after time t are the SSBs that were filtered out at time 0. Possible solutions to avoid this case include e.g. that the UE 120 periodically or at least a predetermined time duration after the partial skipping has taken place, performs radio signal measurements of all radio signals (e.g. SSBs) configured for measurement within the preconfigured measurement period.

As some examples regarding this, the following options are proposed:

- After a certain time, the UE measures again all SSBs. The time after which the UE measures again all SSBs can be configured by the network and/or decided by the UE based on the mobility status.
- When all M SSBs falls below another threshold (TR), the UE measures again all N SSBs. The threshold TR can be configured by the network and/or decided by the UE based on the mobility status. In an embodiment, TR is smaller than T. In another embodiment, TR is the same as T.
- The network forces the measurement of all SSBs by signalling a command not to skip the measurement of the next SMTC window or MG (or by not signalling the command to skip the measurement of the next SMTC window or MG). In other words, the UE can acquire measurements for the entire set of SSBs in SMTC windows and/or MGs that do not need to be partially skipped because e.g. they do not collide with transmission of XR traffic in either DL or UL.

In an embodiment, a weighted power metric for a group of SSBs is applied. As SSBs are likely to be beamformed across the cell coverage area, cases can exist, where two or more equally strong reception directions are possible, yet separated in time so that they fall in the two ends of the MG/SMTC. Consider a case where a large obstacle prevents the UE 120 from having a direct line of sight (LoS), yet two almost equally good paths exist from NLoS propagation. The selection of the MG region/portion/part to skip may therefore be ambiguous at the next occasion when the UE might perform the skipping. It may also be impractical to skip the middle part of the measurement period, as this might result in extra RF switching delays. So, instead of the UE picking the highest (let's say 7th) SSB and skipping the beginning of the MG (or the rest of the SSBs), it can evaluate the summed power of previous measurement of e.g. the first three (or any predetermined number of SSBs) and last three SSBs (or any predetermined number of SSBs), and select the region to skip based on the lower summed power. This means that for the following measurement occasions where the same part of the MG is skipped, the UE may still be measuring the highest power SSBs and those that have the highest chance of becoming the highest power SSB. As a result, the one or more first parts comprises a consecutive subset of those one or more SSBs within the preconfigured measurement period for which a combined power of the consecutive subset of SSBs meet a predetermined condition. The condition may be that the combined power exceeds a predetermined combination threshold or that the combined power is higher than combined power of other possible subsets in the measurement period. The number of SSBs to include in the subsets may be configured. The remaining SSBs (other than the selected subset) may be skipped for measurements and data communication can be prioritized during a time window where the corresponding skipped SSBs are transmitted.

Figure 7 shows an example of how to determine the subset based on the combined power. In Figure 7, the summed power of the three first SSBs is lower than the summed power of the three last SSBs. In this example, the UE may decide to measure the last three SSBs and skip measuring in the others. It should be noted that there could be more than two candidate subsets. For example, each consecutive combination of three (an example value) SSBs can be a candidate subset. In Figure 7 these could be SSBs [0,1,2], [1, 2, 3], [2, 3, 4], [3, 4, 5], [4, 5, 6], and [5, 6, 7], although only [0,1,2] and [5,6,7] are shown in Figure 7. In an alternative embodiment, a joint metric computed on the subset of SSBs is a function of received power of the SSBs in the selected subset, like the weighted sum of the received power of the SSBs, and not necessarily a summed power.

In an embodiment, the determination of step 202 to partially skip the preconfigured measurement period is based on an estimation of data communication in a predetermined future time window. That is, the decision whether to execute the determination of the subset of SSBs to be measured (e.g. of step 500) may be based on information of traffic arrivals and SMTC/MG configuration. For example, the determination of step 500 may take place only when a SMTC window or MG collides with an expected data transmission or reception, whereas no determination is executed when no collision is expected (i.e., all SSBs are measured).

In an embodiment, the determination of step 202 to partially skip the preconfigured measurement period is based on an elapsed time from a previously performed radio signal measurement. For example, if it has been longer than predetermined time duration since the last measurement, the UE may determine that it needs to perform the measurement(s) during the preconfigured measurement period.

In an embodiment, as shown with step 502 of Figure 5, the UE 120 signals “partial skipping” indication (‘first indication’) of the at least one upcoming SMTC window and/or MG to the network. As explained, by “partial skipping” it is meant the UE signals one or more portions (i.e. parts) of the at least one upcoming SMTC window and/or MG where the UE 120 will conduct RRM measurements (e.g. on a subset of the neighbor-cell(s) SSBs), so that the UE can prioritize DL reception and/or UL transmission during the remaining parts/portions of the corresponding SMTC window and/or MG. As an example, the UE 120 may signal as the first indication to the gNB 110 the portions/parts of the at least one upcoming measurement period (e.g. SMTC window and/or MG), where either (i) the UE 120 will conduct the RRM measurements and/or (ii) the UE 120 will prioritize DL receptions/UL transmissions, i.e. not conduct the RRM measurements.

Although above is partially explained in view of a so-called UE centric approach, similar determinations of which SSBs to measure may be applied also for so-called network centric approach, which will be explained next.

In an embodiment of the so-called UE centric approach, the UE 120 transmits a second indication to the gNB 110 indicating that the partial skipping of the preconfigured measurement period is possible. That is, prior to SMTC/MG, the UE transmits indication that RRM measurements could be limited to a specific part of the at least one upcoming SMTC/MG (i.e. the whole duration of the measurement period need not be used for radio signal measurements). Based on sending the second indication, the UE 120 receives a third indication from the gNB 110, the third indication acknowledging (ACK) the partial skipping of the preconfigured measurement period for the UE 120. In this manner the network is in control of allowing the skipping, as it is the gNB 110 that finally indicates the partial skipping of the at least one upcoming SMTC/MG (e.g. using L1/L2 signaling). Prefixes “second” and “third” are herein used to differentiate from the earlier mentioned “first” indication.

In one example embodiment of the network centric approach shown in Figure 8, the UE 120 may determine the division of the preconfigured measurement period into the first and second parts in step 800. Then, in step 802, the UE 120 sends the second indication, and this second indication indicates the determined division to the gNB 110. That is, the gNB 110 may derive, from the partial skipping indication (=second indication here), the division of the preconfigured measurement period into the first and second parts as determined by the UE. Then, the gNB 110 may in step 804 transmit an acknowledgement (ACK) message for the partial skipping of the preconfigured measurement period, the acknowledgement message allowing the partial skipping based on the division as determined by the user equipment. Consequently, based on receiving the third indication, the UE 120 may perform the partial skipping according to the determined division indicated in the second indication. In this way the indication of which part of the at least one upcoming SMTC/MG is skipped (i.e., in which part(s) of the at least one upcoming SMTC/MG data transmissions/receptions are prioritized over RRM measurements) could be implicit so that the network indicates the skipping indication but the portion of the SMTC/MG to be skipped may still be based on what is signalled by the UE in step 802.

Although not shown in Figure 8, there may be also a scheduling message sent from gNB 110 to UE 120 after or in connection of the ACK message.

However, in one embodiment, the gNB 110 in the ACK message overrides/overrules the proposed division and configures the UE 120 with a new division which is to be followed by the UE 120.

In one example embodiment of the network centric approach shown in Figure 9, the UE 120 may in the second indication (step 902, serving as the partial skipping indication) merely indicate that the partial skipping of the preconfigured measurement period is possible. The gNB 110 may then determine the division in step 903, based on any of the above proposed manners. In step 904, the gNB 110 sends the acknowledgment message to the UE, the ACK message (=third indication) indicating the division of the preconfigured measurement period into the first and second parts, as determined by the gNB 110. Based on receiving the third indication, the UE 120 may perform the partial skipping according to the division indicated in the third indication. In this way the indication of which part of the at least one upcoming SMTC/MG is skipped (i.e., in which part(s) of the at least one upcoming SMTC/MG data transmissions/receptions are prioritized over RRM measurements) could be explicit so that the NW explicitly indicates the portion of the SMTC/MG to be skipped and/or used for measurements. Although not shown in Figure 9, there may be also a scheduling message sent from gNB 110 to UE 120 after or in connection of the ACK message.

Let us take a closer look at what the indication of the division (e.g. the indication of steps 502, 802 and 904) may comprise. In an embodiment, the signalling may be performed on a higher layer (e.g. RRC, MAC) or on a physical layer, or a combination of both.

In one possible implementation, the part of the at least one upcoming SMTC/MG where the UE does need to perform RRM measurements is the minimum "reportable portion/part", as that part (e.g. subset of SSBs) is overlapping with the SSBs to be measured. In other words, the "reportable portions/parts" are determined based on the granularity of the skipping. For example, with three "reportable portions", the UE can indicate to skip (i.e. not perform measurements) one, or two, or three parts.

In one example the UE may determine to skip the first half of the at least one upcoming SMTC window/MG for RRM measurements. If the SSBs that the UE does need to measure in the at least one upcoming SMTC/MG are within the second half of the at least one upcoming SMTC/MG, then the minimum "reportable portion" that is overlapping with the SSBs to be measured is the second half of the at least one upcoming SMTC/MG. I.e., the UE may skip the first half of the at least one upcoming SMTC/MG for RRM measurements.

As another example, the UE may determine to skip the second half of the at least one upcoming SMTC window/MG for RRM measurements (as shown in leftmost measurement period of Figure 3C). If the SSBs that the UE does need to measure in the at least one upcoming SMTC/MG are within the first half of the at least one upcoming SMTC/MG, then the minimum "reportable portion" that is overlapping with the SSBs to be measured is the first half of the at least one upcoming SMTC/MG. I.e., the UE may skip the second half of the at least one upcoming SMTC/MG for RRM measurements.

It is noted that the usage of first half and second half of the measurement period above is just an example, and the part/portion to be skipped can lie anywhere within the measurement period. It is also noted that the indication can indicate the portions/parts to be skipped and/or the portions/parts not to be skipped. Note that the UE may not need to signal to the gNB if the UE determines that it shall not skip the at least one upcoming SMTC window/MG for RRM measurements. Further, some measurement periods may be entirely skipped, if no measurements are needed to be performed.

In an embodiment, the UE notifies the gNB of the exact SSBs that it plans to measure (or to skip) in the at least one upcoming measurement period. In one example implementation of indicating this, as shown in Figure 10A, the SSBs that are skipped (or measured) are indicated in a bitmap 1000 with one bit corresponding to one SSB, and a certain bit value denoting that the corresponding SSB is measured or skipped. For example, in Figure 10A, the SSBs with indices 2, 3 and 4 are indicated as the ones to be measured, while SSBs corresponding to indices 0, 1, 5, 6 and 7 need not be measured and can be skipped (i.e. UE can prioritize data communication over measurements during those SSB time instances). Such bitmap can result in high granularity, although increasing overhead.

If reduced signalling overhead is preferred over granularity, then one bit in the bitmap can represent a number of (multiple) SSBs (e.g. a group of consecutive SSBs). This is shown in Figure 10B, where each group comprises two SSBs. In the example, the bitmap 1010 indicates that the UE is to measure SSB groups 1 and 2, corresponding to SSBs 2, 3, 4, and 5.

In yet one embodiment, the UE notifies the gNB (or vice versa in the network centric approach) the first and last SSB identifiers (e.g. indices) of each portion of the measurement period that is to be measured (or skipped). For example, assuming the UE indicates that the measured SSBs are SSBs with indices 9 to 24 and there are 64 SSBs altogether, the following sequences can be indicated: <first SSB 1, last SSB 1>, ... <first SSB N, last SSB N>} = {<9,24>}. If, instead the UE communicates the skipped SSB, the indication can be: {<first SSB 1, last SSB 1>, ... <first SSB N, last SSB N>} = {<1,8>, <25,64>}.

The decision on whether to skip part of the measurement period or not can be done separately for each measurement period. In another embodiment, the determination to skip part of the measurement period is done once for a predetermined number of measurement periods. For example, in one possible embodiment, the UE determines how many of the at least one upcoming measurement periods the decision to partially skip should apply to. The decision on the number of upcoming measurement periods may be based on RSRP and/or UE mobility state. For example, if the SSBs have been measured to be strong in the previous measurements and/or the UEs is fairly static (=low mobility), the UE may decide to enforce the partial skipping decision over several measurement periods, whereas if the UE is in high mobility, then the UE may determine to apply the partial skipping decision only for the next measurement period. The UE may indicate to the gNB, or the gNB to the UE, the number of measurement periods during which the partial skipping with the same division of the measurement period should be performed.

In an embodiment, the UE 120 receives a message allowing partial skipping of the preconfigured measurement window. This may take place in system information when the UE detects the cell, or it can be a dedicated message to a connected UE. Additionally, there may be a separate message to activate the previously allowed/configured partial splitting. Such activation can be implicit, e.g. the configuration of the split from the gNB, or an ACK to the split proposed by the UE, may serve as the activation command. As another embodiment, activation can be implemented with explicit message (e.g. via MAC CE, RRC or PHY signalling).

In an embodiment, the UE further acquires (e.g. receives from the network or determines based on pre-configuration) at least one of: a maximum allowed number of the one or more first parts or a maximum allowed number of the one or more second parts. This may allow the network to at least partially control the division, while still allowing the UE to determine or at least suggest the division to be used.

Figure 11 shows a signaling flow diagram between the UE and the gNB according to one embodiment. In step 1100 the network (e.g. gNB 110) configures the UE120 with partial skipping possibility.

In step 1102, as being allowed to do so, the UE 120 determines that in the next one (or ones) of configured measurement period(s) the UE 120 need not utilize the full duration of the relevant measurement period(s) for performing radio signal measurements. This may be based on any of the previously discussed embodiments, such as based on the mobility of the UE, or based on the time since the UE previously performed measurements.

In step 1104, the UE may determine e.g. the exact SSBs to be used for measurements or which can be skipped to prioritize data communication. This determination may be based on any of above mentioned embodiments, such as based on the SSB(s) exceeding the predetermined threshold level T.

In step 1106 the UE reports, to the network, the part(s) (e.g. exact SSB(s) or group(s) of SSBs) which the UE will use for measurements and/or the part(s) (e.g. exact

SSB(s) or group(s) of SSBs) which the UE will not use for measurements. This may take place according to any of above mentioned embodiments, such as by using the bitmap.

In step 1108, the gNB 110 can determine that the UE 120 priorities data communication during part(s) of the measurement period (i.e. during the determined second part(s)), and can schedule the UE 120 accordingly.

In step 1110 the gNB 110 may send a scheduling message to the UE 120, to allocate UL grant(s) and/or downlink assignment during those part(s) of the measurement period.

In an embodiment, the partial skipping may be configurable by the gNB 110 based on UE's capability. In one possible implementation, while the serving cell's RSRP is above a certain threshold, the UE 120 may determine that full skipping of the measurement period is preferred over partial skipping. Such RSRP threshold could be configured by the gNB 110 to the UE 120. The UE 120 may switch between full and partial skipping, depending on whether its serving cell's RSRP is above or below the threshold. In one embodiment, when switching from partial skipping to full skipping, the full skipping can be signalled as a special case of partial skipping (e.g. all bits in the bitmap indicate skipping). No additional signaling is needed in this case. Alternatively, additional signaling (e.g. MAC CE) can be used by the UE 120 to indicate to the gNB 110 that the UE 120 switches from partial skipping to full skipping, and vice versa.

An embodiment, as shown in Figure 12, provides an apparatus 10 comprising a control circuitry (CTRL) 12, such as at least one processor, and at least one memory 14 storing instructions that, when executed by the at least one processor, cause the apparatus at least to carry out any one of the above-described processes. In an example, the at least one memory and the computer program code (software), are configured, with the at least one processor, to cause the apparatus to carry out any one of the above-described processes. The memory may be implemented using any suitable data storage technology, such as semiconductor-based memory devices, flash memory, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The memory may comprise a database for storing data.

In an embodiment, the apparatus 10 may comprise the terminal device of a communication system, e.g. a user terminal (UT), a computer (PC), a laptop, a tabloid computer, a cellular phone, a mobile phone, a communicator, a smart phone, a palm computer, a mobile transportation apparatus (such as a car), a household appliance, or any other communication apparatus, commonly called as UE in the description. Alternatively, the apparatus is comprised in such a terminal device. Further, the apparatus may be or comprise a module (to be attached to the UE) providing connectivity, such as a plug-in unit, an "USB dongle", or any other kind of unit. The unit may be installed either inside the UE or attached to the UE with a connector or even wirelessly.

In an embodiment, the apparatus 10 is or is comprised in the UE 120. The apparatus may be caused to execute some of the functionalities of the above described processes, such as the steps of Figure 2.

The apparatus may further comprise a radio interface (TRX) 16 comprising hardware and/or software for realizing communication connectivity according to one or more communication protocols. The TRX may provide the apparatus with communication capabilities to access the radio access network, for example.

The apparatus may also comprise a user interface 18 comprising, for example, at least one keypad, a microphone, a touch display, a display, a speaker, etc. The user interface may be used to control the apparatus by the user.

The control circuitry 12 may comprise a partial skipping circuitry 20 for e.g. determining whether to perform the partial skipping and/or determining the division of the measurement period (e.g. which part(s), such as SSBs, of the measurement period to measure and which not), according to any of the embodiments. The control circuitry 12 may further comprise a measurement circuitry 22 for performing radio signal measurements during the first part(s) of the measurement period, according to any of the embodiments. The control circuitry 12 may further comprise a data communication circuitry 24 for performing data communication during the one or more second parts of the measurement period, according to any of the embodiments.

An embodiment, as shown in Figure 13, provides an apparatus 50 comprising a control circuitry (CTRL) 52, such as at least one processor, and at least one memory 54 storing instructions that, when executed by the at least one processor, cause the apparatus at least to carry out any one of the above-described processes. In an example, the at least one memory and the computer program code (software), are configured, with the at least one processor, to cause the apparatus to carry out any one of the above-described processes. The memory may be implemented using any suitable data storage technology, such as semiconductor-based memory devices, flash memory, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The memory may comprise a database for storing data.

In an embodiment, the apparatus 50 may be or be comprised in a network node, such as in gNB/gNB-CU/gNB-DU of 5G. In an embodiment, the apparatus is or is comprised in the network node 110. The apparatus may be caused to execute some of the functionalities of the above described processes, such as the steps of Figure 4.

The apparatus may further comprise communication interface (TRX) 56 comprising hardware and/or software for realizing communication connectivity according to one or more communication protocols. The TRX may provide the apparatus with communication capabilities with at least one user equipment, for example.

The apparatus may also comprise a user interface 58 comprising, for example, at least one keypad, a microphone, a touch display, a display, a speaker, etc. The user interface may be used to control the apparatus by the user.

The control circuitry 52 may comprise a partial kipping configuration circuitry 60 for configuring and/or activating the partial skipping for the UE, and/or for determining the division of the measurement period to the first and second parts, according to any of the embodiments. The control circuitry 52 may comprise a scheduling circuitry 62 e.g. for scheduling the UE so that data communication can take place during the one or more second parts and/or directly after the preconfigured measurement period, according to any of the embodiments. The control circuitry 52 may further comprise a data communication circuitry 64 for performing data communication during the one or more second parts of the measurement period, according to any of the embodiments.

In an embodiment, a CU-DU (central unit – distributed unit) architecture is implemented. In such case the apparatus 50 may be comprised in a central unit (e.g. a control unit, an edge cloud server, a server) operatively coupled (e.g. via a wireless or wired network) to a distributed unit (e.g. a remote radio head/node). That is, the central unit (e.g. an edge cloud server) and the radio node may be stand-alone apparatuses communicating with each other via a radio path or via a wired connection. Alternatively, they may be in a same entity communicating via a wired connection, etc. The edge cloud or edge cloud server may serve a plurality of radio nodes or a radio access networks. In an embodiment, at least some of the described processes may be performed by the central unit. In another embodiment, the apparatus may be instead comprised in the distributed unit, and at least some of the described processes may be performed by the distributed unit. In an embodiment, the execution of at least some of the functionalities of the apparatus 50 may be shared between two physically separate devices (DU and CU) forming one operational entity. Therefore, the apparatus may be seen to depict the operational entity comprising one or more physically separate devices for executing at least some of the described processes. In an embodiment, the apparatus controls the execution of the processes, regardless of the location of the apparatus and regardless of where the processes/functions are carried out.

In an embodiment, an apparatus carrying out at least some of the embodiments described comprises at least one processor and at least one memory including a computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to carry out the functionalities according to any one of the embodiments described. According to an aspect, when the at least one processor executes the computer program code, the computer program code causes the apparatus to carry out the functionalities according to any one of the embodiments described. According to another embodiment, the apparatus carrying out at least some of the embodiments comprises the at least one processor and at least one memory including a computer program code, wherein the at least one processor and the computer program code perform at least some of the functionalities according to any one of the embodiments described. Accordingly, the at least one processor, the memory, and the computer program code form processing means for carrying out at least some of the embodiments described. According to yet another embodiment, the apparatus carrying out at least some of the embodiments comprises a circuitry including at least one processor and at least one memory including computer program code. When activated, the circuitry causes the apparatus to perform the at least some of the functionalities according to any one of the embodiments described.

As used in this application, the term 'circuitry' refers to all of the following: (a) hardware-only circuit implementations, such as implementations in only analog and/or digital circuitry, and (b) combinations of circuits and soft-ware (and/or firmware), such as (as applicable): (i) a combination of processor(s) or (ii) portions of processor(s)/software including digital signal processor(s), software, and memory(ies) that work together to cause an apparatus to perform various functions, and (c) circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present. This definition of 'circuitry' applies to all uses of this term in this application. As a further example, as used in this application, the term 'circuitry' would also cover an implementation of merely a processor (or multiple processors) or a portion of a processor and its (or their) accompanying software and/or firmware. The term 'circuitry' would also cover, for example and if applicable to the particular element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in a server, a cellular network device, or another network device.

In an embodiment, at least some of the processes described may be carried out by an apparatus comprising corresponding means for carrying out at least some of the described processes. Some example means for carrying out the processes may include at least one of the following: detector, processor (including dual-core and multiple-core processors), digital signal processor, controller, receiver, transmitter, encoder, decoder, memory, RAM, ROM, software, firmware, display, user interface, display circuitry, user interface circuitry, user interface software, display software, circuit, antenna, antenna circuitry, and circuitry.

A term non-transitory, as used herein, is a limitation of the medium itself (i.e. tangible, not a signal) as opposed to a limitation on data storage persistency (e.g. RAM vs. ROM).

As used herein the term "means" is to be construed in singular form, i.e. referring to a single element, or in plural form, i.e. referring to a combination of single elements. Therefore, terminology "means for [performing A, B, C]", is to be interpreted to cover an apparatus in which there is only one means for performing A, B and C, or where there are separate means for performing A, B and C, or partially or fully overlapping means for performing A, B, C. Further, terminology "means for performing A, means for performing B, means for performing C" is to be interpreted to cover an apparatus in which there is only one means for performing A, B and C, or where there are separate means for performing A, B and C, or partially or fully overlapping means for performing A, B, C.

The techniques and methods described herein may be implemented by various means. For example, these techniques may be implemented in hardware (one or more devices), firmware (one or more devices), software (one or more modules), or combinations thereof. For a hardware implementation, the apparatus(es) of embodiments may be implemented within one or more application-specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein, or a combination thereof. For firmware or software, the implementation can be carried out through modules of at least one chip set (e.g. procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in a memory unit and executed by processors. The memory unit may be implemented within the processor or externally to the processor. In the latter case, it can be communicatively coupled to the processor via various means, as is known in the art. Additionally, the components of the systems described herein may be rearranged and/or complemented by additional components in order to facilitate the achievements of the various aspects, etc., described with regard thereto, and they are not limited to the precise configurations set forth in the given figures, as will be appreciated by one skilled in the art.

Embodiments as described may also be carried out in the form of a computer process defined by a computer program or portions thereof. Embodiments of the methods described may be carried out by executing at least one portion of a computer program comprising corresponding instructions. The computer program may be in source code form, object code form, or in some intermediate form, and it may be stored in some sort of carrier, which may be any entity or device capable of carrying the program. For example, the computer program may be stored on a computer program distribution medium readable by a computer or a processor. The computer program medium may be, for example but not limited to, a record medium, computer memory, read-only memory, electrical carrier signal, telecommunications signal, and software distribution package, for example. The computer program medium may be a non-transitory medium. Coding of software for carrying out the embodiments as shown and described is well within the scope of a person of ordinary skill in the art.

Following is a list of some aspects of the invention.

According to a first aspect, there is provided a method performed by a user equipment, comprising: acquiring a measurement configuration for a preconfigured measurement period dedicated for performing radio signal measurements; determining to partially skip the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed and one or more second parts during which radio signal measurements are not performed; prioritizing data communication on the one or more second parts of the preconfigured measurement period; and ending the radio signal measurements associated with the preconfigured measurement period at latest at the end of the preconfigured measurement period.

Various embodiments of the first aspect may comprise at least one feature from the following bulleted list:

- determining the division of the preconfigured measurement period into the first and second parts; and transmitting a first indication of the partial skipping of the preconfigured measurement period to a network node, wherein the first indication indicates the determined division.
- transmitting a second indication to a network node indicating that the partial skipping of the preconfigured measurement period is possible; and receiving a third indication from the network node, the third indication acknowledging the partial skipping of the preconfigured measurement period for the user equipment.
- determining the division of the preconfigured measurement period into the first and second parts, wherein the second indication further indicates the division; and based on receiving the third indication, perform the partial skipping according to the determined division indicated in the second indication.
- wherein the third indication further indicates the division of the preconfigured measurement period into the first and second parts, the method further comprising: based on receiving the third indication, performing the partial skipping according to the division indicated in the third indication.
- wherein each of the one or more first parts comprise one or more synchronization signal blocks (SSBs) to be measured, and wherein an indication indicating the division of the preconfigured measurement period into the first and second parts comprises identification of the one

or more SSBs to measure.

- wherein the one or more second parts comprise at least two second parts within the preconfigured measurement period, wherein each two second parts are separated by at least one of the one or more first parts.
- wherein the one or more first parts comprise at least two first parts within the preconfigured measurement period, wherein each two first parts are separated by at least one of the one or more second parts.
- wherein the preconfigured measurement period is at least one of a measurement gap (MG) or a time widow based on a synchronization signal block based measurement timing configuration (SMTC).
- wherein the at least one radio signal measurement comprises a measurement of at least one synchronization signal block (SSB) or at least one channel state information reference signal (CSI-RS).
- wherein the determination to partially skip the preconfigured measurement period is based on an elapsed time from a previously performed radio signal measurement.
- wherein the determination to partially skip the preconfigured measurement period is based on an estimation of data communication in a predetermined future time window.
- Receiving a message allowing partial skipping of the preconfigured measurement window.
- Acquiring at least one of: a maximum allowed number of the one or more first parts or a maximum allowed number of the one or more second parts.
- wherein the one or more first parts comprise a subset of those at least one synchronization signal block (SSB) within the preconfigured measurement period for which a previous radio signal measurement exceeded a predetermined signal strength threshold.
- Performing radio signal measurements of all radio signals configured for measurement within the preconfigured measurement period periodically or at least a predetermined time duration after the partial skipping has taken place.
- receiving a scheduling message, the message scheduling data communication to take place on the one or more second parts of the preconfigured measurement period.

According to a second aspect, there is provided a method performed by a network node, such as a base station, the method comprising: determining a configuration for a preconfigured measurement period dedicated for performing radio signal measurements by a user equipment; receiving, from the user equipment, a partial skipping indication indicating partial skipping of the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed by the user equipment and one or more second parts during which radio signal measurements are not performed by the user equipment; determining, based on the partial skipping indication, that the user equipment prioritizes data communication on the one or more second parts of the preconfigured measurement period; and determining that further data communication with the user equipment can be scheduled to take place directly after the end of the preconfigured measurement period.

Various embodiments of the second aspect may comprise at least one feature from the following bulleted list:

- deriving, from the partial skipping indication, the division of the preconfigured measurement period into the first and second parts as determined by the user equipment; and transmitting an acknowledgement message for the partial skipping of the preconfigured measurement period, the acknowledgement message allowing the partial skipping based on the division as determined by the user equipment.
- based on receiving the partial skipping indication from the user equipment, determining the division of the preconfigured measurement period into the first and second parts; and transmitting an acknowledgement message for the partial skipping of the preconfigured measurement period, the acknowledgment message comprising the determined division of the preconfigured measurement period into the first and second parts.
- scheduling data communication for the user equipment to take place on the one or more second parts of the preconfigured measurement period.
- determining that scheduling restrictions with respect to data communication apply for the user equipment on any of the one or more first parts.

According to a third aspect, there is provided an apparatus, comprising: at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to: acquire a measurement configuration for a preconfigured measurement period dedicated for performing radio signal measurements; determine to partially skip the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed and one or more second parts during which radio signal measurements are not performed; prioritize data communication on the one or more second parts of the preconfigured measurement period; and end the radio signal measurements associated with the preconfigured measurement period at latest at the end of the preconfigured measurement period.

Various embodiments of the third aspect may comprise at least one feature from the bulleted list under the first aspect.

According to a fourth aspect, there is provided an apparatus, comprising: at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to: determine a configuration for a preconfigured measurement period dedicated for performing radio signal measurements by a user equipment; receive, from the user equipment, a partial skipping indication indicating partial skipping of the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed by the user equipment and one or more second parts during which radio signal measurements are not performed by the user equipment; determine, based on the partial skipping indication, that the user equipment prioritizes data communication on the one or more second parts of the preconfigured measurement period; and determine that further data communication with the user equipment can be scheduled to take place directly after the end of the preconfigured measurement period.

Various embodiments of the fourth aspect may comprise at least one feature from the bulleted list under the second aspect.

According to a fifth aspect, there is provided a computer program product embodied on a distribution medium and comprising program instructions which, when executed by an apparatus, cause the apparatus to carry out the method according to the first aspect.

According to a sixth aspect, there is provided a computer program product embodied on a distribution medium and comprising program instructions which, when executed by an apparatus, cause the apparatus to carry out the method according to the second aspect.

According to a seventh aspect, there is provided a computer program product comprising program instructions which, when executed by an apparatus, cause the apparatus to carry out the method according to the first aspect.

According to an eight aspect, there is provided a computer program product comprising program instructions which, when executed by an apparatus, cause the apparatus to carry out the method according to the second aspect.

According to a ninth aspect, there is provided an apparatus, comprising means for performing the method according to the first aspect, and/or means configured to cause the apparatus to perform the method according to the first aspect.

According to a tenth aspect, there is provided an apparatus, comprising means for performing the method according to the second aspect, and/or means configured to cause the apparatus to perform the method according to the second aspect.

According to an eleventh aspect, there is provided computer implemented system, comprising: a server and at least one radio node; and at least one processor and at least one memory storing instructions that, when executed by the at least one processor, cause the system at least to carry out the method according to the first aspect and/or the method according to the second aspect.

According to a twelfth aspect, there is provided computer implemented system, comprising: one or more processors; at least one data storage, and one or more computer program instructions to be executed by the one or more processors in association with the at least one data storage for carrying out the method according to the first aspect and/or the method according to the second aspect.

Even though the invention has been described above with reference to an example according to the accompanying drawings, it is clear that the invention is not restricted thereto but can be modified in several ways within the scope of the appended claims. Therefore, all words and expressions should be interpreted broadly and they are intended to illustrate, not to restrict, the embodiment. It will be obvious to a person skilled in the art that, as technology advances, the inventive concept can be implemented in various ways. Further, it is clear to a person skilled in the art that the described embodiments may, but are not required to, be combined with other embodiments in various ways.

CLAIMS

1. An apparatus, comprising:

at least one processor; and

at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to:

acquire a measurement configuration for a preconfigured measurement period dedicated for performing radio signal measurements;

determine to partially skip the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed and one or more second parts during which radio signal measurements are not performed;

prioritize data communication on the one or more second parts of the preconfigured measurement period; and

end the radio signal measurements associated with the preconfigured measurement period at latest at the end of the preconfigured measurement period.

2. The apparatus of claim 1, wherein the apparatus is further caused to:

determine the division of the preconfigured measurement period into the first and second parts; and

transmit a first indication of the partial skipping of the preconfigured measurement period to a network node, wherein the first indication indicates the determined division.

3. The apparatus of claim 1, wherein the apparatus is further caused to:

transmit a second indication to a network node indicating that the partial skipping of the preconfigured measurement period is possible; and

receive a third indication from the network node, the third indication acknowledging the partial skipping of the preconfigured measurement period for the user equipment.

4. The apparatus of claim 3, wherein the apparatus is further caused to:

determine the division of the preconfigured measurement period into the first and second parts, wherein the second indication further indicates the division; and

based on receiving the third indication, perform the partial skipping according to the determined division indicated in the second indication.

5. The apparatus of claim 3, wherein the third indication further indicates the

division of the preconfigured measurement period into the first and second parts, and the apparatus is further caused to:

based on receiving the third indication, perform the partial skipping according to the division indicated in the third indication.

6. The apparatus of any of claims 1 to 5, wherein each of the one or more first parts comprise one or more synchronization signal blocks (SSBs) to be measured, and wherein an indication indicating the division of the preconfigured measurement period into the first and second parts comprises identification of the one or more SSBs to measure.

7. The apparatus of any of claims 1 to 6, wherein the determination to partially skip the preconfigured measurement period is based on an elapsed time from a previously performed radio signal measurement and/or based on an estimation of data communication in a predetermined future time window.

8. The apparatus of any of claims 1 to 7, wherein the apparatus is further caused to:

acquire at least one of: a maximum allowed number of the one or more first parts or a maximum allowed number of the one or more second parts.

9. The apparatus of any of claims 1 to 8, wherein the one or more first parts comprise a subset of those at least one synchronization signal block (SSB) within the preconfigured measurement period for which a previous radio signal measurement exceeded a predetermined signal strength threshold.

10. The apparatus of any of claims 1 to 9, wherein the apparatus is further caused to:

periodically or at least a predetermined time duration after the partial skipping has taken place, perform radio signal measurements of all radio signals configured for measurement within the preconfigured measurement period.

11. An apparatus, comprising:

at least one processor; and

at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to:

determine a configuration for a preconfigured measurement period dedicated for performing radio signal measurements by a user equipment;

receive, from the user equipment, a partial skipping indication indicating partial skipping of the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed by the user equipment and one or more second parts during which radio signal measurements are not performed by the user equipment;

determine, based on the partial skipping indication, that the user equipment prioritizes data communication on the one or more second parts of the preconfigured measurement period; and

determine that further data communication with the user equipment can be scheduled to take place directly after the end of the preconfigured measurement period.

12. The apparatus of claim 11, wherein the apparatus is further caused to:

derive, from the partial skipping indication, the division of the preconfigured measurement period into the first and second parts as determined by the user equipment; and

transmit an acknowledgement message for the partial skipping of the preconfigured measurement period, the acknowledgement message allowing the partial skipping based on the division as determined by the user equipment.

13. The apparatus of claim 11, wherein the apparatus is further caused to:

based on receiving the partial skipping indication from the user equipment, determine the division of the preconfigured measurement period into the first and second parts; and

transmit an acknowledgement message for the partial skipping of the preconfigured measurement period, the acknowledgment message comprising the determined division of the preconfigured measurement period into the first and second parts.

14. A method performed by a user equipment, comprising:

acquiring a measurement configuration for a preconfigured measurement period dedicated for performing radio signal measurements;

determining to partially skip the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed and one or more second parts during which radio signal measurements are not performed;

prioritizing data communication on the one or more second parts of the preconfigured measurement period; and

ending the radio signal measurements associated with the preconfigured measurement period at latest at the end of the preconfigured measurement period.

15. A method performed by a network node, comprising:

determining a configuration for a preconfigured measurement period dedicated for performing radio signal measurements by a user equipment;

receiving, from the user equipment, a partial skipping indication indicating partial skipping of the preconfigured measurement period, wherein the partial skipping comprises division of the preconfigured measurement period into first and second parts such that the preconfigured measurement period comprises one or more first parts during which radio signal measurements are performed by the user equipment and one or more second parts during which radio signal measurements are not performed by the user equipment;

determining, based on the partial skipping indication, that the user equipment prioritizes data communication on the one or more second parts of the preconfigured measurement period; and

determining that further data communication with the user equipment can be scheduled to take place directly after the end of the preconfigured measurement period.

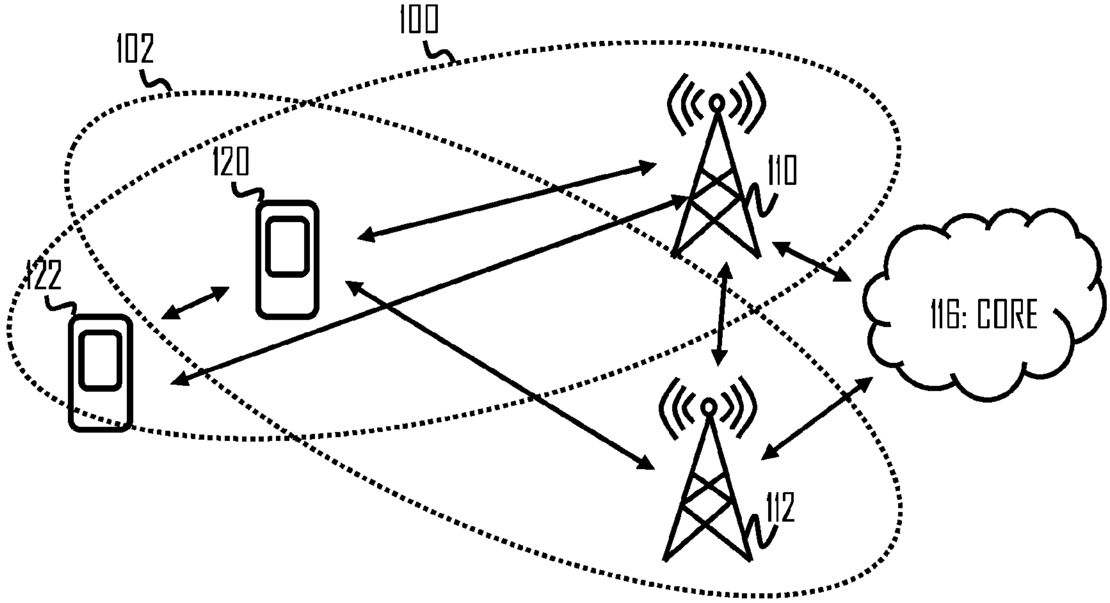
100
102
120
110
122
116: CORE
112

FIG. 1

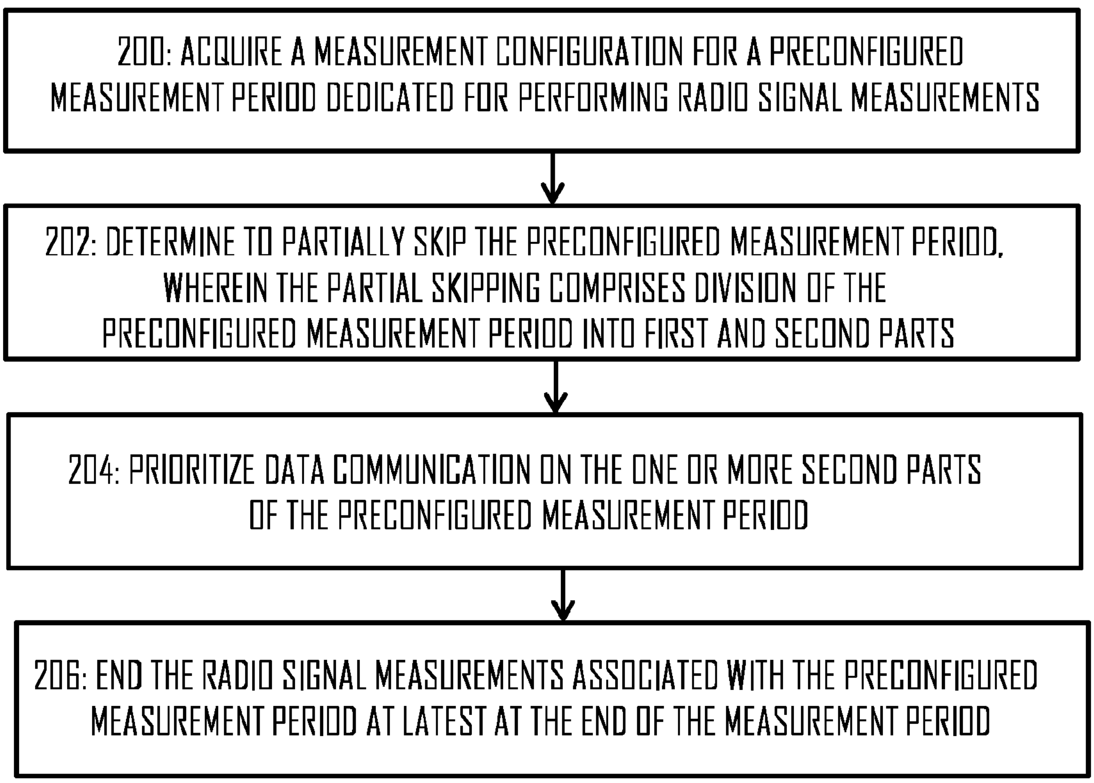
200: ACQUIRE A MEASUREMENT CONFIGURATION FOR A PRECONFIGURED MEASUREMENT PERIOD DEDICATED FOR PERFORMING RADIO SIGNAL MEASUREMENTS
202: DETERMINE TO PARTIALLY SKIP THE PRECONFIGURED MEASUREMENT PERIOD, WHEREIN THE PARTIAL SKIPPING COMPRISES DIVISION OF THE PRECONFIGURED MEASUREMENT PERIOD INTO FIRST AND SECOND PARTS
204: PRIORITIZE DATA COMMUNICATION ON THE ONE OR MORE SECOND PARTS OF THE PRECONFIGURED MEASUREMENT PERIOD
206: END THE RADIO SIGNAL MEASUREMENTS ASSOCIATED WITH THE PRECONFIGURED MEASUREMENT PERIOD AT LATEST AT THE END OF THE MEASUREMENT PERIOD

FIG. 2

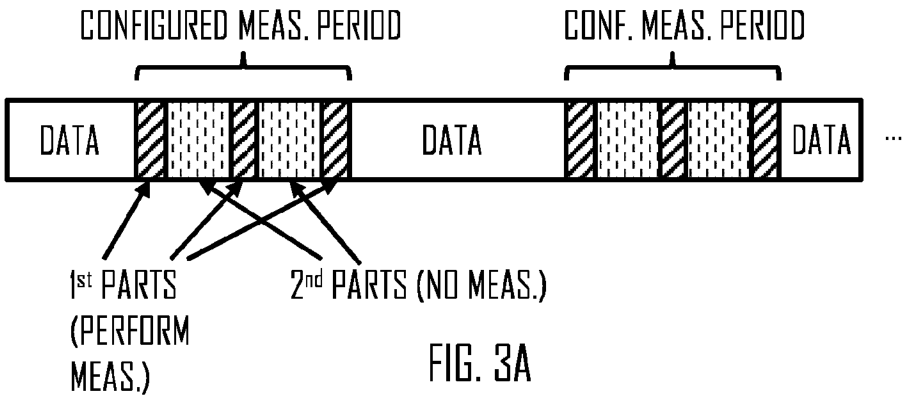

FIG. 3A

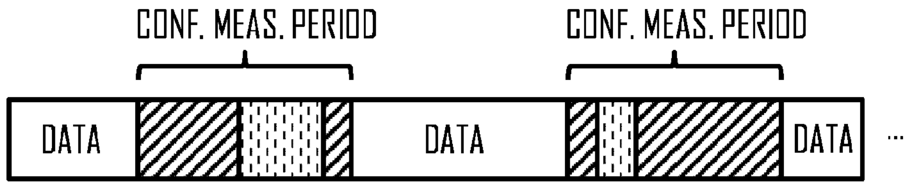

FIG. 3B

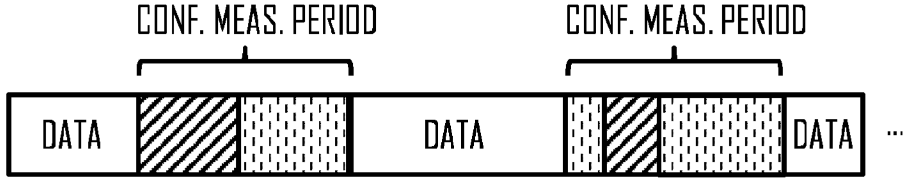

FIG. 3C

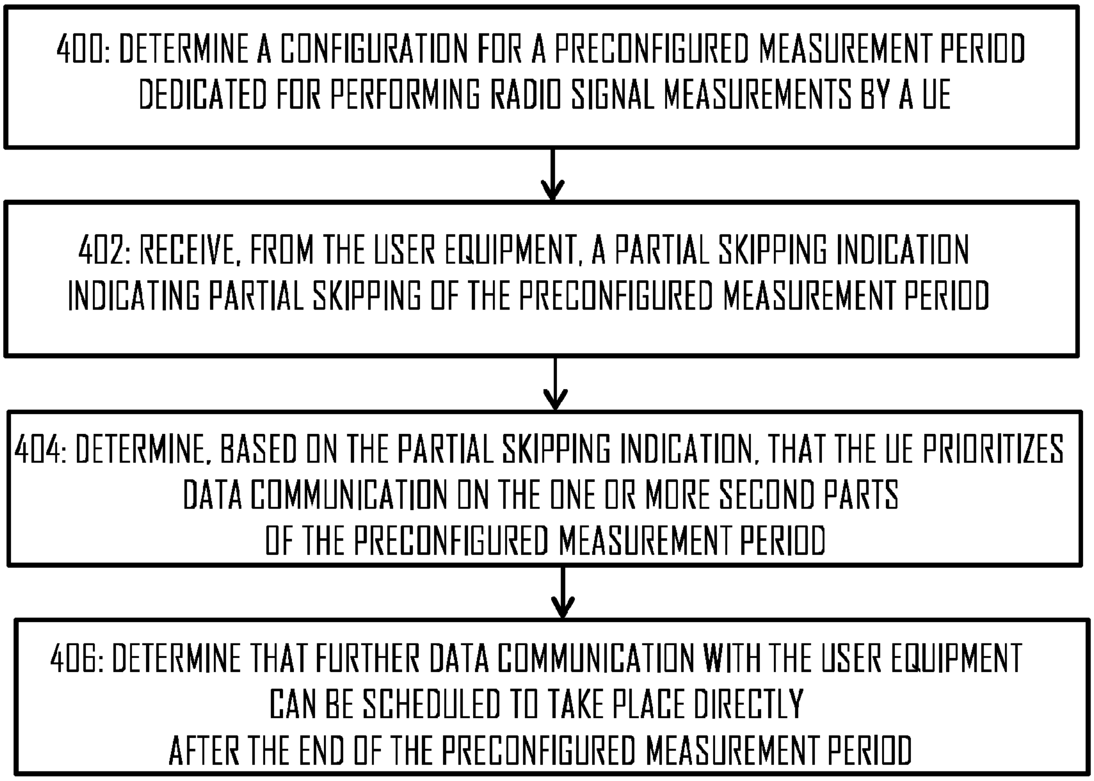
400: DETERMINE A CONFIGURATION FOR A PRECONFIGURED MEASUREMENT PERIOD DEDICATED FOR PERFORMING RADIO SIGNAL MEASUREMENTS BY A UE
402: RECEIVE, FROM THE USER EQUIPMENT, A PARTIAL SKIPPING INDICATION INDICATING PARTIAL SKIPPING OF THE PRECONFIGURED MEASUREMENT PERIOD
404: DETERMINE, BASED ON THE PARTIAL SKIPPING INDICATION, THAT THE UE PRIORITIZES DATA COMMUNICATION ON THE ONE OR MORE SECOND PARTS OF THE PRECONFIGURED MEASUREMENT PERIOD
406: DETERMINE THAT FURTHER DATA COMMUNICATION WITH THE USER EQUIPMENT CAN BE SCHEDULED TO TAKE PLACE DIRECTLY AFTER THE END OF THE PRECONFIGURED MEASUREMENT PERIOD

FIG. 4

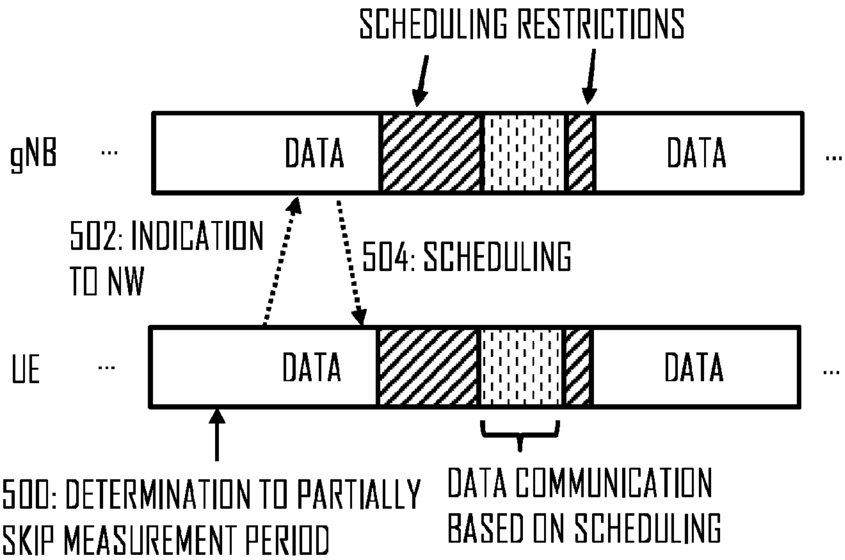
SCHEDULING RESTRICTIONS
gNB
...
DATA
DATA
...
502: INDICATION TO NW
504: SCHEDULING
UE
...
DATA
DATA
...
500: DETERMINATION TO PARTIALLY SKIP MEASUREMENT PERIOD
DATA COMMUNICATION BASED ON SCHEDULING

FIG. 5

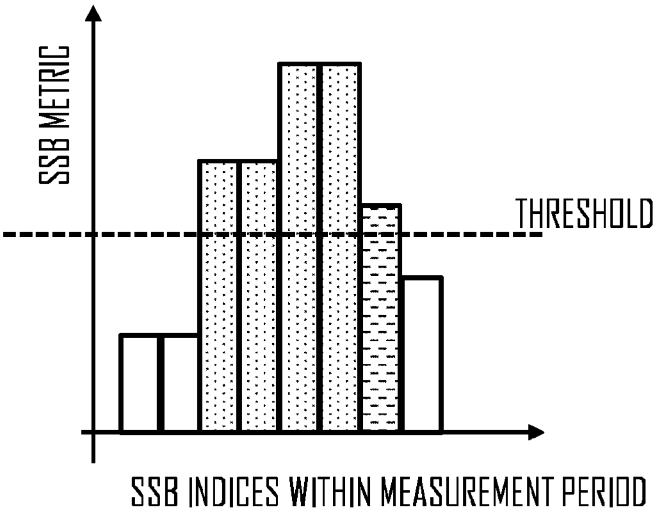
SSB METRIC
THRESHOLD
SSB INDICES WITHIN MEASUREMENT PERIOD

FIG. 6A

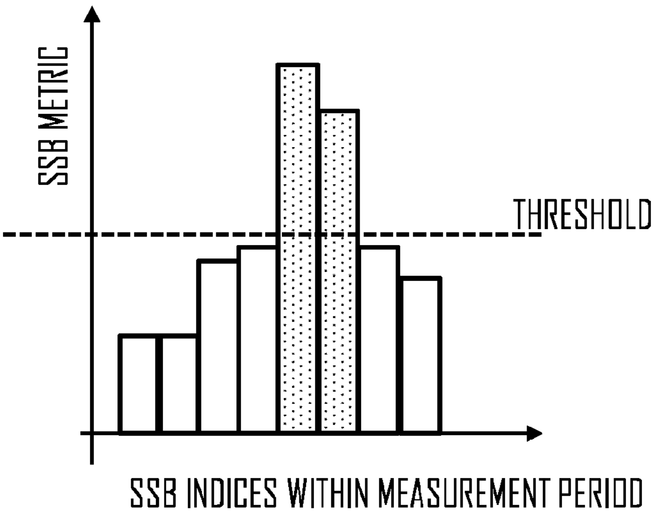
SSB METRIC
THRESHOLD
SSB INDICES WITHIN MEASUREMENT PERIOD

FIG. 6B

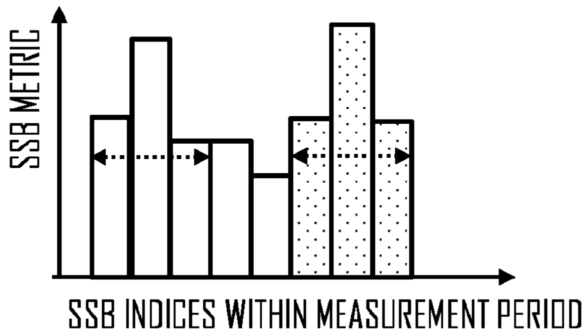

FIG. 7

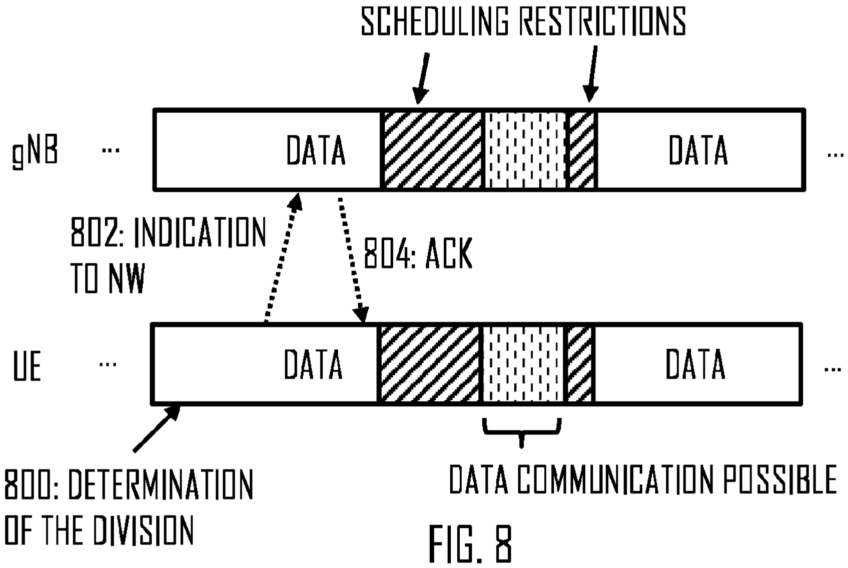

FIG. 8

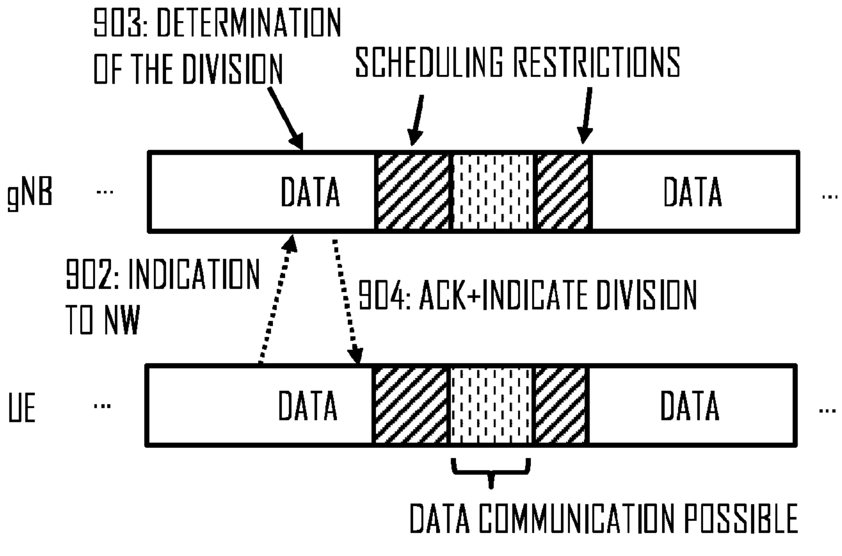

FIG. 9

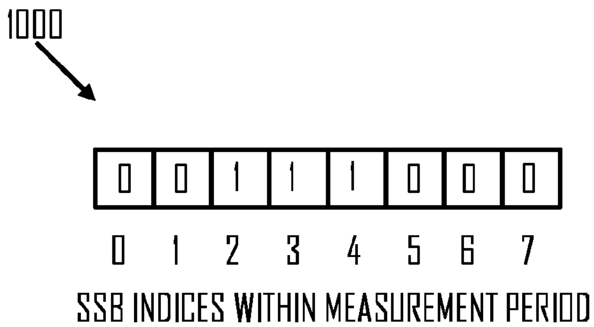

FIG. 10A

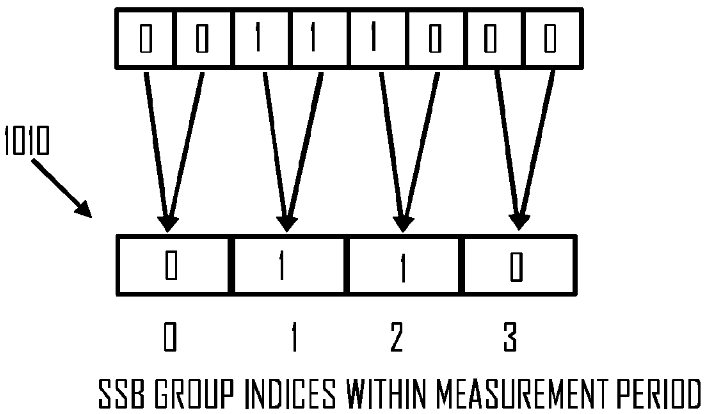

FIG. 10B

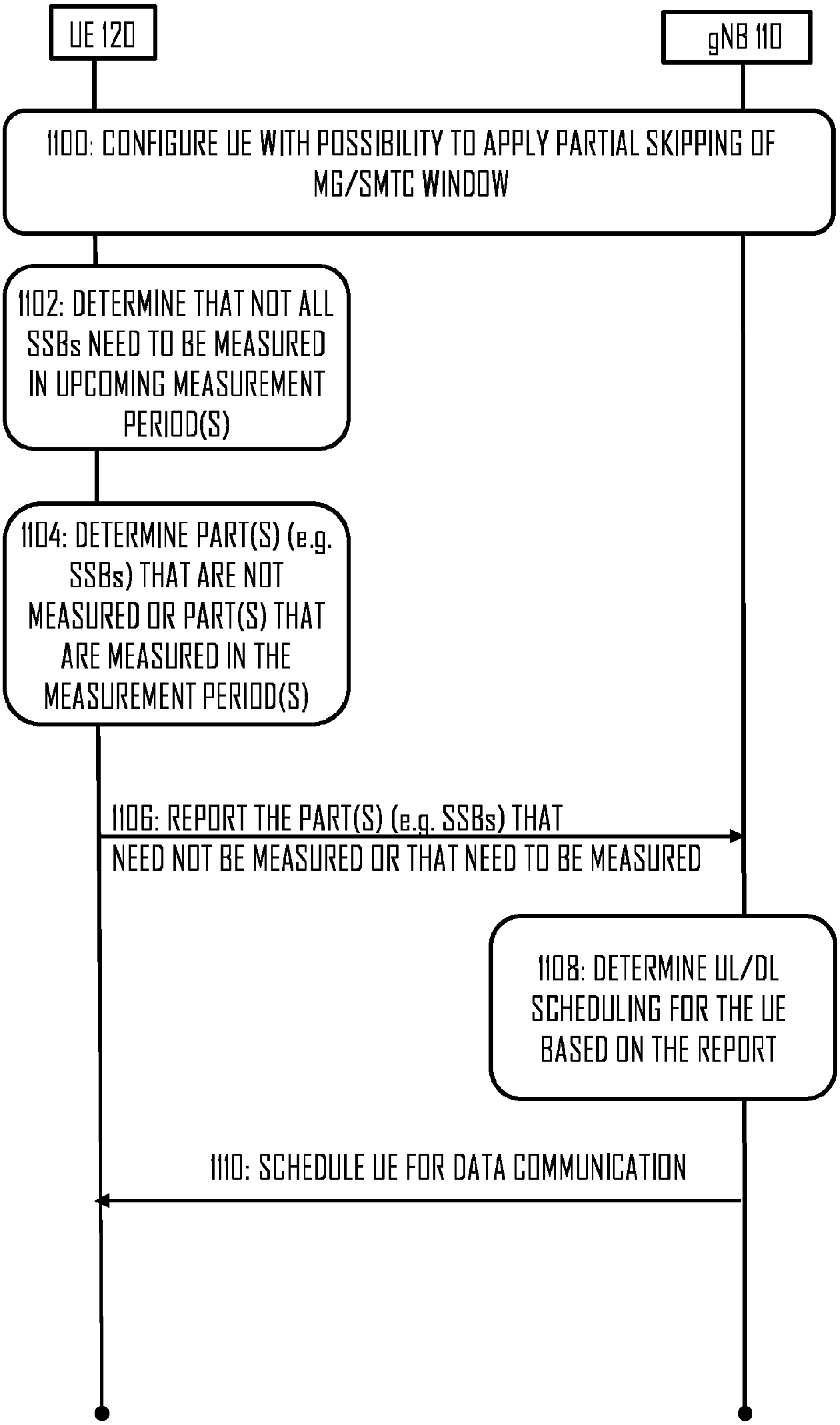
UE 120
gNB 110
1100: CONFIGURE UE WITH POSSIBILITY TO APPLY PARTIAL SKIPPING OF MG/SMTC WINDOW
1102: DETERMINE THAT NOT ALL SSBs NEED TO BE MEASURED IN UPCOMING MEASUREMENT PERIOD(S)
1104: DETERMINE PART(S) (e.g. SSBs) THAT ARE NOT MEASURED OR PART(S) THAT ARE MEASURED IN THE MEASUREMENT PERIOD(S)
1106: REPORT THE PART(S) (e.g. SSBs) THAT NEED NOT BE MEASURED OR THAT NEED TO BE MEASURED
1108: DETERMINE UL/DL SCHEDULING FOR THE UE BASED ON THE REPORT
1110: SCHEDULE UE FOR DATA COMMUNICATION

FIG. 11

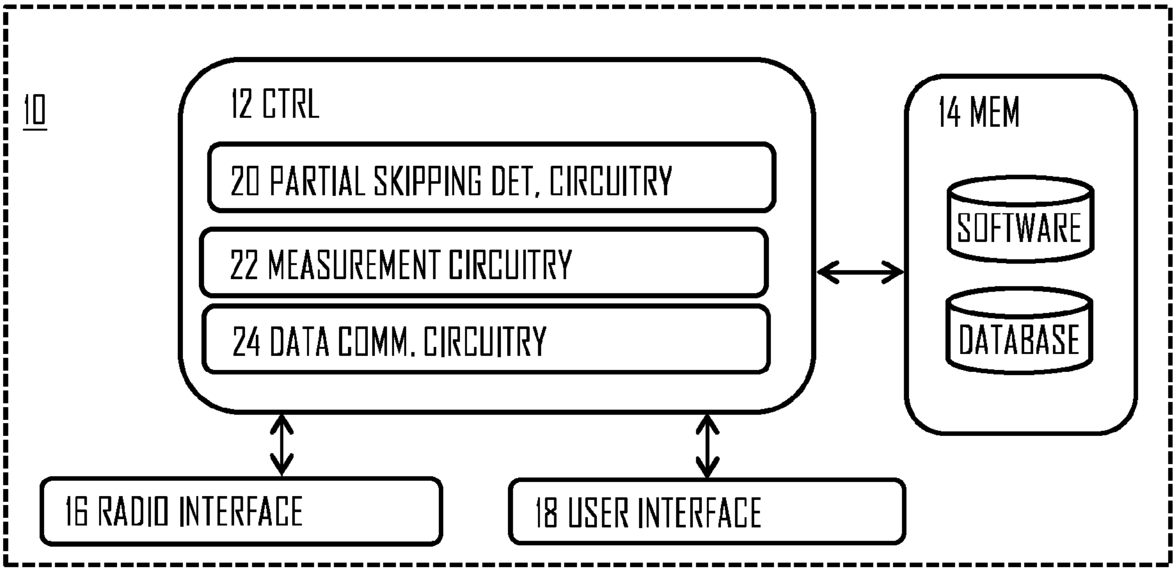
10
12 CTRL
20 PARTIAL SKIPPING DET. CIRCUITRY
22 MEASUREMENT CIRCUITRY
24 DATA COMM. CIRCUITRY
14 MEM
SOFTWARE
DATABASE
16 RADIO INTERFACE
18 USER INTERFACE

FIG. 12

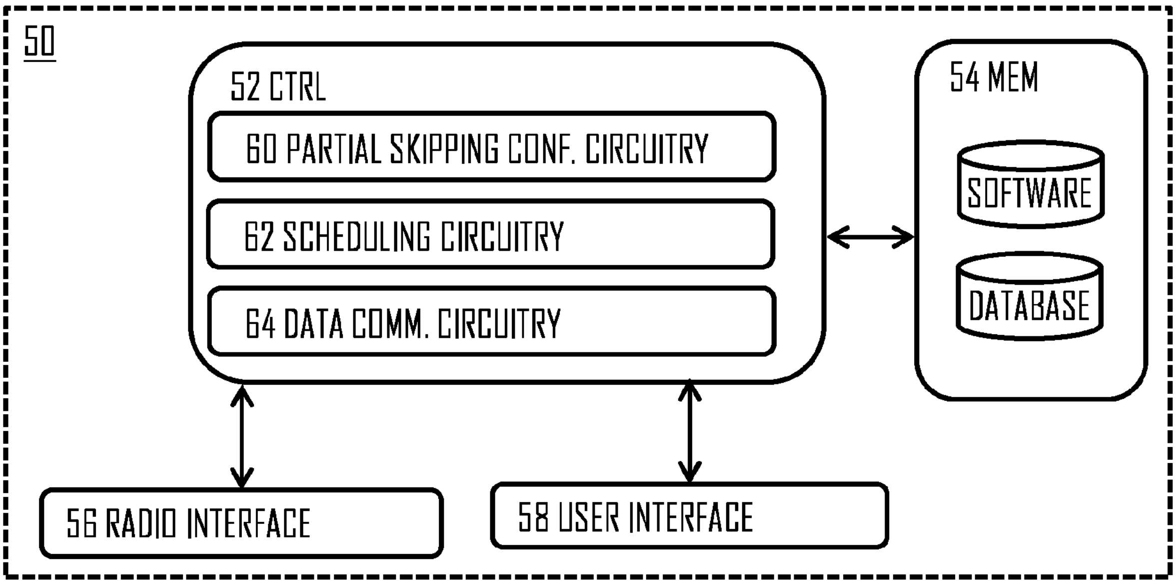
50
52 CTRL
60 PARTIAL SKIPPING CONF. CIRCUITRY
62 SCHEDULING CIRCUITRY
64 DATA COMM. CIRCUITRY
54 MEM
SOFTWARE
DATABASE
56 RADIO INTERFACE
58 USER INTERFACE

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/076095

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/1268 H04W24/10
ADD. H04W72/21 H04W88/02 H04W88/08 H04L47/56

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

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

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

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	US 2022/264622 A1 (LEE EUNJONG [KR] ET AL) 18 August 2022 (2022-08-18)	1,2, 6-11,14, 15
A	claims 1-11 figures 3,14 paragraphs [0008], [0026], [0094], [0096], [0221], [0224] - [0226], [0232], [0233], [0238], [0256] -----	3-5,12, 13
X	US 2017/127397 A1 (HAHN GENEBECK [KR] ET AL) 4 May 2017 (2017-05-04)	1,6-9, 11,14,15
A	figures 8,10,12-14,25 paragraphs [0165] - [0203], [0218], [0221] - [0233], [0253], [0256], [0340] - [0350], [0366] -----	3-5,12, 13
A	US 2022/078650 A1 (LEE EUNJONG [KR] ET AL) 10 March 2022 (2022-03-10) the whole document -----	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
29 November 2024	09/12/2024

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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