[0009] According to some examples, the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform: configuring the apparatus in the priority state.

[0010] According to some examples the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform receiving a configuration for the one or more buffer symbols.

[0011] According to some examples, the configuration for the buffer symbols is received from one or more of: a base station; a network.

[0012] According to some examples, the using one or more buffer symbols is based on the received configuration for the one or more buffer symbols.

[0013] According to some examples, the one or more buffer symbols are used to give the apparatus sufficient time to perform beam switching for reception of the one or more positioning reference signals.

[0014] According to some examples, the one or more buffer symbols are used to give the apparatus sufficient time to process received downlink control information.

[0015] According to some examples, the one or more buffer symbols are positioned at the beginning of the time window.

[0016] According to some examples, at least one of the one or more buffer symbols is positioned before the start of the time window.

[0017] According to some examples, the priority information indicates one of: a first priority state; a second priority state; a third priority state.

[0018] According to some examples the first priority state comprises a high priority state for the one or more positioning reference signals, the second priority state comprises an intermediate priority state for the one or more positioning reference signals, and the third priority state comprises a low priority state for the one or more positioning reference signals.

[0019] According to some examples, when the priority information indicates the first priority state, the apparatus is configured to prioritize the one or more positioning reference signals relative to a physical downlink shared channel, such that for at least part of the time window the physical downlink shared channel is dropped in favour of the one or more positioning reference signals.

[0020] According to some examples, the apparatus is configured to prioritize low latency traffic on a physical downlink shared channel relative to the one or more

[0031] According to some examples, the using one or more buffer symbols is based on the received configuration for the one or more buffer symbols.

[0032] According to some examples, the one or more buffer symbols are used to give the apparatus sufficient time to perform beam switching for reception of the one or more positioning reference signals.

[0033] According to some examples, the one or more buffer symbols are used to give the apparatus sufficient time to process received downlink control information.

[0034] According to some examples, the one or more buffer symbols are positioned at the beginning of the time window.

[0035] According to some examples, at least one of the one or more buffer symbols is positioned before the start of the time window.

[0036] According to some examples, the priority information indicates one of: a first priority state; a second priority state; a third priority state.

[0037] According to some examples the first priority state comprises a high priority state for the one or more positioning reference signals, the second priority state comprises an intermediate priority state for the one or more positioning reference signals, and the third priority state comprises a low priority state for the one or more positioning reference signals.

[0038] According to some examples, when the priority information indicates the first priority state, the apparatus is configured to prioritize the one or more positioning reference signals relative to a physical downlink shared channel, such that for at least part of the time window the physical downlink shared channel is dropped in favour of the one or more positioning reference signals.

[0039] According to some examples, the apparatus is configured to prioritize low latency traffic on a physical downlink shared channel relative to the one or more positioning reference signals, when the priority information indicates the second priority state.

[0040] According to some examples, the apparatus is configured to drop at least one of the one or more positioning reference signals in favour of at least one of the one or more buffer symbols, when the priority information indicates the second priority state.

[0041] According to some examples, the means are further configured to perform a positioning reference signal measurement based on a partial position reference resource due to the drop of the at least one of the one or more positioning reference signal symbols; and/or sending an indication that the positioning reference signal

[0053] According to some examples, the one or more buffer symbols are used to give the apparatus sufficient time to process received downlink control information.

[0054] According to some examples, the one or more buffer symbols are positioned at the beginning of the time window.

[0055] According to some examples, at least one of the one or more buffer symbols is positioned before the start of the time window.

[0056] According to some examples, the priority information indicates one of: a first priority state; a second priority state; a third priority state.

[0057] According to some examples the first priority state comprises a high priority state for the one or more positioning reference signals, the second priority state comprises an intermediate priority state for the one or more positioning reference signals, and the third priority state comprises a low priority state for the one or more positioning reference signals.

[0058] According to some examples, when the priority information indicates the first priority state, the method comprises prioritizing the one or more positioning reference signals relative to a physical downlink shared channel, such that for at least part of the time window the physical downlink shared channel is dropped in favour of the one or more positioning reference signals.

[0059] According to some examples, the method comprises prioritizing low latency traffic on a physical downlink shared channel relative to the one or more positioning reference signals, when the priority information indicates the second priority state.

[0060] According to some examples, the method comprises dropping at least one of the one or more positioning reference signals in favour of at least one of the one or more buffer symbols, when the priority information indicates the second priority state.

[0061] According to some examples, the method comprises performing a positioning reference signal measurement based on a partial position reference resource due to the drop of the at least one of the one or more positioning reference signal symbols; and/or sending an indication that the positioning reference signal measurement made by the apparatus is based on the partial positioning reference signals resource.

[0062] According to some examples, the indication is sent to the network.

[0063] According to some examples, the method comprises considering the one or more positioning reference signals as lower priority than a physical downlink control

Brief description of Figures

[0083] The invention will now be described in further detail, by way of example only, with reference to the following examples and accompanying drawings, in which:

[0084] Figure 1 schematically shows a prior art example of a UE receiving positioning reference signals;

[0085] Figure 2 schematically shows a UE receiving positioning reference signals according to an example;

[0086] Figure 3 schematically shows a UE receiving positioning reference signals according to an example;

[0087] Figure 4 schematically shows a flow chart of a method according to an example;

[0088] Figure 5 schematically shows a flow chart of a method according to an example;

[0089] Figure 6 schematically shows an example of a user equipment;

[0090] Figure 7 schematically shows an example of a control apparatus;

[0091] Figure 8 is a flow chart of a method according to an example;

[0092] Figure 9 is a flow chart of a method according to an example;

[0093] Figure 10 shows a schematic representation of a non-volatile memory medium storing instructions which when executed by a processor allow a processor to perform one or more of the steps of the methods of some embodiments.

Detailed description

[0094] The following positioning solutions are specified for NR Rel-16:

- Downlink Time Difference of Arrival (DL-TDOA)
- Uplink Time Difference of Arrival (UL-TDOA)
- Downlink Angle of Departure (DL-AoD)
- Uplink Angle of Arrival (UL-AoA)
- Multi-cell Round Trip Time (Multi-RTT)

[0095] In Rel-17, 3GPP started NR positioning enhancement work [RP-210897, “Revised WID on NR Positioning Enhancements”], focusing on increasing accuracy,

reducing latency and increasing efficiency (low complexity; low power consumption; low overhead) based on Rel-16 solutions.

[0096] As part of the work on reducing latency, a new feature allowing a UE to measure the Positioning Reference Signal (PRS) outside of the measurement gap (MG) was introduced.

[0097] Subject to UE capability, support PRS measurement outside the MG, within a PRS processing window, and UE measurement inside the active downlink bandwidth part (DL BWP), with PRS having the same numerology as the active DL BWP.

- Inside the PRS processing window (PPW), subject to the UE determining that DL PRS to be higher priority, support the following UE capabilities:
    - Capability 1: PRS prioritization over all other DL signals/channels in all symbols inside the PRS processing window.
        - Capability 1A: The DL signals/channels from all DL CCs (per UE) are affected.
        - Capability 1B: Only the DL signals/channels from a certain band/CC are affected.
    - Capability 2: PRS prioritization over other DL signals/channels only in the PRS symbols inside the PRS processing window.
    - A UE shall be able to declare a PRS processing capability outside MG.
- For the purpose of this feature, PRS-related conditions are expected to be specified, with the following to be down-selected:
    - Alt. 1: Applicable to serving cell PRS only
    - Alt. 2: Applicable to all PRS under conditions to PRS of non-serving cell.

[0098] When the UE determines higher priority for other DL signals/channels over the PRS measurement/processing, the UE is not expected to measure/process DL PRS which is applicable to all of the above capability options.

[0099] The following options are supported, subject to UE capability for priority handling of PRS when PRS measurement is outside MG.

- Option 1: UE may indicate support of two priority states.

one or more neighboring cells). This is shown schematically in Figure 1, which shows a PPW starting at time t0. In the example of Figure 1, PDCCH 102 is received before the PPW is commenced, and PDSCH 104 is received once the PPW has commenced. The positioning reference signal (PRS) is shown schematically at 106. As shown in Figure 1, the UE receives PDCCH to determine PRS priority (for example from a DCI, the DCI including information indicating a priority of the PDSCH), but may not have time to switch beams for PRS reception. Accordingly, the PRS may be dropped. However, the current specifications make an assumption that the UE has received the PRS.

[0103] Additionally, the present disclosure identifies another problem which may occur is that if the PDCCH is in the symbol prior to high priority PRS (e.g., State 1 in any of the PRS priority options) then the UE is expected to always measure the PRS. However, the UE again may not have time to switch beams to receive the PRS, as the UE first needs to finish receiving the PDCCH which is outside of the PRS processing window (or inside but prior to the PRS symbols), even if the UE does not need to decode the DCI to determine priority over PDSCH.

[0104] It is believed that the issue of how "Capability 2" from the working assumption interacts with "Option 2" from the Agreement has not been considered prior to the present disclosure.

[0105] With the above considerations in mind, the present disclosure proposes how a UE can handle PRS priority, when the PRS is received outside of a measurement gap (MG) but in the PPW.

[0106] According to examples, a UE is configured with a positioning processing window (PPW) for positioning reference signal (PRS) reception outside of the measurement gap (MG). Moreover, the UE supports "Capability 2" for PRS reception outside the MG. As mentioned above, Capability 2 is PRS prioritization over other DL signals/channels only in the PRS symbols inside the PPW. As part of this configuration a PRS priority state is indicated to the UE, and the UE prioritizes the PRS in the symbols where the PRS is configured under the current 3GPP standards.

[0107] The UE then determines or is pre-configured to interpret that the PRS, inside the PPW, is immediately following a PDCCH symbol that the UE needs to monitor.

[0108] In examples, the UE uses a buffer symbol to assist with the reception of the PRS outside of the MG. According to examples, the buffer symbol can be used according to any of the following alternatives, dependent on requirement:

priority or a low priority. In some examples, at least a part of the DCI may be used for indicating the PRS priority.

[0128] In some examples, the PPW is configured using any one or more of: RRC signalling; MAC CE; DCI.

[0129] At S403, the gNB 450 configures one or more buffer symbols for the UE 460. For example, the gNB may configure buffer symbols for the UE as shown in the examples of Figures 2 and 3. In some examples, the one or more buffer symbols are implicitly allocated. For example, the one or more symbols may be allocated before or after the start of the PPW which is outside of a measurement gap, such that the UE is able to receive the PRSs or decode the DCI. Alternatively, the one or more buffered symbols are configured as the PRSs.

[0130] At S404, the UE 460 decodes DCI and determines PRS priority (e.g. priority relative to PDSCH).

[0131] At S405, the UE 460 applies the one or more buffer symbols. For example, the UE 460 may apply one or more buffer symbols for DCI decoding and/or receive beam (Rx beam) switching.

[0132] Then, at S406 the UE 460 receives one or more PRS.

[0133] At S407, the UE 460 reports PRS measurements to LMF 440.

[0134] If any PRS symbols were dropped, the UE 460 may indicate this to the LMF at S408.

[0135] In a further example, if a base station (gNB) is aware of PRS occasions (or the gNB assumes that the PRS are configured during PPW), the gNB may use cross-slot scheduling. With cross-slot scheduling, a UE can already decode a DCI in a prior slot so that the UE knows priority of PDSCH versus PRS in a “current” slot. In such an example, the gNB can use cross-slot scheduling for PDSCH overlapped with PRS. This allows the gNB to send DCI earlier, to allow more time for decoding / beam switching. However, this may not always be possible for the gNB due to scheduling constraints or URLLC traffic which arrives quickly and may not be able to wait for later slots to be scheduled, due to QoS requirements. Figure 5 is a flow chart that schematically shows this process with cross-slot scheduling.

[0136] With reference to Figure 5, S501 and S502 are the same as S401 and S402 in Figure 4.

[0137] At S503, the gNB 550 uses cross-slot scheduling to provide an early alert to UE 560 of PDSCH.

device may need human interaction for communication, or may not need human interaction for communication. In the present teachings the terms UE or “user equipment” are used to refer to any type of wireless communication device.

[0146] The wireless device 600 may receive signals over an air or radio interface 607 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 6 transceiver apparatus is designated schematically by block 606. The transceiver apparatus 606 may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the wireless device.

[0147] A wireless device is typically provided with at least one data processing entity 601, at least one memory 602 and other possible components 603 for use in software and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 604. The user may control the operation of the wireless device by means of a suitable user interface such as key pad 605, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 608, a speaker and a microphone can be also provided. Furthermore, a wireless communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto.

[0148] Figure 7 shows an example of a control apparatus 700 for a communication system, for example to be coupled to and/or for controlling a station of an access system, such as a RAN node, e.g. a base station, gNB, a central unit of a cloud architecture or a node of a core network such as an MME or S-GW, a scheduling entity such as a spectrum management entity, or a server or host. The control apparatus may be integrated with or external to a node or module of a core network or RAN. In some embodiments, base stations comprise a separate control apparatus unit or module. In other embodiments, the control apparatus can be another network element such as a radio network controller or a spectrum controller. In some embodiments, each base station may have such a control apparatus as well as a control apparatus being provided in a radio network controller. For example, the control apparatus could be a base station or gNB as described with respect to Figures 2 to 5. The control

[0159] Figure 10 shows a schematic representation of non-volatile memory media 1000a (e.g., computer disc (CD) or digital versatile disc (DVD)) and 1000b (e.g., universal serial bus (USB) memory stick) storing instructions and/or parameters 1002 which when executed by a processor allow the processor to perform one or more of the steps of the methods of Figures 8 to 9.

[0160] In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects of the invention may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0161] As used in this application, the term “circuitry” may refer to one or more or all of the following: (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and(b) combinations of hardware circuits and software, such as (as applicable): (i) a combination of analog and/or digital hardware circuit(s) with software/firmware and (ii) any portions of hardware processor(s) with software (including digital signal processor(s), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and (c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation. This definition of circuitry applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term circuitry also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network device, or other computing or network device.