(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
07 May 2020 (07.05.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/091645 A1

(51) International Patent Classification:
H04W 72/12 (2009.01) *H04L 5/00* (2006.01)
H04W 72/04 (2009.01) *H04W 52/02* (2009.01)
H04W 72/08 (2009.01)

(21) International Application Number:
PCT/SE2019/051001

(22) International Filing Date:
11 October 2019 (11.10.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/753,368 31 October 2018 (31.10.2018) US

(71) Applicant: **TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)** [SE/SE]; 164 83 Stockholm (SE).

(72) Inventors: **SHREEVASTAV, Ritesh**; Jordbrukargatan 41, SE-194 47 Upplands Väsby (SE). **GUNNARSSON, Fredrik**; Tinnerbäcksgränd 28, SE-587 50 LINKÖPING (SE). **SIOMINA, Iana**; Näsbyvägen 10, SE-183 30 TÄBY (SE). **MODARRES RAZAVI, Sara**; Vårbruksgatan 67, SE-583 32 LINKÖPING (SE). **MUNIER, Florent**; Fredagstomten 2, SE-426 53 VÄSTRA FRÖLUNDA (SE).

(74) Agent: **AYOUB, Nabil**; Ericsson AB, Patent Unit Kista RAN 2, 164 80 Stockholm (SE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: NETWORK NODE, WIRELESS COMMUNICATION DEVICE AND METHOD THEREIN FOR BEAM TRANSMISSION OF REFERENCE SIGNAL IN A WIRELESS COMMUNICATION NETWORK

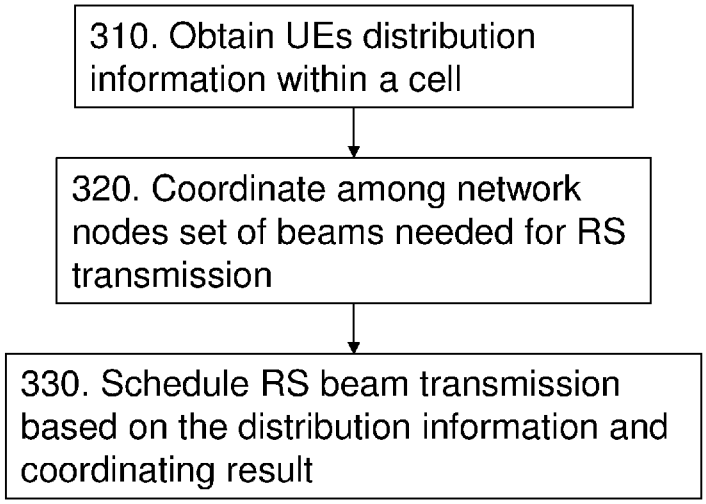


Fig. 3

(57) Abstract: Methods and apparatus for scheduling and handling beam transmission and reception of reference signals in a wireless communication network are disclosed. A network node obtains distribution information of wireless communication devices located within a cell and determines a set of beams needed for reference signals transmission by co-ordinating beam information among network nodes. The network node schedules the set of beams for reference signal beam transmission based on the distribution information.The reference signal beams are selected and scheduled in such a way that the UE can hear the neighbor beam without any interference such that the reference signal measurement is not error prone.

WO 2020/091645 A1

[Continued on next page]

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

NETWORK NODE, WIRELESS COMMUNICATION DEVICE AND METHOD THEREIN FOR BEAM TRANSMISSION OF REFERENCE SIGNAL IN A WIRELESS COMMUNICATION NETWORK

TECHNICAL FIELD

Embodiments herein relate to a network node and a wireless communication device and methods therein. In particular, they relate to scheduling and selecting beam transmission of a reference signal, such as a Positioning Reference signal (PRS) in a wireless communication network.

BACKGROUND

In a typical wireless communication network, wireless devices, also known as wireless communication devices, mobile stations, stations (STA) and/or user equipments (UE), communicate via a Radio Access Network (RAN) to one or more core networks (CN). The RAN covers a geographical area which is divided into service areas or cell areas, which may also be referred to as a beam or a beam group, with each service area or cell area being served by a radio network node such as a radio access node e.g., a Wi-Fi access point or a radio base station (RBS), which in some networks may also be denoted, for example, a transmission point, a “NodeB” or “eNodeB” or “gNB”. A service area or cell area is a geographical area where radio coverage is provided by the radio network node. The radio network node communicates over an air interface operating on radio frequencies with the wireless device within a range of the radio network node.

A Universal Mobile Telecommunications System (UMTS) is a third generation (3G) telecommunication network, which evolved from the second generation (2G) Global System for Mobile Communications (GSM). Specifications for the Evolved Packet System (EPS), also called a Fourth Generation (4G) network, have been completed within the 3rd Generation Partnership Project (3GPP) and this work continues in the coming 3GPP releases, for example to specify a Fifth Generation (5G) New Radio (NR) network.

According to the NR positioning study item agreed for 3GPP standard Rel.16, the 3GPP NR radio-technology is uniquely positioned to provide added value in terms of enhanced location capabilities. The operation in low and high frequency bands i.e. below and above 6GHz and utilization of massive antenna arrays provides additional degrees of freedom to substantially improve the positioning accuracy. The possibility to use wide signal bandwidth in low and especially in high bands brings new performance bounds for

user location for well-known positioning techniques based Observed Time Difference of Arrival (OTDOA) and Uplink-Time Difference of Arrival (UTDOA), Cell Identity (Cell-ID) or Enhanced Cell Identity (E-Cell-ID) etc., utilizing timing measurements to locate UE. The recent advances in massive antenna systems, i.e. massive Multiple Input Multiple Output (MIMO) may provide additional degrees of freedom to enable more accurate user location by exploiting spatial and angular domains of propagation channel in combination with time measurements.

With 3GPP Release 9 Positioning Reference Signals (PRS) have been introduced for antenna port 6 as the Release 8 cell-specific reference signals (CS-RS) are not sufficient for positioning. The simple reason is that the required high probability of detection may not be guaranteed. A neighbor cell with its synchronization signals, i.e. Primary and Secondary Synchronization Signals, and reference signals is seen as detectable, when the Signal-to-Interference-and-Noise Ratio (SINR) is at least -6 dB. Simulations during standardization have shown, that this may be only guaranteed for 70% of all cases for the 3rd best-detected cell, means the 2nd best neighboring cell. This is not enough and has been assumed an interference-free environment, which may not be ensured in a real-world scenario. However, PRS have still some similarities with cell-specific reference signals as defined in 3GPP Release 8. It is a pseudo-random Quadrature Phase Shift Keying (QPSK) sequence that is being mapped in diagonal patterns with shifts in frequency and time to avoid collision with cell-specific reference signals and an overlap with the control channels Physical Downlink Control Channel (PDCCH).

PRS is configured mainly by below parameters:

a) Number of consecutive PRS Subframes (Nprs)

b) PRS Occasion: Interval for PRS transmission. Every time PRS is transmitted there will be Nprs

c) PRS Occasion group Length: How many times PRS occasion will appear

d) PRS muting pattern: A bit pattern that specifies the PRS muting configuration of a cell. If a bit in the PRS muting sequence is set to "0", then the PRS is muted in all the PRS occasions in the corresponding PRS occasion group.

To support increased traffic capacity and to enable a transmission bandwidth needed to support very high data rate services, 5G will extend the range of frequencies used for mobile communication. This includes new spectrum below 6GHz, as well as

spectrum in higher frequency bands such as 28 GHz. High frequency bands provide contiguous larger bandwidth for higher rates in data communication. In such high frequency bands, the radio links are highly susceptible to rapid channel variations and suffer from severe path loss and atmospheric absorption. To address these challenges, the base stations and the mobile terminals in 5G will use highly directional antennas for beamforming to achieve sufficient link budget in a wide area network.

Depending upon the possibility of generating and projecting a number of beams, three different beamforming architectures may be used. These architectures are as follows:

a) Analog beamforming: This approach shapes the beam through a signal radio frequency (RF) chain for all the antenna elements. The processing is done in analog domain and is possible to transmit and receive beam in only one direction at a time.

b) Hybrid beamforming: This approach requires RF chains equivalent to the number of beams to be formed. A number N of RF chain hybrid beamformer may hence produce N beams and enables a transceiver to transmit and receive N analog beams in N simultaneous directions.

c) Digital beamforming: Unlike hybrid and analog beamforming architectures, digital beamforming technique requires a separate RF chain and data converters for each antenna element and allows processing of received signals in digital domain. Digital beamforming potentially allows transceiver to direct beams in infinite directions.

Figure 1 is an example of beam sweeping.

A geographical area is covered by a set of beams transmitted and received according to a pre-defined intervals and direction in downlink (DL). UE selects the best beam in DL based upon measurements on a set of beams.

New Radio is characterized by massive MIMO, antenna array and beam forming. The LTE PRS has very good characteristics such as:

a) Subframes containing PRS only transmits PRS. Thus, the subframe is dedicated only for PRS.

b) Frequency V-shift may provide up to 6 unique patterns for PRS. Thus, cell planning of PRS can greatly reduce any frequency domain interference.

c) PRS Muting is possible and may be used to mute if PRS collide in the frequency domain.

LTE does not have support of PRS transmitted via beam. In NR it is expected that any reference signal that will be used for transmission will be transmitted via beam.

PRS Muting makes it is possible for UE to hear far away PRS transmitted from a distant cell or beam. In LTE Cell PRS muting is performed in a more static way. As mentioned in earlier section, If a bit in the PRS muting sequence is set to "0", then the PRS is muted in all the PRS occasions in the corresponding PRS occasion group.

To optimize energy and power needed for the transmission of PRS beams, an efficient muting and scheduling of beams transmitting PRS is needed.

SUMMARY

Therefore, it is an object of embodiments herein to provide an improved technique for scheduling and configuration beams transmitting RS in a wireless communication network.

According to one aspect of embodiments herein, the objective is achieved by a method performed in a network node for scheduling beam transmission of a reference signal (RS) in a wireless communication network. The network node obtains distribution information of wireless communication devices located within a cell. The network node further determines a set of beams needed for RS transmission based on co-ordinating beam information among network nodes and schedules the set of beams for RS beam transmission based on the distribution information.

According to one aspect of embodiments herein, the objective is achieved by a network node for scheduling beam transmission of a reference signal (RS) in a wireless communication network. The network node is configured to obtain distribution information of wireless communication devices located within a cell. The network node is further configured to determine a set of beams needed for RS transmission based on co-ordinating beam information among network nodes and schedule the set of beams for RS beam transmission based on the distribution information.

The distribution information of wireless communication devices within a cell may comprise a number of wireless communication devices served by a beam or a number of wireless communication devices in a portion of the cell.

The distribution information may be received from a location server.

The set of beams may comprise any one or a combination of a number of beams, availability indication of beams, a pattern of beams, a probability or portion of time when a beam is not muted.

Each beam for transmitting a RS may comprise a start time, periodicity and a duration for how long the RS is transmitted. The start time, periodicity and the duration are configurable.

Beams in a region may be scheduled in a non-overlapping time period and frequency domain.

According to some embodiments herein, the network node coordinates beam information among network nodes may be performed by co-ordinating in conjunction with a location server such that only one or few beams transmit RS at a time, or a new beam is introduced for RS transmission, or a beam for RS transmission is stopped.

According to some embodiments herein, the network node coordinates beam information among network nodes may be performed by co-ordinating in conjunction with a location server the set of beams needed for RS transmission based on a service level required by the wireless communication device in terms of accuracy, latency and reliability. A beam transmission pattern in time may be configured to cover a wireless communication device with shortest latency service requirement earlier in a beam transmission cycle. That is the set of beams may be scheduled to send an RS beam for a wireless communication device with the shortest latency service requirement first in a beam transmission cycle.

According to some embodiments herein, the network node schedules RS beam transmission may be performed by scheduling the RS beam transmission in a round robin fashion such that the network nodes cyclically switch off transmission of RS beams to minimize interference.

The network node may further receive beam utilization information from a location server.

The network node may further adapt beam scheduling and configuration based on the received beam utilization information.

According to some embodiments herein, the network node schedules RS beam transmission may be performed by switching off a RS beam transmission if the number of wireless communication devices in a coverage of the beam reduces or if the number of wireless communication device is not using the RS.

According to some embodiments herein, the network node schedules RS beam transmission may be performed by muting a RS beam “A” based on the number of

wireless communication devices served by a certain beam “B” in a neighbor cell, where the beams “A” and “B” have a common coverage.

According to some embodiments herein, the set of beams may comprise a pattern-based set of beams, wherein a bit string indicating a number of beams per cell with a bit denotes whether corresponding beam is muted or not.

According to some embodiments herein, the network node may further receive information on which beams RS should be transmitted per cell from a location server and inform neighboring network nodes which beams that should be selected for transmitting RS.

According to some embodiments herein, the network node may further receive information from another network node or a location server, on a number of beams for RS transmission needed for a wireless communication device located in a different cell. The information may be received from another network node based on beam sweeping and beam measurement procedures performed by the wireless communication device. The information may be received from a location server based upon beam ID information obtained from E-CID or in an LTE positioning protocol (LPP) message.

The location server may receive information from a wireless communication device indicating the best Beam ID, about a time of arrival timing per beam, characterized by a Synchronization Signal Block (SSB) index or a Cell-specific RS (CSI-RS) index as a reference, and time difference information for the other indices, using E-CID positioning method or in any other LPP message.

The network node may further configure a beam as a neighbor RS beam transmitted with a relatively high power.

According to some embodiments herein, the network node schedules RS beam transmission based on the distribution information may be performed by starting RS transmission with a minimum number of beams and increasing the number of beams transmitting RS in case of change in the number of wireless communication devices located in its service area or based on receiving request from neighbor network node, a location server or any other network node.

According to some embodiments herein, the network node may further send a request for RS information to a location server or another network node and send network node related RS information to a neighbor network node or Self organizing networks (SON), an operation and maintenance (O&M) node. The network node may schedule and transmit RS beams until receiving a new update request procedure from another network node.

The network node may further send scheduling information to wireless communication devices.

The network node may further maintain a mapping between different beam IDs, such as the beam ID used in communications between network nodes, the beam IDs the wireless communication devices retrieves, and the beam ID the location server uses.

The reference signal may be any one of a NR RS, such as Positioning Reference signal (PRS), Channel State Information Reference Signal (CSI-RS), Phase Tracking Reference Signal (PTRS), Demodulation Reference Signal (DM-RS).

According to one aspect of embodiments herein, the object is achieved by a method performed in a wireless communication device for receiving, identifying and measuring beam RS in a wireless communication network. The wireless communication device obtains an RS configuration and receives one or more RS through one or more beams from one or more network nodes. The wireless communication device further performs measurements based on the beamed RS received from one or more network nodes and reports measurements based on the beamed RS received from one or more network nodes.

According to one aspect of embodiments herein, the object is achieved by a wireless communication device for receiving, identifying and measuring beam RS in a wireless communication network. The wireless communication device is configured to obtain an RS configuration and receive one or more RS through one or more beams. The wireless communication device is further configured to perform measurements based on the beamed RS received from one or more network nodes and report measurements based on the beamed RS received from one or more network nodes.

The wireless communication device may further perform beam switching accordingly if any change in beam transmitting the RS.

According to some embodiments herein, the wireless communication device obtains an RS configuration may be performed by sweeping over beams close to a known beam direction of the wireless communication device and identify beams transmitting RS.

According to some embodiments herein, the wireless communication device obtains an RS configuration may be performed by receiving the RS configuration from a network node.

According to some embodiments herein, the wireless communication device obtains an RS configuration may be performed by receiving a signal from a network node comprising a bit string pattern specifying beams transmitting RS.

According to some embodiments herein, the wireless communication device obtains an RS configuration may be performed by receiving RS configuration via LPP message or in Radio Resource Control (RRC) System via Info Broadcast or unicast.

According to some embodiments herein, the wireless communication device obtains an RS configuration may be performed by identifying RS beams based on beam ID.

The wireless communication device may further include the best beam ID determined after beam sweeping in a LTE positioning protocol (LPP) message or as a part of Enhanced Cell ID, E-CID, report.

The best beam may be determined based on time of arrival, compensated for a difference in time of transmission during the beam sweeping.

The best beam may be determined based on received signal strength per beam.

The best beam may be determined based on a combination of received signal strength and time of arrival after difference in transmission time compensation.

According to one aspect of embodiments herein, the object is achieved by a method performed in a location server for assisting a network node and a wireless communication device handling beams for RS transmission and receiving. The location server evaluates distribution information of wireless communication devices located within a cell and sends the distribution information to a network node for assisting the network node in configuring, selecting and scheduling a set of beams for RS transmission. The location server further receives information on the best beam ID from the wireless communication device and maintains a beam relation information.

According to one aspect of embodiments herein, the object is achieved a location server for assisting a network node and a wireless communication device handling beams for RS transmission and receiving. The location server is configured to evaluate distribution information of wireless communication devices located within a cell and send the distribution information to a network node for assisting the network node in configuring, selecting and scheduling a set of beams for RS transmission. The location server is further configured to receive information on the best beam ID from the wireless communication device and maintains a beam relation information.

The beam relation information may comprise Round Trip Time (RTT) or Timing Advance (TA), indicating a distance to a serving cell.

The location server may further configure neighbor cell beams in assistance data to the wireless communication device depending on its serving beam.

The location server may further identify overlapping beams with finer granularity based on the beam relation information.

The location server may further collect beam utilization information, such as beam identity verses number of wireless communication devices configured to measure it, via assistance data and feedback it to a network node for adapting its beam configuration.

Embodiments herein provide a mechanism on how beams may be selected and scheduled for a reference signal, e.g. PRS, transmission. The selection and schedule may be done in such a way that it meets a quality needed for Reference Signal Time Difference (RSTD) measurements while conserving transmission power in base station, i.e. becoming green or energy efficient.

When PRS is transmitted through beams a more dynamic approach is needed. Further the PRS beam selected by a location server to be used by UE for neighbor PRS and RSTD measurement may be easily heard with good Signal to Noise/Interference Ratio (SNR/SINR).

The PRS beams are selected and scheduled in such a way that the UE can hear the neighbor beam without any interference such that the PRS measurement is not error prone.

Embodiments herein provide a mechanism to enhance LTE PRS muting which may be used for NR. Further mechanisms on how neighbor beam selection and projection may be done are also provided.

By selecting an optimum number of beams for PRS transmission and by switching off the PRS transmission in a more opportunistic way, it is possible to be energy efficient.

BRIEF DESCRIPTION OF THE DRAWINGS

Examples of embodiments herein are described in more detail with reference to attached drawings in which:

Figure 1 is a schematic block diagram depicting an example of beam sweeping;

Figure 2 illustrating a wireless communication network in which embodiments herein may be implemented;

Figure 3 is a flow chart illustrating a method performed in a network node according embodiment herein;

Figure 4 is a flow chart illustrating a method performed in a wireless communication according embodiment herein;

Figure 5 is a flow chart illustrating a method performed in a location server according embodiment herein; and

Figure 6 is a schematic block diagram illustrating one embodiment of a network node or a wireless communication device or a location server.

DETAILED DESCRIPTION

In NR, it is expected that a cell would be segmented into different beams. In such case, an energy conserving mechanism is needed whereby PRS is only transmitted when needed. A location server is expected to prepare a neighbor beam list. The neighbor beam list should be selected in such a way that the UE can hear the neighbor beam without any interference such that the PRS measurement is not error prone.

Figure 2 is a schematic overview depicting **a communication network 200** in which embodiments herein may be implemented. The communication network 200 may be any wireless system or cellular network, such as a Long Term Evolution (LTE) network, any 3rd Generation Partnership Project (3GPP) cellular network, Worldwide interoperability for Microwave Access (Wimax) network, Wireless Local Area Network (WLAN/Wi-Fi), a Fourth Generation (4G) network, a Fifth Generation (5G) cellular network etc.

In the wireless communication network 200, wireless communication devices e.g. **a user equipment 230** such as a mobile station or terminal, or a wireless terminal, communicate via one or more Access Networks (AN), e.g. RAN, to one or more core networks (CN). It should be understood by the skilled in the art that "wireless communication device" is a non-limiting term which means any terminal, wireless communication terminal, user equipment, Machine Type Communication (MTC) device, Device to Device (D2D) terminal, or node e.g. smart phone, laptop, mobile phone, sensor, relay, mobile tablets or even a small base station communicating within a cell. The terms "user equipment", "UE" and "wireless communication device" are used interchangeable herein.

Network nodes operate in the wireless communication network 200 such as **a first network node 210** and a **second network node 220**. The first network node 210 provides radio coverage over a geographical area, a cell area or **a service area 211**, which may also be referred to as a beam or a beam group where the group of beams is covering the service area of a radio access technology (RAT), such as 5G, LTE, Wi-Fi or similar. The second network node 220 provides radio coverage over a geographical area, **a service area 221**, which may also be referred to as a beam or a beam group where the group of beams is covering the service area of a radio access technology (RAT), such as 5G, LTE, Wi-Fi or similar.

The first and second network nodes 210 and 220 may be a transmission and reception point e.g. a radio access network node such as a Wireless Local Area Network (WLAN) access point or an Access Point Station (AP STA), an access controller, a base station, e.g. a radio base station such as a NodeB, a gNB, an evolved Node B (eNB, eNode B), a base transceiver station, a radio remote unit, an Access Point Base Station, a base station router, a transmission arrangement of a radio base station, a stand-alone access point or any other network unit capable of communicating with a wireless communication device within the service area served by the respective first and second network nodes 210, 220. The first and second network nodes 210, 220 may be referred to as a serving radio network node and communicates with the wireless communication device 230 with Downlink (DL) and Uplink (UL) transmissions. The terms “base station”, “BS”, “network node”, “NW node”, “transmission point/TP” are used interchangeable herein.

The wireless communication network 200 may further comprise other network nodes capable to serve a wireless communication device in a wireless communication network, whereof an internet server node, e.g. a positioning node **240**, e.g. Evolved Serving Mobile Location Center (E-SMLC), a Location Based Service server **LBS 242** are depicted in Figure 2. The positioning node 240 may determine and possibly maintain position information for the wireless communication devices. The wireless communication devices 230 may communicate with the positioning node 240 and the LBS 242 via network nodes.

The wireless communication network 200 may further comprise a **Network Controller NC 250** which communicates with the first and second network nodes 210, 220, and acts as a handling unit or a controller for different RATs. The Network Controller 250 may be a separate node as depicted in the figure, or its corresponding functionalities

may be incorporated within another network node such as e.g. the network nodes 210, 220.

Number of Beams transmitting PRS

Base station or any other network node needs to decide how many beams will be needed for PRS transmission. If there are few UEs in a cell which are concentrated in one area, there may be need for only one beam in that direction where PRS may be transmitted. However, if UEs are distributed in a cell, more narrow beams or wider beams may be required.

A method performed in a network node 210, 220 for scheduling Reference Signal (RS), e.g. PRS, transmission will be described with reference to Figure 3. Although the method is described for PRS, it is applicable to other NR RSs as well, such as Channel State Information Reference Signal (CSI-RS), Phase Tracking Reference Signal (PTRS), Demodulation Reference Signal (DM-RS). The method comprises the following actions which may be performed in any suitable order.

Action 310

The NW node 210, 220 obtains and evaluates UEs distribution information located within a cell, continuously on a periodic basis. It is important that, not only a number of UEs but also explicit or implicit UE distribution information within the cell, e.g., number of UEs served by beam #1, #2, etc., or number of UEs in cell portion A, B, C, etc.. is evaluated in continuous periodic basis. This is a very helpful information since a cell may be large but beam coverage is actually quite small.

So according to some embodiments herein, the distribution information of wireless communication devices located within a cell may comprise information about a number of wireless communication devices, i.e. how many wireless communication devices, that are served by a particular beam or information about a number of wireless communication devices, i.e. how many wireless communication devices, that are located in a certain portion of the cell.

The distribution information may be received from a location server, e.g. LBS 242.

Action 320

The network node determines a set of beams needed for RS transmission based on co-ordinating beam information among network nodes.

The NW node 210, 220 coordinates among network nodes a set of beams that will be needed for PRS transmission. The coordination may include not only the number of beams but the set of beams e.g., beam #1 and #3 but not #2, and may also include some

availability indication of the beam e.g., a pattern for beam or probability or portion of time when the beam is actually not muted.

So according to some embodiments herein, the set of beams may comprise any one or a combination of a number of beams, availability indication of beams, a pattern of beams, a probability or portion of time when a beam is not muted etc..

Action 330

The NW node 210, 220 schedules the set of beams for RS beam transmission based on the distribution information and on the co-ordinating result.

According to some embodiments herein, the UE may include the best beam ID, e.g. determined after beam sweeping, in a LTE positioning protocol (LPP) message while requesting Assistance Data. In one embodiment, the best beam may be determined based on the received signal strength per beam. In another embodiment, the best beam may be based on time of arrival, compensated for the difference in time of transmission during the beam sweeping. In the latter case, the beam corresponding to the first time of arrival after compensating for the difference in transmission time, is most likely to be line of sight. In yet another embodiment, the best beam may be determined based on a combination of received signal strength and time of arrival after difference in transmission time compensation.

According to some embodiments herein, the UE may include the best beam ID as part of an Enhanced Cell ID (E-CID) report. The best beam ID may be determined as discussed above. A location server may use analytics to determine if UEs are concentrated in one area or distributed. Based upon that, the location server may guide the base station in selecting the number and type or configuration of beams. The location server may include in the assistance data for UE measurements e.g. a set #Y1 of beams in cell Y and a set #Z1 of beams in cell Z for UE served in cell X by beam #1 and a set #Y2 of beams in cell Y and a set #Z2 of beams in cell Z for UE served in cell X by beam #2. The location server may also maintain a beam relation information, based on which it may configure neighbor cell beams in the assistance data to the UE depending on its serving beam. The beam relation information may also include Round Trip Time (RTT) or Timing Advance (TA), indicating a distance to the serving cell, which also may be a means to identify overlapping beams with finer granularity.

If some beams are muted, the location server may receive this information from corresponding BS and account for this information when configuring assistance data, to

avoid UE measuring beams when they are muted. The location server may also collect the beam utilization information e.g., beam identity vs number of UEs configured to measure it via assistance data and feedback it to appropriate BSs to allow the BSs to adapt its beam configuration e.g., beam muting, beam width, depending on whether and how much its beams are used for positioning, to avoid transmitting PRS on beams which are not used by any UE.

In yet another embodiment, the location server may inform a serving cell which beams per cell that may be activated, and then the serving base station will inform neighboring base stations which beams that should be transmitted. The beam ID used in the communication between base stations may be different from the beam IDs that the UE can retrieve and also what beam ID the location server uses. In those cases, the base station will maintain a mapping between different beam IDs.

The UE performs a measurement on an RS with a certain identifier such as a Channel State Information Reference Signal (CSI-RS) resource index or Synchronization Signal or Physical Broadcast Channel (SS/PBCH) block index and determines which beam is suitable for receiving that RS. The beam ID may be thus based upon, CSI-RS resource index or SS/PBCH block index or PRS-ID.

The Information Element (IE) ECID-SignalMeasurementInformation is used by a target device to provide various UE measurements to the location server.

An example of such configuration is shown with bold text in the following with an ASN.1 structure:

```
-- ASN1START
ECID-SignalMeasurementInformation ::= SEQUENCE {
  primaryCellMeasuredResults  MeasuredResultsElement OPTIONAL,
  measuredResultsList         MeasuredResultsList,
          ...
}
MeasuredResultsList ::= SEQUENCE (SIZE(1..32)) OF
MeasuredResultsElement
MeasuredResultsElement ::= SEQUENCE {
  physCellId          INTEGER (0..503),
  cellGlobalId        CellGlobalIdEUTRA-AndUTRA OPTIONAL,
  arfcnEUTRA          ARFCN-ValueEUTRA,
  systemFrameNumber   BIT STRING (SIZE (10))  OPTIONAL,
  rsrp-Result         INTEGER (0..97)  OPTIONAL,
  rsrq-Result         INTEGER (0..34)  OPTIONAL,
  ue-RxTxTimeDiff       INTEGER (0..4095)  OPTIONAL,
          ...,
  [[arfcnEUTRA-v9a0  ARFCN-ValueEUTRA-v9a0  OPTIONAL -- Cond
EARFCN-max
```

```
            ]],
    [[nrsrp-Result-r14       INTEGER (0..113)            OPTIONAL,
    nrsrq-Result-r14         INTEGER (0..74)             OPTIONAL,
    carrierFreqOffsetNB-r14 CarrierFreqOffsetNB-r14 OPTIONAL, --
Cond NB-IoT
    hyperSFN-r14             BIT STRING (SIZE (10)) OPTIONAL
    ]],
    [[
      rsrp-Result-v1470    NTEGER (-17..-1)            OPTIONAL,
      rsrq-Result-v1470    INTEGER (-30..46)           OPTIONAL
    ]],
    [[
      beamIdentity    INTEGER (0..maxBeamID) OPTIONAL  -- Cond NR
    ]]
}
-- ASN1STOP
```

The reporting from UE to the location server concerning NR quantities may also change in line with what already has been added in NR RRC as shown below. This may further be enriched by including information about the time of arrival timing per beam, typically characterized by a SSB index or a CSI-RS index as a reference, and then time difference information for the other indices. Below, is the reference separate for SSB and CSI-RS but they could also have a common time reference.

***MeasResults* information element**

```
MeasResults ::=                SEQUENCE {
  measId                         MeasId,
  measResultServingMOList      MeasResultServMOList,
  measResultNeighCells           CHOICE {
  measResultListNR                   MeasResultListNR,
                      ...
          }

          OPTIONAL,
          ...
}

MeasResultServMOList ::= SEQUENCE SIZE(1..maxNrofServingCells)) OF
MeasResultServMO

MeasResultServMO ::= SEQUENCE {
  servCellId                  ServCellIndex,
  measResultServingCell       MeasResultNR,
  measResultBestNeighCell     MeasResultNR        OPTIONAL,
          ...
}

MeasResultListNR ::= SEQUENCE(SIZE (1..maxCellReport)) OF
MeasResultNR
MeasResultNR ::=    SEQUENCE {
```

```
    physCellId                  PhysCellId
                                                        OPTIONAL,
    --FFS: Details of cgi info
    measResult          SEQUENCE {
    cellResults         SEQUENCE{
      resultsSSB-Cell   MeasQuantityResults          OPTIONAL,
      resultsCSI-RS-Cell MeasQuantityResults        OPTIONAL
                        },
      rsIndexResults    SEQUENCE{
        resultsSSB-Indexes ResultsPerSSB-IndexList  OPTIONAL,
        resultsCSI-RS-Indexes   ResultsPerCSI-RS-IndexList OPTIONAL,
        refSSB-Index            SSB-Index           Cond SSB-TD,
        refCSI-RS-Index       CSI-RS-Index          Cond CSI-RS-TD
                        }
                        OPTIONAL
            },
            ...
}
MeasQuantityResults ::=                 SEQUENCE {
    rsrp    RSRP-Range                              OPTIONAL,
    rsrq    RSRQ-Range                              OPTIONAL,
    sinr    SINR-Range                              OPTIONAL
}

ResultsPerSSB-IndexList::= SEQUENCE (SIZE (1..maxNrofSSBs)) OF
ResultsPerSSB-Index

ResultsPerSSB-Index ::=                 SEQUENCE {
    ssb-Index                           SSB-Index,
    ssb-Results             MeasQuantityResults     OPTIONAL
    ssb-TD                  TimeDifference          Cond SSB-TD
}

ResultsPerCSI-RS-IndexList::= SEQUENCE (SIZE (1..maxNrofCSI-RS))
OF ResultsPerCSI-RS-Index

ResultsPerCSI-RS-Index ::=    SEQUENCE {
    csi-RS-Index     CSI-RS-Index,
    csi-RS-Results   MeasQuantityResults            OPTIONAL
    csi-RS-TD        TimeDifference                 Cond CSI_RS-TD
}
```

PRS Beam scheduling/muting concept

In one of the embodiments each beam for transmitting a RS comprises a start time and a duration for how long the RS is transmitted. The start time may be an absolute time. The start time may a relative time in any one of a radio frame number, subframe number or a slot number. The duration for how long the RS is transmitted may be any one of a number of seconds, frames, subframes or slots. The start time and the duration are configurable. The beams in a region may be scheduled in a non-overlapping time period.

For example, each beam transmitting PRS will have a start time, periodicity and duration for how long the PRS will be transmitted. Base stations in conjunction with a location server will co-ordinate among themselves such that PRS muting takes place in a coordinated fashion such that only one or few Beams transmit the PRS at a time.

When there are many UEs that are distributed in many different beams, the beams can be muted in a coordinated fashion. Base stations cyclically, i.e. in a round robin fashion may switch off the transmission of beams to minimize interference, if any. Further, if the number of UEs in a beam reduces or is not using positioning services then the PRS transmission can be switched off.

Therefore, according to some embodiments herein, scheduling RS beam transmission may comprise scheduling the RS beam transmission in a round robin fashion such that the network nodes cyclically switch off transmission of RS beams to minimize interference.

In one of the embodiments, the location server will use the service level required by the UE in terms of accuracy, latency and reliability to prioritize the UEs in the beam transmission or muting pattern constructions.

Therefore, according to some embodiments herein, co-ordinating among network nodes may comprise co-ordinating in conjunction with a location server the set of beams needed for RS transmission based on a service level required by the wireless communication device in terms of accuracy, latency and reliability. A beam transmission or muting pattern in time may be configured to cover UEs with shortest latency service requirement earlier in a beam transmission or muting cycle.

As an exemplary, considering there are 3 beams transmitting PRS. Beam1, Beam2, Beam3.

Beam1 start time = t1

Beam2 start time = t2

Beam3 start time = t3

Considering the durations of Beam1, Beam2 and Beam3 are $\Delta t1$, $\Delta t2$, $\Delta t3$

Base stations co-ordinate the Beam PRS muting or scheduling such that at a time only one Beam is transmitted. Thus $t2 > t1 + \Delta t1$, $t3 > t2 + \Delta t2$

Further each beam may have its own periodicity. The periodicity of different beams in a region can also be coordinated in a non-overlapping fashion.

The main objective of beam scheduling is to mitigate intra/inter Beam interference.

The values of t1, t2 and t3 is reset or shifted after every cycle, i.e. after transmission of 3 beams. For example, t1 = t2 + Δt2 + t3 + Δt3. However, Base station in co-ordination with location server or input from location server may vary the start time or stop PRS transmission or even introduce a new beam for PRS transmission. The factors impacting are number of UEs, whether UE are concentrated or distributed and further upon service level required by the UE in terms of accuracy, latency and reliability.

Therefore, according to embodiments herein, co-ordinating among network nodes may comprise co-ordinating in conjunction with a location server such that only one or few beams transmit RS at a time, a new beam is introduced for RS transmission, or a beam for RS transmission is stopped.

The beam where the PRS is transmitted may change over time: the UE cannot assume that the PRS with a certain identifier is always transmitted in the same beam.

An example PRS Beam muting or scheduling structure is provided below with ASN.1 structure:

```
-- ASN1START
PRS-Beam-Scheduling-Info ::= SEQUENCE {
      prsBeamID                    INTEGER (0..maxBeamID)
      prsBeamStartTime             UTCTime
      prsBeamDuration              INTEGER (0..100)
      prsBeamPeriodicty            ENUMERATED{ms20, ms40,
ms60, ms80}
}
-- ASN1STOP
```

In another example, the BS will mute a PRS beam based on the utilization information for its beams e.g., received from Location server. For example, it may be muted, if not used or used by too few UEs.

Therefore, according to some embodiments herein, the network node may receive beam utilization information from a location server and adapt beam scheduling and configuration based on the received beam utilization information. And scheduling RS beam transmission may comprise switching off a RS beam transmission if the number of wireless communication devices in a coverage of the beam reduces or UEs are not using the RS, e.g. not using positioning services.

In another example, the BS will mute a PRS beam "A" based on whether there are sufficiently many UEs e.g., at least 1 in a special case, served by a certain beam "B" in a neighbor cell where the beams "A" and "B" have a common coverage. It may also be required that sufficiently many UEs need to perform positioning measurements. Note that beams "A" and "B" do not need to be transmitted at the same time, especially if they are likely to be interfering e.g., carrying PRS with the same frequency shift or in the overlapping Resource Elements (REs). It is sufficient if they are made available for UE during a measurement period which may comprise several positioning occasions. If beams "A" and "B" are not strongly interfering, then they may be transmitted even in overlapping time resources.

So scheduling RS beam transmission may comprise muting a RS beam "A" based on a number of wireless communication devices served by a certain beam "B" in a neighbor cell, where the beams "A" and "B" have a common coverage.

Another muting example is pattern based, such as a bit string of length 8 for 8 beams per cell, where 0/1 is used to denote whether the corresponding beam is muted or not. The bit string may be up to 64 beams for frequency range FR2 and up to 8 for FR1, i.e., it may be frequency range dependent.

So according to some embodiments herein the set of beams may comprise a pattern-based set of beams. A bit string may be used for indicating a number of beams per cell with a bit denoting whether the corresponding beam is muted or not.

In one of the embodiments, the Beam transmission separation may be done in frequency domain such that the beams transmitting RS for positioning in a cluster or region are allocated in non-overlapping bandwidth.

Neighbor Beam Selection and Projection

The base station needs to decide how many beams for PRS transmission may be required such that it can transmit the PRS for a UE located in a different cell. In one of the embodiments, a location server provides this information to base stations based upon beam ID information obtained from E-CID or in LPP message. Further, in some cases the base station may obtain that information from another base station as a result of beam sweeping and beam measurement procedures performed by the UE. This information may be used by the base station while selecting the beams that will be used as a neighbor PRS beam. The neighbor PRS beam may be transmitted with a relatively high power so that a distant UE can hear it with an acceptable quality level.

So according to embodiments herein, the network node may receive information from another network node or a location server, on a number of beams for RS transmission needed for a wireless communication device located in a different cell. The network node may configure a beam as a neighbor RS beam transmitted with a relatively high power.

The location server may receive information from a wireless communication device indicating the best Beam ID, SSB Index, CSI-RS Index, PRS index, using E-CID positioning method or in any other LPP message.

In one embodiment, the base station may start with a minimum number of beams for PRS transmission for energy serving purposes, while it may increase the number of beams transmitting PRS in case of change in number of UEs in its service area or upon receiving a request from neighbor base stations or the location server or any other network node.

Therefore according to some embodiments herein scheduling RS beam transmission based on the distribution information and co-ordinating result may comprise starting RS transmission with a minimum number of beams and increasing the number of beams transmitting RS in case of change in number of wireless communication devices in its service area or upon receiving a request from a neighbor network node, a location server or any other network node.

According to some embodiments herein, the network node may receive information on which beams RS should be transmitted per cell from a location server and inform neighboring network nodes which beams that should be selected for transmitting RS.

According to some embodiments herein, the network node may send a request for RS information to a location server or another network node. The network node may send network node related RS information to neighbor network nodes or other nodes e.g. Self organizing networks (SON), operation and maintenance (O&M) node. The network node schedules and transmits RS through beam until receiving a new update request procedure from another network node. The network node may send scheduling information to the wireless communication devices.

UE identifying the beams transmitting PRS

In one of the embodiments, the LPP OTDOA reference cell and neighbor cell configuration may be augmented with Beam Identifier. An example of such configuration is shown below with an ASN.1 structure.

```
-- ASN1START

OTDOA-ReferenceCellInfo ::= SEQUENCE {
  beamIdentifierList SEQUNENCE (SIZE(1..maxNumberOfBeam)) OF
BeamIdentifier
  physCellId                              INTEGER (0..1007),
  cellGlobalId                ECGI OPTIONAL,      -- Need ON
  earfcnRef                   ARFCN-ValueEUTRA    OPTIONAL,
        -- Cond NotSameAsServ0
  antennaPortConfig     ENUMERATED {ports1-or-2, ports4, ... }
                              OPTIONAL,           -- Cond
NotSameAsServ1
  cpLength          ENUMERATED { normal, extended, ... },
  prsInfo           PRS-Info  OPTIONAL,           -- Cond PRS
        ...,
  [[ earfcnRef-v9a0 ARFCN-ValueEUTRA-v9a0 OPTIONAL -- Cond
NotSameAsServ2
        ]],
  [[ tpId-r14       INTEGER (0..4095)   OPTIONAL, -- Need ON
  cpLengthCRS-r14   ENUMERATED { normal, extended, ... }
                              OPTIONAL,           -- Cond CRS
  sameMBSFNconfigRef-r14      BOOLEAN   OPTIONAL, -- Need ON
  dlBandwidth-r14   ENUMERATED {n6, n15, n25, n50, n75, n100}

                              OPTIONAL,           -- Cond
NotSameAsServ3
  addPRSconfigRef-r14 SEQUENCE (SIZE (1..maxAddPRSconfig-r14)) OF
PRS-Info                                  OPTIONAL  -- Need ON
        ]]
}

maxAddPRSconfig-r14  INTEGER ::= 2
BeamIdentifier ::= INTEGER(1..maxNumberOfBeam)

-- ASN1STOP
```

The UE performs a measurement on an RS with a certain identifier such as PRS-ID, CSI-RS resource index or SS/PBCH block index and determines which beam is suitable for receiving that RS. The beam ID may be thus based upon, PRS-ID, CSI-RS resource index or SS/PBCH block index.

In yet another embodiment, it is provided how PRS beam handling or management may be performed.

Alternative 1: The UE is required to perform beam sweep over all beams within a cell.

Alternative 2: For PRS dedicated to one UE, PRS is transmitted only in the beam in the known beam direction for the UE or UE may sweep only over beams close to the known beam direction of the UE.

The alternative that the UE may apply for beam handling would be signaled in the LPP message or in the RRC System Info Broadcast or unicast mechanism.

One more criterion for beam selection would be that it should be easier for UE to identify which beam is basically transmitting the PRS. In one of the embodiments, it is claimed that a signaling mechanism may specify which beam is transmitting PRS. An exemplary signaling is provided below.

prsBeam *BIT STRING (SIZE (maxNumberOfBeam))*

The BIT STRING pattern may basically specify if a certain beam is transmitting a PRS or not. Considering in a list if a Transmission Point (TP) uses 10 beams, a bit string pattern of 0101000001 may be signaled to the UE such that, this may imply Beam ID 1, 7 and 9 are transmitting PRS.

In another embodiment, to simplify identifying the PRS beam, there may be a certain fixed beam ID that is always used for the PRS transmission. This may be useful for neighbor beam transmission.

According to embodiments herein, a method performed in a wireless communication device 230 for receiving and measuring beam RS in a wireless communication networks will be described with reference to **Figure 4**. The method comprises the following actions which may be performed in any suitable order.

Action 410

The wireless communication device 230 obtains RS configuration.

The wireless communication device 230 may obtain RS configuration by sweeping over beams close to a known beam direction of the wireless communication device and identifying beams transmitting RS.

The wireless communication device 230 may obtain RS configuration by receiving RS configuration from a network node.

The wireless communication device 230 may obtain RS configuration by receiving a signal from a network node comprising a bit string pattern specifying beams transmitting RS.

The wireless communication device 230 may obtain RS configuration by receiving RS configuration via LPP message or in RRC System via Info Broadcast or unicast.

The wireless communication device 230 may obtain RS configuration by identifying RS beams based on beam ID.

Action 420

The wireless communication device 230 receives RS through one or more beams.

Action 430

The wireless communication device 230 performs measurements based on the beamed RS received from different network nodes.

Action 440

The wireless communication device 230 reports measurements based on the beamed RS received from different network nodes.

Action 450

The wireless communication device 230 performs beam switching accordingly if any change in beam transmitting the RS.

A method performed in a location server 242 for assisting a network node and a wireless communication device handling beams for RS transmission and receiving will be described with reference to **Figure 5**. The method comprises the following actions which may be performed in any suitable order.

Action 510

The location server 242 evaluates distribution information of wireless communication devices within a cell.

Action 520

The location server 242 sends the distribution information to a network node for assisting the network node in configuring, selecting and scheduling a set of beams for RS transmission.

Action 530

The location server 242 receives information on the best beam ID from the wireless communication device.

Action 540

The location server 242 maintains a beam relation information. The beam relation information may comprise Round Trip Time (RTT) or Timing Advance (TA), indicating a distance to a serving cell.

The location server 242 may further configure neighbor cell beams in assistance data to the wireless communication device depending on its serving beam.

The location server 242 may further identify overlapping beams with finer granularity based on the beam relation information.

Action 550

The location server 242 may further collect beam utilization information, such as beam identity versus number of wireless communication devices configured to measure it, via assistance data and feedback it to a network node for adapting its beam configuration.

To perform the method in the UE 230, in the network node 210, 220, in the location server 242, the UE 230, the network node 210, 220, the location server 242 comprises modules as shown in **Figure 6**. The UE/network node/location server comprises a **receiving module 610**, **a transmitting module 620, a determining module 630, a processing module 640, a memory 650** etc.

The network node 210, 220 is configured to obtain distribution information of wireless communication devices located within a cell and co-ordinating among network nodes a set of beams needed for RS transmission.

The network node 210, 220 is further configured to schedule RS beam transmission based on the distribution information and co-ordinating result.

The wireless communication device 230 is configured to obtain RS configuration. This may be performed by sweeping over beams close to a known beam direction of the wireless communication device and identifying beams transmitting RS, or by receiving RS configuration from a network node, or by receiving a signal from a network node comprising a bit string pattern specifying beams transmitting RS, or by receiving RS configuration via LPP message or in RRC System via Info Broadcast or unicast, or by identifying RS beams based on beam ID.

The wireless communication device 230 is further configured to receive RS through one or more beams and performs measurements based on the beamed RS received from different network nodes.

The wireless communication device 230 is further configured to report measurements based on the beamed RS received from different network nodes and perform beam switching accordingly if any change in beam transmitting the RS.

Embodiments herein provide methods, mechanism and configurations to provide energy efficient RS transmission along with how to select and schedule beams and how to detect beams carrying RS.

Embodiments herein allow a more dynamic beam selection and scheduling of RS beams.

Embodiments herein use beam muting to avoid interference when estimating beam TOA. The UE may benefit since it will not need to search for muted RS signals.

Embodiments herein provide mechanism to NW node to select and project reference and neighbor beam such that UEs performing the PRS measurement hear the PRS with good quality.

Embodiments herein provide mechanism to the UE to detect beams transmitting PRS.

CLAIMS

1. A method performed in a network node (210, 220) for scheduling beam transmission of a reference signal, RS, in a wireless communication network (200), the method comprising:

obtaining (310) distribution information of wireless communication devices located within a cell;

determining (320) a set of beams needed for RS transmission based on co-ordinating beam information among network nodes;

scheduling (330) the set of beams for RS beam transmission based on the distribution information.

2. The method according to claim 1, wherein the distribution information of wireless communication devices located within a cell comprises information on how many wireless communication devices that are served by a particular beam or information on how many wireless communication devices that is located in a certain portion of the cell.

3. The method according to any one of claims 1-2, wherein the distribution information is received from a location server.

4. The method according to any one of claims 1-3, wherein *determining* (320) a set of beams needed for RS transmission based on co-ordinating beam information among network nodes comprises co-ordinating in conjunction with a location server such that only one or few beams transmit RS at a time, or a new beam is introduced for RS transmission, or a beam for RS transmission is stopped.

5. The method according to any one of claims 1-4, wherein *determining* (320) a set of beams needed for RS transmission is further based on a service level required by a wireless communication device in terms of accuracy, latency and reliability.

6. The method according to claim 5, wherein scheduling the set of beam comprises sending beams for a wireless communication device with the shortest latency service requirement first.

7. The method according to any one of claims 1-6, wherein scheduling the set of beams for RS beam transmission comprises scheduling the set of beams for RS

beam transmission in a round robin fashion such that the network nodes cyclically switch off transmission of RS beams to minimize interference.

8. The method according to any one of claims 1-7, further comprising receiving beam utilization information from a location server.

9. The method according to claims 8, further comprising adapting beam scheduling and configuration based on the received beam utilization information.

10. The method according to claim 9, wherein scheduling the set of beams for RS beam transmission comprises switching off a RS beam transmission if the number of wireless communication devices in a coverage of the beam reduces or if the wireless communication device is not using the RS.

11. The method according to any one of claims 1-10, wherein scheduling the set of beams for RS beam transmission comprises muting a RS beam “A” based on a number of wireless communication devices served by a certain beam “B” in a neighbor cell, where the beams “A” and “B” have a common coverage.

12. The method according to any one of claims 1-11, wherein a bit string pattern is used to denote the set of beams for RS beam transmission, wherein each bit indicates whether corresponding beam is muted or not.

13. The method according to any one of claims 1-12, further comprising:

receiving information on which beams RS should be transmitted per cell from a location server;

informing neighboring network nodes which beams that should be selected for transmitting RS.

14. The method according to any one of claims 1-12, further comprising:

receiving information from another network node or a location server, on a number of beams for RS transmission needed for a wireless communication device located in a different cell.

15. The method according to claim 14, wherein the information is received from another network node based on beam sweeping and beam measurement procedures performed by the wireless communication device.

16. The method according to claim 14, wherein the information is received from a location server based upon beam Identity, ID, information obtained from Enhanced Cell Identity, E-CID, or in an LTE positioning protocol, LPP, message.

17. The method according to any one of claims 14-16, further comprising configuring a beam as a neighbor RS beam transmitted with a relatively high power.

18. The method according to any one of claims 1-17, wherein scheduling the set of beams for RS beam transmission comprises starting RS transmission with a minimum number of beams and increasing the number of beams transmitting RS in case of change in the number of wireless communication devices in its service area or based on receiving a request from a neighbor network node, a location server or any other network node.

19. The method according to any one of claims 1-18, further comprising:

sending a request for RS information to a location server or another network node;

sending network node related RS information to a neighbor network node or a self organizing networks, SON, node, or an operation and maintenance, O&M, node;

scheduling and transmitting RS beam until receiving a new update request procedure from another network node.

20. The method according to any one of claims 1-19, further comprising:

sending RS scheduling information to wireless communication devices.

21. The method according to any one of claims 1-19, further comprising:

maintaining a mapping between different beam IDs, such as the beam IDs used in communications between network nodes, the beam IDs the wireless communication devices retrieves, and the beam IDs the location server uses.

22. The method according to any proceeding claims, wherein the reference signal is any one of a Positioning Reference signal, PRS, Channel State Information

Reference Signal, CSI-RS, Phase Tracking Reference Signal, PTRS, Demodulation Reference Signal, DM-RS.

23. A method performed in a wireless communication device (230) for receiving and measuring beam RSs in a wireless communication networks, the method comprising:

obtaining (410) an RS configuration;

receiving (420) one or more RS through one or more beams from one or more network nodes;

performing (430) measurements based on the beamed RS received from the one or more network nodes;

reporting (440) measurements based on the beamed RS received from the one or more network nodes.

24. The method according to claim 23 further comprising performing (450) beam switching if any change in beam transmitting the RS.

25. The method according to claim 23, wherein *obtaining* (410) an RS configuration comprises:

sweeping over beams close to a known beam direction of the wireless communication device;

identifying beams transmitting RS.

26. The method according to claim 25 further comprising including the best beam ID determined after beam sweeping in an LPP message or as a part of E-CID, report.

27. The method according to claim 26, wherein the best beam is determined based on any one or a combination of received signal strength and time of arrival compensated for a difference in time of transmission during the beam sweeping.

28. The method according to claim 23, wherein obtaining (410) an RS configuration comprises receiving the RS configuration from a network node.

29. The method according to claim 23, wherein obtaining (410) an RS configuration comprises receiving a signal from a network node comprising a bit string pattern specifying beams transmitting RS.

30. The method according to claim 23, wherein obtaining (410) an RS configuration comprises receiving the RS configuration via LPP message or in Radio Resource Control, RRC, System via Info Broadcast or unicast.

31. The method according to claim 23, wherein obtaining (410) an RS configuration comprises identifying RS beams based on beam ID.

32. A method performed in a location server (242) for assisting a network node (210, 220) and a wireless communication device (230) handling beams for RS transmission and receiving, the method comprising:

evaluating (510) distribution information of wireless communication devices located within a cell;

sending (520) the distribution information to a network node for assisting the network node in configuring, selecting and scheduling a set of beams for RS transmission;

receiving (530) information on the best beam ID from the wireless communication device;

maintaining (540) a beam relation information.

33. The method according to claim 32, wherein the beam relation information comprises Round Trip Time (RTT) or Timing Advance (TA), indicating a distance to a serving cell.

34. The method according to claim 32, further comprising configuring neighbor cell beams in assistance data to the wireless communication device depending on its serving beam.

35. The method according to claim 32, further comprising identifying overlapping beams with finer granularity based on the beam relation information.

36. The method according to claim 32, further comprising collecting (550) beam utilization information.

37. A network node (210, 220) for scheduling beam transmission of a reference signal, RS, in a wireless communication network, the network node is configured to:

obtain distribution information of wireless communication devices located within a cell;

determine a set of beams needed for RS transmission based on co-ordinating beam information among network nodes; and

schedule the set of beams for RS beam transmission based on the distribution information.

38. A wireless communication device (230) for receiving and measuring beam RSs in a wireless communication networks, the wireless communication device (230) is configured to:

obtain an RS configuration;

receive one or more RS through one or more beams;

perform measurements based on the beamed RS received from one or more network nodes;

report measurements based on the beamed RS received from one or more network nodes.

39. A location server (242) for assisting a network node and a wireless communication device handling beams for RS transmission and receiving, the location server (242) is configured to:

evaluate distribution information of wireless communication devices located within a cell;

send the distribution information to a network node for assisting the network node in configuring, selecting and scheduling a set of beams for RS transmission;

receive information on the best beam ID from the wireless communication device; and

maintain a beam relation information.

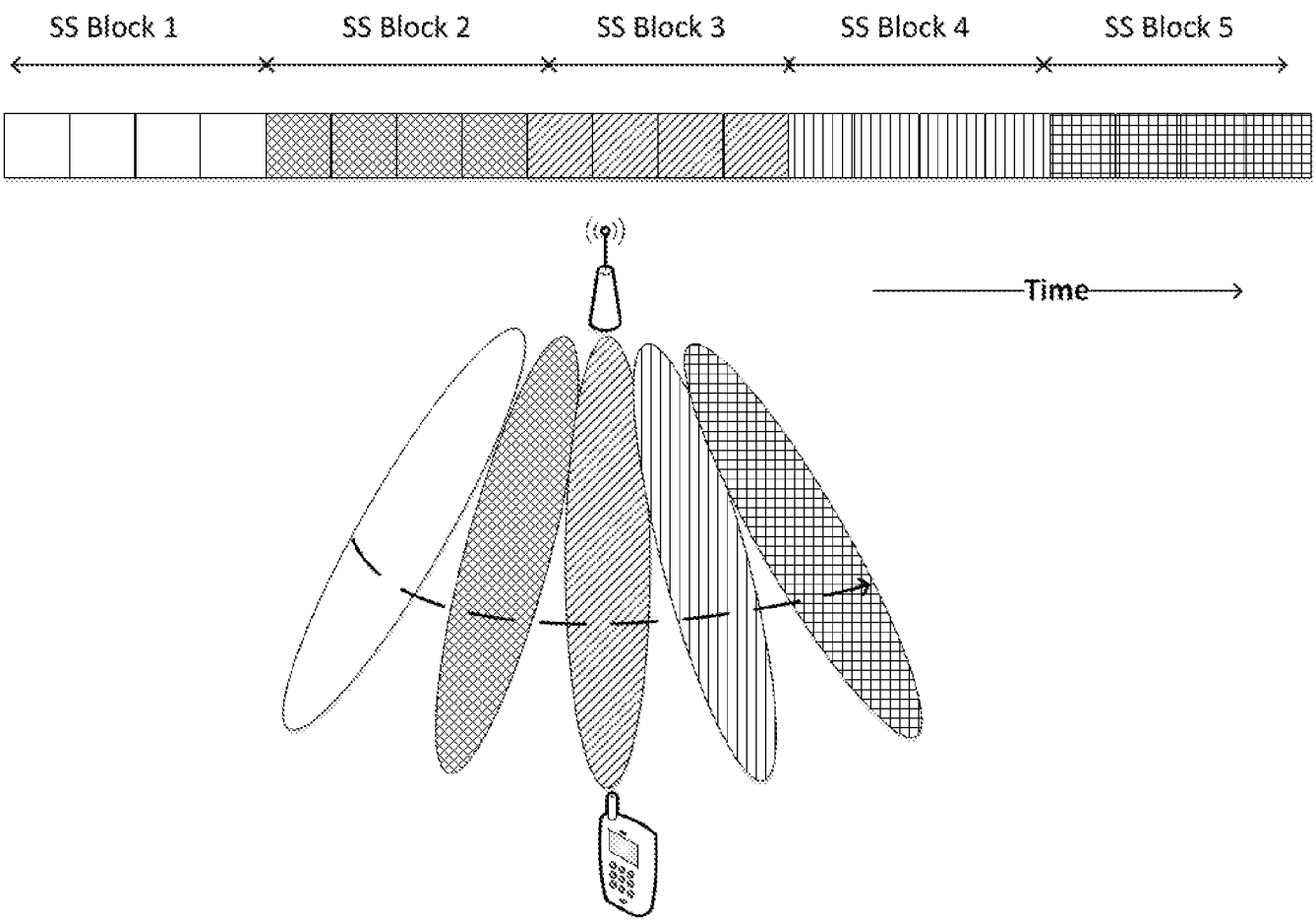


Fig. 1

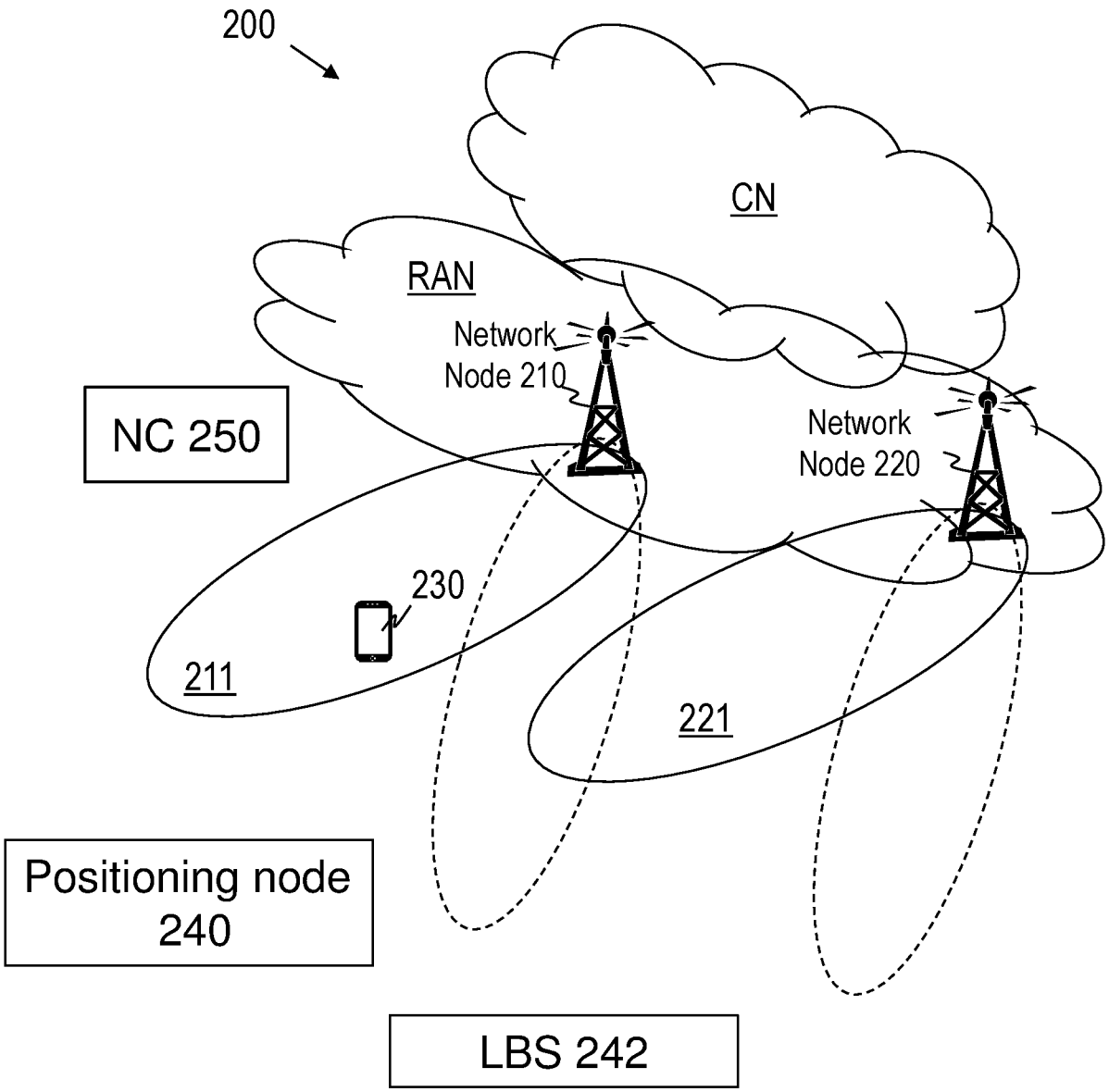

200
CN
RAN
Network
Node 210
Network
Node 220
NC 250
230
211
221
Positioning node
240
LBS 242

Fig. 2

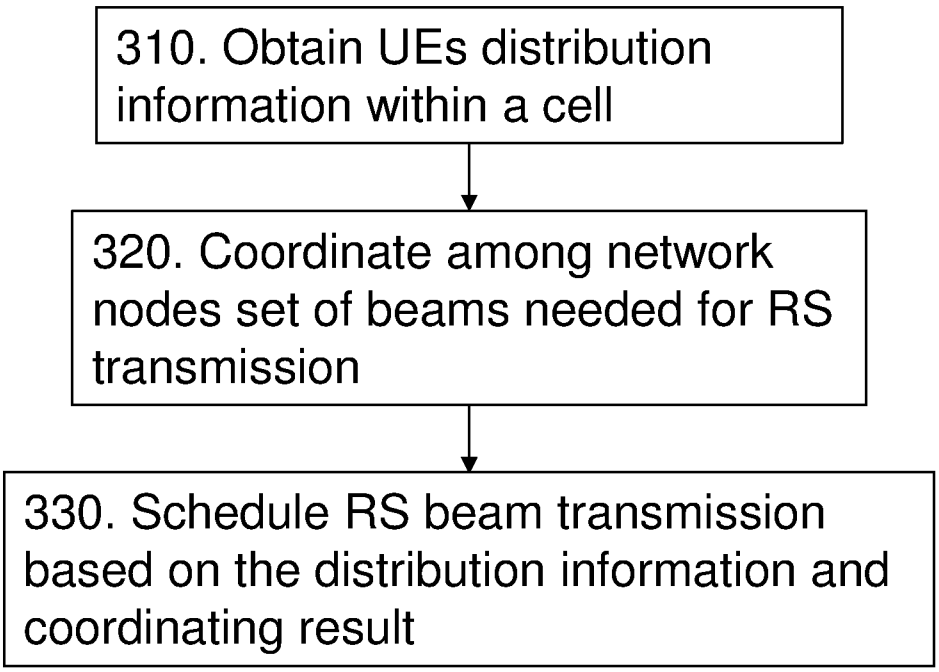

310. Obtain UEs distribution information within a cell
320. Coordinate among network nodes set of beams needed for RS transmission
330. Schedule RS beam transmission based on the distribution information and coordinating result

Fig. 3

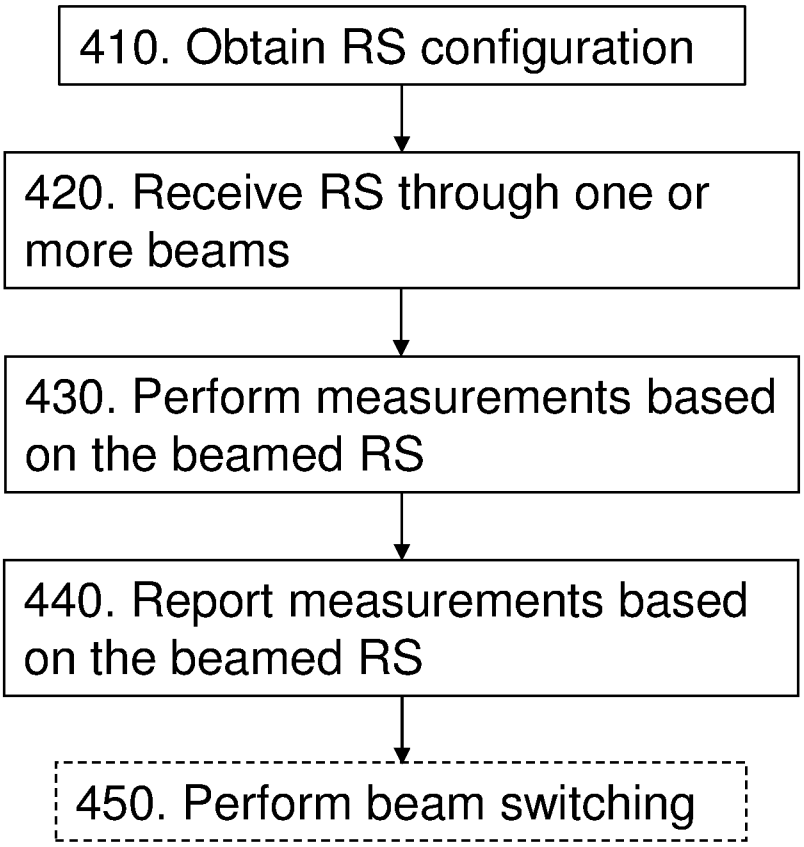

410. Obtain RS configuration
420. Receive RS through one or more beams
430. Perform measurements based on the beamed RS
440. Report measurements based on the beamed RS
450. Perform beam switching

Fig. 4

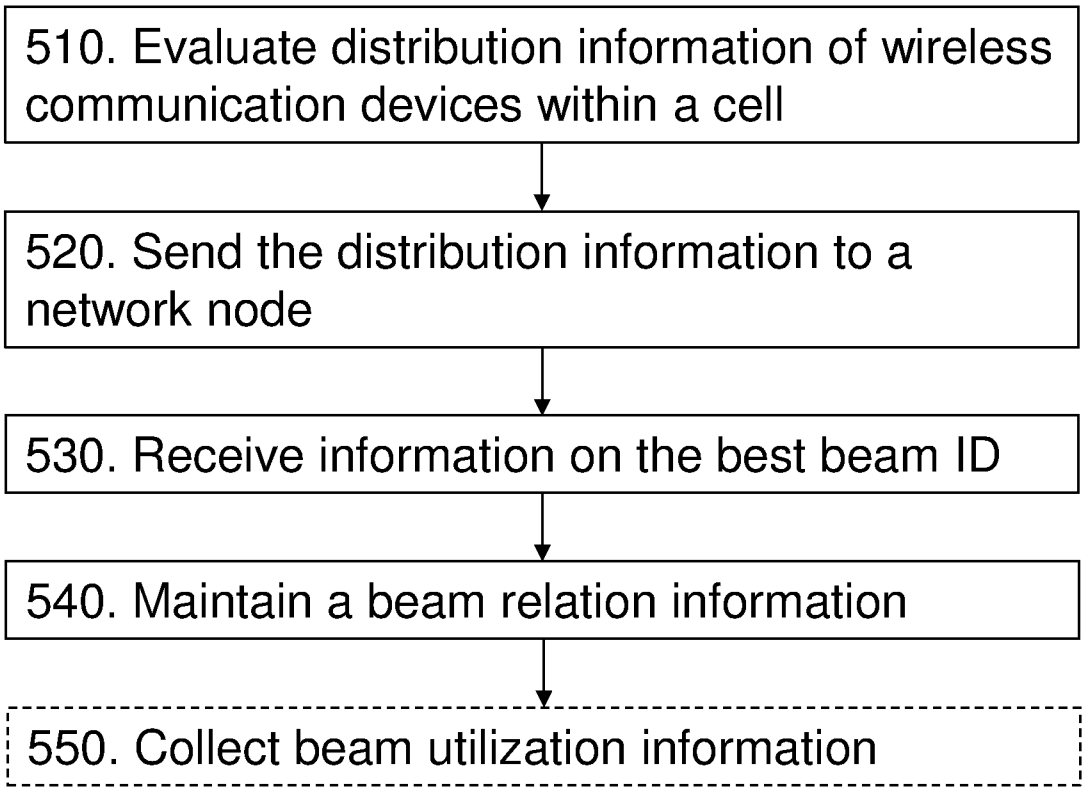

510. Evaluate distribution information of wireless communication devices within a cell
520. Send the distribution information to a network node
530. Receive information on the best beam ID
540. Maintain a beam relation information
550. Collect beam utilization information

Fig. 5

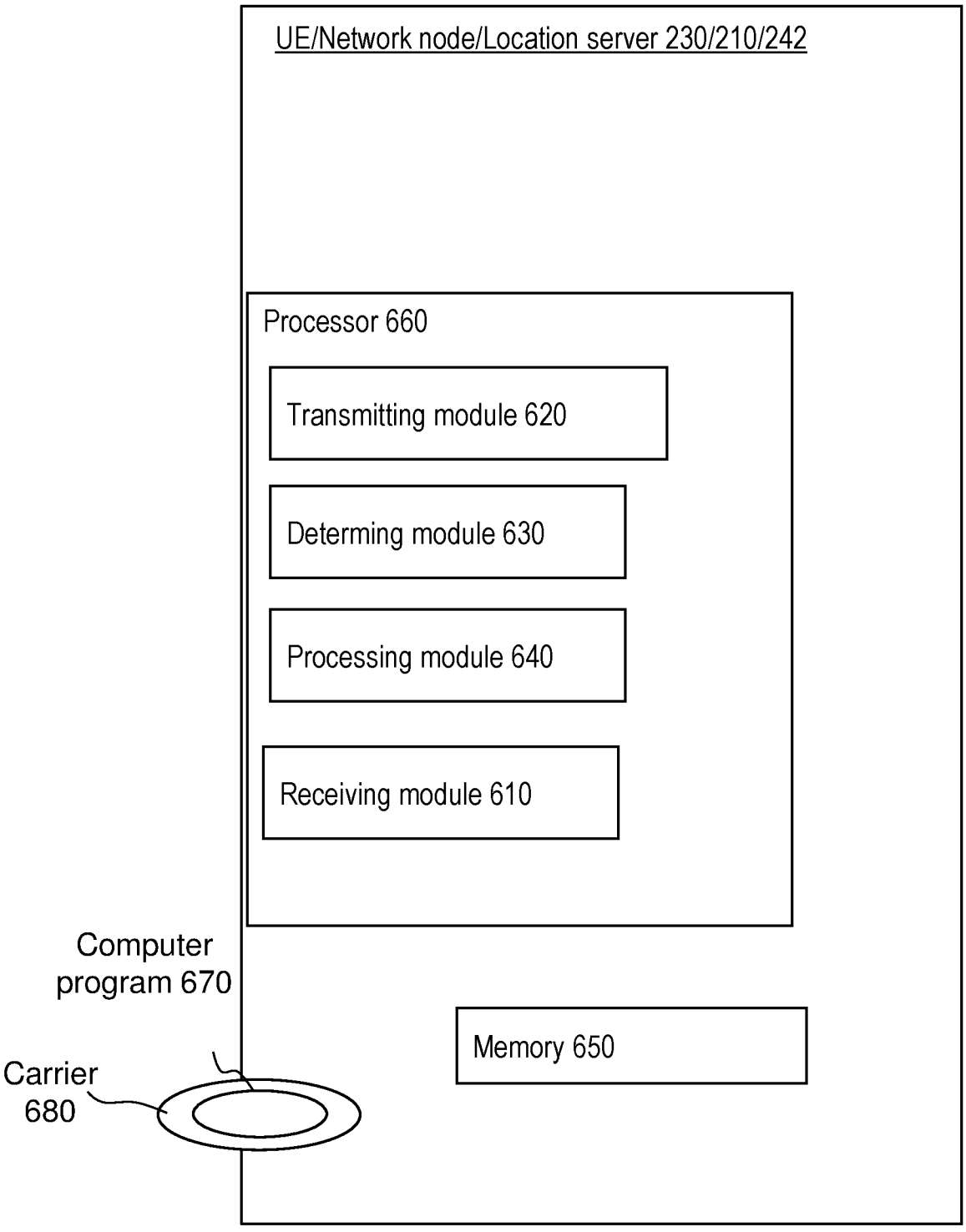

UE/Network node/Location server 230/210/242
Processor 660
Transmitting module 620
Determing module 630
Processing module 640
Receiving module 610
Computer program 670
Memory 650
Carrier 680

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2019/051001

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/12
ADD. H04W72/04 H04W72/08 H04L5/00 H04W52/02

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/207841 A1 (KIM TAE-YOUNG [KR] ET AL) 20 July 2017 (2017-07-20) paragraph [0015] - paragraph [0018] paragraph [0041] - paragraph [0048]; figures 2, 3A, 3B paragraph [0051] - paragraph [0059]; figure 4 paragraph [0060] - paragraph [0070]; figure 5 paragraph [0072] - paragraph [0080]; figure 6 paragraph [0083] - paragraph [0090]; figure 7 paragraph [0093] - paragraph [0098]; figure 8 paragraph [0100] - paragraph [0107]; figure 9 paragraph [0108] - paragraph [0115]; figure 10 -/--	1-39

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

[X] See patent family annex.

* Special categories of cited documents :

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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2020	20/01/2020

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

2

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

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2018/049149 A1 (LEE HYUNHO [KR] ET AL) 15 February 2018 (2018-02-15) paragraph [0009] - paragraph [0024] paragraph [0081] - paragraph [0083]; figure 5; table 5 paragraph [0091] - paragraph [0109]; figures 8, 9, 10 paragraph [0102] - paragraph [0116]; figure 11	1-39
X	QUALCOMM INCORPORATED: "Considerations on NR Positioning using PRS", 3GPP DRAFT; R1-1811287_(OTDOA-RTT-PRS), 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Chengdu, CN; 20181008 - 20181012 29 September 2018 (2018-09-29), XP051518690, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg%5Fran/WG1%5FRL1/TSGR1%5F94b/Docs/R1%2D1811287%2Ezip [retrieved on 2018-09-29] section "3.1 Hearability ("near-far problem")"; figures 2, 3, 4, 5 section "3.5 On-demand Positioning Signal"; Requirements 3 - 11; section "4. Summary".	1-39

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/SE2019/051001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017207841 A1	20-07-2017	AU 2012302492 A1	13-03-2014
		CA 2846830 A1	07-03-2013
		CN 103765794 A	30-04-2014
		EP 2751935 A2	09-07-2014
		JP 6212041 B2	11-10-2017
		JP 6321269 B2	09-05-2018
		JP 2014527370 A	09-10-2014
		JP 2017188941 A	12-10-2017
		KR 20130025102 A	11-03-2013
		US 2013059619 A1	07-03-2013
		US 2016073393 A1	10-03-2016
		US 2017207841 A1	20-07-2017
		WO 2013032188 A2	07-03-2013
US 2018049149 A1	15-02-2018	US 2018049149 A1	15-02-2018
		WO 2016163770 A1	13-10-2016