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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
02 April 2020 (02.04.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/064129 A1

(51) International Patent Classification:
H04B 7/06 (2006.01) *H04L 5/00* (2006.01)

(21) International Application Number:
PCT/EP2018/076482

(22) International Filing Date:
28 September 2018 (28.09.2018)

(25) Filing Language: English

(26) Publication Language: English

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

(72) Inventors: **HAKOLA, Sami**; Peikontie 7, 90450 Kempele (FI). **KOSKELA, Timo**; Harjapäänkatu 32 B 30, 90120 Oulu (FI). **KARJALAINEN, Juha**; Huiskilotie 6, 90540 Oulu (FI). **KAIKKONEN, Jorma**; Kuuselantie 8, 90800 Oulu (FI).

(74) Agent: **BERTHIER, Karine**; Alcatel-Lucent International, Site de Nokia Paris-Saclay, Route de Villejust, 91620 NOZAY (FR).

(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, 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).

(54) Title: REDUCING POWER CONSUMPTION IN A WIRELESS COMMUNICATION NETWORK

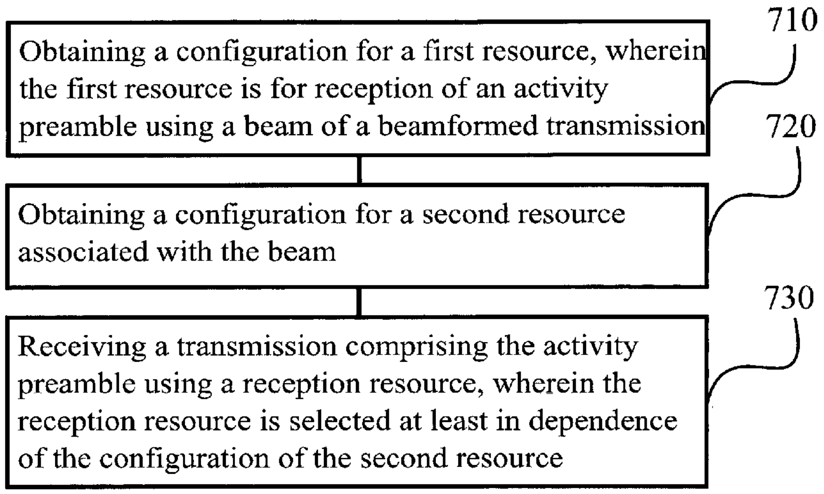

FIGURE 7

(57) Abstract: According to an example aspect of the present invention, there is provided a method comprising, obtaining a configuration for a first resource, wherein the first resource is for reception of an activity preamble using a beam of a beamformed transmission, obtaining a configuration for a second resource associated with the beam and receiving a transmission comprising the activity preamble using a reception resource, wherein the reception resource is selected at least in dependence of the configuration of the second resource.

WO 2020/064129 A1

[Continued on next page]

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

REDUCING POWER CONSUMPTION IN A WIRELESS COMMUNICATION NETWORK

FIELD

[0001] Various example embodiments relate in general to wireless communication networks, and reducing power consumption in such networks.

BACKGROUND

[0002] Wireless terminals typically have limited power. Hence, saving power of wireless terminals is important in various cellular networks, such as, in networks operating according to Long Term Evolution, LTE, and/or 5G radio access technology. 5G radio access technology may also be referred to as New Radio, NR, access technology. Since its inception, LTE has been widely deployed and 3rd Generation Partnership Project, 3GPP, still develops LTE. Similarly, 3GPP also develops standards for 5G/NR.

[0003] One of the topics in the 3GPP discussions is power consumption of wireless terminals, which may be reduced by using Discontinuous Reception, DRX. Similar enhancements may also be employed in other cellular networks and in several other wireless communication networks as well, such as, for example, in Wireless Local Area Networks, WLANs. Nevertheless, due to the limited capacity of wireless terminals there is still a need to provide improved methods, apparatuses and computer programs for reducing power consumption of wireless terminals.

SUMMARY

[0004] According to some aspects, there is provided the subject-matter of the independent claims. Some embodiments are defined in the dependent claims.

[0005] According to a first aspect, there is provided a first method comprising obtaining a configuration for a first resource, wherein the first resource may be for reception of an activity preamble using a beam of a beamformed transmission, obtaining a configuration for a second resource associated with the beam and receiving a transmission comprising the activity preamble using a reception resource, wherein the reception resource is selected at least in dependence of the configuration of the second resource.

[0006] In the first method, the first resource may comprise a candidate location for reception of the activity preamble and a monitoring occasion for a downlink control channel of the beam after the candidate location.

[0007] The first method may also comprise determining a distance in time between the first resource and the second resource and selecting the reception resource in dependence of the distance in time between the first resource and the second resource.

[0008] According to the first method, a third resource may be selected as the reception resource as a response to the distance in time between the first resource and the second resource being less than a threshold or the first resource may be selected as the reception resource as a response to the distance between the first resource and the second resource being larger than a threshold.

[0009] According to the first method, a third resource may be at least partly frequency division multiplexed with the second resource.

[0010] The first method may also comprise obtaining a configuration for a measurement window and selecting the reception resource in dependence of a location of the second resource and a location of the measurement window. A third resource may be selected as the reception resource when the second resource is located outside of the measurement window. The first resource may be selected as the reception resource when the second resource is located inside of the measurement window.

[0011] According to the first method, the second resource associated with the beam may be quasi co-located with the first resource.

[0012] According to the first method, the second resource may be allocated to reception of a broadcast transmission. The activity preamble may be frequency division multiplexed with the broadcast transmission. Also, the broadcast transmission may comprise a synchronization signal block or remaining minimum system information.

[0013] According to the first method, the obtaining the configuration for the first resource may comprise receiving a configuration message comprising the configuration for the first resource and the obtaining the configuration for the second resource may comprise receiving a configuration message comprising the configuration for the second resource.

[0014] The first method may also comprise receiving a configuration for the activity preamble, a third resource, a measurement window and/or a threshold.

[0015] According to a second aspect, there is provided a second method comprising determining a configuration for a first resource, wherein the first resource may be for transmission of an activity preamble using a beam of a beamformed transmission, determining a configuration for a second resource associated with the beam and transmitting a transmission comprising the activity preamble using a transmission resource, wherein the transmission resource is selected at least in dependence of the configuration of the second resource.

[0016] According to the second method, the first resource may comprise a candidate location for transmission of the activity preamble and a monitoring occasion for a downlink control channel of the beam after the candidate location.

[0017] The second method may also comprise determining a distance in time between the first resource and a second resource associated with the beam and selecting the transmission resource in dependence of the distance between the first resource and the second resource.

[0018] According to the second method, a third resource may be selected as the transmission resource as a response to the distance in time between the first resource and the second resource being less than a threshold or the first resource may be selected as the transmission resource as a response to the distance between the first resource and the second resource being larger than a threshold.

[0019] According to the second method, the third resource is at least partly frequency division multiplexed with the second resource.

[0020] The second method may also comprise determining a configuration for a measurement window and selecting the transmission resource in dependence of a location of the second resource and a location of the measurement window.

[0021] According to the second method, a third resource may be selected as the transmission resource when the second resource is located outside of the measurement window or the first resource is selected as the transmission resource when the second resource may be located inside of the measurement window.

[0022] According to the second method, the second resource associated with the beam may be quasi co-located with the first resource.

[0023] According to the second method, the second resource may be allocated to transmission of a broadcast transmission. The activity preamble may be frequency division multiplexed with the broadcast transmission. Also, the broadcast transmission may comprise a synchronization signal block or remaining minimum system information.

[0024] The second method may also comprise transmitting a configuration message comprising the configuration for the first resource and transmitting a configuration message comprising the configuration for the second resource.

[0025] The second method may also comprise transmitting a configuration for the activity preamble, a third resource and/or a threshold.

[0026] According to a third aspect of the present invention, there is provided an apparatus comprising at least one processing core, at least one memory including computer program code, the at least one memory and the computer program code being configured to, with the at least one processing core, cause the apparatus at least to perform the first method.

[0027] According to a fourth aspect of the present invention, there is provided an apparatus comprising at least one processing core, at least one memory including computer program code, the at least one memory and the computer program code being configured to, with the at least one processing core, cause the apparatus at least to perform the second method.

[0028] According to a fifth aspect of the present invention, there is provided an apparatus comprising means for performing the first method. According to a sixth aspect of the present invention, there is provided an apparatus comprising means for performing the second method.

[0029] According to a seventh aspect of the present invention, there is provided non-transitory computer readable medium having stored thereon a set of computer readable instructions that, when executed by at least one processor, cause an apparatus to at least perform the first method. According to an eighth aspect of the present invention, there is provided non-transitory computer readable medium having stored thereon a set of computer readable instructions that, when executed by at least one processor, cause an apparatus to at least perform the second method.

[0030] According to a ninth aspect of the present invention, there is provided a computer program configured to perform the first method. According to a tenth aspect of the present invention, there is provided a computer program configured to perform the second method.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] FIGURE 1 illustrates an exemplary network scenario in accordance with at least some embodiments;

[0032] FIGURE 2 illustrates an example of the use of a wake-up signal in accordance with at least some embodiments;

[0033] FIGURE 3 illustrates an example of a candidate location pattern for SSBs in accordance with at least some embodiments;

[0034] FIGURE 4 illustrates an exemplary realization of search space locations in accordance with at least some embodiments;

[0035] FIGURE 5 illustrates an exemplary implementation in accordance with at least some embodiments;

[0036] FIGURE 6 illustrates an example apparatus capable of supporting at least some embodiments;

[0037] FIGURE 7 illustrates a flow graph of a first method in accordance with at least some embodiments;

[0038] FIGURE 8 illustrates a flow graph of a second method in accordance with at least some embodiments.

EMBODIMENTS

[0039] Power consumption of wireless networks may be reduced by the procedures described herein. A first resource, which may comprise a candidate location for transmission of a wake-up signal using a beam of a beamformed transmission, and a second resource associated with the beam may be configured for a wireless device. The second resource may be, e.g., for a broadcast transmission, such as, for a transmission of synchronization signals. A third resource, which may be frequency multiplexed with the second resource, may be used for transmission of the wake-up signal. Thus, power consumption of a wireless terminal may be improved by changing the resource that may be used for transmission of the wake-up signal. That is to say, the wake-up signal may be transmitted in association with some other swept signal/channel, e.g., the second resource, instead of the candidate location whenever it is possible.

[0040] The wake-up signal, i.e., an activity preamble, may be transmitted by a base station to a wireless terminal, to indicate to the wireless terminal whether it should monitor a subsequent downlink control channel, or not. A simple detector and signal processing unit may be used for detecting the wake-up signal while allowing the wireless terminal to keep a main baseband receiver, which may be used for detection of the downlink control channel, in a sleep mode as much as possible.

[0041] Power efficiency of wireless terminals is becoming even more important issue than before due to constantly increasing data rates, bandwidths and antenna array sizes of wireless terminals. Wireless communication networks should therefore support efficient network access and data transmission with minimum power consumption. Power consumption of wireless terminals may be reduced, e.g., by allowing a network to configure wireless terminals with different DRX cycles, thereby enabling different sleeping periods for UEs.

[0042] Moreover, in beamformed wireless communication systems an additional sweeped signal implies overhead and detection of such a signal would consume power. Especially in case of hybrid/analogue beamforming systems, entire transmission may be transmitted to a single spatial direction using one beam of a set of transmitted beams. One example may be a so-called grid of beams. For example, in case of analog beamforming, beamforming cannot be applied per transmitted frequency carrier, i.e., different frequency parts of the transmission cannot be beamformed to different directions.

[0043] Therefore, transmitting a control signal with a low amount of info bits, like a wake-up signal, would be extremely expensive for a wireless communication system using beamforming, because non-frequency selective beamforming due to analogue parts of a beamformer and other signal(s) may be frequency division multiplexed only if transmitted to the same direction using the beam.

[0044] Embodiments of the present invention efficiently reduce overhead caused by transmissions of wake-up signals, which is an issue for example in analog beamforming systems, and hence improve power saving possibilities for wireless terminals.

[0045] FIGURE 1 illustrates an exemplary network scenario in accordance with at least some embodiments. According to the example scenario of FIGURE 1, there may be a beam-based wireless communication system, which comprises User Equipments, UEs, 110, one or more Base Stations, BS, 120, and core network element 130. UEs 110 may be connected to BS 120 via air interface using beams 115.

[0046] UEs 110 may comprise, for example, a smartphone, a cellular phone, a Machine-to-Machine, M2M, node, machine-type communications node, an Internet of Things, IoT, node, a car telemetry unit, a laptop computer, a tablet computer or, indeed, another kind of suitable wireless terminal or mobile station. In the example system of FIGURE 1, UEs 110 may communicate wirelessly with a cell of Base Station, BS, 120 via at least one beam 115. Beams 115 may be referred to as transmit beams, transmitted by BS 120. BS 120 may be considered as a serving BS for UEs 110. Air interface between UEs 110 and BS 120 may be configured in accordance with a Radio Access Technology, RAT, which both UE 110 and base station 120 are configured to support.

[0047] Examples of cellular RATs include Long Term Evolution, LTE, New Radio, NR, which may also be known as fifth generation, 5G, radio access technology and MulteFire. On the other hand, examples of non-cellular RATs include Wireless Local Area Network, WLAN, and Worldwide Interoperability for Microwave Access, WiMAX. For example, in the context of LTE, BS 120 may be referred to as eNB while in the context of NR, BS 120 may be referred to as gNB. Also, for example in the context of WLAN, BS 120 may be referred to as an access point. In general, BS 120 may be referred to as a network node. UEs 110 may be similarly referred to as wireless terminals or mobile stations in general. In any case, embodiments are not restricted to any particular wireless technology. Instead, embodiments may be exploited in any system which uses beamforming for wireless transmissions.

[0048] BS 120 may be connected, directly or via at least one intermediate node, with core network 130 via interface 125. Core network 110 may be, in turn, coupled via interface 135 with another network (not shown in FIGURE 1), via which connectivity to further networks may be obtained, for example via a worldwide interconnection network. BS 120 may be connected with at least one other BS as well via an inter-base station interface (not shown in FIGURE 1), even though in some embodiments the inter-base station interface may be absent. BS 120 may be connected, directly or via at least one intermediate node, with core network 130 or with another core network.

[0049] Nowadays at least some traffic, if not all, going through a communication network may be sporadic by nature. For example one transmission of , Internet Protocol, IP, based packet data traffic may need to be transmitted and received in a short time duration, but the time between consecutive transmissions may be relatively long. That is to say, transmissions may be bursty while there are no transmissions between two subsequent bursts. A UE may be in a sleep mode, e.g., turn off the radio, between two subsequent bursts to save power. Hence, a UE may be in a sleep mode for most of the time, thereby enabling savings in power consumption.

[0050] As an example, in LTE power consumption of UEs may be reduced by exploiting Discontinuous Reception, DRX. If the UE is in the idle mode, the UE may stay in a sleeping mode defined by a DRX cycle, which may be provided in System Information Block 2, SIB2, transmitted by a BS. According to the provided DRX cycle, the UE may periodically wake-up for a monitoring occasion, to monitor a downlink control channel, e.g., Primary Downlink Control Channel, PDCCH, and check for presence of paging information. The paging information may be scrambled with Paging – Radio Network Temporary Identifier, P-RNTI, according the DRX cycle.

[0051] If the downlink control channel, e.g., PDCCH, indicates paging information, the UE may need to demodulate a downlink shared channel, e.g., Primary Downlink Shared Channel, PDSCH, resources indicated by the downlink control channel. However, if the downlink control channel does not comprise an indication about paging information, the UE may go to the sleep mode to save power. As an example, a sub-frame time index where the paging information, e.g., P-RNTI, may be transmitted on the downlink control channel, such as, PDCCH, may be referred as a paging occasion.

[0052] A network may also configure a UE for a sleep mode, even if an UE is in a connected mode, by using a Connected mode DRX, C-DRX. If the UE is configured with C-DRX, the UE may periodically monitor the downlink control channel, e.g., PDCCH, in connected mode according to the configured C-DRX cycle for a potential downlink shared channel, e.g., PDSCH, scheduling grant. Consequently, the UE may wake up when there is data available for the UE. In this case, the time reserved for monitoring of the downlink channel for the downlink shared channel scheduling grant and for demodulating the downlink shared channel may be referred to as onDuration.

[0053] LTE may also support different groups of UEs, which monitor different time instants for their paging messages. Depending on monitoring periodicity of the downlink control channel, e.g., PDCCH, power consumption of UEs may be controlled by network. Hence, different groups of UEs may be configured for different power saving modes, i.e, power consumption of different UEs may be different.

[0054] DRX functionality may be exploited for saving power of the UE in the context of NR as well. If a UE is in a DRX mode, it may monitor a downlink control channel, e.g. PDCCH, periodically to find out whether there is data available for it or not. In NR, a network may be able to configure long and short DRX cycles for UEs. As an example, if a DRX cycle is configured, active time may include the time where *drx-onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimerDL* or *drx-RetransmissionTimerUL* or *ra-ContentionResolutionTimer* is running; or a Scheduling Request, SR, is sent on Primary Uplink Control Channel, PUCCH, and is pending; or a PDCCH indicating a new transmission addressed to a Cell-Radio Network Temporary Identifier, C-RNTI, of the Media Access Control, MAC entity has not been received after successful reception of a random access response for a random access preamble not selected by the MAC entity among contention-based random access preambles.

[0055] Moreover, a wake-up signal may be used to further enhance power saving of a device in addition to DRX. For example, a specific preamble signal, i.e., a wake-up signal, may be suitable for devices operating according to LTE, NR or Institute of Electrical and Electronics Engineers, IEEE 802.11ba standard, to indicate to a device about availability of data. A device may have a specific receiver for detection of wake-up signals. The receiver may be as simple and low-power as possible to enable enhanced power savings. In some embodiments, the wake-up signal may be referred to as an activity preamble as well.

[0056] In the context of NR wake-up signals may exploited at least for devices supporting even Further Enhanced Machine Type Communication, eFEMTC, and eFE-NB-IoT. In general, in cellular networks wake-up signals may be used to reduce power consumption of the UE caused by the need to monitor a downlink control channel, e.g., PDCCH. Periodic monitoring of a downlink control channel would lead to a shortened battery life of an UE in idle mode, because monitoring of a downlink control channel requires Fast Fourier Transform, FFT, computation, channel estimation, blind decoding of downlink control channel candidates for each configured search space as well as related decoding of channel coding. Power consumption in connected mode may be reduced for the same reasons similarly using wake-up signals.

[0057] Unnecessary monitoring of the downlink control channel may be avoided by using wake-up signals, which may indicate to the UE whether it needs to monitor the downlink control channel, or not, for example for paging in idle mode or for a scheduling grant in connected mode. As the UE may use a simple and low-power receiver for monitoring wake-up signals, monitoring of wake-up signals does not consume as much power as monitoring of the downlink control channel, thereby enabling further power savings.

[0058] FIGURE 2 illustrates an example of the use of a wake-up signal in accordance with at least some embodiments. The example of FIGURE 2 may be applicable at least for UEs in idle mode. In FIGURE 2, time is represented on the x-axis while frequency, or bandwidth, is represented on the y-axis. Wake-up signal is denoted by 210, downlink control channel, e.g., PDCCH, is denoted by 230 and a downlink shared channel, e.g., PDSCH, is denoted by 240. Time instant *t1* refers to the transmission time of wake-up signal 210 while time instant *t2* refers to the transmission time of downlink control channel 230. Delay 220 refers to the delay between wake-up signal 210 and downlink control channel 230, i.e., the difference between time instants *t1* and *t2*.

[0059] Downlink shared channel 240 may be associated with downlink control channel 230. In other words, downlink control channel 230 may comprise an indicator to downlink shared channel 240, for indicating to the UE, by the BS, a resource allocated for the UE on downlink shared channel 240.

[0060] According to the example of FIGURE 2, wake-up signal 210 may be placed prior to downlink control channel 230 in time, possibly with a timing offset, e.g., delay 220. The timing offset may be configured by a network. Wake-up signal 210 may have specific monitoring parameters, such as, for example, periodicity, offset and pattern. To enable maximum battery life of the UE, a specific detector, i.e. receiver, may be implemented for reception of wake-up signals. Such a detector may be as simple as possible, e.g., a correlator bank.

[0061] In the example of FIGURE 2 wake-up signal 210 may be used together with DRX to indicate whether a UE needs to decode, or not, downlink control channel 230 for idle mode paging. Single wake-up signal 210 may be used to inform the UE whether to monitor a paging occasion of downlink control channel 230. In addition, wake-up signal 210 may be used together with synchronization signals, to enable time and frequency tracking when long DRX cycles are used, e.g., in case of enhanced Machine Type Communications, eMTC.

[0062] Various signals may be used as wake-up signals. For example, in the context of cellular networks the following signals may be considered as wake-up signals:

- Demodulation Reference Signal, DMRS, of PDCCH;
- DMRS of Physical Broadcast Channel, PBCH;
- Channel State Information – Reference Signal, CSI-RS, for frequency and time tracking; and
- CSI-RS for beam management.

[0063] A UE may obtain time and frequency synchronisation to a cell and identity of the cell by detecting a Synchronization Signal Block, SSB. Moreover, SSB may comprise a Primary Synchronisation Signal, PSS, Secondary Synchronisation Signal, SSS, and

Primary Broadcast Channel, PBCH, together with DMRS associated with PBCH. Identity of the cell may be carried by PSS and SSS via sequence initialization. In addition, PBCH may carry a Master Information Block, MIB, DMRS, SSB index/SSB time location index, and other information. In some embodiments, SSBs with different indices may be transmitted to different spatial directions in time multiplexed manner using one beam at a time, to to provide coverage for a cell area using multiple narrow beams when a single, narrow beam is not able to cover the whole cell area. Thus, a beam of a beamformed transmission may correspond to a certain spatial direction. Beamformed transmission may comprise multiple beams, wherein each beam is transmitted to a different direction. The beam of a beamformed transmission may also be referred to as a beamforming beam.

[0064] FIGURE 3 illustrates an example of a candidate location pattern for SSBs in accordance with at least some embodiments. The example demonstrates candidate locations in a half-frame (5ms) for CaseB- 30kHz subcarrier spacing according to 3GPP TS 38.213 standard. According to the example of FIGURE 3, frame 310 may have a length of 10ms. Half of a frame comprising SSB candidate locations, i.e., SSB transmission, is denoted by 320. Then, SSB period 330 may have a length of, e.g., 80ms. Distance between two consecutive half frames 320, which comprise SSB candidate locations, may be equal to SSB period 330. That is to say, SSB transmissions 320 may take place every 80ms, for example.

[0065] One slot within SSB transmission 320, which may have a length of 0.5ms, is denoted by 340. One slot 340 may comprise 14 symbols. Moreover, SSB transmission 320 may comprise multiple candidate locations for SSB, for example, 8 candidate locations. Each candidate location for SSB may be referred to as a SSB index. In FIGURE 3, SSB index 0 is denoted by 350, SSB index 1 is denoted by 351, SSB index 2 is denoted by 352 and so forth.

[0066] The pattern of candidate locations for SSB 350 – 357 may be repeated with certain SSB period 330. SSB period 330 may be for example 5,10,20,40,80 or 160 ms. A UE may be configured for a System Information Block 1, SIB1, via MIB (‘pdcch-ConfigSIB1’) with, for example, monitoring pattern for Type0-PDCCH, scheduling the SIB1. Such a configuration may give the UE a length of a Control Resource Set, CORESET, in terms of symbols, e.g., {1,2,3}, number of contiguous Resource Blocks, RBs, e.g. {24,48,96}, frequency location of the CORESET (in relation to a location of SSB transmission 320) and used pattern and parametrisation for the monitoring pattern.

[0067] A UE may be configured for monitoring a SSB specific CORESET. For example, for SS/PBCH and CORESET monitoring pattern 1, wherein monitoring occasion may occur every 20ms, the UE may be given an offset from a start of radio frame 310, wherein monitoring occasions may occur. The offset may comprise a shift placing a monitoring occasion corresponding to SSB transmission 320 in time, together with number of possible monitoring occasions per slot 340. Based at least partly on a detected SSB index and information provided by MIB, the UE may determine the monitoring occasion, i.e., search space, corresponding to each SSB index 350 – 357.

[0068] FIGURE 4 illustrates an exemplary realization of search space locations in accordance with at least some embodiments, e.g., a result of the configuration above. The exemplary realization of FIGURE 4 may correspond to a search space pattern for Type0-PDCCH. SS/PBCH block indices from 0 to 7 may correspond to SSB indices from 350 to 357 of FIGURE 3, respectively, and the corresponding search space locations for each SS Block (index) may be indicated on symbol level. In this example, the CORESET is 3 symbols and there are two search space locations for each SSB.

[0069] In some embodiments, it may be determined whether a first resource, which may be allocated for transmission and reception of an activity preamble using a beam of a beamformed transmission, is in close proximity of a second resource. The second resource may be for transmission and reception of another transmission associated with the beam, e.g., a broadcast transmission of system information. The determination of whether the first resource is in close proximity of the second resource may comprise comparing a distance between the first resource and the second resource in time, and when the distance is less than a threshold, the first resource may be determined to be in close proximity of the second resource. On the other hand, when the distance is larger than the threshold, the first resource may be determined not to be in close proximity of the second resource. Determination of whether the first resource is in close proximity of the second resource, or not, may be done at the UE and the BS independently. Threshold may be configured by network or it may be predefined.

[0070] Transmission and reception of the activity preamble may depend on whether it is determined that the first resource is in close proximity of the second resource, or not. If it is determined that the first resource is in close proximity of the second resource, a location of the transmission of the activity preamble may be aligned with the second resource. In addition, or alternatively, the transmission of the activity preamble may be aligned depending on a configuration of a measurement window, i.e., depending on whether the second resource is inside or outside of the measurement window.

[0071] The alignments may be done so that the Quasi Co-Location, QCL, is maintained between the first resource and the resource that is used after the alignment for the transmission. For example, the transmission of the activity preamble may be aligned so that it is carried on a third resource and the third resource may be, possibly, frequency division multiplexed with the second resource. On the other hand, if it is determined that the first resource is in not close proximity of the second resource, the transmission of the activity preamble may be carried on the first resource.

[0072] In some embodiments QCL may be maintained by ensuring that a symbol transmitted on the third resource would be received similarly on the first resource, i.e., the first and third resource are so close to each other in time and/or frequency that the transmitted symbol would go through a similar radio channel or same spatial filter/beam is used for transmitting the signals. So if QCL is maintained, it may mean from a perspective of an UE that the UE may use similar assumptions for each signal that share the same QCL properties. That is to say, the UE could receive and infer the transmitted symbol in the same way regardless of the whether the first or the third resource is used as a reception/transmission resource. As an example, when two different signals share the same QCL type or assumption, they may share the same indicated properties. As an example, the QCL properties may be, e.g., delay spread, average delay, doppler spread, doppler shift, spatial RX.

[0073] With reference to 3GPP TS 38.214 standard specification, at least the following QCL types may be considered:

- 'QCL-TypeA': {Doppler shift, Doppler spread, average delay, delay spread}
- -'QCL-TypeB': {Doppler shift, Doppler spread}
- -'QCL-TypeC': {Doppler shift, average delay}
- -'QCL-TypeD': {Spatial Rx parameter}

[0074] As a further example, if a CSI-RS and SSB have the type D QCL assumption between each other, the UE may utilize same RX spatial filter, i.e., beam, to receive these signals.

[0075] In beamforming, a receiver typically sweeps through the beams one-by-one, one beam at a time. The second resource may thus be, e.g., another swept signal/channel on the beam that is used for the first resource or on another beam close to the beam that that is used for the first resource, as long as QCL is maintained. Moreover, the second resource may be associated with a transmission of a broadcast channel. The UE may be aware of the timing and periodicity of the second resource, i.e., those may be known to the UE in advance.

[0076] FIGURE 5 illustrates an exemplary implementation in accordance with at least some embodiments of the present invention. Elements 310 – 357 of FIGURE 3are also present in the exemplary implementation of FIGURE 5, although not marked for clarity. The exemplary implementation of FIGURE 5 may refer to using SSB pattern case-D (30kHz sub-carrier spacing). The exemplary implementation demonstrates two different options, (a) and (b), for the transmission and reception of wake-up signal 510, i.e., an activity preamble. With reference to FIGURE 2, wake-up signal 510 may correspond to wake-up signal 210.

[0077] First resource 500, for reception and transmission of activity preamble 510, may comprise a candidate location for activity preamble 510 and monitoring occasion for a downlink control channel 515 for a beam of a beamformed transmission. That is to say, first resource 500 may be suitable for reception and transmission of activity preamble 510, i.e., first resource 500 may be allocated, by a BS, for reception and transmission of activity preamble 510, using the beam. The BS may determine a configuration for first resource 500 and transmit a configuration message comprising the configuration to an UE. The UE may then obtain the configuration for first resource 500. Thus, the UE may obtain the configuration for first resource 500 by receiving the configuration message from the BS. Based on the configuration, the UE and the BS may determine a time for a potential transmission on first resource 500. The UE may determine the configuration for first resource 500 based on the received configuration message.

[0078] Monitoring occasion for the downlink control channel 515 may be after the candidate location of activity preamble 510. That is to say, a candidate location, i.e., a configured time, of transmission of activity preamble 510, may precede monitoring occasion for the downlink control channel 515.

[0079] If the UE is in idle mode, monitoring occasion for a downlink control channel 515 may be suitable for reception and transmission of paging information for downlink transmission, i.e., monitoring occasion for a downlink control channel 515 may be allocated, by the BS, for reception and transmission of paging information for a downlink transmission using the beam. Similarly, If the UE is in connected mode, monitoring occasion for a downlink control channel 515 may be suitable for reception and transmission of a scheduling grant for downlink transmission, i.e., monitoring occasion for a downlink control channel 515 may be allocated, by the BS, for reception and transmission of a scheduling grant for a downlink transmission using the beam.

[0080] The candidate location, i.e., configured time, for transmission of activity preamble 510 may be determined and configured by a BS. The BS may also transmit a configuration message for the candidate location to the UE. The configuration message for the candidate location may comprise a starting time for transmission of activity preamble 510. The UE may therefore receive the configuration message comprising a configuration for activity preamble 510 and determine the candidate location based on the configuration for activity preamble 510.

[0081] With reference to FIGURE 2 again, monitoring occasion for the downlink control channel 515 may correspond to downlink control channel 230. The BS may also configure monitoring occasion 515 for at least one beam in a same way as it may configure activity preamble 510 or first resource 500. Thus, the UE may determine a configuration for monitoring occasion 515 based on a configuration message received from the BS. In some embodiments, monitoring occasion for the downlink control channel 515 may be referred to as C-DRX onDuration.

[0082] The configurations may be for the beam or multiple beams. The configuration may also indicate an activation of the beam or multiple beams, possibly for a downlink control channel associated with the beam or multiple beams, respectively. In general, the beam or multiple beams of the beamformed transmission are transmit beams, for transmitting information in downlink from the BS to the UE.

[0083] Second resource associated with the at least one beam is denoted by 520 in FIGURE 5. Second resource 520 may be allocated for a broadcast transmission using the beam or another beam associated with the beam. For example, second resource 520 may be allocated for a broadcast transmission using the beam. The broadcast transmission may comprise a SSB transmission or a transmission of a Remaining Minimum System Information, RMSI. With reference to FIGURE 3, second resource 520 may correspond to a half of a frame 320, comprising SSB candidate locations.

[0084] Second resource 520 may be configured by the BS, for a beam or multiple beams similarly as first resource 500. Thus, the UE may determine a time for a transmission on second resource 520 based on a configuration message for second resource 520, received from the BS. The configuration message for second resource 520 may comprise information related to second resource 520, e.g., a starting time for second resource 520. Second resource 520 may be associated with the beam and be suitable for reception and transmission of, e.g., a broadcast transmission. In some embodiments, second resource 520 may be allocated, by the BS, for reception and transmission using the beam. Second resource 520 may be quasi co-located with first resource 500. That is to say, second resource 520 may be relatively close to first resource 500 (in time and/or frequency) so that a symbol transmitted on first resource 500 may be inferred correctly even if the symbol would be transmitted on second resource 520. Both, first resource 500 and second resource 520, may be transmitted using a same beam, i.e., said resources may be associated with the same beam.

[0085] In FIGURE 5, a distance in time between first resource 500 and second resource 520 is denoted by 505. Distance 505 may be associated with the beam. A configuration for first resource 500 may comprise a first time, for a transmission on first resource 500, and a configuration for second resource 520 may comprise a second time, for a transmission on second resource 520. Then, distance 505 may be calculated by subtracting the first time from the second time. The BS and the UE may calculate distance 505 independently. For example, the UE may receive the first time and the second time from the BS, and determine distance 505 in time between first resource 500 and second resource 520, e.g., by subtracting the received first time from the received second time.

[0086] Distance 505 in time may be used for determining whether first resource 500 is in close proximity of second resource 520. The determination of whether first resource 500 is in close proximity of second resource 520 may comprise comparing distance 505 to a threshold. The threshold may be configured by the BS and transmitted to the UE. Respectively, the UE may receive the threshold and apply it for determining whether first resource 500 is in close proximity of second resource 520.

[0087] The determination that first resource 500 is in close proximity of second resource 520 may also comprise determining that first resource 500 is quasi co-located with second resource 520. In other words, quasi co-location of first resource 500 and second resource 520 may be required to determine that first resource 500 is in close proximity of second resource 520. Such a requirement may be needed to ensure that the transmission of activity preamble 510 can be received correctly.

[0088] Moreover, a reception/transmission resource for activity preamble 510 may be selected in dependence of distance 505 in time between first resource 500 and second resource 520. Selection of the reception/transmission resource may be done at the UE and the BS independently. For example, in option (a) it may be determined that first resource 500 is not in close proximity of second resource 520. That is to say, first resource 500 may be selected as the reception/transmission resource as a response to distance 505 between first resource 500 and second resource 520 being larger than a threshold. Consequently, the BS may transmit and the UE may receive activity preamble 510 using first resource 500 as the reception/transmission resource when distance 505 is larger than the threshold.

Thus, the threshold may be used for determining that first resource 500 should be used as the reception/transmission resource. Consequently, the BS may transmit and the UE may receive the transmission comprising the activity preamble on the first resource when distance 505 in time between first resource 500 and second resource 520 is larger than the threshold.

[0089] In some embodiments, first resource 500 may be determined as not being in close proximity of second resource 520 if second resource 520 does not have a same or similar QCL assumption, e.g., spatial rx, as configured for first resource 500, which may comprise activity preamble 510. In such a case, first resource 500 may be selected as the reception/transmission resource and used for transmitting and receiving activity preamble 510. So according to option (a), activity preamble 510 may be sent independently on a preconfigured time occasion/period, i.e., a candidate location of activity preamble 510. Thus, the candidate location of activity preamble 510 may be selected as the reception/transmission resource in this case.

[0090] On the other hand, option (b) may refer to a case, wherein first resource 500 is in close proximity of second resource 520. That is to say, a candidate location, i.e., configured timing, of transmission of activity preamble 510 may be in close proximity of second resource 520. In such a case, activity preamble 510 may be placed closely after second resource 520. Second resource 520 may also have a same or similar QCL, e.g., spatial rx, assumption as configured for first resource 500 and/or for activity preamble 510. Second resource 520 may be for a SSB transmission as an example. In case of option (b), distance 505 between first resource 500, comprising a candidate location of an activity preamble 510, and second resource 520 may be less than the threshold.

[0091] Thus, according to option (b) a transmission time of activity preamble 510 may be changed from a candidate location to another location in time and, possibly, in frequency as well. Alignment of transmission time of activity preamble 510 is demonstrated by 525 in FIGURE 5. That is to say, a candidate location of activity preamble 510 may not be used for transmission of activity preamble if distance 505 between first resource 500 and second resource 520 is less than the threshold. Instead, activity preamble 510 may be sent on third resource 560 in such a case, i.e., third resource 560 may be used as the reception/transmission resource. Both, the BS and the UE, may independently determine whether the alignment of transmission time of activity preamble 510 can be done. The BS may configure third resource 560 and transmit a configuration for third resource 560 to the UE. Consequently, the UE may determine a location of third resource 560 in time and/or frequency based on the received configuration.

[0092] Third resource 560 may be associated with second resource 520. For example, third resource 560 may be at least partly frequency division multiplexed with second resource 520. In some embodiments, a transmission on second resource 520 may be transmitted by the BS and received by the UE. Second resource 520 may comprise PSS 530, PBCH including DMRS 540 and SSS 550. In addition, or alternatively, second resource 520 and/or third resource 560 may be quasi co-located with first resource 500. Third resource 560 may be configured by the BS as well.

[0093] That is to say, third resource 560 may be selected as the reception/transmission resource as a response to distance 505 between first resource 500 and second resource 520 being less than the threshold. Consequently, the BS may transmit and the UE may receive the transmission comprising the activity preamble on third resource 560, such that third resource 560 is the reception/transmission resource, when distance 505 in time between first resource 500 and second resource 520 is smaller than the threshold.

[0094] In addition, or alternatively, in some embodiments third resource 560 may be aligned with transmission of RMSI. For example, third resource 560 may be frequency division multiplexed with a transmission of RMSI. In general, a RMSI transmission may comprise a downlink control channel, e.g., PDCCH, for scheduling and downlink shared channel, e.g., PDSCH, for the RMSI transmission.

[0095] As first resource 500 may comprise a candidate location for reception of activity preamble 510, the determination of whether first resource 500 is in close proximity of second resource 520 may comprise determining a distance between the candidate location of activity preamble 510 in time to a location of second resource 520 in time. If the distance between the candidate location of activity preamble 510 in time and the location of second resource 520 in time is below the threshold, third resource 560 may be used as a reception/transmission resource for transmission and reception of activity preamble 510. However, if the distance between the candidate location of activity preamble 510 in time to and the location of second resource 520 in time is larger than the threshold, first resource 500 may be used as the reception/transmission resource for transmission and reception of activity preamble 510.

[0096] As first resource 500 may comprise monitoring occasion for a downlink control channel 515, the determination of whether first resource 500 is in close proximity of second resource 520 may comprise determining a distance between a location of monitoring occasion for a downlink control channel 515 in time and a location of second resource 520 in time. If the distance between the location of monitoring occasion for a downlink control channel 515 and the location of second resource 520 in time is below the threshold, third resource 560 may be used as the reception/transmission resource for transmission and reception of activity preamble 510. However, if the distance between the location of monitoring occasion for a downlink control channel 515 and the location of second resource 520 in time is larger than the threshold, first resource 500 may be used as the reception/transmission resource for transmission and reception of activity preamble 510.

[0097] BS may configure the UE with two physical resources, comprising the candidate location of activity preamble 510, which may precede monitoring occasion for the downlink control channel 515, and third resource 560, wherein third resource 560 may be frequency division multiplexed with second resource 520. For example, if second resource 520 comprises a SSB transmission, third resource 560 may be quasi co-located, e.g., spatially, with the SSB transmission on the same beam as the downlink control channel, e.g., PDCCH

[0098] In addition, the BS may configure the UE with a time domain threshold. The time domain threshold may be referred to a threshold in general. The time domain threshold may be used by both, the UE and the BS, to determine whether to use first resource 500 or third resource 560 as the reception/transmission resource for transmitting and receiving activity preamble 510, i.e., a wake-up signal. Thus, the BS may configure the UE by transmitting a configuration message comprising a configuration for first resource 500, second resource 520, third resource 560 and/or the threshold. The configuration message may also comprise a starting time, and possibly a length in time, for first resource 500, second resource 520, third resource 560 and/or the threshold. In addition, the configuration message may comprise information related to frequency, bandwidth and/or RBs configured for first resource 500, second resource 520, third resource 560 and/or the threshold.

[0099] Consequently, the UE may calculate a time difference between second resource 520, which may be quasi co-located, e.g., spatially, with a configured downlink control channel associated with a beamforming beam, and monitoring occasion of the downlink control channel 515. Thus, in some embodiments the UE may calculate the time difference difference between the SSB transmission, which may spatially quasi co-located with the configured PDCCH beam, and the PDCCH monitoring occasion.

[00100] If the time difference is less than or equal to the threshold, the UE may try to detect wake-up signal 510 on a third resource 560. Third resource 560 may be frequency division multiplexed with second resource 510, e.g., with a SSB transmission. Otherwise, the UE may try to detect wake-up signal 510 at a candidate location preceding monitoring occasion of the downlink control channel 515. In other words, in some embodiments, the

UE may try to detect wake-up signal 510 at the PDCCH monitoring occasion, i.e., not multiplexed with second resource 520, such as, a SSB transmission.

[00101] In addition, or alternatively, in some embodiments third resource 560 alignment may be conditioned based on a location and/or timing of a measurement window, such as, for example, a SS/PBCH Block Measurement Timing Configuration, SMTC, window. In general, SMTC may be referred to as an SSB-based measurement timing configuration, possibly configured by SSB-MeasurementTimingConfiguration as specified in 3GPP TS 38.331 standard specification. A set of parameters for measurement window periodicities, duration and offset configuration may be used to steer the UE SSB based mobility measurements for neighbor cells.

[00102] The UE may obtain, or receive, a configuration for the measurement window from the BS. The configuration for the measurement window may comprise a location of the measurement window, e.g., a time and possibly length of the measurement window. Third resource 560 may be selected as the transmission/reception resource, and possibly frequency division multiplexed with second resource 520, if second resource 520 is located outside of the measurement window. That is to say, third resource 560 may be frequency division multiplexed with SSB transmissions that are outside of the SMTC window. Even if second resource 520 would be located outside of the measurement window, it may also be required that distance 505 in time between first resource 500 and second resource 520 is less than the threshold. That is to say, if a distance in time between an activity preamble and a specific SSB transmission is less than the threshold and the SSB transmission is outside SMTC window, the activity preamble may be frequency division multiplexed with SSB.

[00103] On the other hand, if second resource 520 is located inside the measurement window, first resource 500 may be selected as the reception/transmission resource, possibly regardless of the time difference, i.e., distance 505. In other words, if an activity preamble corresponds to a SSB transmission that is inside SMTC window, the activity preamble may be mapped to first resource 500 regardless of distance 505 in time.

[00104] So in general, the transmission/reception resource may be selected in dependence of the configuration of second resource 520. For example, the transmission/reception resource may be selected in dependence of the configuration of first resource 500 and the configuration of second resource 520. The configurations may comprise a time or location in time, such as a starting time, and possibly a length as well. The configurations may also comprise a frequency for the resources. In some embodiments, distance 505 in time may be determined between first resource 500 and second resource

520, and the transmission/reception resource may be selected in dependence of distance 505 between first resource 500 and second resource 520.

[00105] In addition, or alternatively, in some embodiments the transmission/reception resource may be selected in dependence of a configuration of the measurement window and the configuration of second resource 520. The configuration for the measurement window may be determined, or obtained from the BS, by the UE. The configuration of the measurement window may comprise a time or location in time, such as a starting time, and possible a length as well. The configuration of the measurement window may also comprise a frequency. The transmission/reception resource may then be selected in dependence of a location of second resource 520 and a location of the measurement window. Embodiments may be combined as well. For example, third resource 560 may be selected as the transmission/reception resource as a response to distance 505 in time between first resource 500 and second resource 520 being less than the threshold when second resource 520 is located outside of the measurement window.

[00106] Upon receiving activity preamble 510, the UE may proceed and try to detect a transmission during monitoring occasion 515 for the downlink control channel. If the UE is in connected mode, it may detect the transmission, possibly comprising a scheduling grant, during monitoring occasion 515 for the downlink control channel and then receive data on a downlink shared channel according to the scheduling grant. On the other hand, if the UE is in idle mode, it may detect the transmission, possibly comprising paging information, during monitoring occasion 515 for the downlink control channel and then receive data on a downlink shared channel in accordance with the paging information.

[00107] FIGURE 6 illustrates an example apparatus capable of supporting at least some embodiments. Illustrated is device 600, which may comprise, for example, UEs 110, or wireless terminals in general, or BS 120, such as, a network node of FIGURE 1. Comprised in device 600 is processor 610, which may comprise, for example, a single- or multi-core processor wherein a single-core processor comprises one processing core and a multi-core processor comprises more than one processing core. Processor 610 may comprise, in general, a control device. Processor 610 may comprise more than one processor. Processor 610 may be a control device. A processing core may comprise, for example, a Cortex-A8 processing core manufactured by ARM Holdings or a Steamroller processing core produced by Advanced Micro Devices Corporation. Processor 610 may comprise at least one Qualcomm Snapdragon and/or Intel Atom processor. Processor 610 may comprise at least one application-specific integrated circuit, ASIC. Processor 610 may comprise at least one field-programmable gate array, FPGA. Processor 610 may be means for performing method steps in device 600. Processor 610 may be configured, at least in part by computer instructions, to perform actions.

[00108] A processor may comprise circuitry, or be constituted as circuitry or circuitries, the circuitry or circuitries being configured to perform phases of methods in accordance with embodiments described herein. 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.

[00109] 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.

[00110] Device 600 may comprise memory 620. Memory 620 may comprise random-access memory and/or permanent memory. Memory 620 may comprise at least one RAM chip. Memory 620 may comprise solid-state, magnetic, optical and/or holographic memory, for example. Memory 620 may be at least in part accessible to processor 610. Memory 620 may be at least in part comprised in processor 610. Memory 620 may be means for storing information. Memory 620 may comprise computer instructions that processor 610 is configured to execute. When computer instructions configured to cause processor 610 to perform certain actions are stored in memory 620, and device 600 overall is configured to run under the direction of processor 610 using computer instructions from memory 620, processor 610 and/or its at least one processing core may be considered to be configured to perform said certain actions. Memory 620 may be at least in part comprised in processor 610. Memory 620 may be at least in part external to device 600 but accessible to device 600.

[00111] Device 600 may comprise a transmitter 630. Device 600 may comprise a receiver 640. Transmitter 630 and receiver 640 may be configured to transmit and receive, respectively, information in accordance with at least one cellular or non-cellular standard. Transmitter 630 may comprise more than one transmitter. Receiver 640 may comprise more than one receiver. Transmitter 630 and/or receiver 640 may be configured to operate in accordance with Global System for Mobile communication, GSM, Wideband Code Division Multiple Access, WCDMA, 5G, Long Term Evolution, LTE, IS-95, Wireless Local Area Network, WLAN, Ethernet and/or Worldwide Interoperability for Microwave Access, WiMAX, standards, for example.

[00112] Device 600 may comprise a Near-Field Communication, NFC, transceiver 650. NFC transceiver 650 may support at least one NFC technology, such as Bluetooth, Wibree or similar technologies.

[00113] Device 600 may comprise User Interface, UI, 660. UI 660 may comprise at least one of a display, a keyboard, a touchscreen, a vibrator arranged to signal to a user by causing device 600 to vibrate, a speaker and a microphone. A user may be able to operate device 600 via UI 660, for example to accept incoming telephone calls, to originate telephone calls or video calls, to browse the Internet, to manage digital files stored in memory 620 or on a cloud accessible via transmitter 630 and receiver 640, or via NFC transceiver 650, and/or to play games.

[00114] Device 600 may comprise or be arranged to accept a user identity module 670. User identity module 670 may comprise, for example, a Subscriber Identity Module, SIM, card installable in device 600. A user identity module 670 may comprise information identifying a subscription of a user of device 600. A user identity module 670 may comprise cryptographic information usable to verify the identity of a user of device 600 and/or to facilitate encryption of communicated information and billing of the user of device 600 for communication effected via device 600.

[00115] Processor 610 may be furnished with a transmitter arranged to output information from processor 610, via electrical leads internal to device 600, to other devices comprised in device 600. Such a transmitter may comprise a serial bus transmitter arranged to, for example, output information via at least one electrical lead to memory 620 for storage therein. Alternatively to a serial bus, the transmitter may comprise a parallel bus transmitter. Likewise processor 610 may comprise a receiver arranged to receive information in processor 610, via electrical leads internal to device 600, from other devices comprised in device 600. Such a receiver may comprise a serial bus receiver arranged to, for example, receive information via at least one electrical lead from receiver 640 for processing in processor 610. Alternatively to a serial bus, the receiver may comprise a parallel bus receiver.

[00116] Device 600 may comprise further devices not illustrated in FIGURE 4. For example, where device 600 comprises a smartphone, it may comprise at least one digital camera. Some devices 600 may comprise a back-facing camera and a front-facing camera, wherein the back-facing camera may be intended for digital photography and the front-facing camera for video telephony. Device 600 may comprise a fingerprint sensor arranged to authenticate, at least in part, a user of device 600. In some embodiments, device 600 lacks at least one device described above. For example, some devices 600 may lack a NFC transceiver 650 and/or user identity module 670.

[00117] Processor 610, memory 620, transmitter 630, receiver 640, NFC transceiver 650, UI 660 and/or user identity module 670 may be interconnected by electrical leads internal to device 600 in a multitude of different ways. For example, each of the aforementioned devices may be separately connected to a master bus internal to device 600, to allow for the devices to exchange information. However, as the skilled person will appreciate, this is only one example and depending on the embodiment various ways of interconnecting at least two of the aforementioned devices may be selected without departing from the scope of the embodiments.

[00118] FIGURE 7 is a flow graph of a first method in accordance with at least some embodiments. The phases of the illustrated first method may be performed by UE 110, or wireless terminal or mobile station in general, or by a control device configured to control the functioning thereof, possibly when installed therein.

[00119] The first method may comprise, at step 710, obtaining a configuration for a first resource, wherein the first resource is for reception of an activity preamble using a beam of a beamformed transmission. The first method may also comprise, at step 720, obtaining a configuration for a second resource associated with the beam. In addition, the first method may comprise, at step 730, receiving a transmission comprising the activity preamble using a reception resource, wherein the reception resource is selected at least in dependence of the configuration of the second resource.

[00120] FIGURE 8 is a flow graph of a second method in accordance with at least some embodiments. The phases of the illustrated second method may be performed by BS 120 or a network node in general, or by a control device configured to control the functioning thereof, possibly when installed therein.

[00121] The second method may comprise, at step 810, determining a configuration for a first resource, wherein the first resource is for transmission of an activity preamble using a beam of a beamformed transmission. The second method may also comprise, at step 820, determining a configuration for a second resource associated with the beam. In addition, the second method may comprise, at step 830, transmitting a transmission comprising the activity preamble using a transmission resource, wherein the transmission resource is selected at least in dependence of the configuration of the second resource.

[00122] It is to be understood that the embodiments disclosed are not limited to the particular structures, process steps, or materials disclosed herein, but are extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

[00123] Reference throughout this specification to one embodiment or an embodiment means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment. Where reference is made to a numerical value using a term such as, for example, about or substantially, the exact numerical value is also disclosed.

[00124] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and examples may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as de facto equivalents of one another, but are to be considered as separate and autonomous representations.

[00125] In an exemplary embodiment, an apparatus, such as, for example, a terminal or a network node, may comprise means for carrying out the embodiments described above and any combination thereof.

[00126] In an exemplary embodiment, a computer program may be configured to cause a method in accordance with the embodiments described above and any combination thereof. In an exemplary embodiment, a computer program product, embodied on a non-transitory computer readable medium, may be configured to control a processor to perform a process comprising the embodiments described above and any combination thereof.

[00127] In an exemplary embodiment, an apparatus, such as, for example, a terminal or a network node, may comprise at least one processor, and at least one memory including computer program code, wherein 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 the embodiments described above and any combination thereof.

[00128] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the preceding description, numerous specific details are provided, such as examples of lengths, widths, shapes, etc., to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

[00129] While the forgoing examples are illustrative of the principles of the embodiments in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

[00130] The verbs “to comprise” and “to include” are used in this document as open limitations that neither exclude nor require the existence of also un-recited features. The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated. Furthermore, it is to be understood that the use of "a" or "an", that is, a singular form, throughout this document does not exclude a plurality.

INDUSTRIAL APPLICABILITY

[00131] At least some embodiments find industrial application in wireless communication networks, wherein it is desirable to reduce power consumption of wireless terminals.

ACRONYMS LIST

3GPP	3rd Generation Partnership Project
BS	Base Station
C-DRX	Connected mode DRX
C-RNTI	Cell-Radio Network Temporary Identifier
CORESET	Control Resource Set
CSI-RS	Channel State Information – Reference Signal
DMRS	Demodulation Reference Signal
DRX	Discontinuous Reception
eFEMTC	even Further Enhanced Machine Type Communication
eMBB	enhanced Mobile BroadBand
eFE-NB-IoT	Even Further Enhanced Narrowband IoT
GSM	Global System for Mobile communication
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IP	Internet Protocol
LTE	Long-Term Evolution
M2M	Machine-to-Machine
MAC	Media Access Control
MIB	Master Information Block
NFC	Near-Field Communication
NR	New Radio

P-RNTI	Paging – Radio Network Temporary Identifier
PBCH	Physical Broadcast Channel
PDCCH	Primary Downlink Control Channel
PDSCH	Primary Downlink Shared Channel
PUCCH	Primary Uplink Control Channel
PSS	Primary Synchronization Signal
QCL	Quasi Co-Location
RAT	Radio Access Technology
RB	Resource Block
SIB	System Information Block
SIM	Subscriber Identity Module
SMTC	SS/PBCH Block Measurement Timing Configuration
SSB	Synchronization Signal Block
SSS	Secondary Synchronization Signal
UE	User Equipment
UI	User Interface
WCDMA	Wideband Code Division Multiple Access
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network

REFERENCE SIGNS LIST

110	User Equipment
115	Air interface
120	Base station
125, 135	Wired interface
130	Core network
210, 510	Wake-up signal, i.e., activity preamble
220	Delay
230, 515	Downlink control channel
240	Downlink shared channel
310	Frame
320	Half of a frame, comprising SSB candidate locations
330	SSB period
340	One slot within a SSB transmission
350 – 357	SSB indices
500	First resource
505	Distance in time
520	Second resource
530	PSS
540	PBCH including DMRS
550	SSS
560	Third resource
600 – 670	Structure of the apparatus of FIGURE 6
710 – 730	Phases of the first method in FIGURE 7
810 – 830	Phases of the second method in FIGURE 8

CLAIMS:

1. A method, comprising:

- obtaining a configuration for a first resource, wherein the first resource is for reception of an activity preamble using a beam of a beamformed transmission;
- obtaining a configuration for a second resource associated with the beam; and
- receiving a transmission comprising the activity preamble using a reception resource, wherein the reception resource is selected at least in dependence of the configuration of the second resource.

2. A method according to claim 1, wherein the first resource comprises a candidate location for reception of the activity preamble and a monitoring occasion for a downlink control channel of the beam after the candidate location.

3. A method according to claim 1 or claim 2, further comprising:

- determining a distance in time between the first resource and the second resource; and
- selecting the reception resource in dependence of the distance in time between the first resource and the second resource.

4. A method according to claim 3, wherein a third resource is selected as the reception resource as a response to the distance in time between the first resource and the second resource being less than a threshold.

5. A method according to claim 3, wherein the first resource is selected as the reception resource as a response to the distance between the first resource and the second resource being larger than a threshold.

6. A method according to any of the preceding claims, wherein a third resource is at least partly frequency division multiplexed with the second resource.

7. A method according to any of the preceding claims, further comprising:

- obtaining a configuration for a measurement window; and
- selecting the reception resource in dependence of a location of the second resource and a location of the measurement window.

8. A method according to claim 7, wherein a third resource is selected as the reception resource when the second resource is located outside of the measurement window.

9. A method according to claim 7, wherein the first resource is selected as the reception resource when the second resource is located inside of the measurement window.

10. A method according to any of the preceding claims, wherein the second resource associated with the beam is quasi co-located with the first resource.

11. A method according to any of the preceding claims, wherein the second resource is allocated to reception of a broadcast transmission.

12. A method according to claim 11, wherein the activity preamble is frequency division multiplexed with the broadcast transmission.

13. A method according to claim 11 or claim 12, wherein the broadcast transmission comprises a synchronization signal block or remaining minimum system information.

14. A method according to any of the preceding claims, wherein the obtaining the configuration for the first resource comprises receiving a configuration message comprising the configuration for the first resource and the obtaining the configuration for the second resource comprises receiving a configuration message comprising the configuration for the second resource.

15. A method according to any of the preceding claims, further comprising:

- receiving a configuration for the activity preamble, a third resource, a measurement window and/or a threshold.

16. A method comprising,

- determining a configuration for a first resource, wherein the first resource is for transmission of an activity preamble using a beam of a beamformed transmission;
- determining a configuration for a second resource associated with the beam; and
- transmitting a transmission comprising the activity preamble using a transmission resource, wherein the transmission resource is selected at least in dependence of the configuration of the second resource.

17. A method according to claim 16, wherein the first resource comprises a candidate location for transmission of the activity preamble and a monitoring occasion for a downlink control channel of the beam after the candidate location.

18. A method according to claim 16 or claim 17, further comprising:

- determining a distance in time between the first resource and a second resource associated with the beam; and
- selecting the transmission resource in dependence of the distance between the first resource and the second resource.

19. A method according to claim 18, wherein a third resource is selected as the transmission resource as a response to the distance in time between the first resource and the second resource being less than a threshold.

20. A method according to claim 18, wherein the first resource is selected as the transmission resource as a response to the distance between the first resource and the second resource being larger than a threshold.

21. A method according to any of claims 16 – 20, wherein the third resource is at least partly frequency division multiplexed with the second resource.

22. A method according to any of claims 16 – 21, further comprising:

- determining a configuration for a measurement window; and
- selecting the transmission resource in dependence of a location of the second resource and a location of the measurement window.

23. A method according to claim 22, wherein a third resource is selected as the transmission resource when the second resource is located outside of the measurement window.

24. A method according to claim 22, wherein the first resource is selected as the transmission resource when the second resource is located inside of the measurement window.

25. A method according to any of claims 16 – 24, wherein the second resource associated with the beam is quasi co-located with the first resource.

26. A method according to any of claims 16 – 25, wherein the second resource is allocated to transmission of a broadcast transmission.

27. A method according to claim 26, wherein the activity preamble is frequency division multiplexed with the broadcast transmission.

28. A method according to claim 26 or claim 27, wherein the broadcast transmission comprises a synchronization signal block or remaining minimum system information.

29. A method according to any of claims 16 – 28, further comprising:

- transmitting a configuration message comprising the configuration for the first resource; and
- transmitting a configuration message comprising the configuration for the second resource.

30. A method according to any of claims 16 – 29, further comprising:

- transmitting a configuration for the activity preamble, a third resource and/or a threshold.

31. An apparatus comprising at least one processing core, at least one memory including computer program code, the at least one memory and the computer program code being configured to, with the at least one processing core, cause the apparatus at least to perform:

- obtain a configuration for a first resource, wherein the first resource is for reception of an activity preamble using a beam of a beamformed transmission;
- obtain a configuration for a second resource associated with the beam; and
- receive a transmission comprising the activity preamble using a reception resource, wherein the reception resource is selected at least in dependence of the configuration of the second resource.

32. An apparatus according to claim 31, wherein the at least one memory and the computer program code are further configured to, with the at least one processing core, cause the apparatus at least to perform a method according to any of claims 2 – 15.

33. An apparatus comprising at least one processing core, at least one memory including computer program code, the at least one memory and the computer program code being configured to, with the at least one processing core, cause the apparatus at least to perform:

- determine a configuration for a first resource, wherein the first resource is for transmission of an activity preamble using a beam of a beamformed transmission;
- determine a configuration for a second resource associated with the beam; and
- transmit a transmission comprising the activity preamble using a transmission resource, wherein the transmission resource is selected at least in dependence of the configuration of the second resource.

34. An apparatus according to claim 33, wherein the at least one memory and the computer program code are further configured to, with the at least one processing core, cause the apparatus at least to perform a method according to any of claims 17 – 30.

35. An apparatus comprising:

- means for obtaining a configuration for a first resource, wherein the first resource is for reception of an activity preamble using a beam of a beamformed transmission;
- means for obtaining a configuration for a second resource associated with the beam; and
- means for receiving a transmission comprising the activity preamble using a reception resource, wherein the reception resource is selected at least in dependence of the configuration of the second resource.

36. An apparatus according to claim 35, further comprising means for performing a method according to any of claims 2 – 15.

37. An apparatus comprising:

- means for determining a configuration for a first resource, wherein the first resource is for transmission of an activity preamble using a beam of a beamformed transmission;
- means for determining a configuration for a second resource associated with the beam; and
- means for transmitting a transmission comprising the activity preamble using a transmission resource, wherein the transmission resource is selected at least in dependence of the configuration of the second resource.

38. A apparatus according to claim 37, further comprising means for performing a method according to any of claims 17 – 30.

39. A non-transitory computer readable medium having stored thereon a set of computer readable instructions that, when executed by at least one processor, cause an apparatus to at least perform a method according to any of claims 1 – 15 or 16 – 30.

40. A computer program configured to perform a method according to any of claims 1 – 15 or 16 – 30.

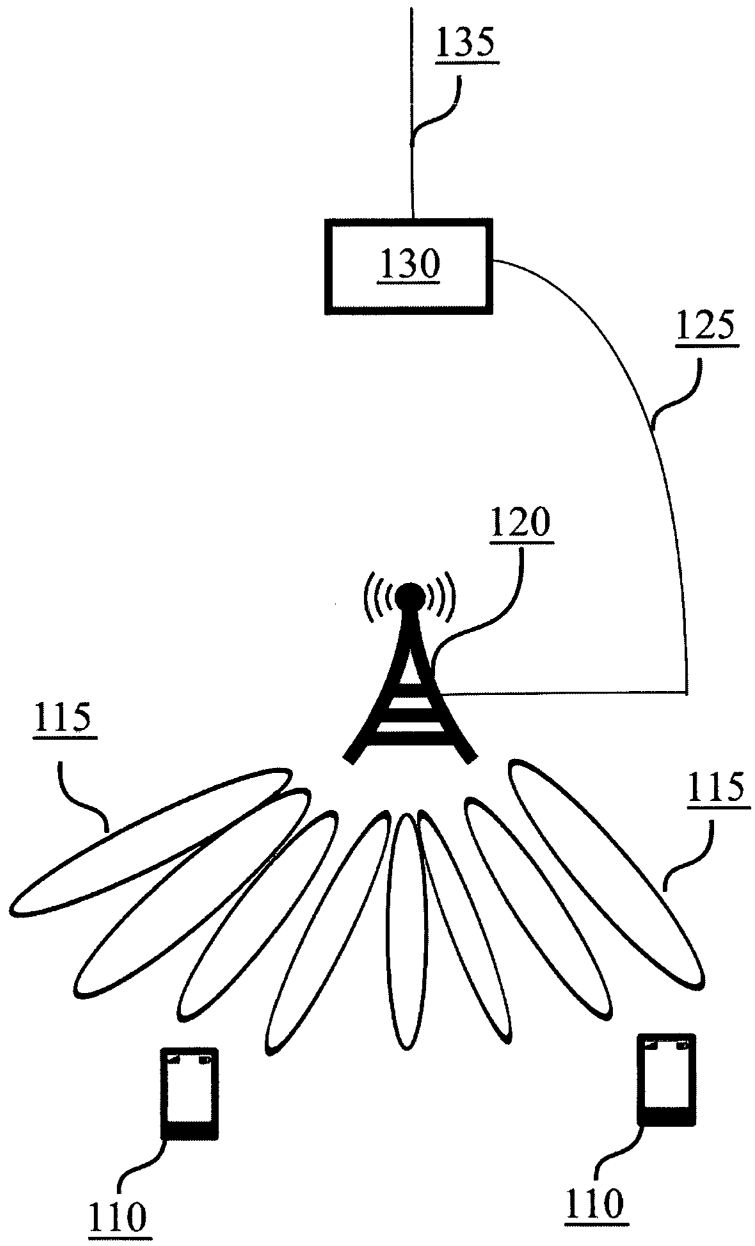

FIGURE 1

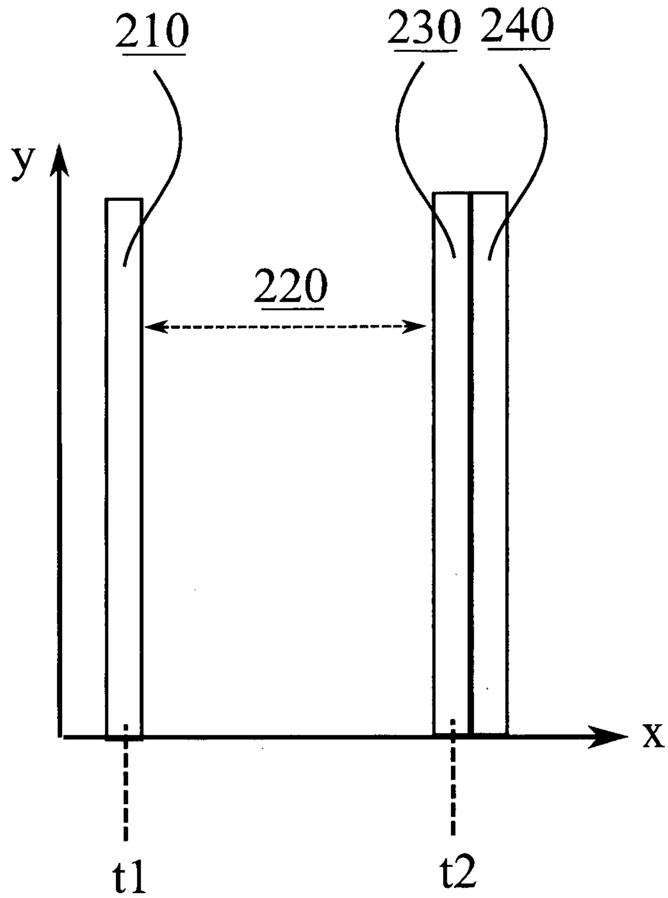

FIGURE 2

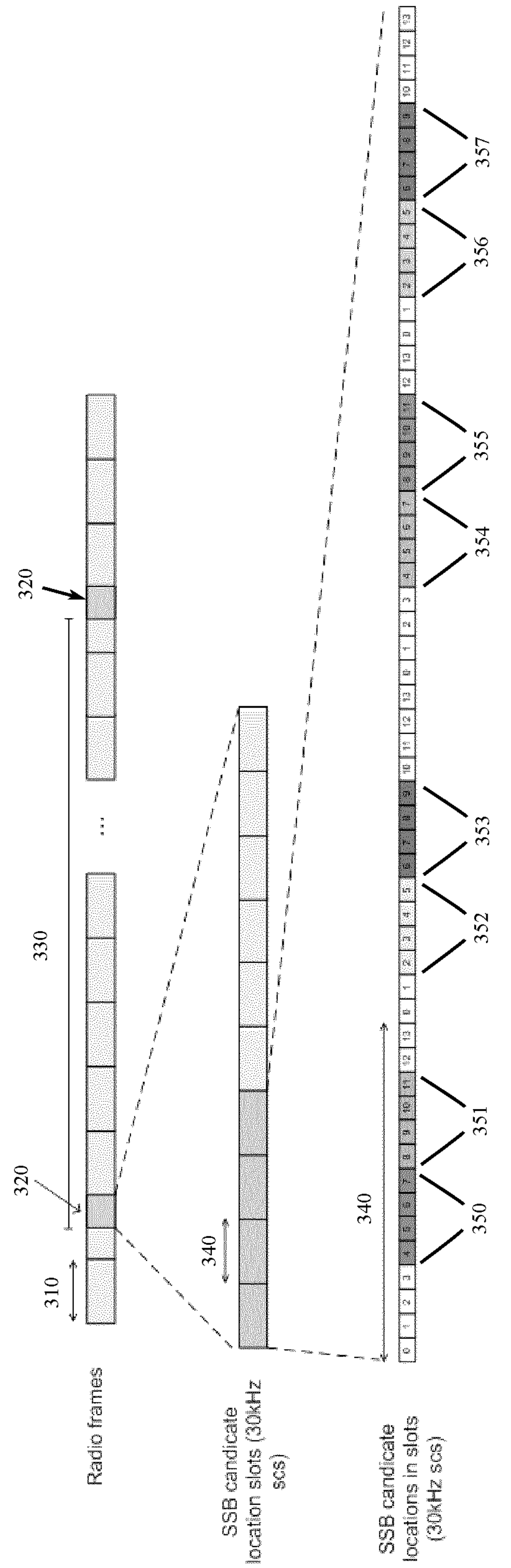
Radio frames
SSB candicate location slots (30kHz scs)
SSB candicate locations in slots (30kHz scs)
310
320
320
330
340
340
350
351
352
353
354
355
356
357

FIGURE 3

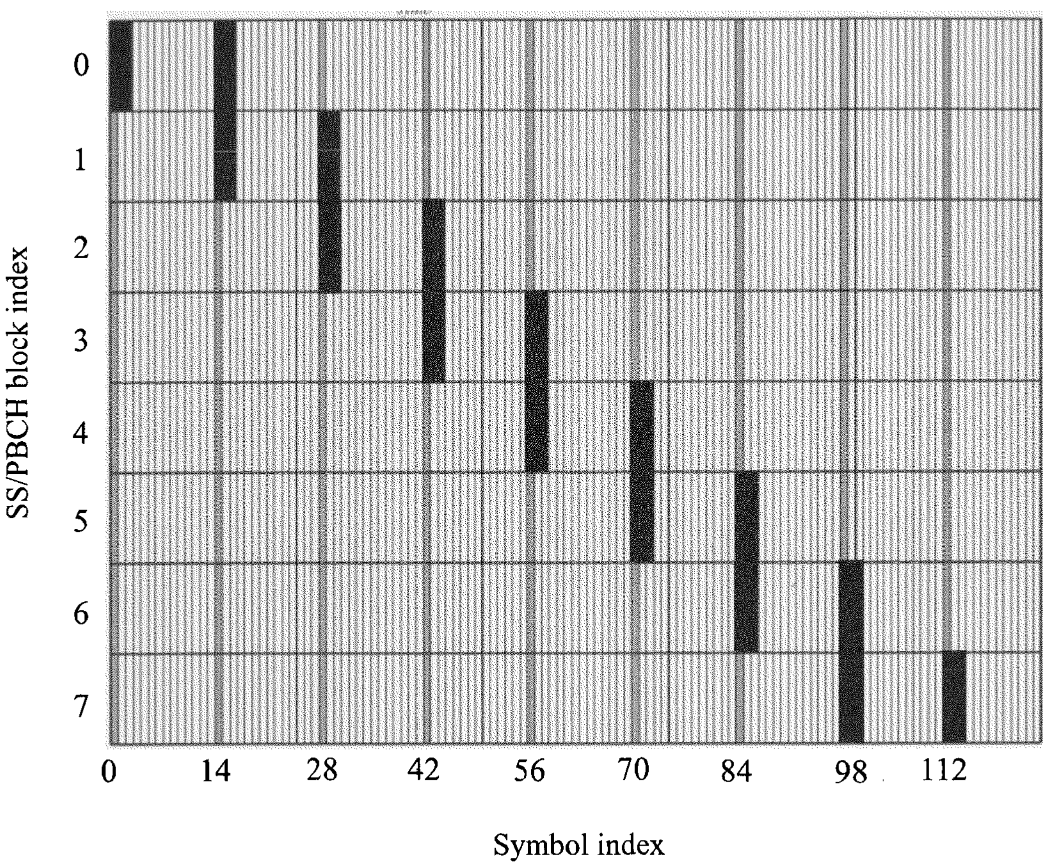
SS/PBCH block index
0
1
2
3
4
5
6
7
0
14
28
42
56
70
84
98
112
Symbol index

FIGURE 4

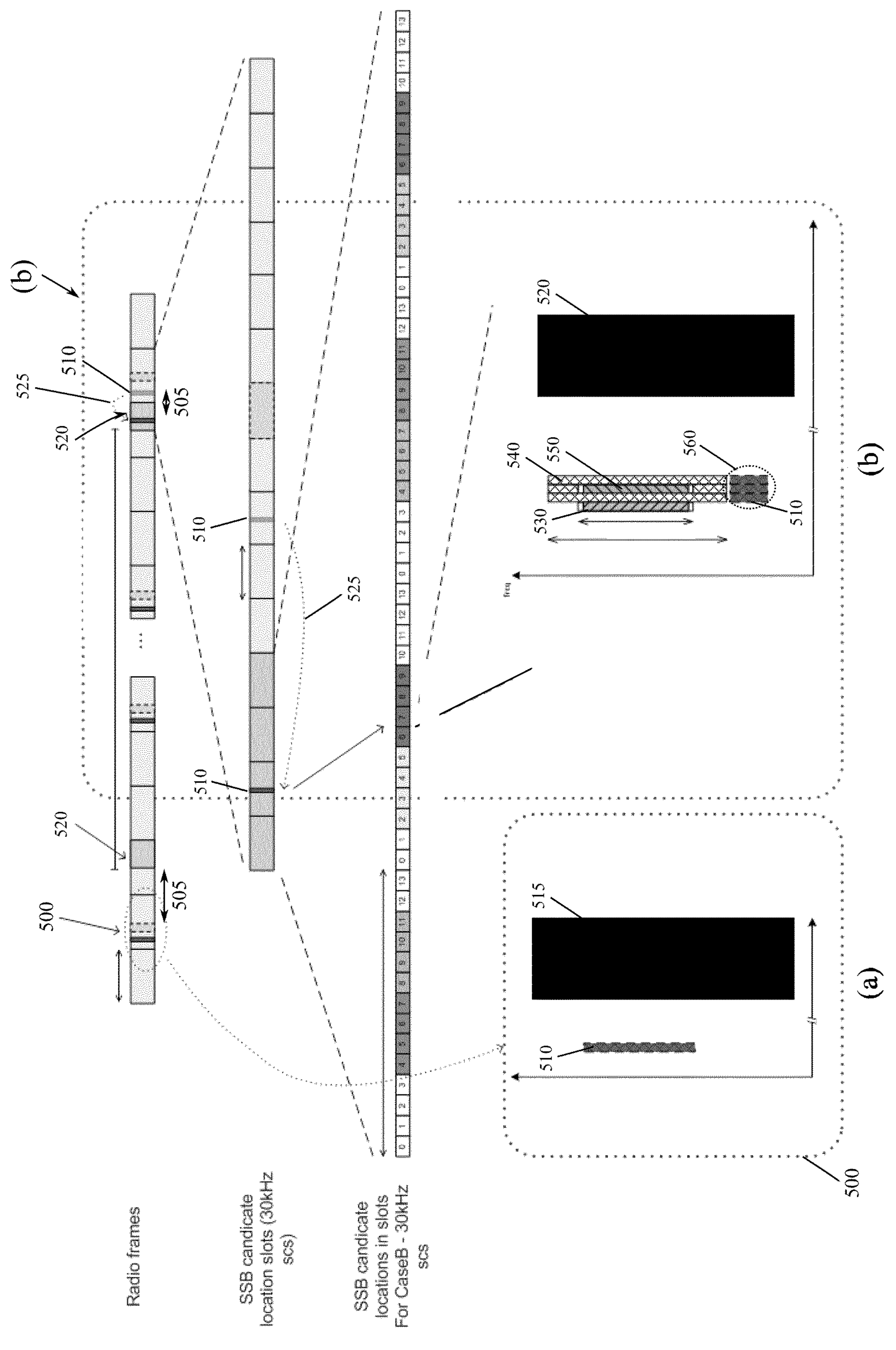
Radio frames
SSB candicate location slots (30kHz scs)
SSB candicate locations in slots For CaseB - 30kHz scs
500
505
510
515
520
525
530
540
550
560
(a)
(b)
freq

FIGURE 5

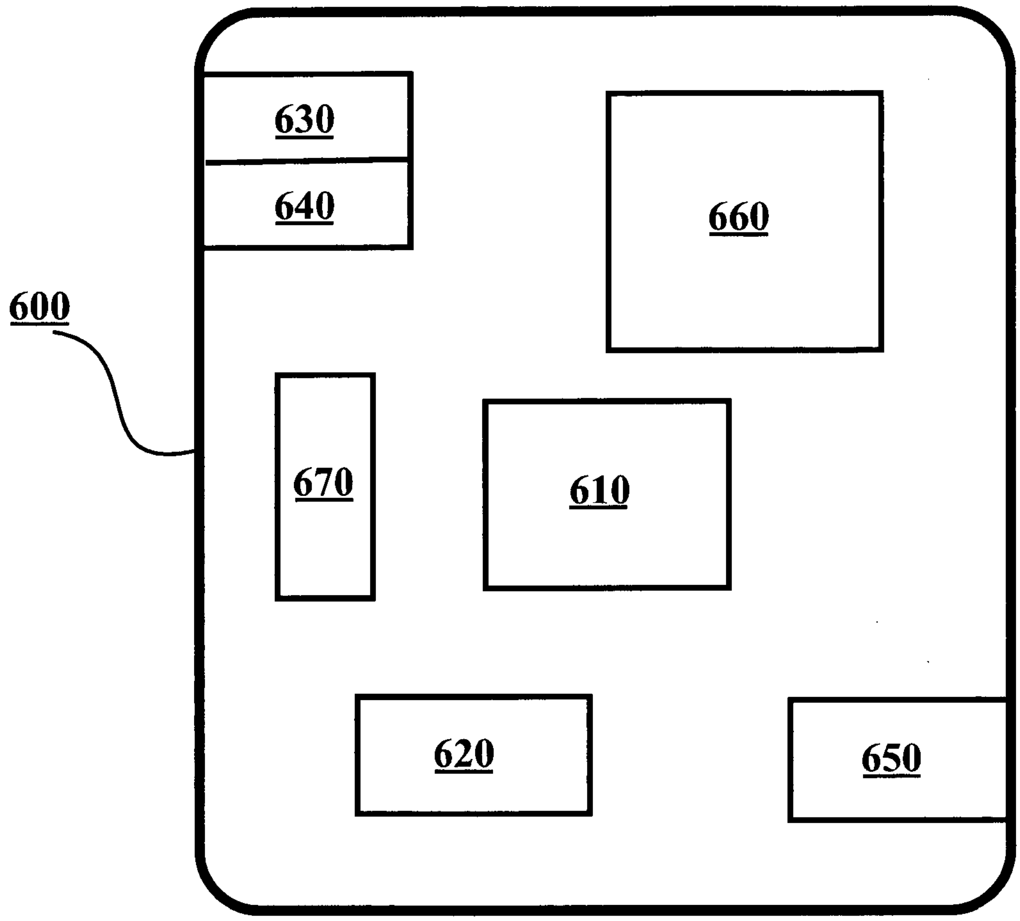

FIGURE 6

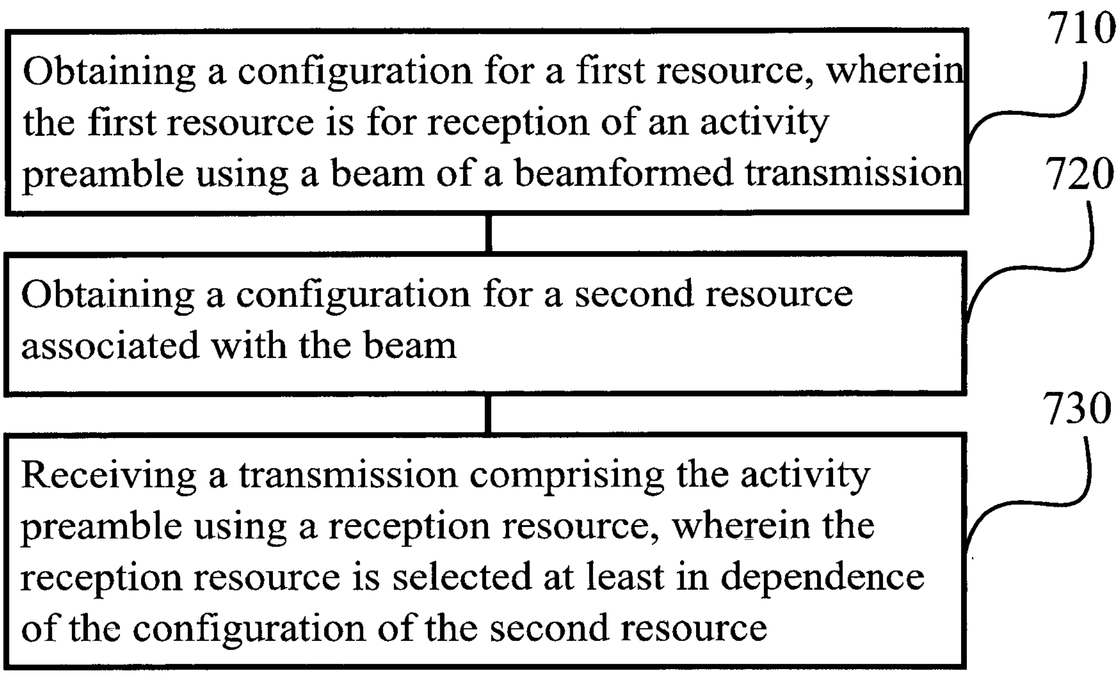
710
Obtaining a configuration for a first resource, wherein the first resource is for reception of an activity preamble using a beam of a beamformed transmission
720
Obtaining a configuration for a second resource associated with the beam
730
Receiving a transmission comprising the activity preamble using a reception resource, wherein the reception resource is selected at least in dependence of the configuration of the second resource

FIGURE 7

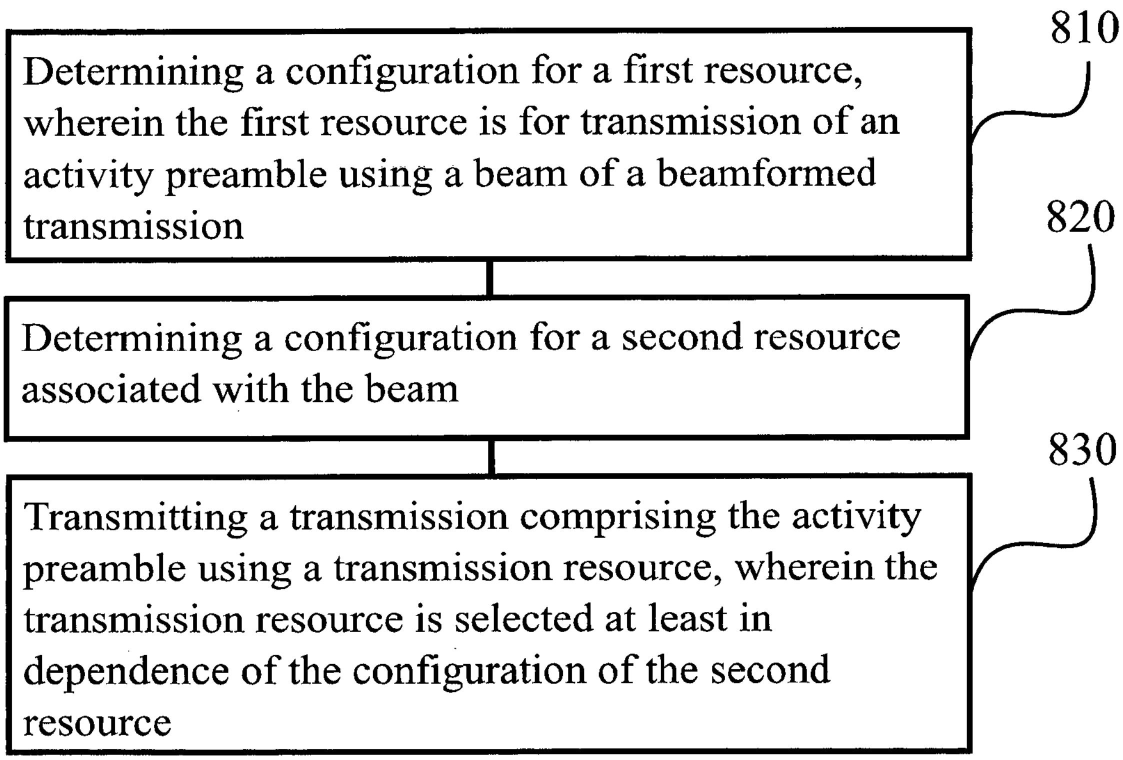
810
Determining a configuration for a first resource, wherein the first resource is for transmission of an activity preamble using a beam of a beamformed transmission
820
Determining a configuration for a second resource associated with the beam
830
Transmitting a transmission comprising the activity preamble using a transmission resource, wherein the transmission resource is selected at least in dependence of the configuration of the second resource

FIGURE 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/076482

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/06 H04L5/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B 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 2018/270756 A1 (BHATTAD KAPIL [IN] ET AL) 20 September 2018 (2018-09-20) abstract paragraphs [0076], [0092], [0105] - [0136] figures 9, 10 -----	1-40

-/--

[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
21 May 2019	07/06/2019

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	Helms, Jochen

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CATT: "Motivation of UE Wakeup Mechanism in NR", 3GPP DRAFT; RP-170410_WUS_MOTIVATION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. TSG RAN, no. Dubrovnik, Croatia; 20170306 - 20170309 5 March 2017 (2017-03-05), XP051233841, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/Docs/ [retrieved on 2017-03-05] pages 2-7 -----	1-40
A	INTEL CORPORATION: "Enhancements to NR DL signals and channels for unlicensed operation", 3GPP DRAFT; R1-1808683_AI7.2.2.3.1 DRS, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Gothenburg, Sweden; 20180820 - 20180824 11 August 2018 (2018-08-11), XP051516058, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg%5Fran/WG1%5FRL1/TSGR1%5F94/Docs/R1%2D1808683%2Ezip [retrieved on 2018-08-11] section 3; pages 6-7 figures 4, 5 -----	1-40

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2018/076482

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2018270756 A1	20-09-2018	TW 201842801 A	01-12-2018
		US 2018270756 A1	20-09-2018