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

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
19 June 2025 (19.06.2025)

WIPO | PCT

(10) **International Publication Number**
WO 2025/123741 A1

(51) **International Patent Classification:**
H04W 52/02 (2009.01)

(21) **International Application Number:**
PCT/CN2024/112837

(22) **International Filing Date:**
16 August 2024 (16.08.2024)

(25) **Filing Language:** English

(26) **Publication Language:** English

(71) **Applicant: ZTE CORPORATION** [CN/CN]; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN).

(72) **Inventors: HU, Youjun**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **CHEN, Mengzhu**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **DAI, Bo**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **LIU, Kun**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **MA, Xiaoying**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN). **GUO, Qiujin**; ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan, Shenzhen, Guangdong 518057 (CN).

(74) **Agent: BEYOND ATTORNEYS AT LAW**; F6, Xijin Centre 39 Lianhuachi East Rd., Haidian District, Beijing 100036 (CN).

(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, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(54) **Title:** METHOD, DEVICE AND COMPUTER PROGRAM PRODUCT FOR WIRELESS COMMUNICATION

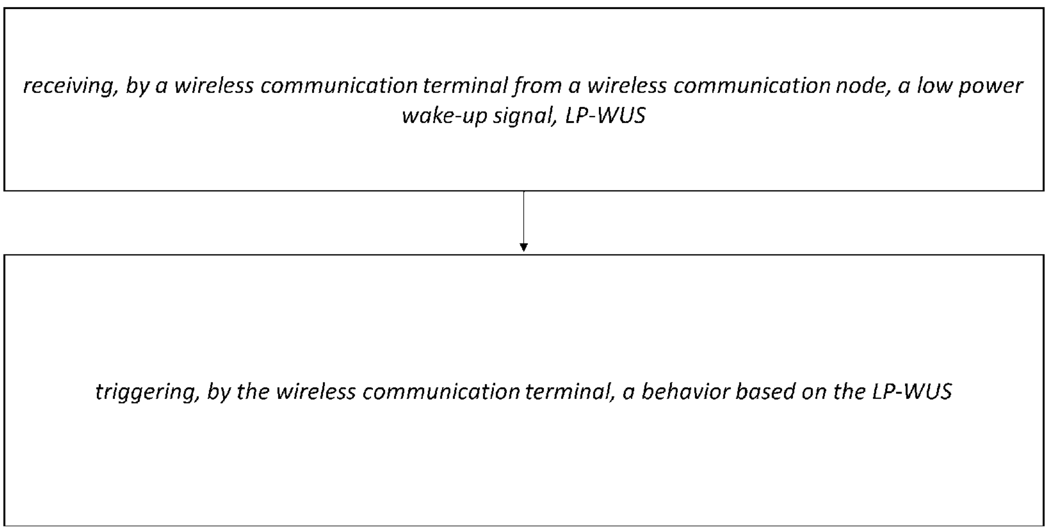

FIG. 15

(57) **Abstract:** A wireless communication method is disclosed. The method comprises receiving, by a wireless communication terminal from a wireless communication node, a low power wake-up signal, LP-WUS; and triggering, by the wireless communication terminal, a behavior based on the LP-WUS, wherein the behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

WO 2025/123741 A1

[Continued on next page]

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, 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, ME, 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))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

— *upon request of the applicant, before the expiration of the time limit referred to in Article 21(2)(a)*

METHOD, DEVICE AND COMPUTER PROGRAM PRODUCT FOR WIRELESS COMMUNICATION

This document is directed generally to wireless communications, and in particular to 5th generation (5G) communications or 6th generation (6G) communications. It is not precluded to be applied in WIFI or other communication systems.

In 5G communication, the Low-Power Wake-Up Signal (LP-WUS) is used for the User Equipment (UE) power saving. However, the application of the LP-WUS is still a topic to be discussed.

This document relates to methods, systems, and computer program products for a wireless communication.

One aspect of the present disclosure relates to a wireless communication method. In an embodiment, the wireless communication method includes: receiving, by a wireless communication terminal from a wireless communication node, a low power wake-up signal, LP-WUS; and triggering, by the wireless communication terminal, a behavior based on the LP-WUS. The behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

Another aspect of the present disclosure relates to a wireless communication method. In an embodiment, the wireless communication method includes: transmitting, by a wireless communication node to a wireless communication terminal, a low power wake-up signal, LP-WUS, to trigger a behavior. The behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

Another aspect of the present disclosure relates to a wireless communication terminal. In an embodiment, the wireless communication terminal includes a communication unit and a processor. The processor is configured for: receiving, via the communication unit from a wireless communication node, a low power wake-up signal, LP-WUS; and triggering a behavior based on the LP-WUS. The behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

Another aspect of the present disclosure relates to a wireless communication node. In an embodiment, the wireless communication node includes a communication unit and a processor. The processor is configured for: transmitting, via the communication unit to a wireless communication terminal, a low power wake-up signal, LP-WUS, to trigger a behavior. The behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

Various embodiments may preferably implement the following features:

Preferably, the LP-WUS indicates one or more subgroups, and the one or more subgroups are indicated based on at least one of:

a configuration comprising at least one of a number of codepoints or bitmap in the LP-WUS, a payload size of the LP-WUS, a length of one codepoint, a maximum number of subgroups per paging occasion, PO, or a number of subgroups for one codepoint;

one or more codepoints indicating the one or more subgroups;

one codepoint with 8 bits or 16 bits indicating one subgroup; or

one or two codepoints with 4bits or 8bits indicating one, two or four subgroups.

Preferably, the one or more codepoints indicating the one or more subgroups comprising:

a first codepoint and a second codepoint after the first codepoint indicates the same subgroup; or

a first codepoint and a second codepoint indicates the different subgroup.

Preferably, the first codepoint and the second codepoint after the first codepoint indicates the same subgroup in response to that an indicated number of subgroups in the LP-WUS is less than a configured number of codepoints.

Preferably, the LP-WUS satisfies at least one of:

the one or more codepoints are increasing or decreasing based on an indicated number of subgroups in LP-WUS; or

a n-th indication indicating a n-th subgroup is based on a (n-1)-th indication indicating a (n-1)-th subgroup.

Preferably, the LP-WUS indicates one or more subgroups, and the one or more subgroups are indicated based on at least one of:

a subgroup indication;

a group indication, wherein a group includes one or more subgroups;

an association indication, wherein the association indication is to determine a corresponding group for a subgroup indication; or

a configuration indicating a maximum number of subgroups based on at least one PO, a number of groups based on at least one PO, a number of subgroups per group, a number of bits for a group bitmap, a codepoint length or size, and/or a payload size of the LP-WUS.

Preferably, the group indication comprises at least one of:

a 4-bits or 8-bits group indication;

a group indication with a bitmap; or

a group indication with a 4-bits or 8-bits bitmap.

Preferably, the subgroup indication comprises at least one of:

a 2-bit, 3-bits, 4-bits, 5-bits, 6-bits or 8-bits subgroup indication;

a subgroup indication based on an index; or

a subgroup indication based on at least one group and/or at least one PO.

Preferably, a number of subgroups indicated by the LP-WUS is {1,8}, {1,16},{1,2,7,8}, {1,2,16,16},{1,2,3,4,8},{1,2,3,14,15,16} or the number of subgroups indicated by the LP-WUS comprises at least one of {1,2,3,4,5,6,7,8, 12,13,14,15, 16}.

Preferably, the LP-WUS indicates one or more subgroups based on an indication state of the LP-WUS.

Preferably, the indication state is determined based on at least one of:

a maximum number of subgroups per PO;

a number of subgroups;

an offset;

a subgroup index; or

a predetermined value or a predetermined value based on a number of subgroups.

Preferably, the LP-WUS indicate all subgroups.

Preferably, the all subgroups comprises at least one of:

all subgroups in a group;

all subgroups for at least one PO or PF;

all subgroups based on a LP-WUS occasion or a LP-WUS monitoring occasion, wherein the LP-WUS occasion includes one or more monitoring occasions;

all subgroups in a paging cycle; or

all subgroups for at least one cell, at least one cell group, at least one DRX group, at least one frequency range.

Preferably, the LP-WUS indicates the all subgroups in response to at least one of:

the LP-WUS comprises a pre-determined indication; or

the LP-WUS is monitored or received at a location.

Preferably, the pre-determined indication comprises at least one of:

a bitmap with a pre-determined value;

an indication state with a pre-determined value; or

an indication state with one or more predetermined sequences.

Preferably, the location is determined by at least one of:

a preamble before the LP-WUS,

a periodicity,

an offset, or

a LP-WUS occasion index or LP-WUS monitoring occasion index.

Preferably, the LP-WUS satisfies at least one of:

the LP-WUS is configured based on one or more group of cells, one or more frequency ranges, or one or more Discontinuous Reception, DRX, groups;

the LP-WUS triggers one or more terminals in one or more DRX groups to start a timer or monitor a control channel;

the LP-WUS triggers one or more terminals in one or more cell groups, one or more cells, or one or more frequency ranges to start a timer or monitoring a control channel;

the LP-WUS triggers terminals in all cell groups, all cells, or all DRX groups to start a first timer or monitoring a first control channel; or

the LP-WUS triggers terminals in one or more cell groups, one or more cells, or one or more DRX groups to start a second timer or monitoring a second control channel.

Preferably, the LP-WUS satisfies at least one of:

1 bit in the LP-WUS triggers the behavior for a first DRX group and second DXR group;

2 bits in the LP-WUS trigger the behavior for the first DRX group and second DXR group;

1 bit in the LP-WUS triggers the behavior for the cells in first frequency range and cells in second frequency range;

2 bits in the LP-WUS trigger the behavior for the cells in first frequency range and cells in second frequency range;

1 bit in the LP-WUS triggers the behavior for the first group of cells and second group of cells;

2 bits in the LP-WUS trigger the behavior for the first group of cells and second group of cells;

X bits with a bitmap in the LP-WUS trigger the behavior for X DRX groups, X frequency ranges, or X groups of cells, wherein X is a positive integer;

a number of bits in the LP-WUS to trigger the behavior is based on the number of DRX groups or frequency ranges, or groups of cells; or

a number of bits in the LP-WUS to trigger the behavior is based on a specific DRX group, frequency range, group of cells.

Preferably, in response to that the LP-WUS is preceded with a preamble, the preamble satisfies at least one of:

an OOK parameter of the preamble is equal to or larger than an OOK parameter of the LP-WUS;

an OOK symbol length of the preamble is less than an OOK symbol length of the LP-WUS;

the preamble indicates a number of codepoints indicated by the LP-WUS;

the preamble indicates a number of subgroups indicated by the LP-WUS;

the preamble indicates a LP-WUS indication is based on a bitmap or a codepoint;

the preamble comprises at least one binary or OFDM sequence;

the preamble comprises at least one binary or OFDM sequence wherein the at least one binary or OFDM sequence is the same as a low power synchronization signal, LP-SS or is a subset of sequences comprised by a LP-SS; or

the preamble indicates a method of paging monitoring;

wherein the OOK parameter is used to determine a number of OOK symbols in an OFDM symbol, or the OOK symbol length.

Preferably, in response to that OFDM sequences overlaid on an OOK symbol of the LP-WUS, the OFDM sequences is determined by at least one parameter.

Preferably, the at least one parameter comprises at least one of a OOK parameter, a Subcarrier Spacing, SCS, a beam index, a LP-WUS occasion index, or a LP-WUS monitoring occasion index, a repetition number, a slot index, a PO index, a PF index, or a system frame number, SFN.

Preferably, the OFDM sequences satisfy at least one of:

a length of the OFDM sequences is determined by the at least one parameter;

a root index of the OFDM sequences is determined by the at least one parameter;

a cyclic shift of the OFDM sequences is determined by the at least one parameter; or

a format of the OFDM sequences is determined by the at least one parameter.

Preferably, the LP-WUS satisfies at least one of:

the LP-WUS has a Quasi-Co-Location, QCL, relationship with at least one of a Synchronization Signal/Physical Broadcast Channel Block, SSB, a Cell-Defining Synchronization Signal/Physical Broadcast Channel Block, CD-SSB, a Tracking Reference Signal, TRS, a Non-Cell-Defining Synchronization Signal/Physical Broadcast Channel Block, NCD-SSB, or a channel status information reference signal, CSI-RS, a low power synchronization signal, LP-SS; or

the TCI state of LP-WUS is determined by at least one of a LP-WUS occasion index, a LP-WUS monitoring occasion index, a Control Resource Set, CORESET, ID, a Search space ID, a bandwidth part, BWP, ID, or a Cell ID.

Preferably, the LP-WUS has a QCL relationship with at least one of CD-SSB, TRS, NCD-SSB, CSI-RS with type C or type D, and/or

wherein the LP-WUS has a QCL relationship with an LP-SS with type A or type B.

Preferably, a Transmission Configuration Indication, TCI, state of the LP-WUS is determined by at least one of a Medium Access Control Control Element, MAC CE, Radio Resource Control, RRC signaling, or Downlink Control Information, DCI.

The present disclosure relates to a computer program product comprising a computer-readable program medium code stored thereupon, the code, when executed by a processor, causing the processor to implement a wireless communication method recited in any one of foregoing methods.

The exemplary embodiments disclosed herein are directed to providing features that will become readily apparent by reference to the following description when taken in conjunction with the accompanying drawings. In accordance with various embodiments, exemplary systems, methods, devices and computer program products are disclosed herein. It is understood, however, that these embodiments are presented by way of example and not limitation, and it will be apparent to those of ordinary skill in the art who read the present disclosure that various modifications to the disclosed embodiments can be made while remaining within the scope of the present disclosure.

Thus, the present disclosure is not limited to the exemplary embodiments and applications described and illustrated herein. Additionally, the specific order and/or hierarchy of steps or operations in the methods disclosed herein are merely exemplary approaches. Based upon design preferences, the specific order or hierarchy of steps or operations of the disclosed methods or processes can be re-arranged while remaining within the scope of the present disclosure. Thus, those of ordinary skill in the art will understand that the methods and techniques disclosed herein present various steps or operations in a sample order, and the present disclosure is not limited to the specific order or hierarchy presented unless expressly stated otherwise.

The above and other aspects and their implementations are described in greater detail in the drawings, the descriptions, and the claims.

FIG. 1 shows a schematic diagram of a wake-up operation according to an embodiment of the present disclosure.

FIG. 2 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 3 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 4 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 5 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 6 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 7 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 8 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 9 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 10 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 11 shows a schematic diagram of a LP-WUS according to an embodiment of the present disclosure.

FIG. 12 shows a schematic diagram of a LP-WUS occasion according to an embodiment of the present disclosure.

FIG. 13 shows an example of a schematic diagram of a wireless communication terminal according to an embodiment of the present disclosure.

FIG. 14 shows an example of a schematic diagram of a wireless communication node according to an embodiment of the present disclosure.

FIG. 15 and FIG. 16 show flowcharts of wireless communication methods according to some embodiments of the present disclosure.

Some embodiments of the present disclosure, when UEs are in the idle mode or the connected mode, the LP-WUS could be used to indicate one or more subgroups of UEs per Paging Occasion (PO) to wake-up and/or monitor Physical downlink control channel (PDCCH), e.g., paging PDCCH. Some embodiments of the present disclosure, a LP-WUS indication method to indicate the subgroup(s) may be introduced. In some embodiments of the present disclosure, how to wake-up UEs in connected mode may also be considered.

FIG. 1 shows a schematic diagram of waking up according to an embodiment of the present disclosure. In FIG. 1, when receiving a LP-WUS from a base station (BS) or gNB (gNodeB), the UE may wake up. For example, the receiver of the UE may wake up.

In some embodiments, a method is provided. The method includes: receiving (include monitoring), by a wireless communication terminal (e.g., a UE) from a wireless communication node (e.g., a BS or gNB), a low power wake-up signal, LP-WUS; and triggering, by the wireless communication terminal, a behavior (e.g., a UE behavior) based on the LP-WUS.

In some embodiments, another method is provided. The method includes: transmitting, by a wireless communication node (e.g., a BS or gNB) to a wireless communication terminal (e.g., a UE), a low power wake-up signal, LP-WUS, to trigger a behavior (e.g., a UE behavior).

In some embodiments, the behavior comprises at least one of the wireless communication terminal waking up, or the wireless communication terminal monitoring a control channel (e.g., PDCCH (physical downlink control channel)) or the wireless communication terminal starting a timer.

In some embodiments, the timer comprises a first timer and a second timer, wherein the first timer is based on C-DRX duration-on timer, the second timer is based on LP-WUS triggered PDCCH monitoring based timer.

In some embodiments, the UE behavior comprises measurement. The LP-WUS could be used to trigger the measurement based on LP-SS, PSS, SSS or SSB. The LP-WUS could be used to trigger the measurement based on a first timer or a second timer.

In some embodiments, the LP-WUS indicates, for example, one or more cells of UEs, one or more groups of UEs, one or more subgroups of UEs, or one or more UEs to perform said behavior, which may be referred to as the indication, indicating, or triggering based on the LP-WUS or by the LP-WUS in the present disclosure. The one or more cells of UEs, one or more groups of UEs, one or more subgroups of UEs, or one or more UEs indicated by the LP-WUS may be referred to as the indicated or triggered cell(s), group(s), subgroup(s), or UE(s) in the present disclosure.

In the paragraphs below, some aspects of the present disclosure are provided, but the present disclosure is not limited thereto. Besides, embodiments in different aspects described below can be combined or cross-referenced unless expressly stated otherwise.

Aspect 0:

In some embodiments, the QCL information of the LP-WUS may be determined based on at least one of: a cell, a BWP ID, a corresponding reference signal, and/or a QCL type.

An example is provided below.

```
QCL-Info ::=                    SEQUENCE {
    cell                            ServCellIndex                                OPTIONAL,
-- Need R
    bwp-Id                          BWP-Id                                       OPTIONAL,
-- Cond CSI-RS-Indicated
    referenceSignal                 CHOICE {
        csi-rs                          NZP-CSI-RS-ResourceId,
        ssb                             SSB-Index
    },
    qcl-Type                        ENUMERATED {typeA, typeB, typeC, typeD},
    ...
}
```

Aspect 1:

In some embodiments, the LP-WUS indicates one or more subgroups of UEs to perform said behavior, and the one or more subgroups are indicated based on at least one of:

a configuration comprising at least one of a number of codepoints or bitmap in the LP-WUS, a payload size of the LP-WUS, a length of one codepoint, a maximum number of subgroups per paging occasion, PO, or a number of subgroups for one codepoint;

one or more codepoints indicating the one or more subgroups;

one codepoint with 8 bits or 16 bits indicating one subgroup; and/or

one or two codepoints with 4bits or 8bits indicating one, two or four subgroups.

In some embodiments, the codepoint could be an index, ID or a value. It is an indication state via the LP-WUS. For example, if the LP-WUS has 8 bits, '00000000' or '11111111' indicated via the LP-WUS is a codepoint.

In some embodiments, the LP-WUS may indicate one or more subgroups by the codepoint.

In some embodiments, at least one of the following information may be configured or preconfigured:

indication 1: number of codepoints, or bitmap, or payload size;

indication 2: maximum number of subgroups per PO, or length of one codepoint (e.g., the number of candidate subgroups to be indicated in each PO; when the maximum number of subgroups is 16 per PO, the LP-WUS may indicate one or more subgroups among the 16 subgroups);

indication 3: each codepoint corresponds to X subgroups, X>=1; and/or

indication 4: CRC bits, it could be pre-configured or pre-determined.

For example, assume one codepoint indicates one subgroup. In some embodiments, if the maximum number of subgroups per PO is 16, the length of one codepoint needs 4 bits to indicate one subgroup. In some embodiments, if the number of codepoints is 2, the LP-WUS has 8 bits payload, it can be used to indicate 2 subgroups, as shown in FIG. 2.

FIG. 2 shows a schematic diagram of the LP-WUS according to an embodiment of the present disclosure. In some embodiments, the LP-WUS including two codepoints indicates two of the subgroups from 16 subgroups.

As another example, assume one codepoint indicates two subgroups (e.g., X=2), if the maximum number of subgroups per PO is 16, the length of one codepoint may be 3 bits to indicate bundled two subgroups.

In some embodiments, the one or more codepoints indicating the one or more subgroups comprising: a first codepoint and a second codepoint after the first codepoint indicates the same subgroup; and/or a first codepoint and a second codepoint indicates the different subgroup.

In some embodiments, the first codepoint and the second codepoint after the first codepoint indicates the same subgroup in response to that an indicated number of subgroups in the LP-WUS (e.g., the number of subgroups indicated by the LP-WUS) is less than a configured number of codepoints (e.g., a maximum number of subgroups per PO may be indicated by the LP-WUS).

In some embodiments, if the indicated number of subgroups (e.g., the number of subgroups indicated by the LP-WUS) is less than the configured number of codepoints (or subgroups) (e.g., a maximum number of subgroups per PO may be indicated by the LP-WUS), the later codepoint may the same as the previous codepoint.

In some embodiments, the n-th codepoint is the same as i-th codepoint, 0<= i<n.

In some embodiments, the n-th codepoint is the same as (n-1)-th codepoint.

In some embodiments, the n-th codepoint is the same as the first codepoint (e.g., the first codepoint in the LP-WUS in position).

In some embodiments, to achieve more efficient indication, the following may also be considered based on codepoints.

In some embodiments, the LP-WUS satisfies at least one of:

the one or more codepoints are increasing or decreasing based on an indicated number of subgroups in LP-WUS (e.g., a codepoint could be an index, a ID or a value); and/or

a n-th indication indicating a n-th subgroup is based on a (n-1)-th indication indicating a (n-1)-th subgroup.

In some embodiments, at least one of the following rules is satisfied:

the indicated subgroup index is increasing or decreasing, e.g., 0, 4, 9; and/or

the n-th codepoint indication is based on the (n-1)-th codepoint indication, e.g., the subgroup 9=4+5, in which the (n-1)-th codepoint indicates 4, and the n-th codepoint indicates 5 and the indicated subgroup index is 4+5=9. In some embodiments, the last codepoint indication may be based on the last second codepoint indication.

Aspect 2:

In some embodiments, the LP-WUS indicates one or more subgroups to perform said behavior (e.g., wake up), and the one or more subgroups are indicated based on at least one of:

a subgroup indication;

a group indication, wherein a group includes one or more subgroups;

an association indication, wherein the association indication is to determine a corresponding group for a subgroup indication; and/or

a configuration indicating a maximum number of subgroups based on at least one PO, a number of groups based on at least one PO, a number of subgroups per group, a number of bits for a group bitmap, a codepoint length or size, and/or a payload size of the LP-WUS.

In some embodiments, the configuration includes the SIB (System Information Block) configuration, RRC configuration, or a pre-configuration.

In some embodiments, at least one of the following information may be configured or preconfigured:

the maximum number of subgroups per PO for the LP-WUS;

the number of groups, or the number of subgroups per group, the number of bits for group bitmap;

the codepoint length/size, the LP-WUS payload size; and/or

the corresponding group for the codepoint.

In some embodiments, the subgroup indication comprises at least one of:

a 2-bit, 3-bits, 4-bits, 5-bits, 6-bits or 8-bits subgroup indication;

a subgroup indication based on an index; and/or

a subgroup indication based on at least one group and/or at least one.

Some examples with specific numbers of subgroups per PO are provided.

256 subgroups:

In some embodiments, for 256 subgroups per PO, the number of subgroups per group is 64, the codepoint length is 6 bits to indicate one subgroup in a group.

In some embodiments, the codepoint length is 6 bits to indicate one subgroup in a group, wherein the group could be configured or predetermined, e.g., configured by the high layer. In some embodiments, the group could be predetermined as the first group or second group.

FIG. 3 shows a schematic diagram of the LP-WUS according to an embodiment of the present disclosure. In FIG. 3, the group bitmap with 4 bits indicates the group, and the two subgroup indication (each has 6 bits) indicate two subgroups in different groups indicated by the group bitmap.

In some embodiments, for 256 subgroups per PO, the number of subgroups per group is 32, and the codepoint length is 5 bits to indicate one subgroup in a group. In some embodiments, if the LP-WUS payload size is 16 bits, the LP-WUS payload may include 8 bits for group bitmap, 5 bits for indicating one subgroup in a group, and 3 bits for indicating a group corresponding to the indicated subgroup (see FIG. 4). In some embodiments, the order of the information in the LP-WUS payload may be changed.

In some embodiments, for 256 subgroups per PO, the number of subgroups per group is 16, and the codepoint length is 0 bits to indicate one subgroup in a group. In some embodiments, if the LP-WUS payload size is 16 bits, the LP-WUS payload may include a 16 bits group bitmap. In some embodiments, all subgroup in the indicated group may be indicated to perform said behavior.

128 subgroups:

In some embodiments, for 128 subgroups per PO, the number of subgroups per group is

16 and number of groups is 8, the codepoint length is 4 bits to indicate one subgroup in a group.

In some embodiments, for 128 subgroups per PO, the number of groups is 16, each bit indicates whether to wake up the subgroups in this group or not.

64 subgroups:

In some embodiments, for 64 subgroups per PO, the number of subgroups per group is 16 and the number of groups is 4, the codepoint length is 4 bits to indicate one subgroup in a group. In some embodiments, a 16 bits LP-WUS payload includes 4 bits for the group bitmap and three 4 bits indications (e.g., each for indicating a subgroup in one group).

In some embodiments, the number of groups is 16, and each group includes 4 subgroups. In some embodiments, 16 bits in the LP-WUS may be a bitmap to indicate the groups. In some embodiments, all subgroups in the indicated groups are indicated to perform said behavior.

32 subgroups:

In some embodiments, the number of groups is 16, and each group includes 2 subgroups. In some embodiments, 16 bits in the LP-WUS may be a bitmap to indicate the groups. In some embodiments, all subgroups in the indicated groups are indicated to perform said behavior.

In some embodiments, the number of groups is 8, and each group includes 4 subgroups. In some embodiments, 8 bits in the LP-WUS may be as bitmap to indicate the groups. In some embodiments, 4 codepoints with 2 bits (8 bits in total) may be used to indicate the subgroups in a group (see FIG. 5).

In some embodiments, the number of groups is 4, and each group includes 8 subgroups. In some embodiments, 4 bits in the LP-WUS may be as bitmap to indicate the groups. In some embodiments, 4 codepoints with 3 bits (12 bits in total) may be used to indicate the subgroups in a group.

FIG. 6 shows a schematic diagram of the LP-WUS according to an embodiment of the present disclosure. In some embodiments, 4 bits in the LP-WUS may be as bitmap to indicate the groups. In some embodiments, 3 codepoints with 4 bits (12 bits in total) may be used to indicate the subgroups in the same or different groups.

Aspect 3:

In some embodiments, a number of subgroups indicated by the LP-WUS is {1,8}, {1,16},{1,2,7,8}, {1,2,16,16},{1,2,3,4,8},{1,2,3,14,15,16} or the number of subgroups indicated by the LP-WUS comprises at least one of {1,2,3,4,5,6,7,8, 12,13,14,15, 16}.

In some embodiments, the LP-WUS indicates one or more subgroups to perform said behavior (e.g., wake up) based on an indication state (also referred to as “state” in present disclosure) of the LP-WUS. In some embodiments, the indication state of the LP-WUS comprises a binary value, decimal value, a codepoint, an index, and/or a ID. Different states correspond to different indications or different subgroups. Some examples are provided below.

One subgroup indication:

In some embodiments, if the maximum number of subgroups per PO (or in at least one PO) is configured as 8, 8 states in the LP-WUS is needed for indicating the subgroup index. In some embodiments, if the maximum number of subgroups per PO (or in at least one PO) is configured as 16/32/64/128/256, the 16/32/64/128/256 states in the LP-WUS is needed for indicating the subgroup index.

In some embodiments, a N (N is a positive integer) bits state in the LP-WUS may indicates the subgroup. For example:

In some embodiments, for configured 8 subgroups, the state may be one of: 000, 001,010,011,100,101,110,111.

In some embodiments, for configured 16 subgroups, the state may be one of: 0000,0001,0010,0011,0100,0101,0110,0111,1000,1001,1010,1011,1100,1101,1110,1111.

In some embodiments, based on 3 bits indication states 000,001,010,011,100,101,110,111, more states with N bits may be constructed. For example, when N=4 bits is used, based on 000,001,010,011,100,101,110,111, it only needs to add ‘1’ or ‘0’ before the 8 indication states, then 16 indication states for 4bits can be obtained.

Two subgroups indication:

In some embodiments, if the maximum number of subgroups per PO (or in at least one PO) is configured as 8/16/32/64/128/256, two subgroups indication requires 28/120/496/2016/8128/32640 states (e.g., 8/16/32/64/128/256 choose 2). In some embodiments, the

LP-WUS can comprise these states in an indication state.

In some embodiments, the indication state is determined based on at least one of:

a maximum number of subgroups per PO;

a number of subgroups;

an offset;

a subgroup index; and/or

a predetermined value or a predetermined value based on number of subgroups.

In some embodiments, a method to indicate these states is:

index *r* is defined based on $\sum_{i=0}^{N_{subgroup}-1} \left\langle \begin{matrix} N_{Maxsubgroup} - s_i \\ N_{subgroup} - i \end{matrix} \right\rangle + offset$;

$N_{Maxsubgroup}$ means the maximum number of subgroups per PO (or in at least one PO);

$N_{subgroup}$ means the indicated number of subgroups for wake-up;

the set $\{s_i\}_{i=0}^{N_{subgroup}-1}, (1 \le s_i \le N_{Maxsubgroup}, s_i < s_{i+1})$ contains the sorted subgroup index or contains the sorted index based on subgroup index; and/or

$\left\langle \begin{matrix} x \\ y \end{matrix} \right\rangle = \begin{cases} \binom{x}{y} & x \ge y \\ 0 & x < y \end{cases}$ is the extended binomial coefficient.

The offset could be determined based on a predetermined value or could be a value based on the number of subgroups indicated by the LP-WUS.

In some embodiments, the index *r* is contained/indicated in the LP-WUS for one or two subgroups or more subgroups.

In some embodiments, the index *r* indicated in the LP-WUS is determined by at least one of the maximum number of subgroups per PO, the indicated number of subgroups, the offset, and/or the subgroup index.

In some embodiments, the number of subgroups indicated in the LP-WUS to perform said behavior includes at least one of $\{1,2,3,4,8,16,32,64,128,256\}$.

In FIG. 7, the subgroup indexes indication is based on the maximum number of subgroups per PO (or in at least one PO). For example, 3 bits subgroup index indication may be used to indicate a subgroup index among 8 subgroups, and 4 bits subgroup index indication may be used to indicate a subgroup index among 16 subgroups.

In FIG. 8, the subgroup index indication is based on the number of indicated subgroups in LP-WUS. For example, a 3 bits subgroup index indication may be used to indicate one subgroup, and a 4 bits subgroup index indication may be used to indicate two subgroups.

Aspect 4:

In some embodiments, implementation examples are provided for 8 subgroups or 16 subgroups configured. In some embodiments, when the LP-WUS consists at least 8 or 16 bits, the subgrouping indication method could be:

indicating all the subgroups (type 1);

indicating one of the subgroups (type 2); or

indicating two of the subgroups for 8 subgroups (type 3).

type 1: indicating one to all the subgroups

In some embodiments, if the subgrouping indication method is indicating up to all the subgroups, a bitmap with 8 or 16 bits may be used. In some embodiments, each bit corresponding to each subgroup according to the ascending/descending order based on the configuration. In some embodiments, when using bitmap, 8 bit Cyclic Redundancy Check (CRC) is attached to the LP-WUS.

type 2: indicating one of the subgroups

In some embodiments, if the subgrouping indication method is indicating one of the subgroups, at least one of the following applies:

a sequence is used for indicating one subgroup; and/or

a sequence with a ON-OFF pattern is used for indicating one subgroup.

The following table can be used for indicating one subgroup based on maximum 8 subgroups per PO (or in at least one PO).

Sequences selection	Subgroup with index
Sequence1	0
Sequence2	1
Sequence3	2
Sequence4	3

Sequence5	4
Sequence6	5
Sequence7	6
Sequence8	7

In some embodiments, if the maximum 16 subgroups per PO (or in at least one PO) are used, 16 sequences may be needed.

In some embodiments, the ON-OFF pattern means the sequence consists only 0 and 1, or -1 and 1. In some embodiments, the ON-OFF pattern consist OOK ON symbols or OOK OFF symbols.

In some embodiments, for maximum 8 subgroups per PO (or in at least one PO), at least one of the sequences in the LP-WUS may be:

10101010, 01010101, 11001100,10011001,00110011,01100110, 11010010,00101101, wherein the sequences are before the Manchester coding.

Method 3: indicating two of the subgroups at most for maximum 8 subgroups

In some embodiments, the LP-WUS may indicate two of the subgroups for maximum 8 subgroups per PO (or in at least one PO).

FIG. 9 shows a schematic diagram of the LP-WUS according to an embodiment of the present disclosure. In FIG. 9, 8 subgroups are divided into 2 groups. The first bit(s) (one or more bits) indicate a first group, and the second bit(s) (one or more bits) indicate a second group.

In FIG. 9, the first two bits are bitmap, each bit corresponds to one group, and each group consists of 4 subgroups.

In FIG. 9, the third bit and forth bit indicate one of subgroups 0~3 in the first group, and the fifth bit and sixth bit indicate one of the subgroups 4~7 in the second group.

FIG. 10 shows a schematic diagram of the LP-WUS according to an embodiment of the present disclosure. In FIG. 10, the first bits (e.g., one or more bits) may indicate one of the 8 subgroups, the second bits (e.g., one or more bits) may indicate one of the 8 subgroups.

FIG. 11 shows a schematic diagram of the LP-WUS according to an embodiment of the present disclosure. In FIG. 11, the first bits (e.g., one or more bits) may indicate one of the 16 subgroups, the second bits (e.g., one or more bits) may indicate one of the 16 subgroups.

In some embodiments, the first indicated subgroup is the same as or different from the second indicated subgroup. If only one subgroup is indicated by the LP-WUS, the first bits and the second bits indicate the same.

Aspect 5:

In some embodiments, the LP-WUS indicates all subgroups to perform said behavior (e.g., wake up).

In some embodiments, the all subgroups comprises at least one of:

all subgroups in a group;

all subgroups for at least one PO or PF (paging frame);

all subgroups based on a LP-WUS occasion or a LP-WUS monitoring occasion, wherein the LP-WUS occasion includes one or more monitoring occasions;

all subgroups in a paging cycle; and/or

all subgroups for at least one cell, at least one cell group, at least one DRX group, at least one frequency range.

In some embodiments, the LP-WUS indicates the all subgroups in response to at least one of:

the LP-WUS comprises a pre-determined indication; and/or

the LP-WUS is monitored or received at a location.

In some embodiments, the pre-determined indication comprises at least one of:

a bitmap with a pre-determined value;

an indication state with a pre-determined value; and/or

an indication state with one or more predetermined sequences.

In some embodiments, the location is determined by at least one of:

a preamble before the LP-WUS,

a periodicity,

an offset, and/or

a LP-WUS occasion index or LP-WUS monitoring occasion index.

In some embodiments, the LP-WUS is used to indicate all the subgroups. In some embodiments, when the LP-WUS uses a bitmap to indicate groups and/or subgroups, all ‘0’s or all

'1's may be used to indicate all the subgroups.

In some embodiments, one state in the LP-WUS may be used to indicate all subgroups, e.g., use all '0' or all '1' to indicate all the subgroups.

In some embodiments, the state in the LP-WUS to indicate all subgroup could be based on same sequences, e.g., [S1, S1, S1, S1...], wherein the state in the LP-WUS N (N is a positive sequence) S1 and S1 is a sequence. In some embodiments, the sequence could be binary sequence, ZC (Zadoff Chu) sequence, m sequence, gold sequence and so on.

In some embodiments, the state in the LP-WUS to indicate all subgroups could be based on a specific sequence, e.g., ZC sequence with a root index or a cyclic shift.

In some embodiments, the state in the LP-WUS to indicate all subgroups could be based on a value. In some embodiments, the LP-WUS state could be a Decimal or binary value.

In some embodiments, the location may be used to determine the LP-WUS indicating all subgroups. In some embodiments, the location comprises occasions. For example, the LP-WUS is monitored or received in some occasions, wherein the occasions are determined by a periodicity and an offset.

In some embodiments, there are two locations for the LP-WUS, i.e., the first location and the second location. In some embodiments, the LP-WUS at the second location may indicate all subgroups. In some embodiments, the LP-WUS at the second location may not indicate all subgroups.

In some embodiments, the location is determined by periodicity, offset, and/or the LP-WUS occasion index.

In some embodiments, the LP-WUS may be configured with the first periodicity and the second periodicity. In some embodiments, based on the second periodicity, the LP-WUS may indicate all subgroups.

In some embodiments, the first periodicity and the second periodicity are multiples of each other.

In some embodiments, the specific LO (LP-WUS occasion) in an SFN/a time duration/a paging cycle for the LP-WUS may indicate all subgroups.

In some embodiments, the first/second/last/ i-th LO in an SFN/a time duration/a paging cycle may indicate all subgroups.

Aspect 6:

In some embodiments, the LP-WUS may indicate the UE performs said behavior (e.g., monitor PDCCH or start a timer) in the connected mode.

In some embodiments, the UE is configured with an index, RNTI (Cell Radio Network Temporary Identifier), or an identity. In some embodiments, the LP-WUS may indicate the index, RNTI, or the identity.

In some embodiments, the LP-WUS is configured with a bitmap, and each bit corresponds to one or more UEs.

In some embodiments, the LP-WUS is configured with bit blocks, and each bit block corresponds to one or more UEs, where the starting position of a block is determined by the high layer parameter. For example, each bit block could comprise several bits, and each bit block is used to indicate the UE behavior triggering for the UEs in one or more cells, one or more cell groups, one or two DRX groups.

In some embodiments, the LP-WUS satisfies at least one of:

the LP-WUS is configured based on one or more group of cells, one or more frequency ranges, or one or more Discontinuous Reception, DRX, groups;

the LP-WUS triggers one or more terminals (e.g., UEs) in one or more DRX groups to start a timer or monitor a control channel;

the LP-WUS triggers one or more terminals in one or more cell groups, one or more cells, or one or more frequency ranges to start a timer or monitoring a control channel;

the LP-WUS triggers terminals in all cell groups, all cells, or all DRX groups to start a first timer or monitoring a first control channel; and/or

the LP-WUS triggers terminals in one or more cell groups, one or more cells, or one or more DRX groups to start a second timer or monitoring a second control channel.

In some embodiments, the LP-WUS satisfies at least one of:

1 bit in the LP-WUS triggers the behavior for a first DRX group and second DXR group;

2 bits in the LP-WUS trigger the behavior for the first DRX group and second DXR group;

1 bit in the LP-WUS triggers the behavior for the cells in first frequency range and cells in second frequency range;

2 bits in the LP-WUS trigger the behavior for the cells in first frequency range and cells

in second frequency range;

1 bit in the LP-WUS triggers the behavior for the first group of cells and second group of cells;

2 bits in the LP-WUS trigger the behavior for the first group of cells and second group of cells;

X bits with a bitmap in the LP-WUS trigger the behavior for X DRX groups, X frequency ranges, or X groups of cells, wherein X is a positive integer (e.g., X is one of {1,2,4,8})

a number of bits in the LP-WUS to trigger the behavior is based on the number of DRX groups or frequency ranges, or groups of cells; and/or

a number of bits in the LP-WUS to trigger the behavior is based on a specific DRX group, frequency range, group of cells.

<u>For CA support:</u>

In some embodiments, for CA support, at least one of the following may be applied:

using 1 bit in the LP-WUS to indicate the first group cells and second group cells (e.g., '0' corresponds to first group cell, '1' corresponds to for second group cells);

using 2 bits in the LP-WUS to indicate the first group cells and second group cells (e.g., '01' corresponds to first group cell, '10' corresponds to for second group cells. '11' corresponds to for both group cells); and/or

using N bits in LP-WUS to indicate N group cells, e.g., with bitmap(s).

In some embodiments, for CA support, at least one of the following may be applied:

using 1 bit in the LP-WUS to indicate the cells in FR1 (Frequency Range 1) or for cells in FR2 (Frequency Range 2) (e.g., '0' corresponds to cells in FR1, '1' corresponds to for cells in FR2);

using 2 bits in the LP-WUS to indicate the cells in FR1 or for cells in FR2 (e.g., '01' corresponds to cells in FR1, '10' corresponds to for cells in FR2, and '11' corresponds to for cells in FR1 and FR2); and/or

using N bits in the LP-WUS to indicate wake-up in N frequency ranges, e.g., with bitmap(s).

In some embodiments, for CA support, at least one of the following may be applied:

using 1 bit in the LP-WUS to indicate the first DRX group and second DXR group (e.g., '0' corresponds to the first DRX group, '1' corresponds to second DRX group);

using 2 bits in the LP-WUS to indicate the first DRX group and second DXR group (e.g., '01' corresponds to first DRX group, '10' corresponds to the second DRX group. '11' corresponds to both DRX groups);

using N bits in the LP-WUS to indicate N DRX groups, e.g., with bitmap(s).

In some embodiments, if the LP-WUS is deployed in FR1, 1 bit may be used. For example, if the LP-WUS operates in FR1, 1 bit in the LP-WUS is used to indicate whether the LP-WUS triggers the behavior for the UEs in a DRX group for FR1, the cells in FR1 or one cell group.

In some embodiments, if the LP-WUS is deployed in FR2, 2 bit may be used. For example, if the LP-WUS operates in FR2, 2 bit in the LP-WUS is used to indicate whether the LP-WUS triggers the behavior for the UEs in in 2 DRX groups for FR2, the cells in FR2 or two cell groups.

For CA support based on some conditions:

In some embodiments, for CA support based on some conditions, at least one of the following may be applied:

if the LP-WUS can be used to trigger the starting of the drx-onDurationTimer (C-DRX active time), the LP-WUS indication may be applied based on DRX group;

if the LP-WUS can be used to trigger PDCCH monitoring, e.g., not based on drx-onDurationTimer (C-DRX active time), the LP-WUS indication may be applied based on the cell group/cells/frequency range;

if the LP-WUS can be used to trigger the starting of the first timer, the LP-WUS indication may be applied for all DRX groups, all the cells, all cell groups; and/or

if the LP-WUS can be used to trigger the starting of the second timer, the LP-WUS indication may be applied for one or more DRX groups, one or more cells, one or more cell groups.

LP-WUS QCL relationship

In some embodiments, the LP-WUS satisfies at least one of:

the LP-WUS has a Quasi-Co-Location, QCL, relationship with at least one of a Synchronization Signal/Physical Broadcast Channel Block, SSB, a Cell-Defining Synchronization

Signal/Physical Broadcast Channel Block, CD-SSB, a Tracking Reference Signal, TRS, a Non-Cell-Defining Synchronization Signal/Physical Broadcast Channel Block, NCD-SSB, a channel status information reference signal, CSI-RS, or a low power synchronization signal, LP-SS; and/or

the TCI state of LP-WUS is determined by at least one of a LP-WUS occasion index, a LP-WUS monitoring occasion index, a Control Resource Set, CORESET, ID, a Search space ID, a bandwidth part, BWP, ID, or a Cell ID.

In some implementations, the ID could be an index. For example, the Cell ID could be a cell index or serving cell index.

In some embodiments, the LP-WUS has a QCL relationship with at least one of CD-SSB, TRS, NCD-SSB, CSI-RS with type C or type D.

In some embodiments, the LP-WUS has a QCL relationship with an LP-SS with type A or type B.

In some embodiments, the LP-WUS has a QCL relationship with another signal could be interpreted as the LP-WUS is QCL-ed with another signal.

In some embodiments, if the LP-WUS has a QCL relationship with the LP-SS (low power synchronization signal), they have a one to one mapping relationship. That is, each LP-WUS beam corresponds to each LP-SS beam.

In some embodiments, a TCI state of the LP-WUS is determined by at least one of a Medium Access Control Control Element, MAC CE, Radio Resource Control, RRC signaling, and/or Downlink Control Information, DCI.

In some embodiments, the LP-WUS is QCL-ed with at least one of CD-SSB, TRS, NCD-SSB, and/or CSI-RS.

In some embodiments, the QCL relationship type could be type A, type B, type C or type D. In some embodiments, the QCL types are determined based on the following:

- 'typeA': {Doppler shift, Doppler spread, average delay, delay spread}

- 'typeB': {Doppler shift, Doppler spread}

- 'typeC': {Doppler shift, average delay}

- 'typeD': {Spatial Rx parameter}

In some embodiments, if the LP-WUS is activated by DCI, the UE assumes the same TCI state of the PDSCH scheduled by the DCI.

In some embodiments, if the LP-WUS is activated by DCI, the UE assumes the same TCI state of PDCCH, wherein the DCI is conveyed by the PDCCH.

In some embodiments, the LP-WUS is configured to activate the PDCCH monitoring for a search space with an ID/Index, and/or a CORESET. In some embodiments, the LP-WUS has the same TCI state with the PDCCH/CORESET.

Aspect 7:

In some embodiments, in response to that the LP-WUS is preceded with a preamble, the preamble satisfies at least one of:

an OOK parameter of the preamble is equal to or larger than an OOK parameter of the LP-WUS; and/or

an OOK symbol length of the preamble is less than an OOK symbol length of the LP-WUS;

the preamble indicates a number of codepoints indicated by the LP-WUS;

the preamble indicates a number of subgroups indicated by the LP-WUS;

the preamble indicates a LP-WUS indication is based on a bitmap or a codepoint;

the preamble comprises at least one binary or OFDM sequence;

the preamble comprises at least one binary or OFDM sequence wherein the at least one binary or OFDM sequence is the same as a LP-SS the sequence comprised by a LP-SS or is a subset of the sequence comprised by LP-SS; and/or

the preamble indicates a method of paging monitoring.

In some embodiments, the preamble comprises at least one binary or OFDM sequence wherein the at least one binary or OFDM sequence is the same as the sequences comprised by a LP-SS or is a subset of the sequences comprised by a LP-SS, or the sequences comprised by the LP-SS is a subset of the at least one binary or OFDM sequence for the preamble.

In some embodiments, the method of paging monitoring is used to determine how the UE monitor the PO and/or is used to determine whether the UE monitor the first PO or second PO.

In some embodiments, the OOK parameter is used to determine a number of OOK symbols in an OFDM (Orthogonal Frequency Division Multiplexing) symbol, or the OOK symbol length.

In some embodiments, in response to that OFDM sequences overlaid on an OOK symbol of the LP-WUS, the OFDM sequences is determined by at least one parameter. In some embodiments, the OOK symbol includes OOK-ON symbol or OOK-OFF symbol or corresponds to high voltage and low voltage or corresponds to '1' or '0' or corresponds to '1' or '-1'. In some embodiments, the OOK symbol is defined in a OFDM symbol. In some embodiments, at least one OOK symbol is included in a OFDM symbol. In some embodiments, the OOK symbols is defined based on On-Off Keying, OOK, modulation, which is a kind of Amplitude Shift Keying, ASK, modulation. In some implementations, the OOK symbol may be defined as (or based on) a chip or is defined based on a clock or time unit.

In some embodiments, the at least one parameter comprises at least one of a OOK parameter, a Subcarrier Spacing, SCS, a beam index, a LP-WUS occasion index, or a LP-WUS monitoring occasion index, a repetition number, a slot index, a PO index (e.g., referring the PO location in a paging cycle), a PF index, or a system frame number, SFN.

In some embodiments, the OFDM sequences satisfy at least one of:

a length of the OFDM sequences is determined by the at least one parameter;

a root index of the OFDM sequences is determined by the at least one parameter;

a cyclic shift of the OFDM sequences is determined by the at least one parameter; and/or

a format of the OFDM sequences is determined by the at least one parameter.

In some embodiments, when the LP-WUS uses OOK-1 or OOK4 with M=4, the preamble is configured with M>1.

In some embodiments, if the LP-WUS is preceded with a preamble, at least one of the following may be applied:

the M value of the preamble is larger than the M value of the LP-WUS; for example, the LP-WUS could be configured with M=1,2, or 4, and the preamble could be configured with M=2,4, or 8, wherein M is configured by the BS or gNB; in some embodiments, the M value is used to determine the number of bits or OOK symbols (e.g., M bits/OOK symbols) transmitted in 1 OFDM symbol;

the OOK symbol/OOK-ON symbol length of the preamble is less than that of LP-WUS; and/or

the M value of the preamble is larger than or equal to the M value of the LP-WUS (it may be determined by the configuration).

In some embodiments, the OFDM sequences may be overlaid on OOK-ON symbol, and the OFDM sequences may be determined by at least one of M, and/or SCS. For example, the OFDM sequences would be overlaid on OOK-ON symbol, and the OFDM sequences is determined by the value of M.

In some embodiments, the length of OFDM sequences may be determined by value M and/or SCS.

In some embodiments, the root index of a OFDM sequences may be determined by the value M and/or the SCS.

In some embodiments, the cyclic shift of OFDM sequences may be determined by the M and/or the SCS.

In some embodiments, the format or selection of OFDM sequences may be determined by the value M and/or the SCS.

In some embodiments, the OFDM sequences is based on at least one of ZC sequence, m sequence, gold sequence, and/or PN (pseudo noise) sequence.

In some embodiments, the UE may not receive/monitor the LP-WUS during a minimum time gap before the PDCCH occasion, before paging PDCCH occasion or before a timer starting (see FIG. 12). In some implementations, if the paging cycle is less than the first threshold, e.g., 640ms, the UE may not receive/monitor the LP-WUS during a minimum time gap before the PDCCH occasion, before paging PDCCH occasion, or the timer starting.

In some embodiments, the time gap is between the LP-WUS reception (e.g., LO or MO (monitoring occasion)) and the start of the PDCCH monitoring, paging occasion, timer starting.

In some embodiments, the time gap is between the ending OOK/OFDM symbol or ending slot of the LP-WUS reception (e.g., LO or MO (monitoring occasion)) and the start of PDCCH monitoring, paging occasion, timer starting.

In some embodiments, the time gap comprises at least one of {1,2,3,4,5,6,7,8,9, 10,16, 20,30,32, 40,64, 80,128, 160,320,480,960,400,800,1280,256} time units, e.g., ms, slots, and so on. In some embodiments, the time gap is based on 2^n or 10*2^n, wherein n could be a integer not less than 0.

In some embodiments, the gNB configures at least one of a time gap value as an offset for the UE via SIB or RRC or MAC CE.

In some embodiments, the UE may report at least one of a time gap value via Non-Access Stratum, NAS or RRC connection or RRC signalling or UE capability report.

In some embodiments, the time gap or offset could be based on at least one of WUR (wake-up radio) type, sleep state, and/or SCS, wherein the WUR type includes at least one of the first WUR type and/or the second WUR type, the sleep state comprises at least one of deep sleep, ultra deep sleep, light sleep, and/or micro sleep, and the SCS comprises at least one of 15KHz and/or 30KHz. In some implementations, the first WUR type decodes binary sequence(s) or OOK symbols, and the second WUR type decodes the OFDM sequences. In some implementations, the different WUR type corresponds to different UE capabilities.

In some embodiments, the LP-SS is used for synchronization or RRM (Radio Resources Management) measurement. In some embodiments, a first periodicity could be configured based on the LP-SS. The LP-SS is transmitted based on the periodicity. A second periodicity could be configured based on LP-SS/Primary Synchronization Signal (PSS)/secondary Synchronization Signal (SSS)/SSB, where the UE monitors or measures LP-SS/PSS/SSS/SSB based on the second periodicity.

FIG. 13 relates to a diagram of a wireless communication terminal 30 according to an embodiment of the present disclosure. The wireless communication terminal 30 may be a tag, a mobile phone, a laptop, a tablet computer, an electronic book or a portable computer system and is not limited herein. The wireless communication terminal 30 may be used to implement the UE described in this disclosure. The wireless communication terminal 30 may include a processor 300 such as a microprocessor or Application Specific Integrated Circuit (ASIC), a storage unit 310 and a communication unit 320. The storage unit 310 may be any data storage device that stores a program code 312, which is accessed and executed by the processor 300. Embodiments of the storage unit 310 include but are not limited to a subscriber identity module (SIM), read-only memory (ROM), flash memory, random-access memory (RAM), hard-disk, and optical data storage device. The communication unit 320 may a transceiver and is used to transmit and receive signals (e.g., messages or packets) according to processing results of the processor 300. In an embodiment, the communication unit 320 transmits and receives the signals via at least one antenna 322 or via wiring.

In an embodiment, the storage unit 310 and the program code 312 may be omitted and the processor 300 may include a storage unit with stored program code.

The processor 300 may implement any one of the steps or operations in exemplified embodiments on the wireless communication terminal 30, e.g., by executing the program code 312.

The communication unit 320 may be a transceiver. The communication unit 320 may as an alternative or in addition be combining a transmitting unit and a receiving unit configured to transmit and to receive, respectively, signals to and from a wireless communication node.

In some embodiments, the wireless communication terminal 30 may be used to perform the operations of the UE described in this disclosure. In some embodiments, the processor 300 and the communication unit 320 collaboratively perform the operations described in this disclosure. For example, the processor 300 performs operations and transmit or receive signals, message, and/or information through the communication unit 320.

FIG. 14 relates to a diagram of a wireless communication node 40 according to an embodiment of the present disclosure. The wireless communication node 40 may be a satellite, a base station (BS), a gNB, a network entity, a Domain Name System (DNS) server, a Mobility Management Entity (MME), Serving Gateway (S-GW), Packet Data Network (PDN) Gateway (P-GW), a radio access network (RAN), a next generation RAN (NG-RAN), a data network, a core network, a communication node in the core network, or a Radio Network Controller (RNC), and is not limited herein. In addition, the wireless communication node 40 may include (perform) at least one network function such as an access and mobility management function (AMF), a session management function (SMF), a user place function (UPF), a policy control function (PCF), an application function (AF), etc. The wireless communication node 40 may be used to implement the BS described in this disclosure. The wireless communication node 40 may include a processor 400 such as a microprocessor or ASIC, a storage unit 410 and a communication unit 420. The storage unit 410 may be any data storage device that stores a program code 412, which is accessed and executed by the processor 400. Examples of the storage unit 410 include but are not limited to a SIM, ROM, flash memory, RAM, hard-disk, and optical data storage device. The communication unit 420 may be a transceiver and is used to transmit and receive signals (e.g., messages or packets) according to processing results of the processor 400. In an embodiment, the communication unit 420 transmits and receives the signals via at least one antenna 422 or via wiring.

In an embodiment, the storage unit 410 and the program code 412 may be omitted. The processor 400 may include a storage unit with stored program code.

The processor 400 may implement any steps or operations described in exemplified embodiments on the wireless communication node 40, e.g., via executing the program code 412.

The communication unit 420 may be a transceiver. The communication unit 420 may as an alternative or in addition be combining a transmitting unit and a receiving unit configured to transmit and to receive, respectively, signals, messages, or information to and from a wireless communication node or a wireless communication terminal.

In some embodiments, the wireless communication node 40 may be used to perform the operations of the base station described in this disclosure. In some embodiments, the processor 400 and the communication unit 420 collaboratively perform the operations described in this disclosure. For example, the processor 400 performs operations and transmit or receive signals through the communication unit 420.

A wireless communication method is also provided according to an embodiment of the present disclosure. In an embodiment, the wireless communication method may be performed by using a wireless communication terminal (e.g., a UE). In an embodiment, the wireless communication terminal may be implemented by using the wireless communication terminal 30 described in this disclosure, but is not limited thereto.

Referring to FIG. 15, in an embodiment, the wireless communication method includes: receiving, by a wireless communication terminal from a wireless communication node, a low power wake-up signal, LP-WUS; and triggering, by the wireless communication terminal, a behavior based on the LP-WUS, wherein the behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

Details in this regard can be ascertained with reference to the paragraphs above, and will not be repeated herein.

Another wireless communication method is also provided according to an embodiment of the present disclosure. In an embodiment, the wireless communication method may be performed by using a wireless communication node (e.g., a BS or a gNB). In an embodiment, the wireless communication node may be implemented by using the wireless communication node 40 described in this disclosure, but is not limited thereto.

Referring to FIG. 16, in an embodiment, the wireless communication method includes: transmitting, by a wireless communication node to a wireless communication terminal, a low power wake-up signal, LP-WUS, to trigger a behavior, wherein the behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

Details in this regard can be ascertained with reference to the paragraphs above, and will not be repeated herein.

In some embodiments, the wireless communication terminal used in the present disclosure may indicate the UE described above.

In some embodiments, the wireless communication node used in the present disclosure may indicate the BS or gNB described above.

While various embodiments of the present disclosure have been described above, it should be understood that they have been presented by way of example only, and not by way of limitation. Likewise, the various diagrams may depict an example architecture or configuration, which are provided to enable persons of ordinary skill in the art to understand exemplary features and functions of the present disclosure. Such persons would understand, however, that the present disclosure is not restricted to the illustrated example architectures or configurations, but can be implemented using a variety of alternative architectures and configurations. Additionally, as would be understood by persons of ordinary skill in the art, one or more features of one embodiment can be combined with one or more features of another embodiment described herein. Thus, the breadth and scope of the present disclosure should not be limited by any one of the above-described exemplary embodiments.

It is understood that, in the present disclosure, the term "and/or" or symbol "/" may include any and all combinations of one or more of the associated listed items. For example, A and/or B and/or C includes any and all combinations of one or more of A, B, and C, including A, B, C, A and B, A and C, B and C, and a combination of A and B and C. Likewise, A/B/C includes any and all combinations of one or more of A, B, and C, including A, B, C, A and B, A and C, B and C, and a combination of A and B and C.

It is also understood that any reference to an element herein using a designation such as "first," "second," and so forth does not generally limit the quantity or order of those elements. Rather, these designations can be used herein as a convenient means of distinguishing between two or more elements or instances of an element. Thus, a reference to first and second elements does not mean that only two elements can be employed, or that the first element must precede the second element in some manner.

Additionally, a person having ordinary skill in the art would understand that information and signals can be represented using any one of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits and symbols, for example, which may be referenced in the above description can be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

A skilled person would further appreciate that any one of the various illustrative logical blocks, units, processors, means, circuits, methods and functions described in connection with the aspects disclosed herein can be implemented by electronic hardware (e.g., a digital implementation, an analog implementation, or a combination of the two), firmware, various forms of program or design code incorporating instructions (which can be referred to herein, for convenience, as "software" or a "software unit"), or any combination of these techniques.

To clearly illustrate this interchangeability of hardware, firmware and software, various illustrative components, blocks, units, circuits, operations, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware, firmware or software, or a combination of these techniques, depends upon the particular application and design constraints imposed on the overall system. Skilled artisans can implement the described functionality in various ways for each particular application, but such implementation decisions do not cause a departure from the scope of the present disclosure. In accordance with various embodiments, a processor, device, component, circuit, structure, machine, unit, etc. can be configured to perform one or more of the functions described herein. The term “configured to” or “configured for” as used herein with respect to a specified operation or function refers to a processor, device, component, circuit, structure, machine, unit, etc. that is physically constructed, programmed and/or arranged to perform the specified operation or function.

Furthermore, a skilled person would understand that various illustrative logical blocks, units, devices, components and circuits described herein can be implemented within or performed by an integrated circuit (IC) that can include a general-purpose processor, a digital signal processor

(DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, or any combination thereof. The logical blocks, units, and circuits can further include antennas and/or transceivers to communicate with various components within the network or within the device. A general-purpose processor can be a microprocessor, but in the alternative, the processor can be any conventional processor, controller, or state machine. A processor can also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other suitable configuration to perform the functions described herein. If implemented in software, the functions can be stored as one or more instructions or code on a computer-readable medium. Thus, the steps or operations of a method or algorithm disclosed herein can be implemented as software stored on a computer-readable medium.

Computer-readable media includes both computer storage media and communication media including any medium that can be enabled to transfer a computer program or code from one place to another. A storage media can be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can include RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to store desired program code in the form of instructions or data structures and that can be accessed by a computer.

In this document, the term "unit" as used herein, refers to software, firmware, hardware, and any combination of these elements for performing the associated functions described herein. Additionally, for purpose of discussion, the various units are described as discrete units; however, as would be apparent to one of ordinary skill in the art, two or more units may be combined to form a single unit that performs the associated functions according to embodiments of the present disclosure.

Additionally, memory or other storage, as well as communication components, may be employed in embodiments of the present disclosure. It will be appreciated that, for clarity purposes, the above description has described embodiments of the present disclosure with reference to different functional units and processors. However, it will be apparent that any suitable distribution of functionality between different functional units, processing logic elements or domains may be used without detracting from the present disclosure. For example, functionality illustrated to be performed by separate processing logic elements, or controllers, may be performed by the same processing logic element, or controller. Hence, references to specific functional units are only references to a suitable means for providing the described functionality, rather than indicative of a strict logical or physical structure or organization.

Various modifications to the implementations described in this disclosure will be readily apparent to those skilled in the art, and the general principles defined herein can be applied to other implementations without departing from the scope of the claims. Thus, the disclosure is not intended to be limited to the implementations shown herein, but is to be accorded the widest scope consistent with the novel features and principles disclosed herein, as recited in the claims below.

CLAIMS

1. A wireless communication method comprising:
receiving, by a wireless communication terminal from a wireless communication node, a low power wake-up signal, LP-WUS; and
triggering, by the wireless communication terminal, a behavior based on the LP-WUS, wherein the behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

2. The wireless communication method of claim 1, wherein the LP-WUS indicates one or more subgroups, and the one or more subgroups are indicated based on at least one of:
a configuration comprising at least one of a number of codepoints or bitmap in the LP-WUS, a payload size of the LP-WUS, a length of one codepoint, a maximum number of subgroups per paging occasion, PO, or a number of subgroups for one codepoint;
one or more codepoints indicating the one or more subgroups;
one codepoint with 8 bits or 16 bits indicating one subgroup; or
one or two codepoints with 4bits or 8bits indicating one, two or four subgroups.

3. The wireless communication method of claim 2, wherein the one or more codepoints indicating the one or more subgroups comprising:
a first codepoint and a second codepoint after the first codepoint indicates the same subgroup; or
a first codepoint and a second codepoint indicates the different subgroup.

4. The wireless communication method of claim 3, wherein the first codepoint and the second codepoint after the first codepoint indicates the same subgroup in response to that an indicated number of subgroups in the LP-WUS is less than a configured number of codepoints.

5. The wireless communication method of any of claims 2 to 4, wherein the LP-WUS

satisfies at least one of:

the one or more codepoints are increasing or decreasing based on an indicated number of subgroups in LP-WUS; or

a n-th indication indicating a n-th subgroup is based on a (n-1)-th indication indicating a (n-1)-th subgroup.

6. The wireless communication method of claim 1, wherein the LP-WUS indicates one or more subgroups, and the one or more subgroups are indicated based on at least one of:

a subgroup indication;

a group indication, wherein a group includes one or more subgroups;

an association indication, wherein the association indication is to determine a corresponding group for a subgroup indication; or

a configuration indicating a maximum number of subgroups based on at least one PO, a number of groups based on at least one PO, a number of subgroups per group, a number of bits for a group bitmap, a codepoint length or size, and/or a payload size of the LP-WUS.

7. The wireless communication method of claim 6, wherein the group indication comprises at least one of:

a 4-bits or 8-bits group indication;

a group indication with a bitmap; or

a group indication with a 4-bits or 8-bits bitmap.

8. The wireless communication method of claim 6 or 7, wherein the subgroup indication comprises at least one of:

a 2-bit, 3-bits, 4-bits, 5-bits, 6-bits or 8-bits subgroup indication;

a subgroup indication based on an index; or

a subgroup indication based on at least one group and/or at least one PO.

9. The wireless communication method of claim 1, wherein a number of subgroups

indicated by the LP-WUS is {1,8}, {1,16},{1,2,7,8}, {1,2,16,16},{1,2,3,4,8},{1,2,3,14,15,16} or the number of subgroups indicated by the LP-WUS comprises at least one of {1,2,3,4,5,6,7,8, 12,13,14,15, 16}.

10. The wireless communication method of claim 1, wherein the LP-WUS indicates one or more subgroups based on an indication state of the LP-WUS.

11. The wireless communication method of claim 10, wherein the indication state is determined based on at least one of:
a maximum number of subgroups per PO;
a number of subgroups;
an offset;
a subgroup index; or
a predetermined value or a predetermined value based on a number of subgroups.

12. The wireless communication method of claim 1 or 6, wherein the LP-WUS indicate all subgroups.

13. The wireless communication method of claim 12, wherein the all subgroups comprises at least one of:

all subgroups in a group;

all subgroups for at least one PO or PF;

all subgroups based on a LP-WUS occasion or a LP-WUS monitoring occasion, wherein the LP-WUS occasion includes one or more monitoring occasions;

all subgroups in a paging cycle; or

all subgroups for at least one cell, at least one cell group, at least one DRX group, at least one frequency range.

14. The wireless communication method of claim 12 or 13, wherein the LP-WUS indicates the all subgroups in response to at least one of:

the LP-WUS comprises a pre-determined indication; or

the LP-WUS is monitored or received at a location.

15. The wireless communication method of claim 14, wherein the pre-determined indication comprises at least one of:

a bitmap with a pre-determined value;

an indication state with a pre-determined value; or

an indication state with one or more predetermined sequences.

16. The wireless communication method of claim 14 or 15, wherein the location is determined by at least one of:

a preamble before the LP-WUS,

a periodicity,

an offset, or

a LP-WUS occasion index or LP-WUS monitoring occasion index.

17. The wireless communication method of any of claims 1 to 16, wherein the LP-WUS satisfies at least one of:

the LP-WUS is configured based on one or more group of cells, one or more frequency ranges, or one or more Discontinuous Reception, DRX, groups;

the LP-WUS triggers one or more terminals in one or more DRX groups to start a timer or monitor a control channel;

the LP-WUS triggers one or more terminals in one or more cell groups, one or more cells, or one or more frequency ranges to start a timer or monitoring a control channel;

the LP-WUS triggers terminals in all cell groups, all cells, or all DRX groups to start a first timer or monitoring a first control channel; or

the LP-WUS triggers terminals in one or more cell groups, one or more cells, or one or more DRX groups to start a second timer or monitoring a second control channel.

18. The wireless communication method of any of claims 1 to 17, wherein the LP-WUS

satisfies at least one of:

1 bit in the LP-WUS triggers the behavior for a first DRX group and second DXR group;

2 bits in the LP-WUS trigger the behavior for the first DRX group and second DXR group;

1 bit in the LP-WUS triggers the behavior for the cells in first frequency range and cells in second frequency range;

2 bits in the LP-WUS trigger the behavior for the cells in first frequency range and cells in second frequency range;

1 bit in the LP-WUS triggers the behavior for the first group of cells and second group of cells;

2 bits in the LP-WUS trigger the behavior for the first group of cells and second group of cells;

X bits with a bitmap in the LP-WUS trigger the behavior for X DRX groups, X frequency ranges, or X groups of cells, wherein X is a positive integer;

a number of bits in the LP-WUS to trigger the behavior is based on the number of DRX groups or frequency ranges, or groups of cells; or

a number of bits in the LP-WUS to trigger the behavior is based on a specific DRX group, frequency range, group of cells.

19. The wireless communication method of any of claims 1 to 18, wherein in response to that the LP-WUS is preceded with a preamble, the preamble satisfies at least one of:

an OOK parameter of the preamble is equal to or larger than an OOK parameter of the LP-WUS;

an OOK symbol length of the preamble is less than an OOK symbol length of the LP-WUS;

the preamble indicates a number of codepoints indicated by the LP-WUS;

the preamble indicates a number of subgroups indicated by the LP-WUS;

the preamble indicates a LP-WUS indication is based on a bitmap or a codepoint;

the preamble comprises at least one binary or OFDM sequence;

the preamble comprises at least one binary or OFDM sequence, wherein the at least one binary or OFDM sequence is the same as a low power synchronization signal, LP-SS or is a subset of sequences comprised by a LP-SS; or

the preamble indicates a method of paging monitoring;

wherein the OOK parameter is used to determine a number of OOK symbols in an OFDM symbol, or the OOK symbol length.

20. The wireless communication method of any of claims 1 to 19, wherein in response to that OFDM sequences overlaid on an OOK symbol of the LP-WUS, the OFDM sequences is determined by at least one parameter.

21. The wireless communication method of claim 20, wherein the at least one parameter comprises at least one of a OOK parameter, a Subcarrier Spacing, SCS, a beam index, a LP-WUS occasion index, or a LP-WUS monitoring occasion index, a repetition number, a slot index, a PO index, a PF index, or a system frame number, SFN.

22. The wireless communication method of claim 20 or 21, wherein the OFDM sequences satisfy at least one of:

a length of the OFDM sequences is determined by the at least one parameter;

a root index of the OFDM sequences is determined by the at least one parameter;

a cyclic shift of the OFDM sequences is determined by the at least one parameter; or

a format of the OFDM sequences is determined by the at least one parameter.

23. The wireless communication method of any of claims 1 to 22, wherein the LP-WUS satisfies at least one of:

the LP-WUS has a Quasi-Co-Location, QCL, relationship with at least one of a Synchronization Signal/Physical Broadcast Channel Block, SSB, a Cell-Defining Synchronization Signal/Physical Broadcast Channel Block, CD-SSB, a Tracking Reference Signal, TRS, a Non-Cell-Defining Synchronization Signal/Physical Broadcast Channel Block, NCD-SSB, or a channel status information reference signal, CSI-RS, a low power synchronization signal, LP-SS; or the TCI state of LP-WUS is determined by at least one of a LP-WUS occasion index, a LP-WUS monitoring occasion index, a Control Resource Set, CORESET, ID, a Search space ID, a bandwidth part, BWP, ID, or a Cell ID.

24. The wireless communication method of claim 23, wherein the LP-WUS has a QCL relationship with at least one of CD-SSB, TRS, NCD-SSB, CSI-RS with type C or type D, and/or

    wherein the LP-WUS has a QCL relationship with an LP-SS with type A or type B.

25. The wireless communication method of claim 23 or 24, wherein a Transmission Configuration Indication, TCI, state of the LP-WUS is determined by at least one of a Medium Access Control Control Element, MAC CE, Radio Resource Control, RRC signaling, or Downlink Control Information, DCI.

26. A wireless communication method comprising:

    transmitting, by a wireless communication node to a wireless communication terminal, a low power wake-up signal, LP-WUS, to trigger a behavior, wherein the behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

27. The wireless communication method of claim 26, wherein the LP-WUS indicates one or more subgroups, and the one or more subgroups are indicated based on at least one of:

    a configuration comprising at least one of a number of codepoints or bitmap in the LP-WUS, a payload size of the LP-WUS, a length of one codepoint, a maximum number of subgroups per paging occasion, PO, or a number of subgroups for one codepoint;

    one or more codepoints indicating the one or more subgroups;

    one codepoint with 8 bits or 16 bits indicating one subgroup; or

    one or two codepoints with 4bits or 8bits indicating one, two or four subgroups.

28. The wireless communication method of claim 27, wherein the one or more codepoints indicating the one or more subgroups comprising:

a first codepoint and a second codepoint after the first codepoint indicates the same subgroup; or

a first codepoint and a second codepoint indicates the different subgroup.

29. The wireless communication method of claim 28, wherein the first codepoint and the second codepoint after the first codepoint indicates the same subgroup in response to that an indicated number of subgroups in the LP-WUS is less than a configured number of codepoints.

30. The wireless communication method of any of claims 27 to 29, wherein the LP-WUS satisfies at least one of:

the one or more codepoints are increasing or decreasing based on an indicated number of subgroups in LP-WUS; or

a n-th indication indicating a n-th subgroup is based on a (n-1)-th indication indicating a (n-1)-th subgroup.

31. The wireless communication method of claim 26, wherein the LP-WUS indicates one or more subgroups, and the one or more subgroups are indicated based on at least one of:

a subgroup indication;

a group indication, wherein a group includes one or more subgroups;

an association indication, wherein the association indication is to determine a corresponding group for a subgroup indication; or

a configuration indicating a maximum number of subgroups based on at least one PO, a number of groups based on at least one PO, a number of subgroups per group, a number of bits for a group bitmap, a codepoint length or size, and/or a payload size of the LP-WUS.

32. The wireless communication method of claim 31, wherein the group indication comprises

at least one of:

a 4-bits or 8-bits group indication;

a group indication with a bitmap; or

a group indication with a 4-bits or 8-bits bitmap.

33. The wireless communication method of claim 31 or 32, wherein the subgroup indication comprises at least one of:

a 2-bit, 3-bits, 4-bits, 5-bits, 6-bits or 8-bits subgroup indication;

a subgroup indication based on an index; or

a subgroup indication based on at least one group and/or at least one PO.

34. The wireless communication method of claim 26, wherein a number of subgroups indicated by the LP-WUS is {1,8}, {1,16},{1,2,7,8}, {1,2,16,16},{1,2,3,4,8},{1,2,3,14,15,16} or the number of subgroups indicated by the LP-WUS comprises at least one of {1,2,3,4,5,6,7,8, 12,13,14,15, 16}.

35. The wireless communication method of claim 26, wherein the LP-WUS indicates one or more subgroups based on an indication state of the LP-WUS.

36. The wireless communication method of claim 35, wherein the indication state is determined based on at least one of:

a maximum number of subgroups per PO;

a number of subgroups;

an offset;

a subgroup index; or

a predetermined value or a predetermined value based on a number of subgroups.

37. The wireless communication method of claim 26 or 31, wherein the LP-WUS indicate all subgroups.

38. The wireless communication method of claim 37, wherein the all subgroups comprises at least one of:

all subgroups in a group;

all subgroups for at least one PO or PF;

all subgroups based on a LP-WUS occasion or a LP-WUS monitoring occasion, wherein the LP-WUS occasion includes one or more monitoring occasions;

all subgroups in a paging cycle; or

all subgroups for at least one cell, at least one cell group, at least one DRX group, at least one frequency range.

39. The wireless communication method of claim 37 or 38, wherein the LP-WUS indicates the all subgroups in response to at least one of:

the LP-WUS comprises a pre-determined indication; or

the LP-WUS is monitored or received at a location.

40. The wireless communication method of claim 39, wherein the pre-determined indication comprises at least one of:

a bitmap with a pre-determined value;

an indication state with a pre-determined value; or

an indication state with one or more predetermined sequences.

41. The wireless communication method of claim 39 or 40, wherein the location is determined by at least one of:

a preamble before the LP-WUS,

a periodicity,

an offset, or

a LP-WUS occasion index or LP-WUS monitoring occasion index.

42. The wireless communication method of any of claims 26 to 41, wherein the LP-WUS satisfies at least one of:

the LP-WUS is configured based on one or more group of cells, one or more frequency ranges, or one or more Discontinuous Reception, DRX, groups;

the LP-WUS triggers one or more terminals in one or more DRX groups to start a timer or monitor a control channel;

the LP-WUS triggers one or more terminals in one or more cell groups, one or more cells, or one or more frequency ranges to start a timer or monitoring a control channel;

the LP-WUS triggers terminals in all cell groups, all cells, or all DRX groups to start a first timer or monitoring a first control channel; or

the LP-WUS triggers terminals in one or more cell groups, one or more cells, or one or more DRX groups to start a second timer or monitoring a second control channel.

43. The wireless communication method of any of claims 26 to 42, wherein the LP-WUS satisfies at least one of:

1 bit in the LP-WUS triggers the behavior for a first DRX group and second DXR group;

2 bits in the LP-WUS trigger the behavior for the first DRX group and second DXR group;

1 bit in the LP-WUS triggers the behavior for the cells in first frequency range and cells in second frequency range;

2 bits in the LP-WUS trigger the behavior for the cells in first frequency range and cells in second frequency range;

1 bit in the LP-WUS triggers the behavior for the first group of cells and second group of cells;

2 bits in the LP-WUS trigger the behavior for the first group of cells and second group of cells;

X bits with a bitmap in the LP-WUS trigger the behavior for X DRX groups, X frequency ranges, or X groups of cells, wherein X is a positive integer;

a number of bits in the LP-WUS to trigger the behavior is based on the number of DRX groups or frequency ranges, or groups of cells; or

a number of bits in the LP-WUS to trigger the behavior is based on a specific DRX group, frequency range, group of cells.

44. The wireless communication method of any of claims 26 to 43, wherein in response to that the LP-WUS is preceded with a preamble, the preamble satisfies at least one of:
an OOK parameter of the preamble is equal to or larger than an OOK parameter of the LP-WUS;
an OOK symbol length of the preamble is less than an OOK symbol length of the LP-WUS;
the preamble indicates a number of codepoints indicated by the LP-WUS;
the preamble indicates a number of subgroups indicated by the LP-WUS;
the preamble indicates a LP-WUS indication is based on a bitmap or a codepoint;
the preamble comprises at least one binary or OFDM sequence;
the preamble comprises at least one binary or OFDM sequence, wherein the at least one binary or OFDM sequence is the same as a low power synchronization signal, LP-SS or is a subset of sequences comprised by a LP-SS; or
the preamble indicates a method of paging monitoring;
wherein the OOK parameter is used to determine a number of OOK symbols in an OFDM symbol, or the OOK symbol length.

45. The wireless communication method of any of claims 26 to 44, wherein in response to that OFDM sequences overlaid on an OOK symbol of the LP-WUS, the OFDM sequences is determined by at least one parameter.

46. The wireless communication method of claim 45, wherein the at least one parameter comprises at least one of a OOK parameter, a Subcarrier Spacing, SCS, a beam index, a LP-WUS occasion index, or a LP-WUS monitoring occasion index, a repetition number, a slot index, a PO index, a PF index, or a system frame number, SFN.

47. The wireless communication method of claim 45 or 46, wherein the OFDM sequences satisfy at least one of:
a length of the OFDM sequences is determined by the at least one parameter;
a root index of the OFDM sequences is determined by the at least one parameter;

a cyclic shift of the OFDM sequences is determined by the at least one parameter; or

a format of the OFDM sequences is determined by the at least one parameter.

48. The wireless communication method of any of claims 26 to 47, wherein the LP-WUS satisfies at least one of:

the LP-WUS has a Quasi-Co-Location, QCL, relationship with at least one of a Synchronization Signal/Physical Broadcast Channel Block, SSB, a Cell-Defining Synchronization Signal/Physical Broadcast Channel Block, CD-SSB, a Tracking Reference Signal, TRS, a Non-Cell-Defining Synchronization Signal/Physical Broadcast Channel Block, NCD-SSB, or a channel status information reference signal, CSI-RS, a low power synchronization signal, LP-SS; or

the TCI state of LP-WUS is determined by at least one of a LP-WUS occasion index, a LP-WUS monitoring occasion index, a Control Resource Set, CORESET, ID, a Search space ID, a bandwidth part, BWP, ID, or a Cell ID.

49. The wireless communication method of claim 48, wherein the LP-WUS has a QCL relationship with at least one of CD-SSB, TRS, NCD-SSB, CSI-RS with type C or type D, and/or

wherein the LP-WUS has a QCL relationship with an LP-SS with type A or type B.

50. The wireless communication method of claim 48 or 49, wherein a Transmission Configuration Indication, TCI, state of the LP-WUS is determined by at least one of a Medium Access Control Control Element, MAC CE, Radio Resource Control, RRC signaling, or Downlink Control Information, DCI.

51. A wireless communication terminal, comprising:

a communication unit; and

a processor configured for: receiving, via the communication unit from a wireless communication node, a low power wake-up signal, LP-WUS; and triggering a behavior based on the LP-WUS, wherein the behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

52. The wireless communication terminal of claim 51, wherein the processor is further configured to perform a wireless communication method of any of claims 2 to 25.

53. A wireless communication node, comprising:

a communication unit; and

a processor configured for: transmitting, via the communication unit to a wireless communication terminal, a low power wake-up signal, LP-WUS, to trigger a behavior, wherein the behavior comprises the wireless communication terminal waking up, the wireless communication terminal monitoring a control channel and/or the wireless communication terminal starting a timer.

54. The wireless communication node of claim 53, wherein the processor is further configured to perform a wireless communication method of any of claims 27 to 50.

55. A computer program product comprising a computer-readable program medium code stored thereupon, the code, when executed by a processor, causing the processor to implement a wireless communication method recited in any one of claims 1 to 50.

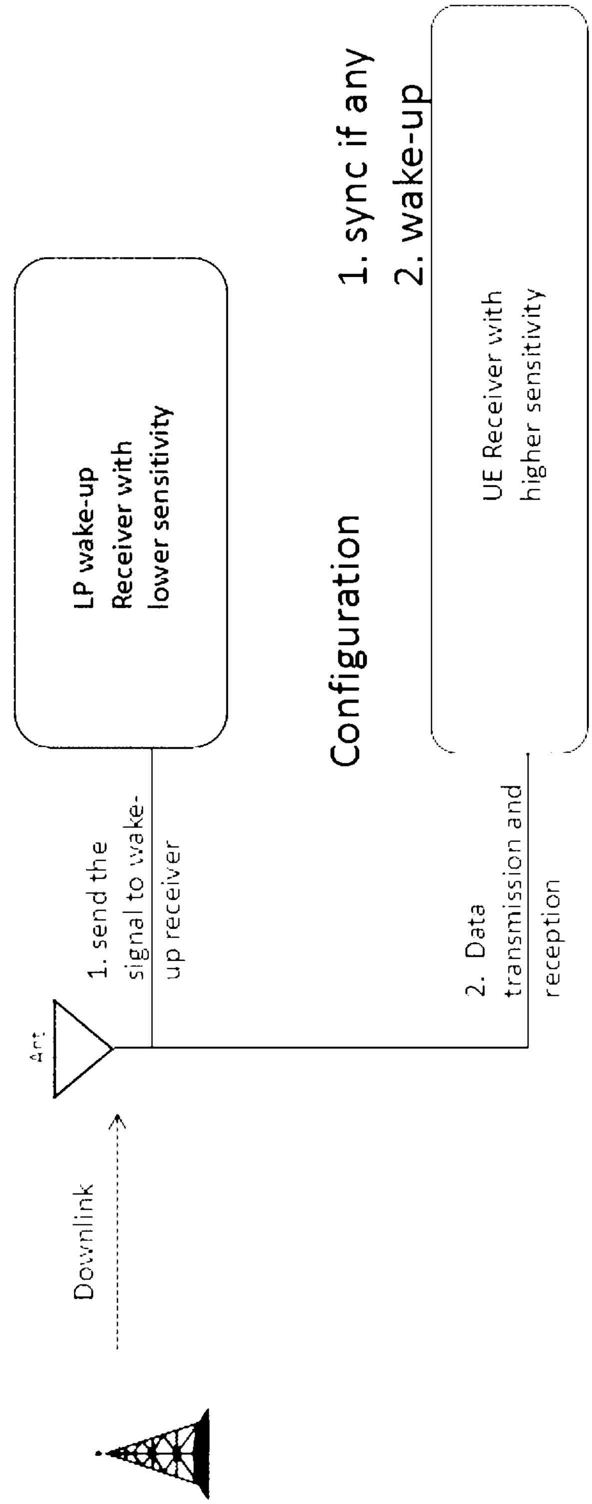
Downlink
Ant
1. send the signal to wake-up receiver
LP wake-up Receiver with lower sensitivity
Configuration
1. sync if any
2. wake-up
2. Data transmission and reception
UE Receiver with higher sensitivity

FIG. 1

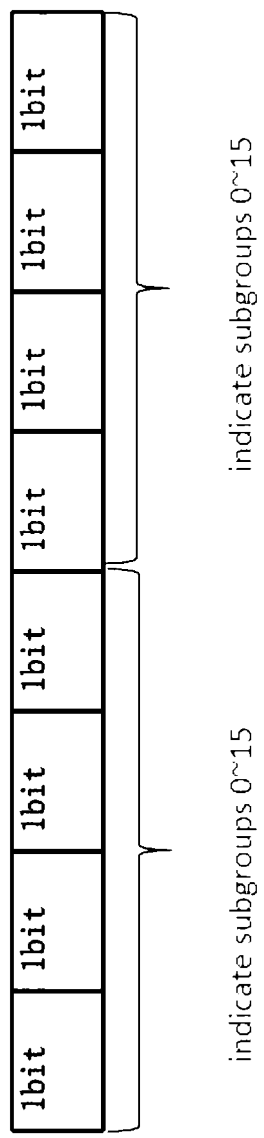
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
indicate subgroups 0~15
indicate subgroups 0~15

FIG. 2

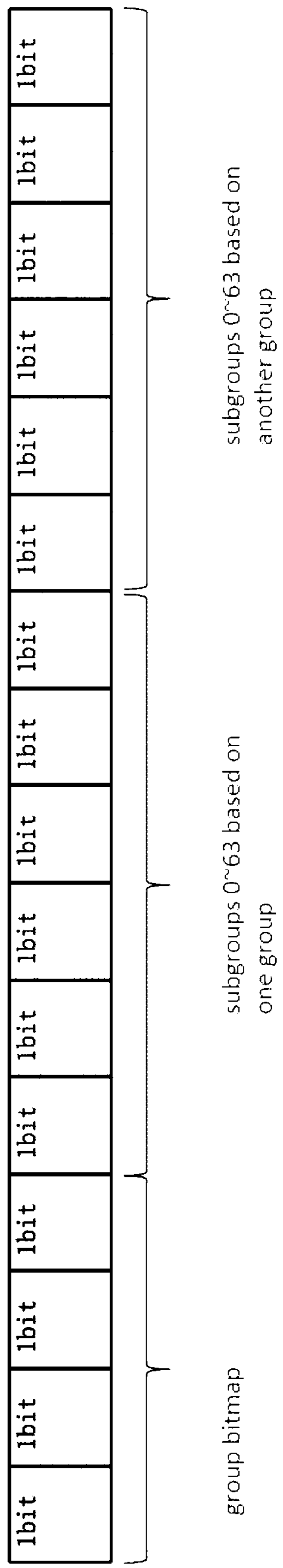
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
group bitmap
subgroups 0~63 based on one group
subgroups 0~63 based on another group

FIG. 3

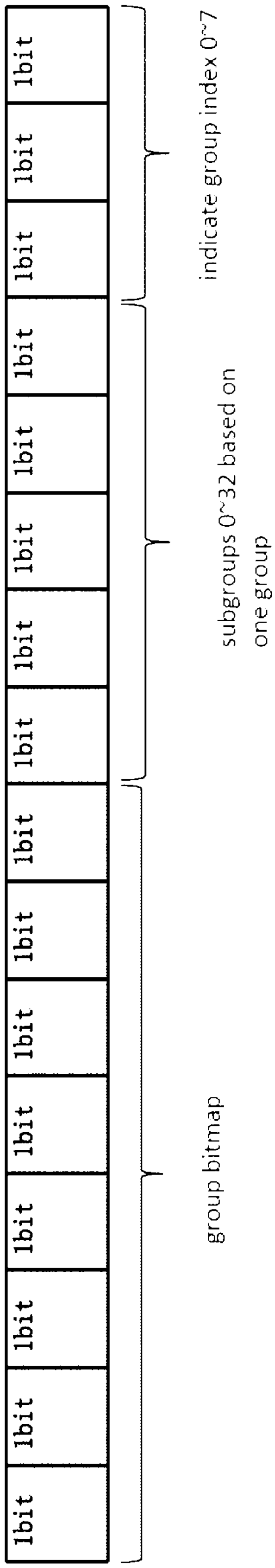
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
group bitmap
subgroups 0~32 based on one group
indicate group index 0~7

FIG. 4

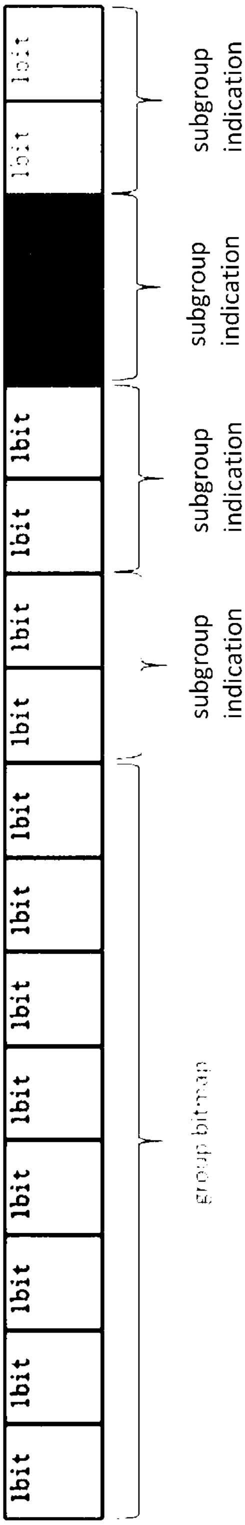
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
group bitmap
subgroup indication
subgroup indication
subgroup indication
subgroup indication

FIG. 5

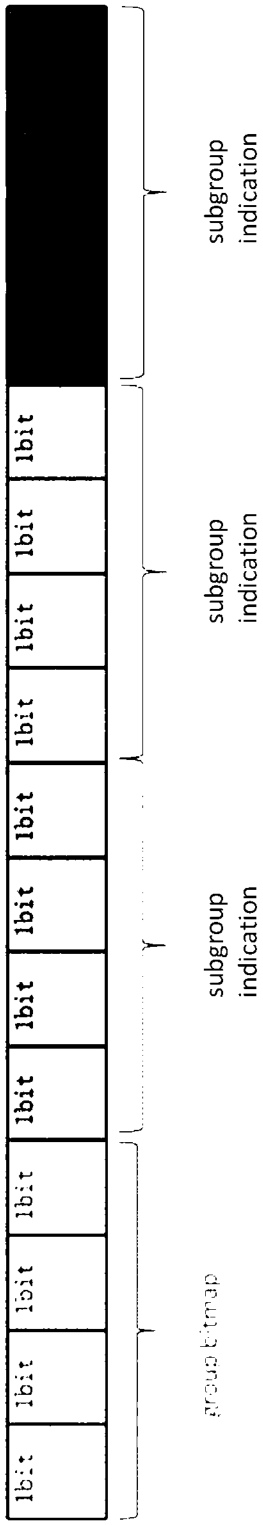
subgroup indication
1bit
1bit
1bit
1bit
subgroup indication
1bit
1bit
1bit
1bit
subgroup indication
1bit
1bit
1bit
1bit
group bitmap

FIG. 6

	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit
For maximum 8 subgroups	Predetermined value					Indicate subgroup indexes		
For maximum 16 subgroups					Indicate subgroup indexes			
....								

FIG. 7

	1bit	1bit	1bit	1bit	1bit	1bit	1bit	1bit
Indicate one subgroup	Predetermined value					subgroup indexes		
Indicate two subgroups					subgroup indexes			
....								
Indicate two subgroups			Predetermined value					

FIG. 8

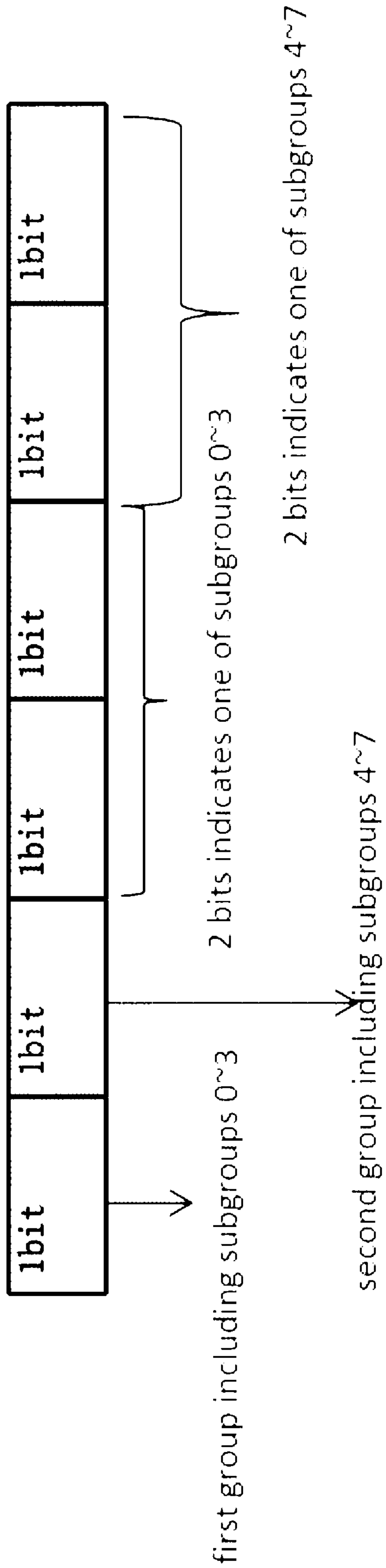
1bit
1bit
1bit
1bit
1bit
1bit
first group including subgroups 0~3
second group including subgroups 4~7
2 bits indicates one of subgroups 0~3
2 bits indicates one of subgroups 4~7

FIG. 9

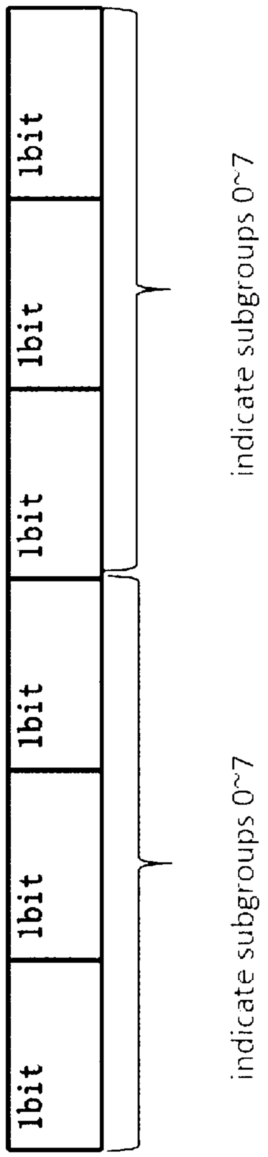
1bit
1bit
1bit
1bit
1bit
1bit
indicate subgroups 0~7
indicate subgroups 0~7

FIG. 10

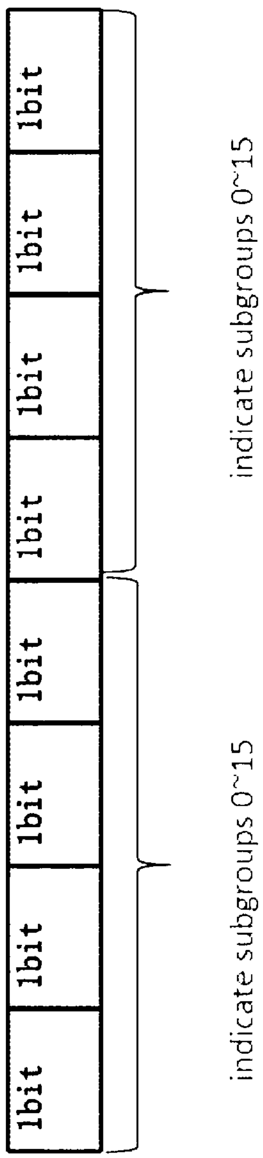
1bit
1bit
1bit
1bit
1bit
1bit
1bit
1bit
indicate subgroups 0~15
indicate subgroups 0~15

FIG. 11

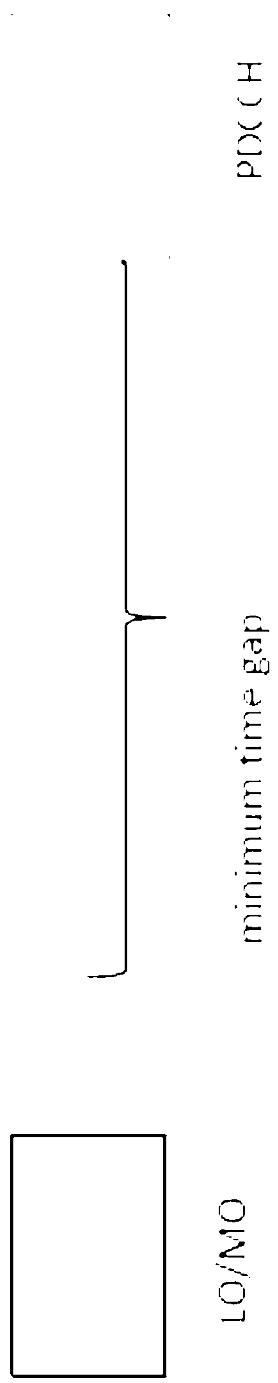

FIG. 12

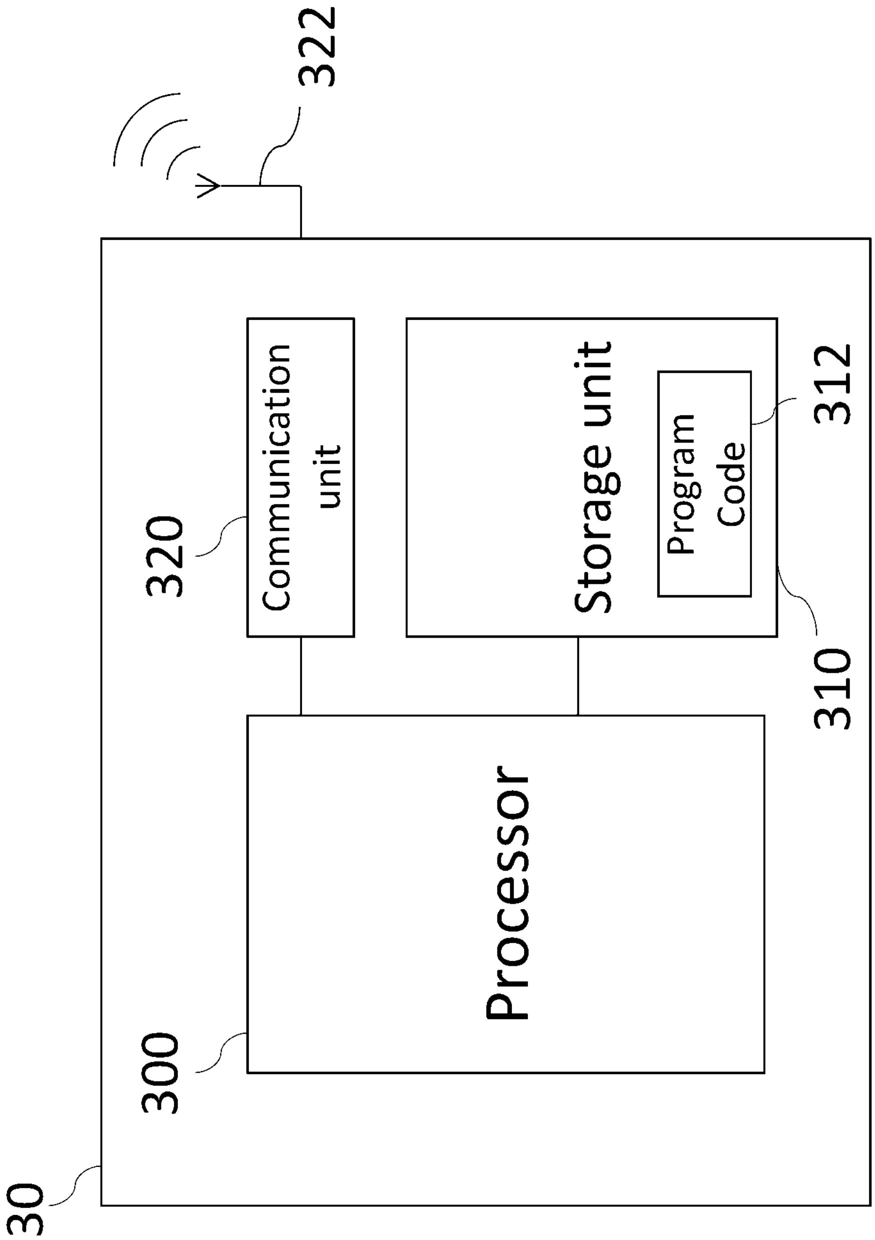
322
320
Communication unit
Storage unit
Program Code
312
310
Processor
300
30

FIG. 13

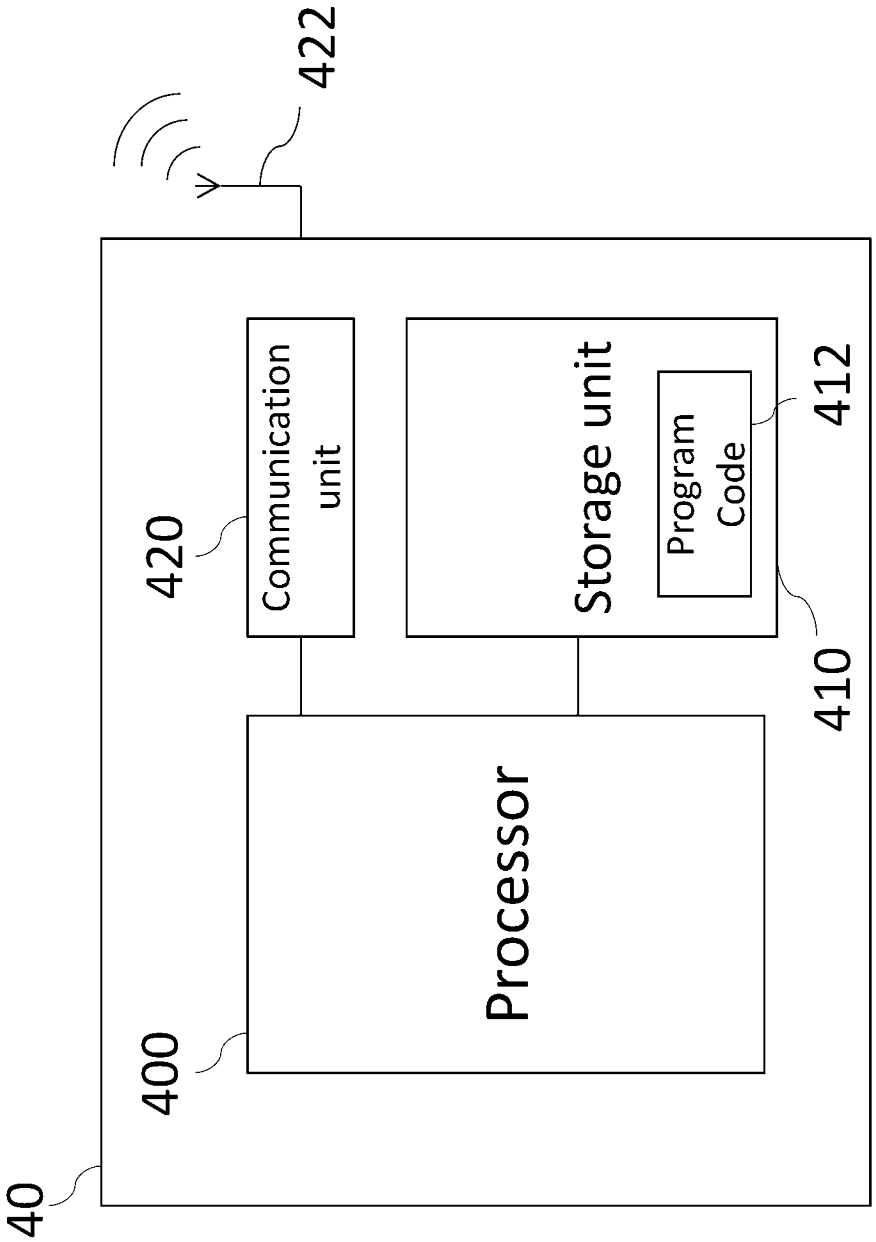
422
420
Communication unit
Storage unit
Program Code
412
410
Processor
400
40

FIG. 14

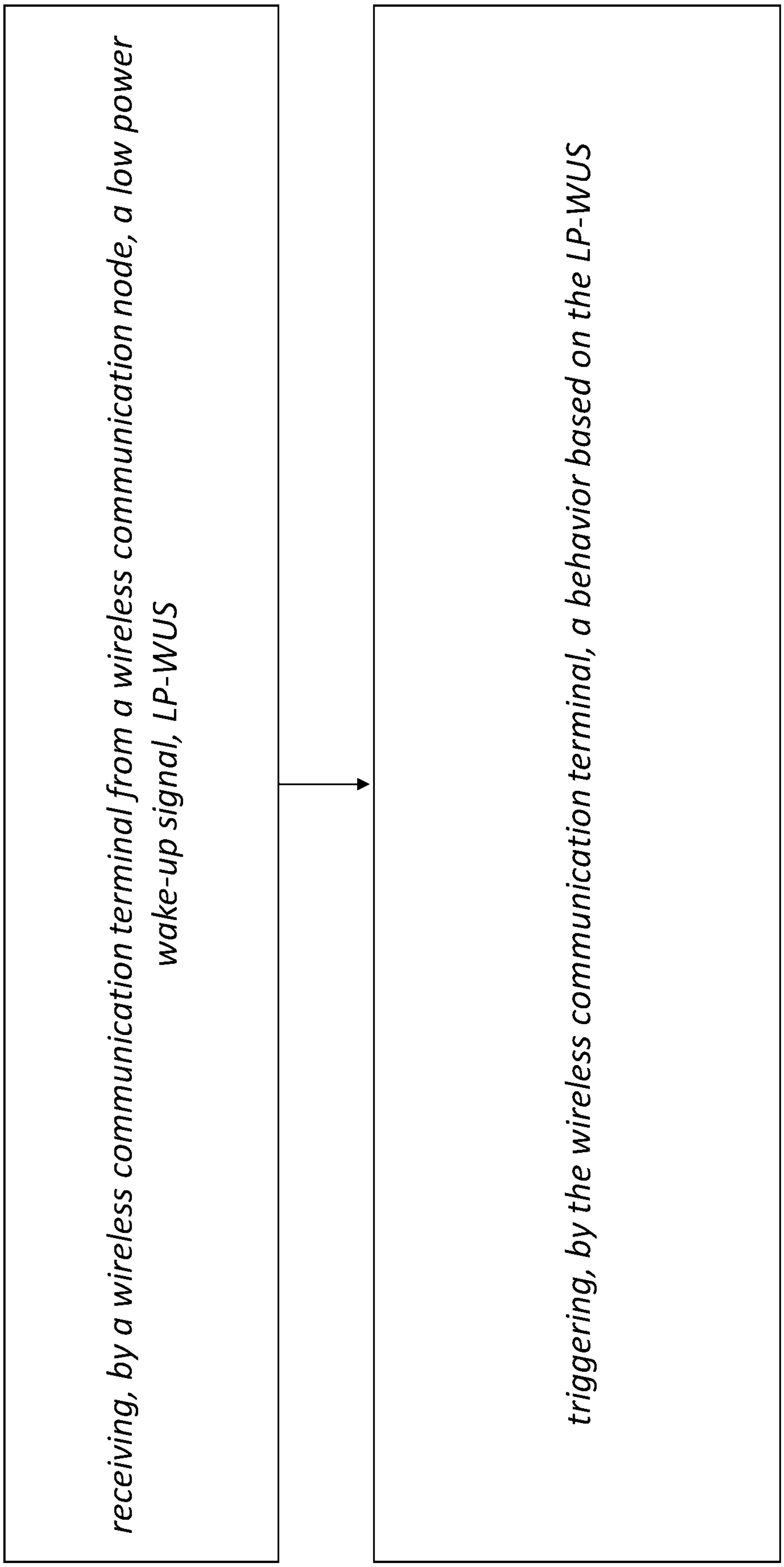
receiving, by a wireless communication terminal from a wireless communication node, a low power wake-up signal, LP-WUS
triggering, by the wireless communication terminal, a behavior based on the LP-WUS

FIG. 15

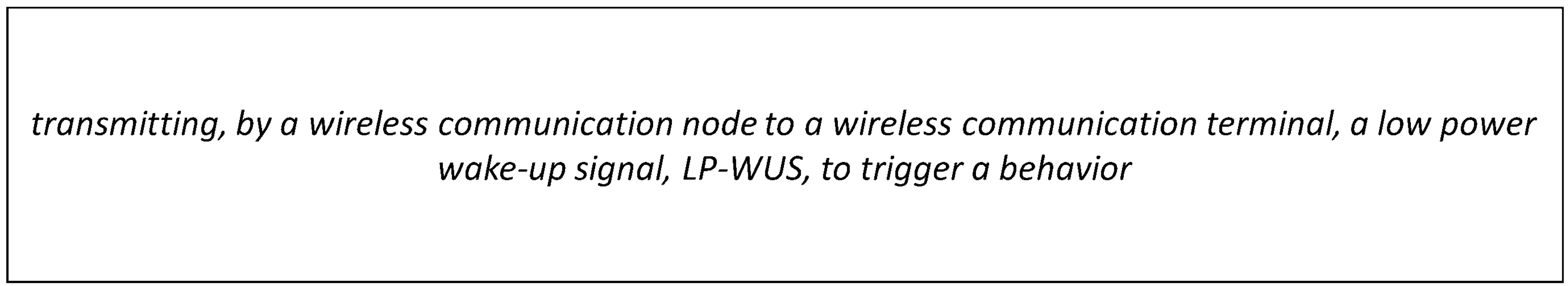
transmitting, by a wireless communication node to a wireless communication terminal, a low power wake-up signal, LP-WUS, to trigger a behavior

FIG. 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/112837

A. CLASSIFICATION OF SUBJECT MATTER

H04W 52/02(2009.01)i

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)

IPC: 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)

CNABS,CNTXT,CNKI,VEN,DWPI,ENTXT: LP WUS, wake up, monitor, control channel, PDCCH, start, timer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2023201577 A1 (BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.) 26 October 2023 (2023-10-26) description, page 6 lines 5-7, 13-30, page 7 lines 21-23	1-55
X	CN 117641536 A (BEIJING SAMSUNG TELECOMMUNICATIONS TECHNOLOGY RESEARCH CO., LTD. et al.) 01 March 2024 (2024-03-01) description paragraphs 0185-0189	1-55
X	WO 2023102788 A1 (GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.) 15 June 2023 (2023-06-15) claims 1,2, page 7 lines 25-30, page 8 lines 24-40	1-55
X	CN 117377040 A (VIVO MOBILE COMMUNICATION CO., LTD.) 09 January 2024 (2024-01-09) description paragraph 0031	1-55
X	XIAOMI. "R1-2404629 Discussion on LP-WUS operation in connected mode" *3GPP TSG RAN WG1 #117,* 24 May 2024 (2024-05-24), section 2.5	1-55

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "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
09 April 2025	**17 April 2025**

Name and mailing address of the ISA/CN	Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	**WANG,YanHua** Telephone No. **(+86) 010-53961656**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ETRI. "R1-2404783 Discussion on LP-WUS operation in CONNECTED modes" *3GPP TSG RAN WG1 Meeting #117,* 24 May 2024 (2024-05-24), section 2.3	1-55
A	US 2024114453 A1 (QUALCOMM INCORPORATED) 04 April 2024 (2024-04-04) the whole document	1-55
A	US 2024155491 A1 (MEDIATEK INC.) 09 May 2024 (2024-05-09) the whole document	1-55

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/112837

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2023201577	A1	26 October 2023	EP	4513976	A1	26 February 2025
				CN	117280772	A	22 December 2023
				IN	202447088539	A	22 November 2024
CN	117641536	A	01 March 2024	WO	2024039180	A1	22 February 2024
WO	2023102788	A1	15 June 2023	US	2024323850	A1	26 September 2024
				CN	118285140	A	02 July 2024
CN	117377040	A	09 January 2024	WO	2024002339	A1	04 January 2024
US	2024114453	A1	04 April 2024		None		
US	2024155491	A1	09 May 2024	CN	117998545	A	07 May 2024