



(51) International Patent Classification:

H04W 72/04 (2009.01)

(21) International Application Number:

PCT/CN2020/080185

(22) International Filing Date:

19 March 2020 (19.03.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/821,555 21 March 2019 (21.03.2019) US

62/826,118 29 March 2019 (29.03.2019) US

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(81) Designated States (unless otherwise indicated, for every

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

(84) Designated States (unless otherwise indicated, for every

kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: SYSTEM INFORMATION UPDATE IN NEXT GENERATION WIRELESS NETWORKS

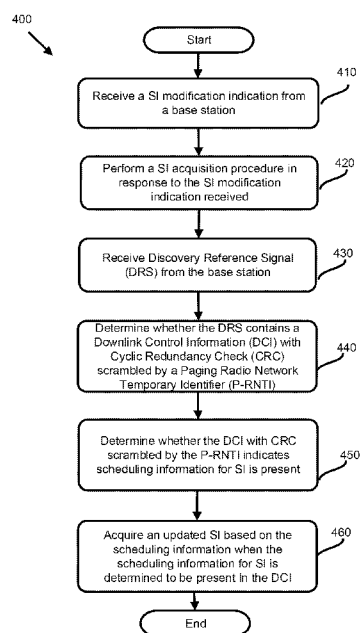


FIG. 4

(57) **Abstract:** A method for system information update for a User Equipment (UE) is the disclosed. The method comprising: receiving, from a base station, a Discovery Reference Signal (DRS); determining, whether the DRS contains a Downlink Control Information (DCI) with Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identifier (P-RNTI); determining, whether the DCI with CRC scrambled by the P-RNTI indicates scheduling information for SI is present when the DRS contains the DCI with CRC scrambled by the P-RNTI; and acquiring, an updated SI based on the scheduling information, when the scheduling information for SI is present.

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))*

SYSTEM INFORMATION UPDATE IN NEXT GENERATION WIRELESS NETWORKS

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] The present application claims the benefits of and priority to a provisional U.S. Patent Application Serial No. 62/821555, filed on March 21, 2019, entitled “System Information Acquisition and Modification in NR-U,” with Attorney Docket No. US76822 (hereinafter referred to as “US76822 application”) and a provisional U.S. Patent Application Serial No. 62/826118, filed on March 29, 2019, entitled “System information Request Procedure in NR-U,” with Attorney Docket No. US76905 (hereinafter referred to as “US76905 application”). The disclosure of the US76406 application is hereby incorporated fully by reference into the present application.

FIELD

[0002] The present disclosure generally relates to wireless communications, and more particularly, to acquire or update the System Information in the next generation wireless networks.

BACKGROUND

[0003] Listen Before Talk (LBT) is a mechanism used by a network connected device for determining whether a shared channel is available for radio transmissions (e.g., using Clear Channel Assessment (CCA)). In an LBT procedure, a transmitter must sense the channel before transmitting. If the transmitter determines that the channel is occupied, the LBT procedure fails and the transmission is suppressed. Some of the wireless networks, such as a Wi-Fi network, may leverage the LBT feature to allow the coexistence of multiple users (e.g., multiple nodes may share the same radio channel using the LBT feature). The 3rd Generation Partnership Project (3GPP) uses a similar LBT scheme when leveraging an unlicensed band (e.g., 5 GHz) in combination with a licensed spectrum (e.g., to boost the performance of a user equipment). For example, the License Assisted Access (LAA) scheme uses carrier aggregation (e.g., in downlink) to combine the Long Term Evolution (LTE) in an unlicensed spectrum with the LTE in the licensed spectrum.

[0004] In New Radio (NR) or LTE, an SI (System Information) message is periodically transmitted in a SI window. The periodicity of the SI message/SI scheduling information is

broadcast in the System Information Block type 1 (SIB1). Based on the SI scheduling information, a UE that is required to receive or update the SI may obtain information such as when and where in the search space to acquire the concerned SI. Other types of SIBs are carried in *SystemInformation* (SI) messages and being transmitted on the Downlink Share Channel (DL-SCH). Each SI message is transmitted within periodically occurring time domain windows (referred to as SI-windows with same length for all SI messages). Each SI message is associated with an SI-window and the SI-windows of different SI messages do not overlap. The SI-windows have the same length for all SI messages. Only the corresponding SI message is transmitted within one SI-window. When a UE acquires an SI message, the UE shall receive the Physical Downlink Control Channel (PDCCH) containing the scheduling Radio Network Temporary Identifier (RNTI), e.g., SI-RNTI in the PDCCH monitoring occasions. The reception of PDCCH starts from the beginning of the SI-window until the end of the SI-window or until the SI message was received. The length of the SI-window (*si-WindowLength*) is defined in SIB1.

[0005] In the network-initiated system information update, the Paging message is used to inform UEs in RRC_IDLE, RRC_INACTIVE, or RRC_CONNECTED state about SI change throughout a modification period. An SI message (or SIB(s) contained in this SI message) may fail to be transmitted within the corresponding pre-configured SI window if LBT for this SI message transmission fails. For example, when a cell is operating on an unlicensed spectrum, since the allocated resources on the unlicensed spectrum may be shared among devices, an SI message (or SIB(s) contained in this SI message) may not be successfully transmitted due to LBT failed. It may happen that the base station may not successfully transmit the SI message in the associated SI window and a UE may failed to receive the concerned SI in a modification period. On the other hand, the UE may need to keep monitoring the PDCCH monitoring occasions before the SI message can be received successfully due to the uncertain SI message transmission caused by failed LBT. If the UE could not update the SI successfully for a long time, the UE may keep using the old version of SI that may cause problems such as using wrong transmission resources to the network.

[0006] A UE may initiate a SI request procedure when one SIB is needed by the UE but not being broadcast. After a UE initiates a SI request procedure, the UE starts to receive on-demand SI after receiving acknowledgment (ACK) for SI request in the current (SI) modification period. The UE continues to receive the on-demand SI until the end of the modification period or until the

on-demand SI is completely received. However, a UE may perform a SI request procedure and receive the ACK for the SI request from the network, but the network may fail to transmit the on-demand SIs in the current modification period. Then the UE may need to re-initiate the SI request procedure that is not necessary.

[0007] Therefore, there is a need for a UE that is capable of operating on the unlicensed spectrum to acquire or update the SI (or on-demand SI) faster, or for a UE to receive the updated SI effectively by increasing the SI transmission opportunities in the time domain.

SUMMARY

[0008] The present disclosure is directed to improving the efficiency of a UE updating system information in the next generation wireless networks.

[0009] In a first aspect of the present disclosure, a method for system information update for a User Equipment (UE) is disclosed. The method comprising: receiving, from a base station, a Discovery Reference Signal (DRS); determining, whether the DRS contains a Downlink Control Information (DCI) with Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identifier (P-RNTI); determining, whether the DCI with CRC scrambled by the P-RNTI indicates scheduling information for SI is present when the DRS contains the DCI with CRC scrambled by the P-RNTI; and acquiring, an updated SI based on the scheduling information, when the scheduling information for SI is present.

[0010] In an implementation of the first aspect, the method further comprises: receiving, from the base station, a SI modification indication; performing, by the UE, a SI acquisition procedure in response to the SI modification indication received to update system information.

[0011] In another implementation of the first aspect, a short message indicator associated with the DCI with CRC scrambled by the P-RNTI indicates whether the scheduling information for System Information is present.

[0012] An implementation of the first aspect, the short message indicator indicates a short message is also present in the DRS.

[0013] In another implementation of the first aspect, the short message contains the scheduling information for SI.

[0014] In another implementation of the first aspect, the short message indicator indicates scheduling information of a Paging message; and the Paging message contains the scheduling

information for SI.

[0015] In another implementation of the first aspect, the UE starts performing the SI acquisition procedure by monitoring PDCCH monitoring occasions within the DRS.

[0016] In another implementation of the first aspect, the UE stops the SI acquisition procedure when the UE acquires the updated SI within the DRS.

[0017] In another implementation of the first aspect, the SI is at least one of other SI and SIB1.

[0018] In another implementation of the first aspect, the UE is capable of operating on unlicensed spectrum.

[0019] In a second aspect of the present disclosure, a UE comprising one or more non-transitory computer-readable media having computer-executable instructions for duplicating PDCP PDUs; and at least one processor is provided. The processor is coupled to the one or more non-transitory computer-readable media, and configured to execute the computer-executable instructions to: receive, from a base station, a Discovery Reference Signal (DRS); determine, whether the DRS contains a Downlink Control Information (DCI) with Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identifier (P-RNTI); whether the DCI with CRC scrambled by the P-RNTI indicates scheduling information for SI is present when the DRS contains the DCI with CRC scrambled by the P-RNTI; and acquire, an updated SI based on the scheduling information, when the scheduling information for SI is present.

[0020] In an implementation of the second aspect, the at least one processor is further configured to execute the computer-executable instructions to: receive, from the base station, a SI modification indication; perform, by the UE, a SI acquisition procedure in response to the SI modification indication received to update system information.

[0021] In another implementation of the second aspect, the at least one processor is further configured to execute the computer-executable instructions to: determine, whether the DRS contains a DCI with CRC scrambled by a System Information RNTI (SI-RNTI); acquire, within the DRS, an updated SI, after determining that the DRS contains the DCI with CRC scrambled by the SI-RNTI.

[0022] In another implementation of the second aspect, the short message indicator indicates a short message is also present in the DRS.

[0023] In another implementation of the second aspect, the short message contains the

scheduling information for SI.

[0024] In another implementation of the second aspect, the short message indicator indicates scheduling information of a Paging message and a short message are present in the DRS; and wherein the Paging message contains the scheduling information for SI.

[0025] In another implementation of the second aspect, the UE starts performing the SI acquisition procedure by monitoring PDCCH monitoring occasions within the DRS.

[0026] In another implementation of the second aspect, the UE stops the SI acquisition procedure when the UE acquires the updated SI within the DRS.

[0027] In another implementation of the second aspect, the SI is at least one of other SI and SIB1.

[0028] In another implementation of the second aspect, the UE is capable of operating on unlicensed spectrum.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Aspects of the exemplary disclosure are best understood from the following detailed description when read with the accompanying figures. Various features are not drawn to scale, and dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

[0030] Figure 1 is a diagram illustrating a System Information message, according to an exemplary implementation of the present disclosure.

[0031] Figure 2 is a diagram illustrating a Paging message including the updated SIB(s), according to an exemplary implementation of the present disclosure.

[0032] Figure 3 is a diagram illustrating a Paging message including the updated SI Message(s), according to an exemplary implementation of the present disclosure.

[0033] Figure 4 is a flowchart illustrating a method for system information update for a User Equipment (UE), according to an exemplary implementation of the present disclosure.

[0034] Figure 5 is a flowchart illustrating a method for system information update for a UE, according to an exemplary implementation of the present disclosure.

[0035] Figure 6 is a flowchart illustrating a method for system information update for a UE, according to an exemplary implementation of the present disclosure.

[0036] Figure 7 is a diagram illustrating a 4-step Random Access (RA) procedure,

according to one example implementation of the present disclosure.

[0037] Figure 8 is a diagram illustrating a 2-step RA procedure, according to one example implementation of the present disclosure.

[0038] Figure 9 is a block diagram illustrating a node for wireless communication, according to one example implementation of the present disclosure.

DETAILED DESCRIPTION

[0039] The following description contains specific information pertaining to example implementations in the present disclosure. The drawings in the present disclosure and their accompanying detailed description are directed to merely example implementations. However, the present disclosure is not limited to merely these example implementations. Other variations and implementations of the present disclosure will occur to those skilled in the art. Unless noted otherwise, like or corresponding elements among the figures may be indicated by like or corresponding reference numerals. Moreover, the drawings and illustrations in the present disclosure are generally not to scale, and are not intended to correspond to actual relative dimensions.

[0040] For the purpose of consistency and ease of understanding, like features may be identified (although, in some examples, not shown) by the same numerals in the example figures. However, the features in different implementations may be differed in other respects, and thus shall not be narrowly confined to what is shown in the figures.

[0041] The description uses the phrases “in one implementation,” or “in some implementations,” which may each refer to one or more of the same or different implementations. The term “coupled” is defined as connected, whether directly or indirectly through intervening components, and is not necessarily limited to physical connections. The term “comprising,” when utilized, means “including, but not necessarily limited to”; it specifically indicates open-ended inclusion or membership in the so-described combination, group, series and the equivalent. The expression “at least one of A, B and C” or “at least one of the following: A, B and C” means “only A, or only B, or only C, or any combination of A, B and C”.

[0042] Additionally, for the purposes of explanation and non-limitation, specific details, such as functional entities, techniques, protocols, standard, and the like are set forth for providing an understanding of the described technology. In other examples, detailed description of well-

known methods, technologies, systems, architectures, and the like are omitted so as not to obscure the description with unnecessary details.

[0043] Persons skilled in the art will immediately recognize that any network function(s) or algorithm(s) described in the present disclosure may be implemented by hardware, software or a combination of software and hardware. Described functions may correspond to modules which may be software, hardware, firmware, or any combination thereof. The software implementation may comprise computer executable instructions stored on computer readable medium such as memory or other type of storage devices. For example, one or more microprocessors or general-purpose computers with communication processing capability may be programmed with corresponding executable instructions and carry out the described network function(s) or algorithm(s). The microprocessors or general-purpose computers may be formed of Applications Specific Integrated Circuitry (ASIC), programmable logic arrays, and/or using one or more Digital Signal Processor (DSPs). Although some of the example implementations described in this specification are oriented to software installed and executing on computer hardware, nevertheless, alternative example implementations implemented as firmware or as hardware or combination of hardware and software are well within the scope of the present disclosure.

[0044] The computer readable medium includes but is not limited to Random Access Memory (RAM), Read Only Memory (ROM), Erasable Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM), flash memory, Compact Disc Read-Only Memory (CD-ROM), magnetic cassettes, magnetic tape, magnetic disk storage, or any other equivalent medium capable of storing computer-readable instructions.

[0045] A radio communication network architecture (e.g., a Long Term Evolution (LTE) system, an LTE-Advanced (LTE-A) system, an LTE-Advanced Pro system, or a 5G NR Radio Access Network (RAN)) typically includes at least one base station, at least one UE, and one or more optional network elements that provide connection towards a network. The UE communicates with the network (e.g., a Core Network (CN), an Evolved Packet Core (EPC) network, an Evolved Universal Terrestrial Radio Access network (E-UTRAN), a 5G Core (5GC), or an internet), through a RAN established by one or more base stations.

[0046] It should be noted that, in the present disclosure, a UE may include, but is not limited to, a mobile station, a mobile terminal or device, a user communication radio terminal. For example, a UE may be a portable radio equipment, which includes, but is not limited to, a mobile

phone, a tablet, a wearable device, a sensor, a vehicle, or a Personal Digital Assistant (PDA) with wireless communication capability. The UE is configured to receive and transmit signals over an air interface to one or more cells in a radio access network.

[0047] A base station may be configured to provide communication services according to at least one of the following Radio Access Technologies (RATs): Worldwide Interoperability for Microwave Access (WiMAX), Global System for Mobile communications (GSM, often referred to as 2G), GSM Enhanced Data rates for GSM Evolution (EDGE) Radio Access Network (GERAN), General Packet Radio Service (GPRS), Universal Mobile Telecommunication System (UMTS, often referred to as 3G) based on basic wideband-code division multiple access (W-CDMA), high-speed packet access (HSPA), LTE, LTE-A, eLTE (evolved LTE, e.g., LTE connected to 5GC), NR (often referred to as 5G), and/or LTE-A Pro. However, the scope of the present disclosure should not be limited to the above-mentioned protocols.

[0048] A base station may include, but is not limited to, a node B (NB) as in the UMTS, an evolved node B (eNB) as in the LTE or LTE-A, a radio network controller (RNC) as in the UMTS, a base station controller (BSC) as in the GSM/GERAN, a ng-eNB as in an E-UTRA base station in connection with the 5GC, a next generation Node B (gNB) as in the 5G-RAN, and any other apparatus capable of controlling radio communication and managing radio resources within a cell. The base station may serve one or more UEs through a radio interface.

[0049] The base station is operable to provide radio coverage to a specific geographical area using a plurality of cells forming the radio access network. The base station supports the operations of the cells. Each cell is operable to provide services to at least one UE within its radio coverage. More specifically, each cell (often referred to as a serving cell) provides services to serve one or more UEs within its radio coverage (e.g., each cell schedules the downlink and optionally uplink resources to at least one UE within its radio coverage for downlink and optionally uplink packet transmissions). The base station may communicate with one or more UEs in the radio communication system through the plurality of cells. A cell may allocate sidelink (SL) resources for supporting Proximity Service (ProSe) or Vehicle to Everything (V2X) services. Each cell may have overlapped coverage areas with other cells.

[0050] As discussed above, the frame structure for NR is to support flexible configurations for accommodating various next generation (e.g., 5G) communication requirements, such as Enhanced Mobile Broadband (eMBB), Massive Machine Type Communication (mMTC), Ultra-

Reliable and Low-Latency Communication (URLLC), while fulfilling high reliability, high data rate and low latency requirements. The Orthogonal Frequency-Division Multiplexing (OFDM) technology as agreed in 3GPP may serve as a baseline for NR waveform. The scalable OFDM numerology, such as the adaptive sub-carrier spacing, the channel bandwidth, and the Cyclic Prefix (CP) may also be used. Additionally, two coding schemes are considered for NR: (1) Low-Density Parity-Check (LDPC) code and (2) Polar Code. The coding scheme adaption may be configured based on the channel conditions and/or the service applications.

[0051] Moreover, it is also considered that in a transmission time interval TX of a single NR frame, a downlink (DL) transmission data, a guard period, and an uplink (UL) transmission data should at least be included, where the respective portions of the DL transmission data, the guard period, the UL transmission data should also be configurable, for example, based on the network dynamics of NR. In addition, sidelink resources may also be provided in an NR frame to support ProSe services or V2X services.

[0052] In addition, the terms “system” and “network” herein may be used interchangeably. The term “and/or” herein is only an association relationship for describing associated objects, and represents that three relationships may exist. For example, A and/or B may indicate that: A exists alone, A and B exist at the same time, or B exists alone. In addition, the character “/” herein generally represents that the former and latter associated objects are in an “or” relationship.

[0053] Network-initiated System Information Update

[0054] As discussed above, when the network changes system information, the network may first notify the UEs about this change throughout modification periods. Generally, after an SI change/modification indication is transmitted from the base station in one modification period, the updated SI may be broadcast in the following modification period(s) or immediately in the current modification period depending on what type the updated SI is. The duration of the modification period is configured by the system information.

[0055] In the LTE or NR, reference signals, such as Discovery Reference Signals (DRS), are transmitted to enable User Equipment (UE) to "discover" an active channel. In some implementations, a DRS may be used on unlicensed spectrum. In some implementations, an DRS may contain Remaining Minimum System Information (or RMSI, or SIB1), Other SI (OSI) and paging. In some implementations, an DRS may contain a control resource set (CORESET) of RMSI and/or the Physical Downlink Shared Channel (PDSCH) associated with the CORESET of

RMSI.

[0056] Table 1 shows the format of a Short Message Indicator in a DCI format 1_0. The UE may receive an indication for SI modification and/or Public Warning System (PWS) notification in DCI format 1_0 from the base station. The SI modification and/or PWS notification indication is about using a Short Message transmitted in a DCI with CRC scrambled by P-RNTI. One bit of the bit field of the Short Message Indicator indicates the presence of the short message and the other bit indicates the presences of the scheduling information for Paging. The SI modification indication (or SI change indication) may occur repetitively within the preceding modification period. When the UE receives a short message and the system information modification bit (e.g., *systemInfoModification*) of the short message in the received DCI (with CRC scrambled by P-RNTI) indicates that the SI has been modified (e.g., Bit 1 is set to 1), the UE may apply the SI acquisition procedure from the start of the next modification period. Note that the UE applies the SI acquisition procedure to acquire the Access Stratum (AS) and Non-access Stratum (NAS) information, e.g., to acquire a MIB or a SIB1 or an SI message in a serving cell. Short messages can be transmitted on PDCCH using P-RNTI with or without an associated Paging message using Short Message field in DCI format 1_0. Table 2 shows the current format of a short message. Bit 1 (*systemInfoModification*) of the short message is the most significant bit.

Bit field	Short Message indicator
00	Reserved
01	Only scheduling information for Paging is present in the DCI
10	Only short message is present in the DCI
11	Both scheduling information for Paging and short message are present in the DCI

Table 1. Short Message Indicator

Bit	Short message
1	<i>systemInfoModification</i> If set to 1: indication of a BCCH modification other than SIB6, SIB7 and SIB8.
2	<i>etwsAndCmasIndication</i> If set to 1: indication of an ETWS primary notification and/or an

	ETWS secondary notification and/or a CMAS notification.
3–[8]	Not used and shall be ignored by UE if received.

Table 2. Short Message

[0057] In some implementations, a UE may receive/detect DRS within a configured or predefined DRS measurement timing configuration (DMTC) when the UE camps on or connects to a cell operating on unlicensed spectrum. The DMTC may be a configuration that specifies information applicable for DRS detection and/or DRS measurement. In some implementations, DMTC may include information of DRS periodicity and offset for a specific frequency. In some implementations, DMTC may include the information of the duration of a DRS occasion for a specific frequency. In some implementations, the specific frequency may be on licensed spectrum or unlicensed spectrum. In some implementations, a predefined DMTC may be stored in USIM (UMTS Subscriber Identity Module). In some implementations, a DMTC may be configured by the last serving cell and the last serving cell may be operated on a licensed or unlicensed spectrum. In some implementations, different predefined/pre-configured DMTCs may be applicable to different cells (or component carriers) that are operating on unlicensed spectrum. In some implementations, a predefined/pre-configured DMTC may be applicable for all cells (or component carriers) that are operating on unlicensed spectrum. In some implementations, a UE may receive/detect DRS within a configured or predefined DRS measurement timing configuration (DMTC) when the UE is camped on or connected to a cell operating on unlicensed spectrum during the Active Time within one DRX cycle. When a DRX cycle is configured, the Active Time may include the time while:

- *drx-onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimerDL* or *drx-RetransmissionTimerUL* or *ra-ContentionResolutionTimer* is running; or
- a Scheduling Request is sent on PUCCH and is pending; or
- a PDCCH indicating a new transmission addressed to the C-RNTI of the Medium Access Control (MAC) entity has not been received after successful reception of a Random Access Response (RAR) for the Random Access Preamble not selected by the MAC entity among the contention-based Random Access Preamble.

[0058] In some implementations, a UE may receive/detect a DRS by following the information (or instruction) provided via the broadcast SI or via the dedicated signalling.

[0059] In some implementations, a gNB (or a base station/cell) may indicate (e.g., via system information, DCI, or MAC Control Element (CE)) whether a DCI with CRC scrambled by a RNTI (e.g., a P-RNTI or a SI-RNTI) is applied for a UE-specific search space or a Cell-specific search space.

[0060] A gNB (or a base station/cell) may indicate whether a DRS (e.g., via system information, DCI, or MAC CE) contains a DCI, and the DCI with CRC is scrambled by what type of RNTI. In some implementations, a gNB (or a base station/cell) may indicate whether a DCI with CRC scrambled by P-RNTI may appear within a DRS (e.g., via system information, DCI, or MAC CE). In some implementations, a gNB (or a base station/cell) may indicate whether a DCI with CRC scrambled by SI-RNTI may appear within a DRS (e.g., via system information, DCI, or MAC CE). In some implementations, a gNB (or a base station/cell) may indicate whether a DCI with CRC scrambled by a specific RNTI may appear within a DRS (e.g., via system information, DCI, or MAC CE).

[0061] In some implementations, a UE may apply the SI acquisition procedure from the start of the next modification period based on the broadcast SI scheduling information and/or the UE may start the SI acquisition procedure in the DRS(s) when the UE receives a short message with system information modification bit that was set to 1. In some implementations, to perform SI acquisition procedure in DRS, a UE may start PDCCH monitoring in the PDCCH monitoring occasion(s) within a DRS (by using SI-RNTI) based on the search space information configured for other system information (e.g., provided in *searchSpaceOtherSystemInformation* field in Common PDCCH configuration). In some implementations, the UE may receive the *searchSpaceOtherSystemInformation* in the DRS. In some implementations, the UE may regard the PDCCH monitoring occasions for SI message reception in SI-window are the same as PDCCH monitoring occasions for SIB1 when the *searchSpaceOtherSystemInformation* field is set to zero. In some implementations, PDCCH monitoring occasions for SI message are determined based on search space indicated by *searchSpaceOtherSystemInformation* when the *searchSpaceOtherSystemInformation* field is not set to zero.

[0062] In some implementations, if a UE successfully updates (concerned) SI (e.g., SIB1 or OSI) within a DRS (i.e. within the modification period), the UE may stop performing SI acquisition/update procedure. For example, the UE may stop performing SI acquisition/update procedure in the next modification period if the UE successfully updates the concerned SI within

a DRS in the current modification period. In some implementations, a UE may implicitly deactivate the corresponding search space of system information in the next DRS (or following DRS(s)) till a defined time period while the UE successfully acquires the SI within a DRS. In some implementations, a UE may implicitly deactivate the corresponding search space of system information in the next DRS (or following DRS(s)) while the UE successfully acquires the SI within a DRS. In some implementations, a UE may implicitly stop CRC check on DCI (or PDCCH) by using SI-RNTI in the next DRS (or following DRS(s)) while the UE successfully acquires the SI within a DRS.

[0063] In some implementations, as shown in Table 3, a gNB (or a base station/cell) may set (and not limited to) the bit field of the short message indicator as “00” to indicate to the UE that both scheduling information of OSI and short message are present in the DCI. It should be noted that the first bit of the Short Message indicator may set (for setting system information modification bit in the short message) as 1 when the scheduling information for OSI is present.

Bit field	Short Message indicator
00	Both scheduling information for OSI and short message are present in the DCI
01	Only scheduling information for Paging is present in the DCI
10	Only short message is present in the DCI
11	Both scheduling information for Paging and short message are present in the DCI

Table 3

[0064] In some implementations, the scheduling information may include the information about frequency domain resource assignment and/or time domain resource assignment that is transmitted by means of (and not limited to) DCI format 1_0 with CRC scrambled by P-RNTI. In some implementations, the resource assignment of OSI indicated by the corresponding scheduling information may be within the DRS or outside of the DRS, and the DCI that includes the scheduling information is received in this DRS. The UE may receive the updated OSI on the indicated PDSCH (physical Downlink Shared Channel) based on the received scheduling information.

[0065] Figure 1 is a diagram illustrating a System Information message, according to an exemplary implementation of the present disclosure. In some implementations, the indicated PDSCH may carry the (updated) system information message which is used to convey one or more SIBs and at least one SIB in the SI message is updated. In some implementations, the value tag and/or area scope (*areaScope*) of each SIB in the SI message may also be provided in the (updated) system information message. A value tag (*valueTag*) is used to indicate the version of the corresponding SIB. In some implementations, the value tag and/or area ID and/or area scope of at least one SIB in the SI message may also be provided in the (updated) system information message. It should be noted that area ID is a bit string to indicate the system information area the cell belongs to, and *areaScope* is a Boolean value to indicate whether a SIB is area specific or not.

[0066] In some implementations, a UE camped on or connected to a cell operating on unlicensed spectrum may treat the bit field “00” of short message indicator as “Reserved” when the UE does not support the feature (or function) that both scheduling information for OSI and short message are present in the DCI. In some implementations, a UE that is allowed to camp on or connect to a cell operating on unlicensed spectrum (e.g., the UE is NR-U capable) may mandatorily support the feature (or function) that both scheduling information for OSI and short message are present in the DCI (i.e., the bit field of the short message indicator is set to “00”).

[0067] Table 4 shows the detail of a short message indicator of a DCI, according to an exemplary implementation of the present disclosure. In some implementations, a gNB (or a base station/cell) may set the bit field of the short message indicator with a value of “00” to indicate to the UE that scheduling information of RMSI (or SIB1) and short message are both present in the DCI. It should be noted that the first bit field (for system information modification) of the short message may set to 1. In some implementations, the scheduling information may include the information (or content), such as frequency domain resource assignment and/or time domain resource assignment, transmitted by means of the DCI format 1_0 (and not limited to) with CRC scrambled by P-RNTI. In some implementations, the resource assignment of RMSI indicated by the corresponding scheduling information may be within the DRS or outside of the DRS, and the DCI including the scheduling information is received in this DRS. In some implementations, a UE camped on or connected to a cell operating on unlicensed spectrum may still regard the bit field of the short message indicator with a value of “00” as “Reserved” when the UE does not support the feature (or function) that both scheduling information for RMSI (or SIB1) and short message are

present in the DCI. In some implementations, a UE that is allowed to camp on or connect to a cell operating on unlicensed spectrum (i.e., the UE is NR-U capable) may mandatorily support the feature (or function) that both scheduling information for RMSI (or SIB1) and short message are present in the DCI (i.e., the bit field of the short message indicator is set as “00”).

Bit field	Short Message indicator
00	Both scheduling information for RMSI (or SIB1) and short message are present in the DCI
01	Only scheduling information for Paging is present in the DCI
10	Only short message is present in the DCI
11	Both scheduling information for Paging and short message are present in the DCI

Table 4

[0068] Figure 2 is a diagram illustrating a Paging message including the updated SIB(s), according to an exemplary implementation of the present disclosure. In some implementations, a gNB (or a base station/ cell) may use the bit field of the short message indicator with value of “11” to indicate that scheduling information of paging message and short message are both present in the DCI, and the paging message may include the updated SI message(s) or updated SIB(s). In some implementations, the updated SIB(s) may be SIB1 or other system information block(s).

[0069] Figure 3 is a diagram illustrating a Paging message including the updated SI Message(s), according to an exemplary implementation of the present disclosure. In some implementations, a UE camped on or connected to a cell operating on unlicensed spectrum may regard the bit field of short message indicator with value “11” as “scheduling information for Paging and short message are both present in the DCI but the DCI does not include updated SIB(s) or updated SI message(s)” when the UE does not support the feature (or function) of the paging message as shown in Fig. 2 or Fig. 3. For a UE that does not support the feature (or function) of the paging message shown in Fig. 2 or Fig. 3, the UE may ignore the *UpdatedSIBInfo* IE (as shown in Figure 2) or the *UpdatedSIMessage* IE (as shown in Figure 3). In some implementations, a UE which is allowed to camp on or connect to a cell operating on unlicensed spectrum (e.g., a NR-U capable UE) may mandatorily support the feature (or function) of the new structure of paging message (i.e., including the updated SI message(s) or updated SIB(s)).

[0070] In some implementations, there may be two kinds of paging messages, one includes

PagingRecord and the other includes updated SIB(s) or updated SI message(s). When the bit field of the short message indicator is set to be “11” and the system information modification bit is set to 1, the UE may consider the paging message is with an updated SIB(s) or updated SI message(s). The UE may consider that the paging message is with PagingRecord when the bit field of short message indicator is set to “11” and the system information modification bit is set to 0.

[0071] In some implementations, a UE may always use P-RNTI and SI-RNTI to decode/descramble DCI (or PDCCH) (e.g., CORESET 0) within a DRS. In some implementations, for SI message acquisition, PDCCH monitoring occasion(s) within a DRS may be determined based on the search space information configured for other system information (e.g., provided in *searchSpaceOtherSystemInformation* field in Common PDCCH configuration). In some implementations, PDCCH monitoring occasions for SI message reception in SI-window are the same as PDCCH monitoring occasions for SIB1 when *searchSpaceOtherSystemInformation* is set to zero. In some implementations, PDCCH monitoring occasions for SI message are determined based on the search space indicated by *searchSpaceOtherSystemInformation* when *searchSpaceOtherSystemInformation* is set to non-zero. In some implementations, when a UE uses P-RNTI and SI-RNTI to decode/descramble DCI (or PDCCH) (e.g., CORESET 0) within a DRS and only a DCI (or PDCCH) is successfully decoded/descrambled by P-RNTI (for CRC check), the UE may start SI acquisition procedure for SI update. In some implementations, when a UE uses P-RNTI and SI-RNTI to decode/descramble DCI (or PDCCH) (e.g., CORESET 0) within a DRS, and only a DCI (or PDCCH) is successfully decoded/descrambled by SI-RNTI (for CRC check), the UE may not need to start SI acquisition procedure for SI update. In some implementations, the UE may use P-RNTI and SI-RNTI to decode/descramble DCI (or PDCCH) (e.g., CORESET 0) within a DRS. The UE may start SI acquisition procedure when only one DCI (or PDCCH) is successfully decoded/descrambled by SI-RNTI (for CRC check). For example, when a UE is just moving into a cell, the UE may use P-RNTI and SI-RNTI to decode/descramble DCI (or PDCCH) (e.g., CORESET 0) within a DRS. If a DCI (or PDCCH) is successfully decoded/descrambled by SI-RNTI (for CRC check) by the UE, the UE may start SI acquisition procedure accordingly.

[0072] In some implementations, a UE may use a new RNTI to decode/descramble DCI (or PDCCH) (e.g., CORESET 0) within a DRS. It should be noted the new RNTI may be predefined (to be used in Common Search Space (CSS)) or be signaling (to be used in User

Specific Search Space (USS)) to the UE. If one DCI is transmitted with CRC scrambled by the new RNTI, this DCI may indicate the scheduling information of OSI. The OSI transmission opportunities that are based on the scheduling information may be within the DRS or outside of the DRS. In some implementations, for SI message acquisition, PDCCH monitoring occasion(s) within a DRS are determined based on the search space information configured for other system information (e.g., provided in *searchSpaceOtherSystemInformation* field in Common PDCCH configuration). In some implementations, PDCCH monitoring occasions for SI message reception in SI-window may be regarded as the same as the PDCCH monitoring occasions for SIB1 when *searchSpaceOtherSystemInformation* is set to zero. In some implementations, PDCCH monitoring occasions for the SI message are determined based on the search space indicated by *searchSpaceOtherSystemInformation* when *searchSpaceOtherSystemInformation* is set to non-zero.

[0073] In some implementations, a gNB (or a base station/cell) may use the short message to indicate the scheduling information of the updated SIB(s) or updated SI message(s). As shown in Table 2, a gNB (or a base station/cell) may make use the remaining 6 bits (i.e., from bit 3 to bit 8) in the short message to indicate the scheduling information of the updated SIB(s) or the updated SI message(s). In some implementations, N1 bits of bit 3 to bit 8 in the short message may be used to indicate the frequency domain resource assignment. N2 bits of bit 3 to bit 8 in the short message may be used to indicate the time domain resource assignment. The total of N1 and N2 may equal to or less than 6. In some implementations, the values of N1 and N2 may be predefined or configured by network via broadcast SI or dedicated signalling. In some implementations, N3 bits in the short message may be used as an index for a mapping table. The mapping table includes the scheduling information for each index. For example, index #1 indicates a specific scheduling information (or resource assignment). In some implementations, the mapping table for scheduling information may be predefined or configured by network via broadcast SI or dedicated signalling. In some implementations, a gNB (or a base station/cell) may use at least one of the remaining 6 bits (i.e., from bit 3 to bit 8) in the short message to indicate whether the scheduling information of OSI is present in the DCI. In some implementations, the UE may receive the DCI within the DRS or outside of the DRS. In some implementations, the UE may receive the OSI within the DRS or outside of the DRS according to the scheduling information of OSI.

[0074] In some implementations, a UE camped on or connected to a cell operating on

unlicensed spectrum may still ignore bit 3 to bit 8 of the short message when the UE does not support the feature (or function) of using the short message to indicate the scheduling information of the updated SIB(s) or updated SI message(s). In some implementations, a UE that is allowed to camp on or connect to a cell operating on unlicensed spectrum (i.e., the UE is NR-U capable) may mandatorily support the feature (or function) of using the short message to indicate the scheduling information of the updated SIB(s) or updated SI message(s).

[0075] In some implementations, a UE camped on or connected to a cell operating on unlicensed spectrum may be required to check the SI status (i.e., whether the concerned SI is updated or not) within a predefined or configured time window. In some implementations, a UE camped on or connected to a cell operating on unlicensed spectrum may be required to update the SI within a predefined or configured time window. In some implementations, a UE camped on or connected to a cell operating on unlicensed spectrum may be required to update the SI within a predefined or configured time window regardless of DRX configuration. An RRC_INACTIVE/RRC_IDLE UE may wake up during the predefined or configured time window to update the SI or check the SI status. The UE may receive the configuration of the time window from the gNB (or a base station/cell) via broadcast system information or dedicated signaling (e.g., RRC message with suspend configuration). In some implementations, a UE may perform cell (re)-selection when the UE is unable to check the SI status within the predefined or configured time window.

[0076] Another way for a UE that camped on or connected to a cell operating on unlicensed spectrum to increase the SI transmission opportunities is to dynamically control the SI window length or SI periodicity. By increasing the SI transmission opportunities, updated SI may be effectively acquired within the SI window.

[0077] In some implementations, a gNB (or a base station/cell) may dynamically increase SI window length or shorten the SI periodicity based on the LBT outcomes, channel busy condition or channel occupancy rate.

[0078] In some implementations, a gNB (or a base station/cell) may indicate the new SI window length or new SI periodicity for SI reception via a DCI (e.g., a DCI with CRC scrambled by P-RNTI), short message, paging message, MAC CE (Control Element), or system information (e.g., in SIB1). In some implementations, the new SI window length or new SI periodicity may be only applicable until the end of the next K modification period(s) (e.g., K may be 1 or 2 or other

value), where the value of K may be predefined and is configured by the network. The network may configure the value of K via system information or via dedicated signaling. In some implementations, the new SI window length may be an index of a mapping table or an exact value.

[0079] In other implementations, the network may provide an extended SI window length or a shortened SI periodicity of an SI message via broadcast system information or dedicated signaling. Then, a UE may decide whether to apply the extended SI window length or the shortened SI periodicity depending on whether a criterion is satisfied. In some implementations, the network may provide a threshold for channel occupancy rate. A UE may consider that the network may transmit the SI message using the extended SI window length or the shorten SI periodicity and may receive the SI message by applying the extended SI window or the shortened SI periodicity when the UE determines that the channel occupancy rate is equal to or higher than the threshold. The unit of the extended SI window length may be in milliseconds (ms), slot, sub-slot, frame or symbol. Moreover, the length of the extended SI window may be infinite so that the UE will monitor the PDCCH to acquire the updated SI regardless of the length of the SI window.

[0080] In some implementations, a gNB (or a base station/cell) may indicate whether a UE need to monitor an additional SI window for receiving the SI message via a DCI, short message, paging message, MAC CE, or system information. The additional SI window of the SI message may be broadcast in the system information or provided in the dedicated signaling by the gNB (a base station/cell).

[0081] In some implementations, the network may provide an additional SI window of a SI message via broadcast system information or dedicated signaling. Then, a UE may decide whether to receive the SI message in the addition SI window depending on whether a criterion is satisfied. In some implementations, the network may provide a threshold for channel occupancy rate. A UE may consider that the network has transmitted the SI message in the corresponding additional SI window and may try to receive the SI message in the corresponding additional SI window when the UE determines that the channel occupancy rate is equal to or higher than the threshold.

[0082] In some implementations, a gNB (or a base station/cell) may indicate whether the UE needs to monitor the configured multiple SI windows for receiving SI message or only monitor the first configured SI window via a DCI, short message, paging message, MAC CE, or system information. The multiple SI windows of a SI message may be broadcast in system information or

provided in dedicated signaling by a gNB (a base station/cell).

[0083] In other implementations, the network may provide the multiple SI windows of an SI message via broadcast system information or dedicated signaling. Then, a UE may decide whether to receive an SI message in the multiple SI windows when a criterion is satisfied. In some implementations, the network may provide a threshold for channel occupancy rate. A UE may consider that the network may transmit the SI message in the corresponding multiple SI windows and may try to receive the SI message in the corresponding multiple SI windows when the UE determines that the channel occupancy rate is equal to or higher than the threshold.

[0084] Figure 4 is a flowchart illustrating a method 400 for system information update for a User Equipment (UE), according to an exemplary implementation of the present disclosure. The UE may be capable of operating on unlicensed spectrum. In action 410, the UE may receive a SI modification indication from a base station.

[0085] In action 420, the UE may perform a SI acquisition procedure in response to the SI modification indication received from the base station in action 410.

[0086] In action 430, the UE may receive Discovery Reference Signal (DRS) from the base station.

[0087] In action 440, the UE may determine whether the DRS contains a Downlink Control Information (DCI) with Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identifier (P-RNTI).

[0088] In action 450, the UE may determine whether the DCI with CRC scrambled by the P-RNTI indicates scheduling information for SI is present when the DRS contains the DCI with CRC scrambled by the P-RNTI. In some implementations, the SI may be at least one of other SI and SIB1.

[0089] In some implementations, a short message indicator may be associated with the DCI with CRC scrambled by the P-RNTI. The short message indicator may indicate whether the scheduling information for System Information is present in the DCI. The short message indicator may also indicate whether a short message is present in the DCI. In some implementations, the short message may contain the scheduling information for the SI. In some implementations, the short message may contain the scheduling information of the updated SIB or updated SI message. In some implementations, the short message indicator may indicate scheduling information of a Paging message. In some implementations, the Paging message may contain the scheduling

information for SI or contain the updated SI message or SIB(s).

[0090] In action 460, the UE may acquire an updated SI based on the scheduling information when the scheduling information for SI is determined to be present in the DCI. After the updated SI is acquired, the process of performing the method 400 for system information update may end.

[0091] It should be noted that the UE may start performing the SI acquisition procedure by monitoring PDCCH monitoring occasions within the DRS and stop the SI acquisition procedure (e.g., in the next modification period) when the UE acquires the updated SI within the DRS.

[0092] It should be noted that although actions 410 to 460 are delineated as separate actions represented as independent blocks in Fig. 4, these separately delineated actions should not be construed as necessarily order dependent. The order in which the actions are performed in Fig. 4, is not intended to be construed as a limitation. Moreover, one or more of the actions 410 to 460 may be omitted in some of the present implementations.

[0093] Figure 5 is a flowchart illustrating a process 500 for system information update for a UE, according to an exemplary implementation of the present disclosure. The UE may be capable of operating on unlicensed spectrum. In action 510, the UE may receive a SI modification indication from a base station. In action 520, the UE may perform a SI acquisition procedure in response to the SI modification indication received from the base station in action 510. In action 530, the UE may receive Discovery Reference Signal (DRS) from the base station. In action 540, the UE may determine whether the DRS contains a Downlink Control Information (DCI) with Cyclic Redundancy Check (CRC) scrambled by a System Information Radio Network Temporary Identifier (SI-RNTI). In action 550, the UE may acquire an updated SI based on the scheduling information when the DRS is determined containing the DCI with CRC scrambled by the SI-RNTI. After the updated SI is acquired, the process of performing the method 500 for system information update may end. The UE may start performing the SI acquisition procedure by monitoring PDCCH monitoring occasions within the DRS and stop the SI acquisition procedure in the next modification period when the UE acquires the updated SI within the DRS.

[0094] It should be noted that although actions 510 to 550 are delineated as separate actions represented as independent blocks in Fig. 5, these separately delineated actions should not be construed as necessarily order dependent. The order in which the actions are performed in Fig. 5, is not intended to be construed as a limitation. Moreover, one or more of the actions 510 to 550

may be omitted in some of the present implementations.

[0095] Figure 6 is a flowchart illustrating a method 600 for system information update for a UE, according to an exemplary implementation of the present disclosure. The UE may be capable of operating on unlicensed spectrum. In action 610, the UE may receive a SI modification indication from a base station.

[0096] In action 620, the UE may perform a SI acquisition procedure in response to the SI modification indication received from the base station in action 610.

[0097] In action 630, the UE may receive a new SI window length (or a new SI periodicity) and a threshold from the base station. In some implementations, the new SI window length (or the new SI periodicity) may be indicated via a DCI, short message, paging message, MAC CE or SI.

[0098] In action 640, the UE may determine whether a channel occupancy rate is higher than the threshold received in action 630.

[0099] In action 650, the UE may decide whether to apply the new extended SI window length (or the new SI periodicity) when the channel occupancy rate is determined to be equal to or higher than the threshold.

[00100] In action 660, the UE may acquire an updated SI. After the updated SI is acquired, the process of performing the method 600 for system information update may end.

[00101] It should be noted that although actions 610 to 660 are delineated as separate actions represented as independent blocks in Fig. 6, these separately delineated actions should not be construed as necessarily order dependent. The order in which the actions are performed in Fig. 6, is not intended to be construed as a limitation. Moreover, one or more of the actions 610 to 660 may be omitted in some of the present implementations.

[00102] System Information Update based on On-demand request by a UE

[00103] In NR, not each SI message may be broadcast. A UE in RRC_IDLE, RRC_INACTIVE or RRC_CONNECTED state may be allowed to initiate a SI request procedure to request a gNB (e.g. a base station/cell) which the UE is camped on to broadcast the on-demand SI message (e.g. Other SI) that has not been broadcast yet. The initialization of SI request procedure made by the UE (e.g., the UE in RRC_IDLE state or the UE in RRC_INACTIVE state) may trigger a random access procedure.

[00104] Figure 7 is a diagram 700 illustrating a 4-step Random Access (RA) procedure, according to one example implementation of the present disclosure. Figure 7 includes a UE 710

and a base station (e.g., a gNB) 720. As shown in the figure, the 4-step RA procedure may be started by the UE 710 sending, in action 730, a Random Access Preamble (Msg-1) to the base station 720. For the sake of SI request, the Msg-1 may be used for indication of the requested Other SI. The UE 710 may send the RA preamble to the base station 720 on a Physical Random Access channel (RACH) in the uplink. In response, in action 740, the base station 720 may send a RAR (Msg-2) to the UE 710. The RAR may be generated by a Medium Access Control (MAC) entity and transmitted on a Downlink Shared Channel (DL-SCH). When Msg-1 is used for SI request, the minimum granularity of the request is one SI message (i.e. a set of SIBs), one RACH preamble and/or PRACH resource may be used to request multiple SI messages and the base station acknowledges the request in Msg-2.

[00105] The RAR, transmitted in action 740 may include an RA-preamble identifier, Timing Alignment information for the primary Timing Advanced Group (pTAG), initial UL grant, and assignment of Temporary Cell-Radio Network Temporary Identity (C-RNTI). After receiving the RAR, the UE 710 may send, in action 750, a first scheduled UL transmission (Msg-3), for example, on an Uplink Shared Channel (UL-SCH) to the base station 720. For the sake of SI request, the Msg-3 may include the SI request message unless the on-demand SI is associated to a subset of the PRACH resources. After the base station 720 receives the first scheduled UL transmission, the base station may send, in action 760, a Contention Resolution message (Msg-4) to the UE 630 on the DL. When Msg-3 is used for SI request, the base station acknowledges the request in Msg-4.

[00106] In an RA procedure, upon receiving a RAR or Msg-2 (e.g., in action 740), if the RAR contains a MAC sub-Protocol Data Unit (subPDU) with an RA preamble identifier that is associated with the transmitted preamble (e.g., when the identifier matches the preamble's index), the RAR reception may be considered as successful. After the UE determines that the RAR reception is successful, the MAC layer (e.g., in the UE) may indicate the received UL grant to the lower layers to transmit the Msg-3 (e.g., in action 750). Once the Msg-3 is transmitted, the MAC entity may start a timer (e.g., the *ra-ContentionResolutionTimer*) and restart the timer (e.g., the *ra-ContentionResolutionTimer*) at each Hybrid Automatic Repeat reQuest (HARQ) retransmission (e.g., in the first symbol after the end of the Msg-3 transmission). An RA procedure may be considered as successfully completed when the contention-resolution is successfully performed (e.g., when the UE Contention Resolution identity in the MAC Control Element (CE) matches the

Common Control Channel (CCCH) Service Data Unit (SDU) transmitted in the Msg-3, or other conditions defined in the 3GPP technical specification (e.g., TS 38.321) are met). However, if the timer (e.g., the *ra-ContentionResolutionTimer*) expires, the Contention-Resolution may be considered not successful if none of the successfully completed conditions (e.g., matching of the UE identifiers, or other conditions defined in the 3GPP TS 38.321) is satisfied.

[00107] The Msg-3 in an RA procedure may not be transmitted to the base station, for example, when an LBT procedure fails. Consequently, the above-mentioned contention-resolution timer may never start (e.g., the MAC entity may never start the timer). As a result, the UE that has initiated such an RA procedure may stay in action 750 for a long period and may not proceed to action 760, or transition back to action 730 (e.g., to send another RA preamble to the base station). To avoid this type of situation, in some of the present implementations, the UE may perform an enhanced RA procedure. That is, the UE may transmit multiple Msg-3's to the base station (e.g., on multiple UL grants provided by the base station).

[00108] Figure 8 is a diagram 800 illustrating a 2-step RA procedure, according to one example implementation of the present disclosure. Figure 8 includes a UE 810, and a base station (e.g., a gNB) 820. In action 830, UE 810 transmits Msg-A to the base station 820. In some implementations, Msg-A contains preamble (on PRACH) and payload (on PUSCH) transmissions of the RA procedure for 2-step RA. In action 840, Msg-B is sent from the base station 820 as a response to the UE 810. In some implementations, the Msg-B may consist of response(s) for contention resolution, fallback indication(s), and backoff indication. Specifically, the Msg-A in 2-step RACH may be a signal to detect the UE and a payload while the Msg-B may be used for contention resolution for RA with a possible payload. The Msg-A for 2-step RA may at least include the equivalent information which may be transmitted in Msg-3 for 4-step RA.

[00109] In some implementations, if the UE receives a fallback indication in the Msg-B, the UE may perform Msg-3 transmission and monitor contention resolution. In some implementations, if contention resolution is not successful after Msg-3 (re)transmission(s), the UE may go back to Msg-A transmission. In some implementations, if the 2-step RA procedure fails to be completed after a number of Msg-A transmissions, the UE may be configured to switch to the 4-step RA procedure.

[00110] It should be noted that the base station (e.g., gNB) may apply respective implementations or different configurations for Msg-1 based/Msg-3 based/Msg-A based SI request

upon NR-U. The corresponding parameter (e.g, different K modification periods) may be used respectively.

[00111] It should be noted that some of the implementations may be applicable for a UE to initiate a SI request to a cell operating on licensed spectrum (e.g., the network want to extend a SI acquisition timer/period for a specific UE or all UEs.

[00112] It should be noted that a NR-U capable UE may be a UE that is allowed to camp on or connect to a cell operating on unlicensed spectrum, and the UE may support the feature (or function) of receiving on-demand SI until the end of the next K modification period(s) or until the on-demand SI is received within the next K modification period(s) after receiving ACK for SI request when the UE camps on or connected to a cell operating on unlicensed spectrum.

[00113] It should be noted in some of the present implementations, a UE that camps on a cell is implying the UE is in RRC_IDLE or RRC_INACTIVE state and a UE that connects to a cell is implying the UE is in RRC_ACTIVE state.

[00114] In some implementations, a UE may only be allowed to initiate (or perform) a Msg-1 based SI request procedure on a cell operating on unlicensed spectrum. In some implementations, a UE may only be allowed to initiate (or perform) a Msg-1 based SI request procedure based on 2-step RA on a cell operating on unlicensed spectrum. For example, a UE may include the on-demand SI that is the payload part of the Msg-A of a 2-step RA procedure in the Msg-1. For example, the payload may include the on-demand SIB(s) (or System Information Block(s) and/or the on-demand SI message(s)). In some implementations, a UE may only be allowed to initiate (or perform) a Msg-3 based SI request procedure on a cell operating on unlicensed spectrum.

[00115] In some implementations, when a UE initiates (or perform) a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum, the UE may start to receive on-demand SI after receiving acknowledgment (ACK) for SI request in the current (SI) modification period, and the UE may continue to receive the on-demand SI until the end of the next K modification period(s) or until the on-demand SI is received within the next K modification period(s). The value of K may be predefined or pre-configured by the network via system information or dedicated signaling.

[00116] In some implementations, if the value of K is predefined or pre-configured (e.g., via an RRC Release message or other dedicated signaling), the UE may ignore K for receiving the on-demand SI after receiving ACK for SI request if the cell that the UE is currently camped on or

connected to is operating on licensed spectrum. If a UE is camping on or connecting to a cell operating on licensed spectrum, and the value of K is pre-configured or predefined by the network, the UE may continue to receive on-demand SI until the end of the current modification period or until the on-demand SI is received within the current modification period after receiving ACK for SI request, when the UE initiates a SI request procedure. For example, if a UE is camping on or connecting to a cell operating on unlicensed spectrum, and the value of K is pre-configured or predefined by the network, the UE may continue to receive on-demand SI until the end of the next K modification period(s) or until the on-demand SI is received within the next K modification period(s) after receiving ACK for SI request, when the UE initiates a SI request procedure.

[00117] In some implementations, if the value of K is not pre-configured, or is not present in a dedicated signaling, or being broadcast in system information, the UE may apply a default value of K that is predefined. In some implementations, if the value of K is not pre-configured, or is not present in a dedicated signaling, or being broadcast in the system information, and if a UE is camping on or connecting to a cell operating on unlicensed spectrum, the UE may continue to receive on-demand SI until the end of the current modification period or until the on-demand SI is received after receiving ACK for SI request when the UE initiates a SI request procedure.

[00118] In some implementations, a NR-U incapable UE may ignore the configuration (or setting) of K. In some implementations, a NR-U capable UE may mandatorily support the feature (or function) to receive on-demand SI until the end of the next K modification period(s) or until the on-demand SI is received within the next K modification period(s) after receiving ACK for SI request.

[00119] In some implementations, when a UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum, the UE may start to receive on-demand SI after receiving ACK for SI request in the current modification period. In some implementations, the UE may continue to receive on-demand SI until a SI acquisition period/timer is expired after receiving the ACK for SI request. In some implementations, the UE may continue to receive on-demand SI until the on-demand SI is fully received while the SI acquisition period/timer is active after receiving the ACK for SI request. The SI acquisition period/timer may be predefined or configured by the network via system information or dedicated signaling. In some implementations, if a SI acquisition period/timer is predefined or pre-configured (e.g., via a *RRCRelease* message or other dedicated signaling), the UE may ignore the SI acquisition

period/timer for receiving the on-demand SI after receiving ACK for SI request when the cell that is currently camped on or connected to is operating on licensed spectrum. For example, if a UE is camping on or connecting to a cell operating on licensed spectrum, and a SI acquisition period/timer is pre-configured or predefined, the UE may continue to receive on-demand SI until the end of the current modification period or until the on-demand SI is received within the current modification period after receiving ACK for SI request, when the UE initiates a SI request procedure. For example, if a UE is camping on or connecting to a cell operating on unlicensed spectrum and a SI acquisition period/timer is pre-configured or predefined, the UE may continue to receive on-demand SI until the SI acquisition period/timer is expired, or until the on-demand SI is received while the SI acquisition period/timer is active after receiving ACK for SI request, when the UE initiates a SI request procedure. In some implementations, if a SI acquisition period/timer is not pre-configured or present in a dedicated signaling, or being broadcast in system information, the UE may apply the default value of a SI acquisition period/timer that is predefined. In some implementations, if a SI acquisition period/timer is not pre-configured, not present in a dedicated signalling or not being broadcast in system information, and if a UE is camping on or connecting to a cell operating on unlicensed spectrum, the UE may continue to receive on-demand SI until the end of the current modification period or until the on-demand SI is received within the current modification period after receiving ACK for SI request when the UE initiates a SI request procedure.

[00120] In some implementations, for a UE that does not support the feature (or function) to receive on-demand SI until a SI acquisition period/timer is expired or until the on-demand SI is received while the SI acquisition period/timer is active after receiving ACK for SI request, the UE may ignore the configuration of the SI acquisition period/timer. In some implementations, for a UE that is allowed to camp on or connect to a cell operating on unlicensed spectrum, the UE may mandatorily support the feature (or function) to receive on-demand SI until a SI acquisition period/timer is expired or until the on-demand SI is received while the SI acquisition period/timer is active after receiving ACK for SI request.

[00121] In some implementations, to increase the success rate for the on-demand SI reception on unlicensed spectrum, a gNB (or a base station/cell) may dynamically change the value of a SI acquisition period/timer, e.g., based on the LBT outcomes, channel busy condition or channel occupancy rate. In some implementations, a gNB (or a base station/cell) may indicate the

new SI acquisition period/timer via a DCI (e.g., a DCI with CRC scrambled by SI-RNTI), MAC CE or system information (e.g., in SIB1). In some implementations, the new SI acquisition period/timer may be only applicable until the end of the next N modification (e.g., N may be 1 or 2 or other value). The value of N may be predefined or pre-configured by the network via system information or dedicated signaling. In some implementations, the value of a new SI acquisition period/timer may be an index of a mapping table or an exact value. In some implementations, a gNB (or a base station/cell) may indicate whether to apply a SI acquisition period/timer via a DCI, MAC CE or system information. In some implementations, a UE may decide whether to apply a SI acquisition period/timer when a criterion is satisfied. In some implementations, network may provide a threshold for channel occupancy rate and a UE may consider that the network may transmit the on-demand SI by considering the SI acquisition period/timer when the UE determines that the channel occupancy rate is equal to or higher than the threshold. It should be noted that the unit of SI acquisition period/timer may be in ms, slot, sub-slot, frame, or symbol.

[00122] In some implementations, when a UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum, the UE may start to receive on-demand SI after receiving acknowledgment for SI request in the current SI modification period until the on-demand SI is successfully received after receiving ACK for SI request.

[00123] In some implementations, when a UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum and the SI acquisition is failed after receiving ACK for SI request, a prohibit timer may be started and the UE is not allowed to re-initiate another SI request procedure on the same cell before the prohibit timer is expired. In some implementations, the prohibit timer may be predefined or configured by the network (via broadcast in system information or dedicated signaling). In some implementations, if a prohibit timer is not pre-configured or present in a dedicated signalling or being broadcast in system information, the UE may apply a predefined default value of a prohibit timer. In some implementations, if a prohibit timer is not pre-configured or present in a dedicated signalling or being broadcast in system information, the UE is allowed to decide whether to re-initiate another SI request procedure.

[00124] In some implementations, a UE is not allowed to re-initiate another SI request procedure on the same cell when the UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum and the SI acquisition is failed after receiving ACK for SI request. In some implementations, a UE may re-select a cell which is operating on

licensed spectrum when the UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum and the SI acquisition is failed after receiving ACK for SI request. In some implementations, a UE may re-select a cell operating on licensed spectrum if the on-demand SI is essential to the UE when the UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum and the SI acquisition is failed after receiving ACK for SI request. In some implementations, a UE may not re-select a cell which is operating on licensed spectrum if the on-demand SI is not essential to the UE, when a UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum and the SI acquisition is failed after receiving ACK for SI request.

[00125] In some implementations, the ACK of a SI request may include the information to indicate the SI acquisition period/time for the (on-demand) SI to the UE. For example, the ACK of SI request may include the value of K. In some implementations, the ACK of SI request may include the value of SI acquisition period/time. In some implementations, the ACK of SI request may include an indication on whether a UE may need to extend or shorten the SI acquisition period for receiving (on-demand) SI after receiving the ACK of SI request.

[00126] In some implementations, when a UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum, the UE may start to receive after receiving ACK for SI request in the current SI modification period, and the UE may continue to receive on-demand SI until the end of the current modification period or until the on-demand SI is received within the current modification period after receiving ACK for SI request. To receive the on-demand SI, the UE may apply the SI acquisition procedure after receiving ACK for SI request (e.g., based on SI scheduling information) and/or the UE may start/apply SI acquisition procedure in an DRS (e.g., a NR-U DRS) within the current modification period. In some implementations, a base station may indicate whether a UE is required to start SI acquisition procedure in a DRS (e.g., a NR-U DRS) within the current modification period via dedicated signalling or broadcast system information. In some implementations, a base station may indicate whether a UE is required to start SI acquisition procedure based on SI scheduling information within the current modification period via dedicated signalling or broadcast system information.

[00127] In some implementations, when a UE starts/applies the SI acquisition procedure in a DRS (e.g., a NR-U DRS), the UE may start monitor a DCI with CRC scrambled by SI-RNTI on the corresponding common search space. In some implementations, when a UE does not start SI

acquisition procedure in a DRS (e.g., there is no ACK of SI request received), the UE may not monitor a DCI with CRC scrambled by SI-RNTI on the corresponding common search space. In some implementations, the UE may stop monitor a DCI with CRC scrambled by SI-RNTI on the corresponding common search space when the on-demand SI is received.

[00128] In some implementations, when a UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum, the UE may start to receive on-demand SI after receiving ACK for SI request in the current SI modification period, and the UE may continue to receive on-demand SI until the end of the next K modification period or until the on-demand SI is received within the next K modification period. To receive the on-demand SI, the UE may apply the SI acquisition procedure after receiving ACK for SI request (e.g., based on SI scheduling information) and/or the UE may start/apply SI acquisition procedure in a DRS (e.g., a NR-U DRS) within the next K modification period. In some implementations, a base station may indicate whether a UE is required to start SI acquisition procedure in a DRS (e.g., a NR-U DRS) within the next K modification period via dedicated signalling or broadcast system information. In some implementations, a base station may indicate whether a UE is required to start SI acquisition procedure based on SI scheduling information within the next K modification period via dedicated signalling or broadcast system information.

[00129] In some implementations, when a UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum, the UE may start to receive on-demand SI after receiving acknowledgment for SI request in the current SI modification period, and the UE may continue to receive until a SI acquisition period/timer is expired or until the on-demand SI is received while the SI acquisition period/timer is active after receiving ACK for SI request. The UE may apply the SI acquisition procedure after receiving ACK for SI request (e.g., based on SI scheduling information) and/or the UE may start/apply SI acquisition procedure in a DRS (e.g., a NR-U DRS) while the SI acquisition period/timer is active to receive the on-demand SI. In some implementations, a base station may indicate whether a UE is required to start SI acquisition procedure in NR-U DRS while the SI acquisition period/timer is active via dedicated signalling or broadcast system information. In some implementations, a base station may indicate whether a UE is required to start SI acquisition procedure based on SI scheduling information while the SI acquisition period/timer is active via dedicated signalling or broadcast system information.

[00130] In some implementations, when a UE initiates a (Msg-1 based or Msg-3 based) SI request procedure on a cell operating on unlicensed spectrum, the UE may start to receive on-demand SI after receiving ACK for SI request in the current SI modification period, and the UE may continue to receive until the on-demand SI is received after receiving ACK for SI request. The UE may apply the SI acquisition procedure after receiving ACK for SI request (e.g., based on SI scheduling information) and/or the UE may start SI acquisition procedure in DRS(s) until the on-demand SI is received. In some implementations, a base station may indicate whether a UE is required to start SI acquisition procedure in NR-U DRS until the on-demand SI is received after receiving ACK for SI request via dedicated signalling or broadcast system information. In some implementations, a base station may indicate whether a UE is required to start SI acquisition procedure based on SI scheduling information until the on-demand SI is received after receiving ACK for SI request via dedicated signalling or broadcast system information.

[00131] In some implementations, to receive the on-demand SI, the UE may apply the SI acquisition procedure after receiving ACK for SI request (e.g., based on SI scheduling information) and/or the UE may start/apply SI acquisition procedure in a DRS (e.g., a NR-U DRS) for on-demand SI reception. In some implementations, a gNB (or a base station/cell) may indicate (e.g., via system information, DCI, or MAC CE) whether the on-demand SI appears within a DRS. In some implementations, a gNB (or a base station/cell) may indicate (e.g., via system information, DCI, or MAC CE) whether a DCI with CRC scrambled by SI-RNTI appears within a DRS for on-demand SI reception. In some implementations, a gNB (or a base station/cell) may indicate (e.g., via system information, DCI, or MAC CE) whether a DCI with CRC scrambled by a specific RNTI appears within a DRS for on-demand SI reception.

[00132] In some implementations, to perform on-demand SI reception in DRS, a UE may start PDCCH monitoring in the PDCCH monitoring occasion(s) within a DRS (by using SI-RNTI) based on the search space information configured for other system information (e.g., provided in *searchSpaceOtherSystemInformation* field in a Common PDCCH configuration). In some implementations, the UE may receive the *searchSpaceOtherSystemInformation* in the DRS. In some implementations, if *searchSpaceOtherSystemInformation* is set to zero, the UE may regard the PDCCH monitoring occasions for on-demand SI message reception in SI-window are the same as PDCCH monitoring occasions for SIB1. In some implementations, if *searchSpaceOtherSystemInformation* is set to non-zero, PDCCH monitoring occasions for on-

demand SI message are determined based on search space indicated by *searchSpaceOtherSystemInformation*.

[00133] It should be noted that a Msg-1 based SI request procedure in the above implementations may be performed based on a 2-step RA procedure or a 4-step RA procedure.

[00134] It should be noted that the above implementations may be also applied for either Msg-A based or Msg-B based SI request procedure (e.g., 2-step RACH be used for SI request).

[00135] Figure 9 is a block diagram illustrating a node for wireless communication, according to one example implementation of the present disclosure. As shown in Figure 9, node 900 may include transceiver 920, processor 926, memory 928, one or more presentation components 934, and at least one antenna 936. Node 900 may also include a Radio Frequency (RF) spectrum band module, a base station communications module, a network communications module, and a system communications management module, input/output (I/O) ports, I/O components, and power supply (not explicitly shown in Figure 9). Each of these components may be in communication with each other, directly or indirectly, over one or more buses 940.

[00136] Transceiver 920 having transmitter 922 and receiver 924 may be configured to transmit and/or receive time and/or frequency resource partitioning information. In some implementations, transceiver 920 may be configured to transmit in different types of subframes and slots including, but not limited to, usable, non-usable and flexibly usable subframes and slot formats. Transceiver 920 may be configured to receive data and control signalings.

[00137] Node 900 may include a variety of computer-readable media. Computer-readable media can be any available media that can be accessed by node 900 and include both volatile and non-volatile media, removable and non-removable media. By way of example, and not limitation, computer-readable media may comprise computer storage media and communication media. Computer storage media includes both volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage of information such as computer-readable instructions, data structures, program modules or other data.

[00138] Computer storage media includes RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices. Computer storage media does not comprise a propagated data signal. Communication media typically embodies computer-readable instructions, data structures, program modules or other data

in a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media. The term “modulated data signal” means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media. Combinations of any of the above should also be included within the scope of computer-readable media.

[00139] Memory 928 may include computer-storage media in the form of volatile and/or non-volatile memory. Memory 928 may be removable, non-removable, or a combination thereof. Exemplary memory includes solid-state memory, hard drives, optical-disc drives, and etc. As illustrated in Figure 9, memory 928 may store computer-readable, computer-executable instructions 932 (e.g., software codes) that are configured to, when executed, cause processor 926 to perform various functions described herein, for example, with reference to Figures 1 through 8. Alternatively, instructions 932 may not be directly executable by processor 926 but be configured to cause node 900 (e.g., when compiled and executed) to perform various functions described herein.

[00140] Processor 926 may include an intelligent hardware device, for example, a central processing unit (CPU), a microcontroller, an ASIC, and etc. Processor 926 may include memory. Processor 926 may process data 930 and instructions 932 received from memory 928, and information through transceiver 920, the base band communications module, and/or the network communications module. Processor 926 may also process information to be sent to transceiver 920 for transmission through antenna 936, to the network communications module for transmission to a core network.

[00141] One or more presentation components 934 presents data indications to a person or other device. For example, one or more presentation components 934 include a display device, speaker, printing component, vibrating component, etc.

[00142] From the above description it is manifest that various techniques can be used for implementing the concepts described in the present disclosure without departing from the scope of those concepts. Moreover, while the concepts have been described with specific reference to certain implementations, a person of ordinary skill in the art may recognize that changes can be made in form and detail without departing from the scope of those concepts. As such, the described

implementations are to be considered in all respects as illustrative and not restrictive. It should also be understood that the present disclosure is not limited to the particular implementations described above, but many rearrangements, modifications, and substitutions are possible without departing from the scope of the present disclosure.

CLAIMS

WHAT IS CLAIMED IS:

1. A method for system information update for a User Equipment (UE), the method comprising:
 - receiving, from a base station, a Discovery Reference Signal (DRS);
 - determining, whether the DRS contains a Downlink Control Information (DCI) with Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identifier (P-RNTI);
 - determining, whether the DCI with CRC scrambled by the P-RNTI indicates scheduling information for SI is present when the DRS contains the DCI with CRC scrambled by the P-RNTI; and
 - acquiring, an updated SI based on the scheduling information, when the scheduling information for SI is present.
2. The method of claim 1, the method further comprises:
 - receiving, from the base station, a SI modification indication;
 - performing, by the UE, a SI acquisition procedure in response to the SI modification indication received to update system information.
3. The method of claim 1, wherein a short message indicator associated with the DCI with CRC scrambled by the P-RNTI indicates whether the scheduling information for System Information is present.
4. The method of claim 3, wherein the short message indicator indicates a short message is also present in the DRS.
5. The method of claim 4, wherein the short message contains the scheduling information for SI.
6. The method of claim 3, wherein the short message indicator indicates scheduling information of a Paging message is present; and wherein the Paging message contains the scheduling information for SI.

7. The method of claim 2, wherein the UE starts performing the SI acquisition procedure by monitoring PDCCH monitoring occasions within the DRS.

8. The method of claim 7, wherein the UE stops the SI acquisition procedure when the UE acquires the updated SI within the DRS.

9. The method of claim 1, wherein the SI is at least one of other SI and SIB1.

10. The method of claim 1, wherein the UE is capable of operating on unlicensed spectrum.

11. A user equipment (UE) comprising:
one or more non-transitory computer-readable media having computer-executable instructions for duplicating packet data convergence protocol (PDCP) protocol data units (PDUs);
and

at least one processor coupled to the one or more non-transitory computer-readable media,
and configured to execute the computer-executable instructions to:

receive, from a base station, a Discovery Reference Signal (DRS);

determine, whether the DRS contains a Downlink Control Information (DCI) with Cyclic Redundancy Check (CRC) scrambled by a Paging Radio Network Temporary Identifier (P-RNTI);

determine, whether the DCI with CRC scrambled by the P-RNTI indicates scheduling information for SI is present when the DRS contains the DCI with CRC scrambled by the P-RNTI; and

acquire, an updated SI based on the scheduling information, when the scheduling information for SI is present.

12. The UE of claim 11, wherein the at least one processor is further configured to execute the computer-executable instructions to:

receive, from the base station, a SI modification indication;

perform, by the UE, a SI acquisition procedure in response to the SI modification indication received to update system information.

13. The UE of claim 11, wherein a short message indicator associated with the DCI with CRC scrambled by the P-RNTI indicates whether the scheduling information for System Information is present.

14. The UE of claim 13, wherein the short message indicator indicates a short message is also present in the DRS.

15. The UE of claim 14, wherein the short message contains the scheduling information for SI.

16. The UE of claim 13, wherein the short message indicator indicates scheduling information of a Paging message is present; and wherein the Paging message contains the scheduling information for SI.

17. The UE of claim 12, wherein the UE starts performing the SI acquisition procedure by monitoring PDCCH monitoring occasions within the DRS.

18. The UE of claim 17, wherein the UE stops the SI acquisition procedure when the UE acquires the updated SI within the DRS.

19. The UE of claim 11, wherein the SI is at least one of other SI and SIB1.

20. The UE of claim 11, wherein the UE is capable of operating on unlicensed spectrum.

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```

SystemInformation ::=          SEQUENCE {
    criticalExtensions          CHOICE {
        systemInformation-r15  SystemInformation-IEs,
        criticalExtensionsFuture SEQUENCE {}
    }
}
UpdatedSystemInformation-IEs ::= SEQUENCE {
    sib-TypeAndInfo SEQUENCE (SIZE (1..maxSIB)) OF SIB-TypeInfo
}
SIB-TypeInfo ::= SEQUENCE {
    type ENUMERATED {sibType2, sibType3, sibType4,
sibType5, sibType6, sibType7, sibType8, sibType9, spare8, spare7, spare6, spare5,
spare4, spare3, spare2, spare1,... },
    valueTag INTEGER (0..31)
OPTIONAL, -- Cond SIB-TYPE
    areaScope ENUMERATED {true}
OPTIONAL -- Need S
}
    lateNonCriticalExtension OCTET STRING OPTIONAL,
    nonCriticalExtension SEQUENCE {} OPTIONAL
}

```

FIG. 1

```

Paging ::= SEQUENCE {
    pagingRecordList PagingRecordList
OPTIONAL, -- Need N
    UpdatedSIBInfo OCTET STRING (CONTAINING Updated SIB(s))
OPTIONAL, -- Need N
    nonCriticalExtension SEQUENCE {}
OPTIONAL
}
PagingRecordList ::= SEQUENCE (SIZE(1..maxNrofPageRec)) OF PagingRecord
PagingRecord ::= SEQUENCE {
    ue-Identity PagingUE-Identity,
    accessType ENUMERATED {non3GPP} OPTIONAL, -- Need N
    ...
}
PagingUE-Identity ::= CHOICE {
    ng-5G-S-TMSI NG-5G-S-TMSI,
    fullI-RNTI I-RNTI-Value,
    ...
}

```

FIG. 2

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```

Paging ::= SEQUENCE {
    pagingRecordList      PagingRecordList
    OPTIONAL, -- Need N
    UpdatedSIMessage      OCTET STRING (CONTAINING Updated
                           SI Message(s))
    OPTIONAL, -- Need N
    nonCriticalExtension   SEQUENCE {}
    OPTIONAL
}

PagingRecordList ::= SEQUENCE (SIZE(1..maxNrofPageRec)) OF
    PagingRecord

PagingRecord ::= SEQUENCE {
    ue-Identity            PagingUE-Identity,
    accessType             ENUMERATED {non3GPP} OPTIONAL, --
    Need N
    ...
}

PagingUE-Identity ::= CHOICE {
    ng-5G-S-TMSI          NG-5G-S-TMSI,
    fullI-RNTI            I-RNTI-Value,
    ...
}

```

FIG. 3

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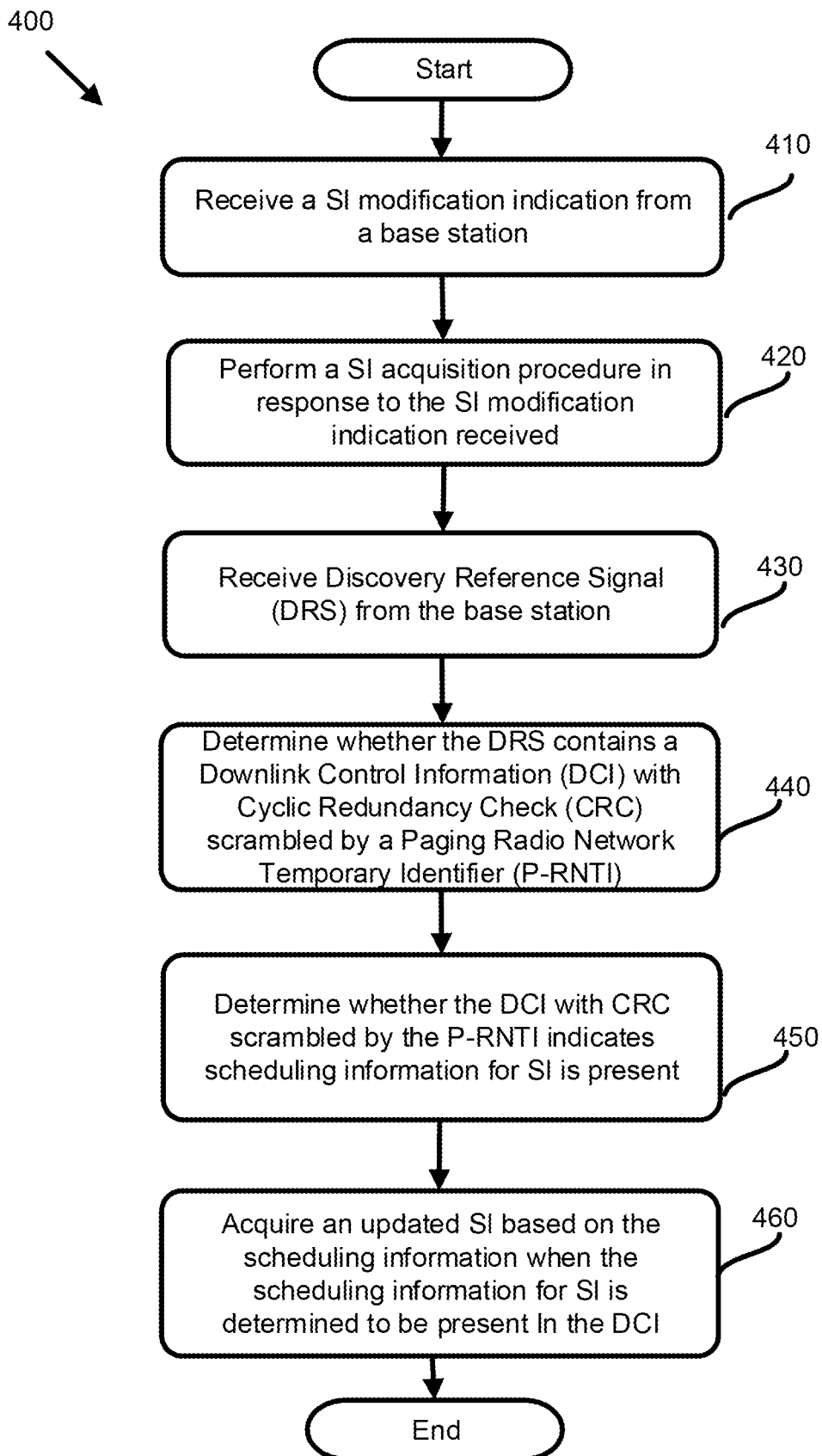


FIG. 4

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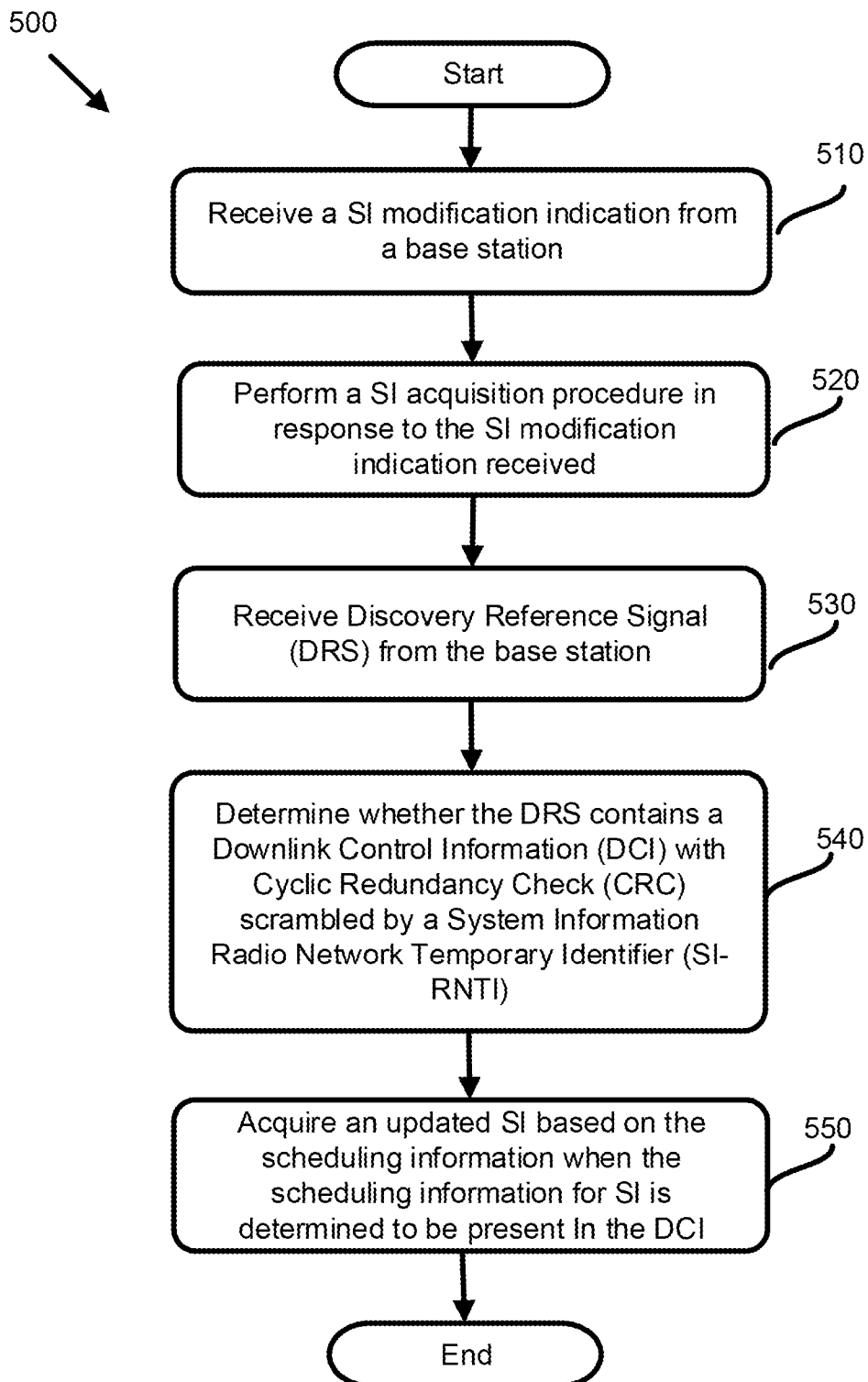


FIG. 5

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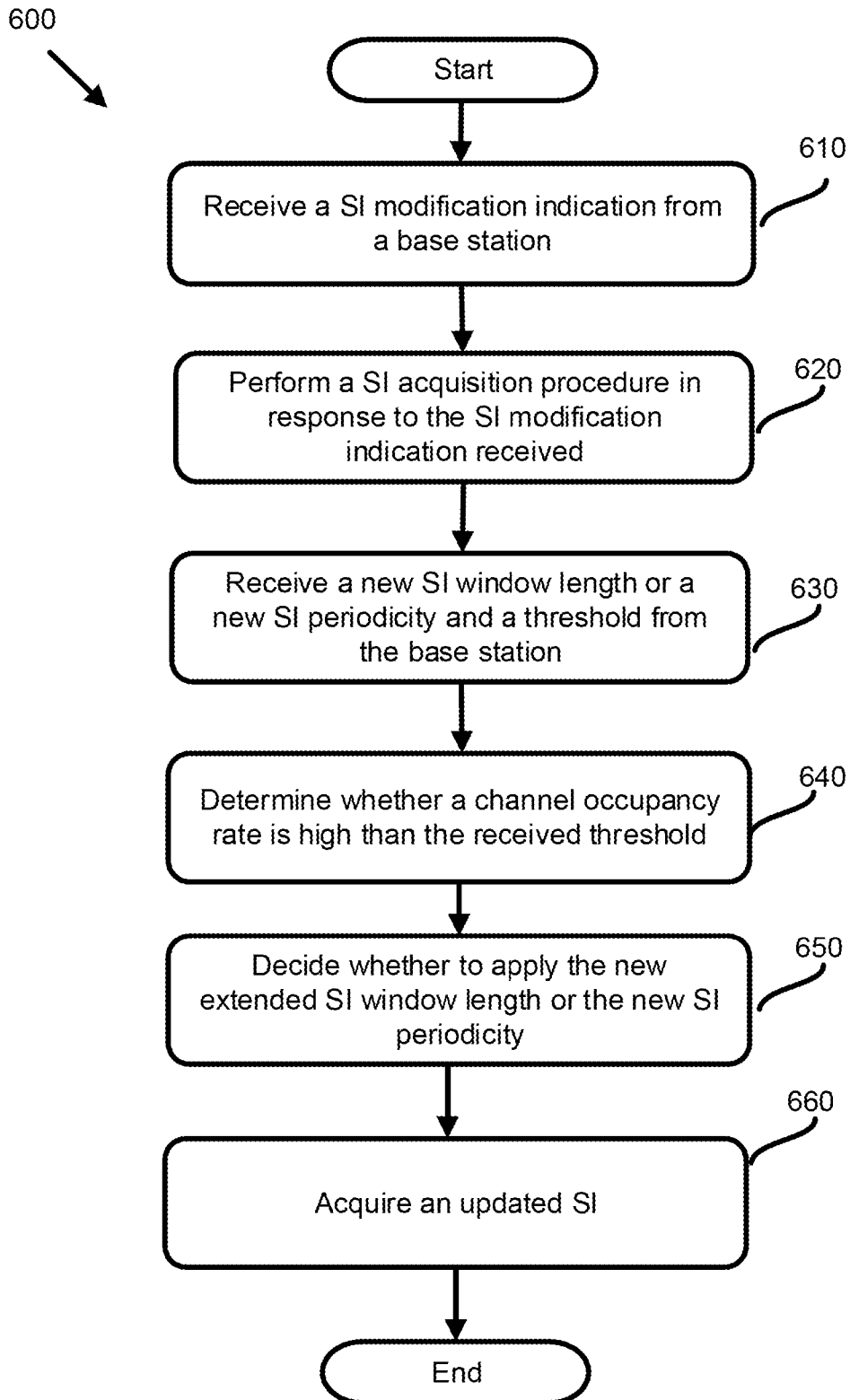


FIG. 6

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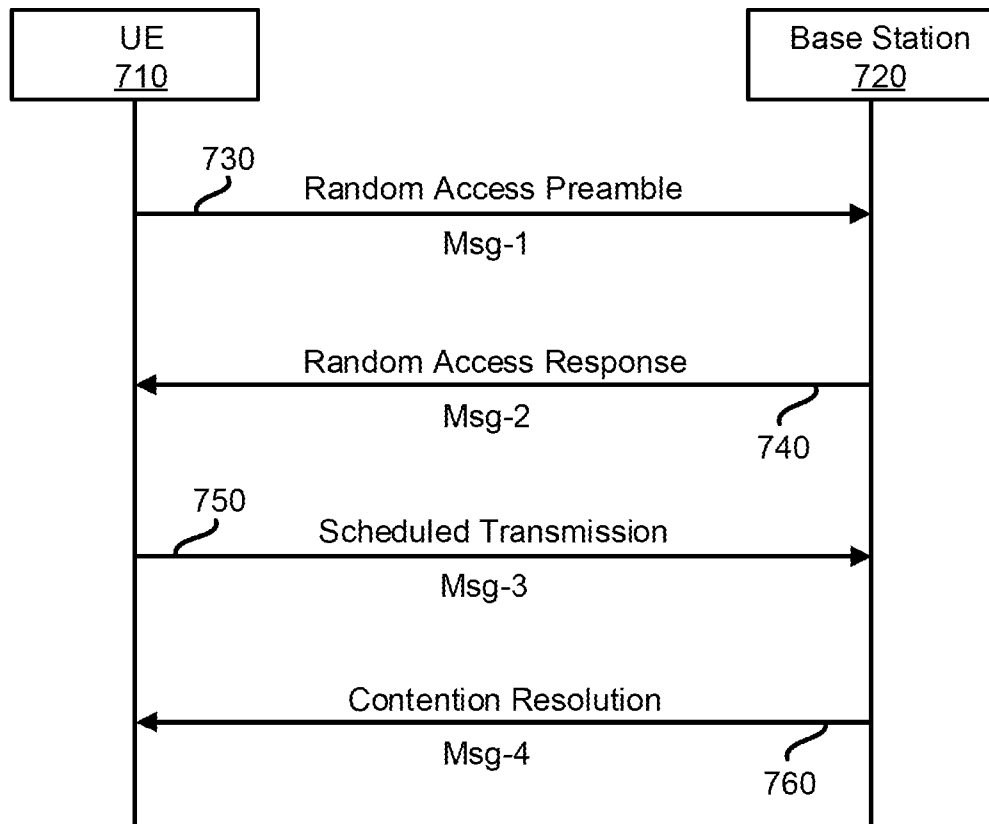
700
↓

FIG. 7

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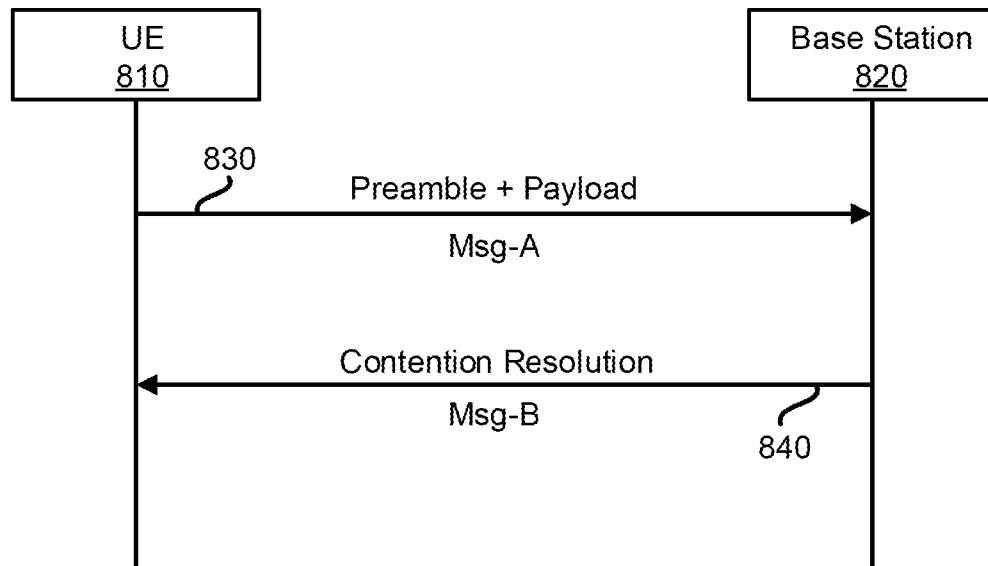
800
↓

FIG. 8

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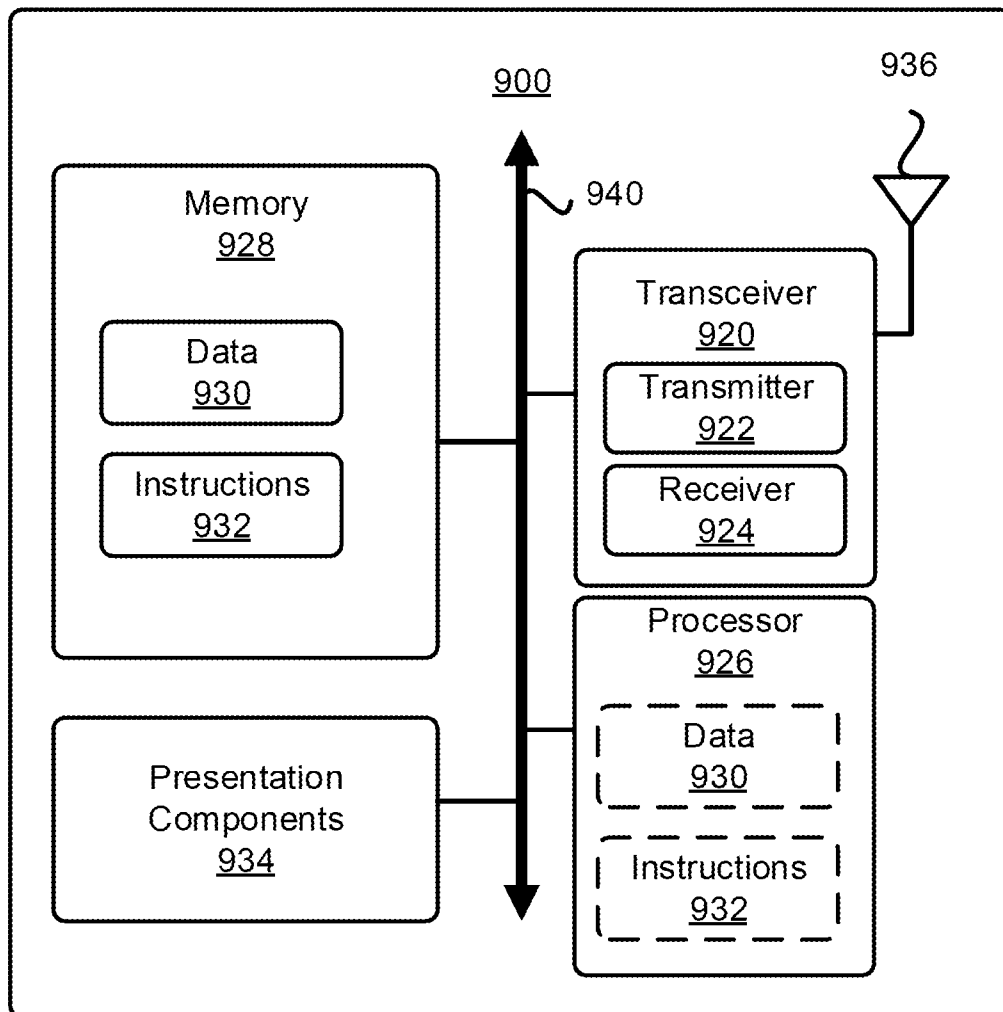


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/080185

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(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)

H04L; H04W

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)

EPTXT;USTXT;WOTXT;CNTXT;CNABS;VEN;3GPP;IETF:system information, SI, discovery reference signal, DRS, cyclic redundancy check,CRC, paging radio network temporary identifier, P-RNTI, DCI, unlicensed spectrum, scrambling, short, message, indication, change, schedule, PDU, PDCP, acquisition, request

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2018054822 A1 (LG ELECTRONICS INC) 22 February 2018 (2018-02-22) see description, paragraphs [0094]-[0138]	1-20
A	US 2017251456 A1 (QUALCOMM INC) 31 August 2017 (2017-08-31) see the whole document	1-20
A	3rd Generation Partnership Project; Technical Specification Group Radio Access Network; . "Multiplexing and channel coding" "3GPP TS 38.212, v15.3.0", 30 September 2018 (2018-09-30), see 7.3.1.2	1-20
A	3rd Generation Partnership Project; Technical Specification Group Radio Access Network; . "Radio Resource Control (RRC) protocol specification" "3GPP TS 38.331, v15.3.0", 30 September 2018 (2018-09-30), see 6.5	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

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"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

20 May 2020

Date of mailing of the international search report

28 May 2020

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/080185

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2018054822	A1	22 February 2018	WO	2016144002	A1	15 September 2016
US	2017251456	A1	31 August 2017	WO	2017147550	A1	31 August 2017
				BR	112018069522	A2	22 January 2019
				KR	20180117620	A	29 October 2018
				EP	3420746	A1	02 January 2019
				TW	201735580	A	01 October 2017
				WO	2017147549	A1	31 August 2017
				EP	3420757	A1	02 January 2019
				EP	3420746	B1	08 January 2020
				JP	2019510407	A	11 April 2019
				KR	20180119576	A	02 November 2018
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