AO 120 (Rev. 08/10)

| TO: | Mail Stop 8<br>Director of the U.S. Patent and Trademark Office<br>P.O. Box 1450<br>Alexandria, VA 22313-1450 | REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK |
|---|---|---|

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of Texas on the following

☐ Trademarks or ☑ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

| DOCKET NO. | DATE FILED | U.S. DISTRICT COURT |
|---|---|---|
| 6:22-cv-327 | 3/28/2022 | Western District of Texas |

| PLAINTIFF | DEFENDANT |
|---|---|
| TOGAIL TECHNOLOGIES LTD. | GOOGLE INC. |

| | PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
|---|---|---|---|
| 1 | 10,743,238 | 8/11/2020 | TOGAIL TECHNOLOGIES LTD. |
| 2 | 10,791,502 | 9/29/2020 | TOGAIL TECHNOLOGIES LTD. |
| 3 | 10,972,972 | 4/6/2021 | TOGAIL TECHNOLOGIES LTD. |
| 4 | 11,115,165 | 9/7/2021 | TOGAIL TECHNOLOGIES LTD. |
| 5 | | | |

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

| DATE INCLUDED | INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading | | |
|---|---|---|---|
| | PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

In the above—entitled case, the following decision has been rendered or judgement issued:

| DECISION/JUDGEMENT |
|---|
| 8/18/2002 - Text Order Granting #18 Joint Motion to Dismiss |

| CLERK | (BY) DEPUTY CLERK | DATE |
|---|---|---|
| Philip J. Devlin | Suzanne Miles | 8/19/2022 |

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AO 120 (Rev. 08/10)

| TO: | REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK |
|---|---|
| **Mail Stop 8**<br>**Director of the U.S. Patent and Trademark Office**<br>**P.O. Box 1450**<br>**Alexandria, VA 22313-1450** | |

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Northern District of Illinois on the following

☐ Trademarks or ☑ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

| DOCKET NO. | DATE FILED | U.S. DISTRICT COURT |
|---|---|---|
| 1:22-cv-02176 | 4/26/2022 | Northern District of Illinois |

| PLAINTIFF | DEFENDANT |
|---|---|
| Togail Technologies Ltd. | Motorola Mobility LLC |

| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
|---|---|---|
| 1 | | See attached |
| 2 | | |
| 3 | | |
| 4 | | |
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In the above---entitled case, the following patent(s)/ trademark(s) have been included:

| DATE INCLUDED | INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading | |
|---|---|---|
| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
| 1 | | |
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| 5 | | |

In the above---entitled case, the following decision has been rendered or judgement issued:

| DECISION/JUDGEMENT |
|---|
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| CLERK | (BY) DEPUTY CLERK | DATE |
|---|---|---|
| Thomas G. Bruton | Jannette Nunez | 8/15/2022 |

**Copy 1---Upon initiation of action, mail this copy to Director Copy 3---Upon termination of action, mail this copy to Director**
**Copy 2---Upon filing document adding patent(s), mail this copy to Director Copy 4---Case file copy**

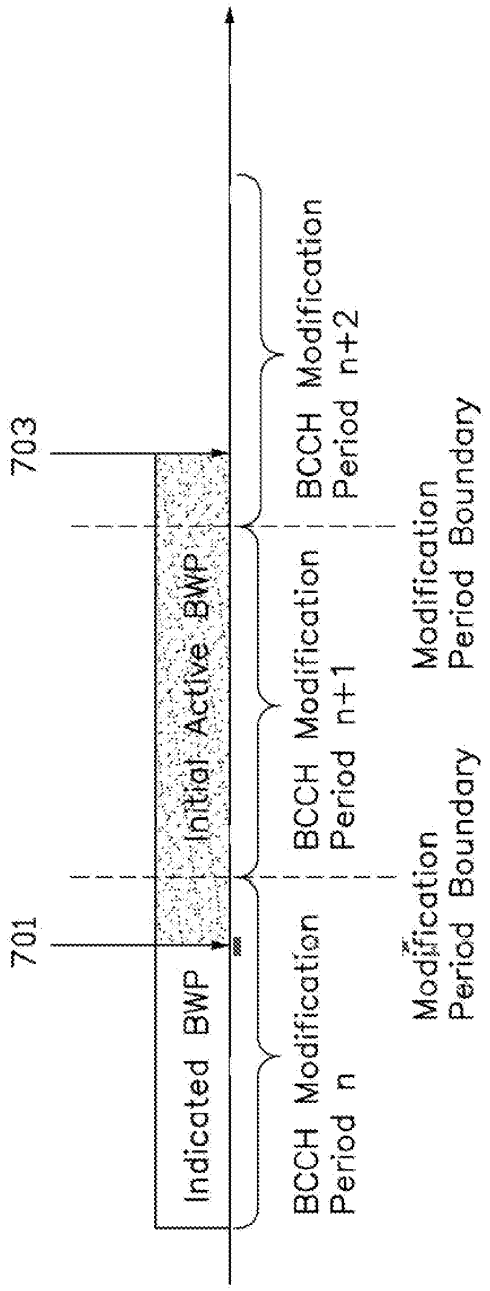
703
701
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 7

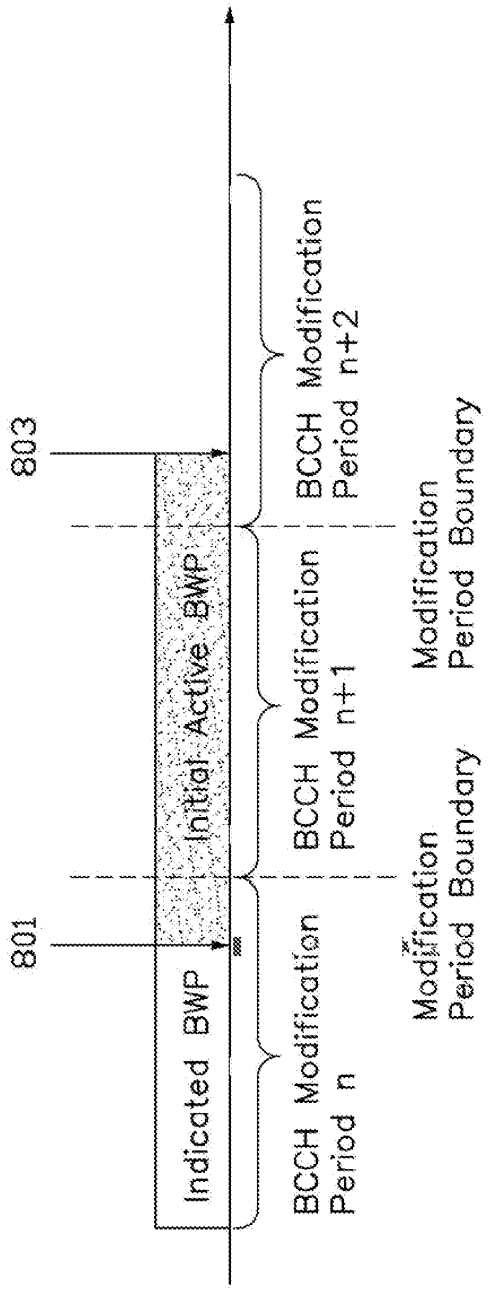
803
801
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 8

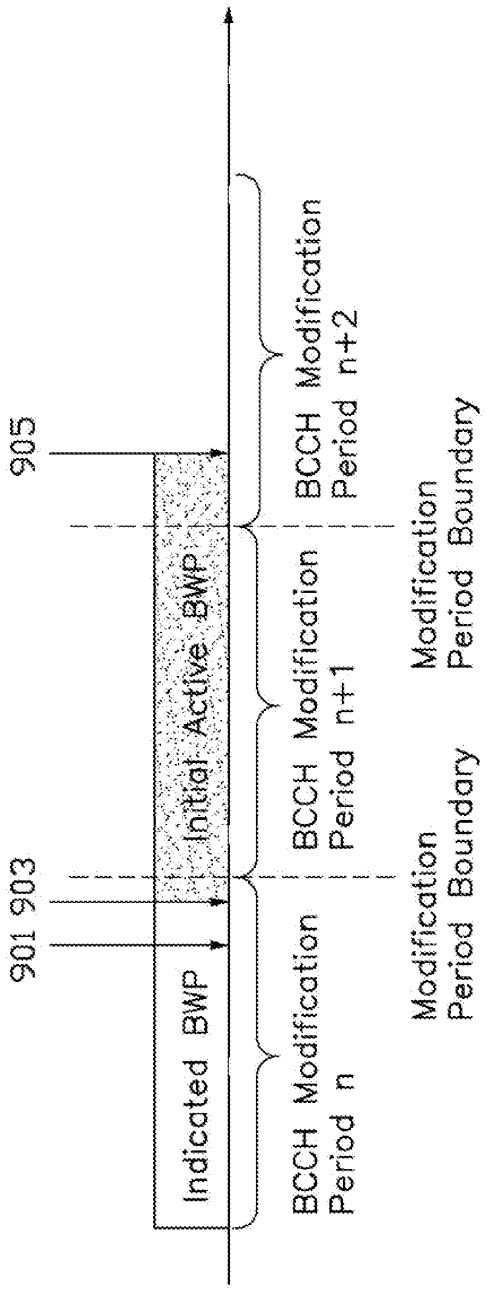
905
901 903
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 9

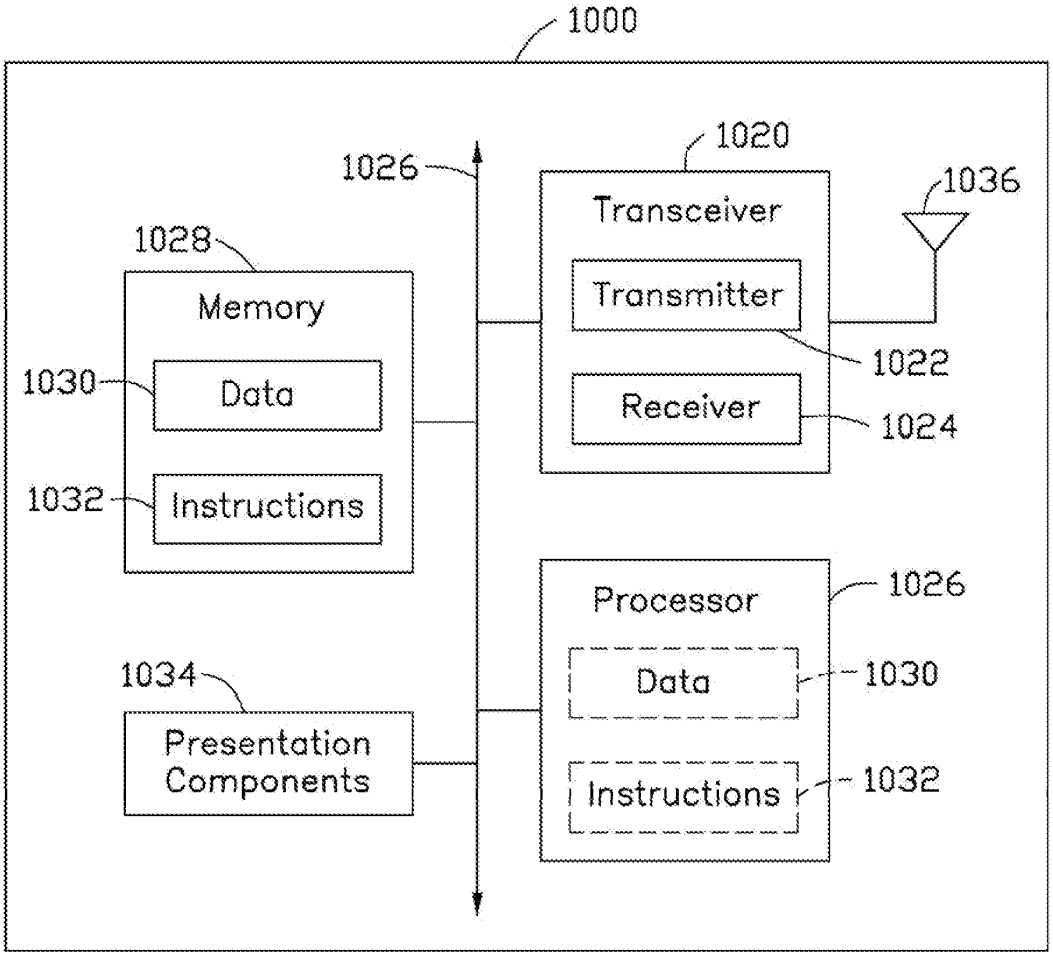
1000
1026
1020
Transceiver
1036
1028
Memory
Transmitter
1030
Data
1022
Receiver
1024
1032
Instructions
Processor
1026
1034
Data
1030
Presentation Components
Instructions
1032

FIG. 10

# SYSTEM INFORMATION UPDATES IN BAND WIDTH PART (BWP) SWITCH OPERATION

## CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and priority to U.S. Provisional Application No. 62/586,598 filed on Nov. 15, 2017 and entitled "SYSTEM INFORMATION UPDATE IN BWP SWITCH OPERATION," (hereinafter referred to as "US72315 application"). The disclosure of the US72315 application is hereby incorporated fully by reference into the present disclosure.

## TECHNICAL FIELD

The present disclosure generally relates to a method for bandwidth part switching operations performed by a user equipment and user equipment performing the same.

## BACKGROUND

In a cellular network, a UE-specific serving cell may configure one or more bandwidth parts (BWPs) in downlink and uplink respectively for a UE by dedicated RRC signaling. One the other hand, a UE may be allocated to with at most one active DL BWP and one active UL BWP at a given time by the cell. A single scheduled downlink control information (DCI) may be applied to switching from one active BWP to another for an operating UE.

For a UE, an initial active DL BWP is defined as the frequency location and bandwidth dedicated for broadcasting remaining minimum SI (RMSI). When the NW sends to a Connected_UE a system information (SI) change indication that notifies of system information change, the Connected_UE may have to switch from the currently active BWP to the initial active BWP for accessing the RMSI and updating to the changed SI if there is no SI broadcasting on the currently active BWP. Furthermore, the Connected_UE may not successfully complete SI update if there is no clear UE behavior defined for BWP switching. As a result of BWP switching inability problem, the UE may not be able to update system information.

## SUMMARY

The present disclosure is directed to bandwidth part (BWP) switching operations in conjunction with system information updates for a user equipment.

In one aspect of the present disclosure, a method for bandwidth part (BWP) operations performed by a user equipment (UE) of a connected state is provided. The method comprises receiving a system information (SI) change indication broadcasted by a paging via a currently active bandwidth part (BWP) during a modification period; switching from the currently active bandwidth part (BWP) for data transmission to an initial active BWP for an SI update; receiving remaining minimum SI (RMSI) via the initial active BWP during a next modification period that immediately follows the modification period, the RMSI including information associated with changed system information blocks (SIBs); determining which of the changed SIBs is required to be updated for the UE; and receiving content of the required changed SIBs based on the determination.



In one aspect of the present disclosure, a user equipment (UE) of a connected state is configured to receive a system information (SI) change indication broadcasted by a paging via a currently active bandwidth part (BWP) during a modification period; to switch from the currently active bandwidth part (BWP) for data transmission to an initial active BWP for an SI update; to receive remaining minimum SI (RMSI) via the initial active BWP during a next modification period that immediately follows the modification period, the RMSI including information associated with changed system information blocks (SIBs); to determine which of the changed SIBs is required to be updated for the UE; and to receive content of the required changed SIBs based on the determination.

## BRIEF DESCRIPTION OF THE DRAWINGS

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, dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. **1** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **2** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **3** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **4** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **5** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **6** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **7** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving a public warning system (PWS) notification indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **8** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving a public warning system (PWS) notification indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **9** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving a public warning system (PWS) notification indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **10** is a block diagram of a device for wireless communication in accordance with various embodiments of the present disclosure.

## DETAILED DESCRIPTION

The following description contains specific information pertaining to exemplary implementations in the present disclosure. The drawings in the present disclosure and their

accompanying detailed description are directed to merely exemplary implementations. However, the present disclosure is not limited to merely these exemplary 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.

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.

It is noted that the term "and/or" includes any and all combinations of one or more of the associated listed items. It will also be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, parts and/or sections, these elements, components, regions, parts and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, part or section from another element, component, region, layer or section. Thus, a first element, component, region, part or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present disclosure.

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 personal digital assistant (PDA), or a television display 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.

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-A, a radio network controller (RNC) as in the UMTS, a base station controller (BSC) as in the GSM/GERAN, an NG-eNB as in an E-UTRA base station in connection with the 5GC, a next generation node B (gNB) as in the 5G Access Network (5G-AN), and any other apparatus capable of controlling radio communication with cellular positioning technology and managing radio resources within a cell. The base station may connect to serve the one or more UEs through a radio interface to the network.

In one embodiment of the present disclosure, a Connected_UE may implicitly switch to an initial active BWP upon receiving a system information (SI) change indication broadcasted by paging from cellular network (NW). The SI change indication indicates a SI change/modification and notifies the UE to update to the changed SI if required by the UE. This results in reduction of redundant L1 signaling for switching from a currently active BWP to the initial active BWP for the UE. In FIG. **1**, a BWP switching operation for a Connected_UE due to receiving an SI change indication is illustrated. In DL, the UE may operate on an indicated BWP as currently active DL BWP for DL data transmission (e.g., based on RRC configuration, DCI control or the behavior for BWP inactivity timer) or operate on an initial active DL BPW able to receive the content of changed SI required for the UE SI update. The UE may also have an uplink (UL) BWP for UL data transmission and an initial active UL BWP. Within n'th broadcast control channel modification period (denoted as BCCH modification period n), the UE may operate on the indicated BWP as the currently active BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE operates on the indicated BWP. Specifically, the UE receives indications about SI modifications and/or PWS notifications using Short Message transmitted with P-RNTI over downlink control information (DCI). At **101**, upon receiving the SI change indication, UE may switch immediately to the initial active BWP from the indicated BWP during BCCH modification period n. The SI change indication is used to inform the UE that there is a system information change(s) or update(s), and may be carried as part of the Short Message. Then, RRC sublayer of the NW may inform the PHY sublayer that the paging has been sent to the UE and the switching of the UE to the initial active BWP has been performed. So, the NW may stop sending to the UE any other L1 signaling (e.g., DCI) for BWP switching operations.

After switching to the initial active BWP, the UE may continue to stay on the initial active BWP until BCCH modification period n+1 ends. The BCCH modification period n+1 immediately follows the BCCH modification period n in time sequence. Although the UE has switched to the initial active BWP at certain timing (e.g., at **101**) within BCCH modification period n, it is in the next BCCH modification period n+1 that the UE performs the system information acquisition to update to changed system information. In modification period n+1, the UE may receive broadcast remaining minimum system information (RMSI) carrying information associated with changed system information blocks (SIBs) via the initial active BWP and perform the SI update(s) according to the information. The RMSI is also known as SIB1 (system information block 1). The UE may receive the RMSI at certain time point in modification period n+1 (e.g., at the start time point of the modification period n+1). After receiving the RMSI, the UE may determine which of the changed SIB(s) is (or are) required for the SI update(s) according to the received information. For example, the UE may identify one or more of the changed SIB(s) that the UE requires for the SI update(s). Then the UE may receive the content(s) of the changed SIBs which are identified as being required for the SI update(s) based on the determination. For another example, the UE may identify none of the changed SIBs is required to update and may not perform any SI update(s). The UE may not update the changed SIB(s) based on the identification within BCCH modification period n+1.

After the UE completes the SI update(s), the NW may re-take control over the BWP switching of the UE on the end of BCCH modification period n+1.

In this case, since the NW may know the UE by default will complete the SI update within modification period n+1, the PHY sublayer may re-take control over the BWP switching after BCCH modification period n+1 ends. Therefore, at **103** on the ending boundary of modification period n+1 the NW re-takes the BWP switching operations by sending L1 signaling to switch the initial active BWP to a BWP for subsequent data transmission.

In one embodiment, the currently active BWP happens to be the initial active BWP. In this case, it is not necessary that a BWP switching operation is involved for updating the SI

when receiving the SI change indication. For example, the Connected UE has already been on the initial active BWP as currently active BWP because of certain on-going services in modification period n and will stay on the initial active BWP to perform system information acquisition to conduct the SI update in BCCH modification period n+1. The PHY sublayer of the NW may consider the completeness of the SI update in the next BCCH modification period n+1. Then, the PHY sublayer of the NW may re-take control over the BWP switching operation on the end of BCCH modification period n+1.

In one embodiment, the UE may be only permitted to receive the Short Message of the paging on the initial active BWP. For example, based on the paging frame and paging occasion derived from an associated UE ID and per-configured parameters, the Short Message cannot be broadcasted on other BWPs but the initial active BWP. On occasions, the UE may switch to the initial active BWP automatically to detect whether there is a Short Message and receiving the Short Message. If receiving the SI change indication carried in the Short Message, the UE may stay on the initial active BWP for the subsequent SI update without the need for additional BWP switching. If receiving no Short Message or no SI change indication carried in the Short Message, the UE may switch back to the previous active BWP without involvement of the NW. Alternatively, the UE may not switch back but stay on the initial active BWP after modification period n+1 ends, waiting for next L1 signaling from the NW (e.g., DCI) for BWP switching.

In one embodiment of the present disclosure, the Connected UE may feedback to the NW while the SI update is completed, and the NW may re-take control over the BWP switching immediately upon receiving the feedback. In FIG. **2**, a BWP switching operation for an RRC_connected UE due to receiving an SI change indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BFW able to receive the content of changed SI required for the UE SI update. Within modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operate on the indicated BWP. At **201**, upon receiving the SI change indication, UE may switch to the initial active BWP immediately from the indicated BWP in BCCH modification period n. The SI change indication is used to inform the UE that there is SI change(s) or update(s), and may be carried as part of Short Message in the paging. Then, RRC sublayer of the NW may inform the PHY sublayer that the paging has been sent to the UE and the switching of the UE to the initial active BWP has been performed. So, the NW may stop sending to the UE any other L1 signaling for BWP switching operations, and wait for the UE feedback indicating the completeness of the SI update.

After switching to the initial active BWP, the UE may continue to stay on the initial active BWP until the update to SI is completed. At **203**, the UE completed the SI update if required and feedback to the NW that the system information update is completed by sending an SI update complete indication. Upon receiving the SI update complete indication as the UE feedback, the PHY sublayer of the NW may re-take control over the BWP switching operation immediately. Although the UE has to operate on the initial active BWP for the SI update in DL, the NW may be still able to schedule data transmission on the initial active BWP.

The UE feedback of SI update complete may be sent by L1 signaling (via PUCCH) or by MAC-CE transmission on an uplink (UL) BWP paired with the initial active DL BWP. If using L1 signaling, the upper sublayer (e.g., RRC) of the UE may inform PHY sublayer that the SI update is completed, and the UE PHY sublayer may feedback it to the NW. The NW may re-take control over the BWP switching after receiving the feedback in NW PHY sublayer. Alternatively, if using MAC-CE transmission, the upper sublayer of the UE may inform MAC sublayer that the system information update is completed, and the UE MAC sublayer may feedback it to the NW. The NW may re-take control over the BWP switching once receiving the feedback in NW MAC sublayer.

In one embodiment of the present disclosure, upon receiving the SI change indication, the UE may not switch to the initial active BPW until the current BCCH modification period ends. In FIG. **3**, a BWP switching operation for an RRC_connected UE due to receiving an SI change indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operate on the indicated BWP. At **301**, upon receiving the SI change indication, UE may continue to stay on the indicated BWP instead of switching immediately to the initial active BWP. Then, the UE switches to the initial active BWP automatically on the ending boundary of BCCH modification period n. The BWP switching operation(s) for the UE could be still performed for certain required services before the automatic switching to the initial active BWP takes place on the end of BCCH modification period n.

In this case, PHY sublayer of the NW may know that the UE switches to the initial active BWP automatically on the end of BCCH modification period n, and may stop sending to the UE any other L1 signaling for BWP switching operations after modification period n ends. The PHY sublayer of the NW may know the UE by default will complete the SI update within the next modification period n+1, the PHY sublayer may re-take control over the BWP switching after BCCH modification period n+1 ends. Therefore, at **303** on the ending boundary of modification period n+1 the NW re-takes the BWP switching operations by sending L1 signaling to switch the initial active BWP to a BWP for data transmission.

After switching to the initial active BWP on the end of modification period n, the UE may wait to receive, via the initial active BWP, broadcast information required for updating to the changed SI in a next BCCH modification period directly following modification period n. Therefore, within BCCH modification period n+1 (the next BCCH modification period as shown in FIG. **3**), the UE performs the system information acquisition to update the changed system information if required.

In this case, since the NW may know the UE by default will complete the SI update within the next modification period n+1, the PHY sublayer may re-take control over the BWP switching after BCCH modification period n+1 ends. Therefore, at **303** on the ending boundary of modification period n+1 the NW re-takes the BWP switching operations by sending L1 signaling to switch the initial active BWP to a BWP for data transmission.

In one embodiment of the present disclosure, the Connected UE may feedback to the NW while the SI update is completed, and the NW may take control over the BWP switching immediately upon receiving the feedback. In FIG. **4**, a BWP switching operation for an RRC_connected UE due to receiving an SI change indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operate on the indicated BWP. At **401**, upon receiving the SI change indication, UE may continue to stay on the indicated BWP instead of switching immediately to the initial active BWP. Then, the UE switches to the initial active BWP automatically on the ending boundary of BCCH modification period n. The BWP switching operation(s) for the UE could be still performed for certain required services before the automatic switching to the initial active BWP takes place on the end of modification period n. In this case, PHY sublayer of the NW may know that the UE switches to the initial active BWP automatically on the end of BCCH modification period n, and may stop sending to the UE any other L1 signaling for BWP switching operations after period n ends.

After switching to the initial active BWP on the end of modification period n, the UE may continue to stay on the initial active BWP until the update of the required SI change(s) is completed. At **403**, the UE complete the SI update and feedback to the NW that the system information update is completed by sending an SI update complete indication. Upon receiving the SI update complete indication as the UE feedback, the PHY sublayer of the NW may re-take control over the BWP switching operation at **403**. Although the UE has to operate on the initial active BWP for the SI update in DL, the NW may be still able to schedule data transmission on the initial active BWP.

The UE feedback of SI update complete may be sent by L1 signaling (via PUCCH) or by MAC-CE transmission on an uplink (UL) BWP paired with the initial active DL BWP. If using L1 signaling, the upper sublayer (e.g., RRC) of the UE may inform PHY sublayer that the SI update is completed, and the UE PHY sublayer may feedback it to the NW. The NW may re-take control over the BWP switching after receiving the feedback in NW PHY sublayer. Alternatively, if using MAC-CE transmission, the upper sublayer of the UE may inform MAC sublayer that the system information update is completed, and the UE MAC sublayer may feedback it to the NW. The NW may re-take control over the BWP switching once receiving the feedback in NW MAC sublayer.

In one embodiment of the present disclosure, after receiving an SI change indication the UE may not switch to an initial active BWP until an L1 signaling is received from the NW. In FIG. **5**, a BWP switching operation for an RRC_connected UE due to receiving an SI change indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operates on the indicated BWP in BCCH modification period n. At **501**, upon receiving the SI change indication, the UE may not switch to the initial active BWP but continue to stay on the indicated BWP. On the NW side, the RRC sublayer may inform the PHY sublayer that the SI change indication is sent to the UE. The SI change indication may be carried as part of the Short Message in the paging. In response to the UE reception of the SI change indication, the PHY sublayer of the NW may schedule the L1 signaling and decide when to send the L1 signaling to switch the UE to the initial active BWP. After sending the SI change indication, the NW may perform the L1 signaling before BCCH modification period n ends.

At **503**, the UE switches to the initial active BWP in response to receiving the L1 signaling sent from the NW in BCCH modification period n, and the NW may also stop sending to the UE any other L1 signaling for BWP switching operations. In this case, the PHY sublayer of the NW may know the UE by default will complete the SI update within the next modification period (i.e., BCCH modification period n+1 as shown in FIG. **5**), and the PHY sublayer may re-take control over the BWP switching after BCCH modification period n+1 ends.

Thus, at **505** the NW re-takes control over the BWP switching operations on the ending boundary of modification period n+1 by sending L1 signaling to switch the initial active BWP to a BWP for data transmission.

Alternatively, the NW may re-take control over the BWP switching operations upon receiving a feedback from the UE indicating the SI update is complete before BCCH modification period n+1 ends. In FIG. **6**, the UE receives a L1 signaling for switching to the initial active BWP at **603** after receiving the SI change indication at **601** in modification period n, followed by the SI update operations in modification period n+1. Once the UE completes the SI update at **605**, the UE feedback of SI update complete (e.g., an SI update completeness indication) may be sent by another L1 signaling (via PUCCH) or by MAC-CE transmission on an uplink (UL) BWP paired with the initial active DL BWP. If using L1 signaling, the upper sublayer (e.g., RRC) of the UE may inform PHY sublayer that the SI update is completed, and the UE PHY sublayer may feedback it to the NW. The NW may re-take control over the BWP switching after receiving the feedback in NW PHY sublayer. If using MAC-CE transmission, the upper sublayer of the UE may inform MAC sublayer that the system information update is completed, and the UE MAC sublayer may feedback it to the NW. The NW may re-take control over the BWP switching once receiving the feedback in NW MAC sublayer.

In one embodiment of the present disclosure, the UE may receive a public warning system (PWS) notification indication for ETWS indication or CMAS indication carried in Short Message of a paging. The PWS notification indication notifies the UE of immediate reception of a PWS notification. When a Connected UE receives a PWS notification indication broadcasted by paging of the NW, the RRC sublayer of the UE may inform the PHY sublayer that a PWS notification reception is required immediately.

If the UE receives the PWS notification indication(s) of a paging from the NW, the UE has to immediately start receiving the PWS notification(s) according to the scheduling information in RMSI. The PWS notification indication may trigger the UE to perform re-acquisition of the scheduling information in RMSI for checking scheduling changes for the SIBs associated with the PWS notification(s). Once the SIB(s) associated with the corresponding PWS notification(s) is no longer scheduled, the UE could stop receives the SIB(s).

in FIG. 7, a BWP switching operation for an RRC_connected UE due to receiving a PWS notification indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP as the current active BWP for data transmission according to L1 signaling.

The PWS notification indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE operates on the indicated BWP. At **701**, upon receiving the PWS notification indication, UE may switch automatically to the initial active BWP from the indicated BWP in BCCH modification period n. The PWS notification indication may be carried as part of Short Message in the paging. Then, RRC sublayer of the NW may inform the PHY sublayer that the paging has been sent to the UE. So, the PHY sublayer of the NW knows successful automatic switching to the initial active BWP and may stop sending to the UE any other L1 signaling for BWP switching operations. The PHY sublayer of the NW would wait for the information from upper layer(s) indicating the stop of broadcasting PWS notification(s) at a certain time point, e.g. at **703** in BBCH modification period n+2. Then, the PHY sublayer in the NW could re-start to take control over BWP switching operation(s).

In another embodiment of the present disclosure, the Connected UE may feedback to the NW while the PWS notification is no longer scheduled, and the NW may re-take control over the BWP switching immediately upon receiving the feedback. In FIG. **8**, a BWP switching operation for an RRC_connected UE due to receiving a PWS notification indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The PWS notification indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operates on the indicated BWP. At **801**, upon receiving the PWS notification indication, UE may switch to the initial active BWP automatically from the indicated BWP in BCCH modification period n. The PWS notification indication may be carried as part of Short Message in the paging. Then, RRC sublayer of the NW may inform the PHY sublayer that the paging has been sent to the UE and the switching of the UE to the initial active BWP has been performed. So, the NW may stop sending to the UE any other L1 signaling for BWP switching operations, and wait for the UE feedback indicating the PWS notification is no longer scheduled.

At **803**, the UE may inform the NW of the stopping broadcast of the PWS notification(s) by a feedback that indicates the PWS notification is no longer scheduled.

In one embodiment of the present disclosure, after receiving a PWS notification indication the UE may not switch to an initial active BWP until an L1 signaling is received from the NW. Since the PWS notification is for emergence, the L1 signalling for switching the UE to the initial active BWP shall be transmitted as fast as possible. In FIG. **9**, a BWP switching operation for an RRC_connected UE due to receiving a PWS notification indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The PWS notification indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operate on the indicated BWP in BCCH modification period n. At **901**, upon receiving the PWS notification indication, the UE may not switch to the initial active BWP but continue to stay on the indicated BWP until an L1 signaling from the NW is received. At **903**, the UE switches to the initial active BWP in response to receiving the L1 signaling sent from the NW in BCCH modification period n, and the NW may also stop sending to the UE any other L1 signaling for BWP switching operations. At **905**, the PHY sublayer of the NW would wait for the information from upper layer(s) indicating the stop of broadcasting PWS notification(s) at a certain time point, e.g. in BCCH modification period n+2. Then, the PHY sublayer in the NW could re-start to take control over BWP switching operation(s).

Alternatively, the UE may inform the NW of the stopping broadcast of the PWS notification(s) by a feedback that indicates the PWS notification is no longer scheduled in this case.

In some embodiments of the present disclosure, a BWP inactivity timer is introduced to switch an ongoing indicated BWP (or the currently active BWP) to a default BWP after a certain inactive time. The BWP inactivity timer may start to run for an inactive time period immediately after the UE switches off the default BWP. In other words, no matter what BWPs the Connected_UE currently operates on, the UE may switch back to the default BWP immediately after the BWP inactivity timer expires.

If the initial active BWP is the default BWP, the currently running BWP inactivity timer would stop after receiving Short Message on the configured active BWP. The UE may switch to another BWP after SI acquisition in response to receiving an L1 signalling, and the BWP inactivity timer would reset with the configured value and start running.

If the initial active BWP is not the default BWP, the currently running BWP inactivity timer may keep running. In some embodiments, the BWP inactivity timer would restart with the configured value and start running. It is noted that the configured value may be different from the normal one (i.e., the normal one is not used for SI acquisition upon switching to the initial active BWP). For example, gNB(s) may configure the BWP inactivity timer with two values, one is 5 ms, the other is 40 ms (e.g., equal to the duration of one BCCH modification period), and UE will automatically apply the second one when the UE needs to perform SI acquisition after receiving the SI change indication carried in the Short Message.

In one embodiment of the present application, if the BWP inactivity timer expires but the SI update is not complete, the UE may keep staying on the initial active BWP until the next L1 signalling (e.g., DCI) controls the UE to perform another BWP switching. The NW may need the timing of the SI update completeness by an NW control mechanism (e.g., waiting for the whole BCCH modification period for SI updated as introduced in the above embodiments) or an UE control mechanism (e.g., by waiting for the UE feedback as introduced in the above embodiments). The BWP inactivity timer would then reset and restart while the UE is switched to another BWP, which is not the default BWP. On the other hand, if the BWP inactivity timer is expired but the PWS notification receiving is not complete, the UE would keep staying on the initial active BWP until the next L1 signalling

(e.g., DCI) controls the UE to perform another BWP switch. The NW would need the timing of the SI complete by an NW control mechanism (e.g., waiting for the whole BCCH modification period for SI updated as introduced in the embodiments) or an UE control mechanism (e.g., by waiting for the UE feedback as introduced in the embodiment). The BWP inactivity timer may then reset and restart while the UE switches to another BWP, which is not the default BWP. If there is no system information change indication or Public Warning System (PWS) notification indication indicating that the following SI update or PWS notification receiving procedure is required, once the BWP inactivity timer expires, the UE would automatically switch to the default BWP without L1 signalling.

FIG. **10** illustrates a block diagram of a device for wireless communication, according to various exemplary implementations of the present disclosure. As shown in FIG. **10**, device **1000** may include transceiver **1020**, processor **1026**, memory **1028**, one or more presentation components **1034**, and at least one antenna **1036**. Device **1000** may also include an 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 FIG. **10**). Each of these components may be in communication with each other, directly or indirectly, over one or more buses **1026**.

Transceiver **1020** having transmitter **1022** and receiver **1024** may be configured to transmit and/or receive time and/or frequency resource partitioning information. In some implementations, transceiver **1020** 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 **1020** may be configured to receive data and control channels.

Device **1000** may include a variety of computer-readable media. Computer-readable media can be any available media that can be accessed by device **1000** 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.

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.

Memory **1028** may include computer-storage media in the form of volatile and/or non-volatile memory. Memory **1028** 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 FIG. **10**, memory **1028** may store computer-readable, computer-executable instructions **1032** (e.g., software codes) that are configured to, when executed, cause processor **1026** to perform various functions described herein, for example, with reference to FIGS. **1** through **9**. Alternatively, instructions **1032** may not be directly executable by processor **1026** but be configured to cause device **1000** (e.g., when compiled and executed) to perform various functions described herein.

Processor **1026** may include an intelligent hardware device, e.g., a central processing unit (CPU), a microcontroller, an ASIC, and etc. Processor **1026** may include memory. Processor **1026** may process data **1030** and instructions **1032** received from memory **1028**, and information through transceiver **1020**, the base band communications module, and/or the network communications module. Processor **1026** may also process information to be sent to transceiver **1020** for transmission through antenna **1036**, to the network communications module for transmission to a core network.

One or more presentation components **1034** presents data indications to a person or other device. Exemplary one or more presentation components **1034** include a display device, speaker, printing component, vibrating component, and etc.

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 would 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.

What is claimed is:

**1**. A method for a user equipment (UE) of a connected state, the method comprising:

receiving a system information (SI) change indication broadcasted by a paging via a currently active bandwidth part (BWP) during a modification period;

in response to receiving the SI change indication, switching from the currently active BWP to an initial active BWP for an SI update;

receiving remaining minimum SI (RMSI) via the initial active BWP during a next modification period that immediately follows the modification period, wherein the RMSI includes information associated with changed system information blocks (SIBs);

determining which of the changed SIBs is required to be updated for the UE according to the received RMSI; and

receiving content of the required changed SIBs based on the determination.

**2**. The method of claim **1**, wherein the currently active BWP is switched to the initial active BWP automatically on the end of the modification period.

**3**. The method of claim **1**, wherein the currently active BWP is switched to the initial active BWP immediately upon receiving the SI change indication.

# Exhibit 1

4. The method of claim 1, wherein the currently active BWP is switched to the initial active BWP in response to receiving downlink control information (DCI).

5. The method of claim 1, further comprising:

completing the SI update of the required changed SIBs within the next modification period in response to receiving the content of the required changed SIBs.

6. The method of claim 1, further comprising:

sending an SI update complete indication as a feedback indicating completeness of the SI update via an uplink BWP.

7. The method of claim 1, wherein the UE is pre-configured with a default BWP and a BWP inactivity timer for the connected state, and wherein the UE starts the BWP inactivity timer after switching off the default BWP and switches back to the default BWP after the BWP inactivity timer expires.

8. The method of claim 7, wherein the BWP inactivity timer stops after the currently active BWP for data transmission is switched to an initial active BWP in response to receiving the SI change indication.

9. The method of claim 7, wherein the BWP inactivity timer is further configured to have a short period and a long period, and wherein the UE selects the long period for the BWP inactivity timer upon receiving the SI change indication.

10. The method of claim 7, wherein the UE stays on the initial active BWP in order to complete the SI update after the BWP inactivity timer expires.

11. A user equipment (UE) for wireless communication, comprising:

a non-transitory machine-readable medium storing computer-executable instructions;

a processor coupled to the non-transitory computer-readable medium, and configured to execute the computer-executable instructions to cause the UE of a connected state to perform operations comprising:

receiving a system information (SI) change indication broadcasted by a paging via a currently active bandwidth part (BWP) during a modification period;

in response to receiving the SI change indication, switching from currently active BWP to an initial active BWP for an SI update; and

receiving remaining minimum SI (RMSI) via the initial active BWP during a next modification period that immediately follows the modification period, wherein the RMSI includes information associated with changed system information block (SIB);

determining which of the changed SIBs is required to be updated for the UE according to the received RMSI; and

receiving content of the required changed SIBs based on the determination.

12. The UE of claim 11, wherein the currently active BWP is switched to the initial active BWP automatically on the end of the modification period.

13. The UE of claim 11, wherein the currently active BWP is switched to the initial active BWP immediately upon receiving the SI change indication.

14. The UE of claim 11, wherein the currently active BWP is switched to the initial active BWP in response to receiving downlink control information (DCI).

15. The UE of claim 11, wherein the processor is further configured to execute the computer-executable instructions to cause the UE of a connected state to perform operations comprising:

completing the SI update of the required changed SIBs within the next modification period in response to receiving the content of the required changed SIBs.

16. The UE of claim 15, wherein the processor is further configured to execute the computer-executable instructions to cause the UE of a connected state to perform operations comprising:

sending an SI update complete indication as a feedback indicating completeness of the SI update via an uplink BWP.

17. The UE of claim 11, wherein the UE is pre-configured with a default BWP and a BWP inactivity timer for the connected state, and wherein the UE starts the BWP inactivity timer after switching off the default BWP and switches back to the default after the BWP inactivity timer expires.

18. The UE of claim 17, wherein the BWP inactivity timer stops after the currently active BWP for data transmission is switched to an initial active BWP in response to receiving the SI change indication.

19. The UE of claim 17, wherein the BWP inactivity timer is further configured to have a short period and a long period, and wherein the UE selects the long period for the BWP inactivity timer upon receiving the SI change indication.

20. The UE of claim 17, wherein the UE stays on the initial active BWP in order to complete the SI update after the BWP inactivity timer expires.

* * * * *

# Exhibit 2

US010791502B2

(12) **United States Patent**
**Chen et al.**

(10) **Patent No.: US 10,791,502 B2**
(45) **Date of Patent: Sep. 29, 2020**

(54) **ON-DEMAND SYSTEM INFORMATION REQUEST PROCEDURE AND ERROR HANDLING**

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(72) Inventors: **Hung-Chen Chen**, Hsinchu (TW); **Chie-Ming Chou**, Hsinchu (TW); **Yung-Lan Tseng**, Hsinchu (TW)

(73) Assignee: **FG Innovation Company Limited**, Tuen Mun (HK)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Apr. 1, 2019**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

| | |
|---|---|
| ***H04W 4/00*** | (2018.01) |
| ***H04W 48/14*** | (2009.01) |
| ***H04W 48/16*** | (2009.01) |
| ***H04W 76/18*** | (2018.01) |
| ***H04W 36/30*** | (2009.01) |
| ***H04W 76/15*** | (2018.01) |
| ***H04W 36/08*** | (2009.01) |
| *H04W 74/08* | (2009.01) |
| *H04W 76/28* | (2018.01) |

(52) **U.S. Cl.**

CPC ..... ***H04W 48/14*** (2013.01); ***H04W 36/08*** (2013.01); ***H04W 36/305*** (2018.08); ***H04W 48/16*** (2013.01); ***H04W 76/15*** (2018.02); ***H04W 76/18*** (2018.02); *H04W 74/0833* (2013.01); *H04W 76/28* (2018.02)

(58) **Field of Classification Search**

CPC ..... H04W 48/14; H04W 48/16; H04W 76/18; H04W 36/305; H04W 76/15; H04W 36/08; H04W 74/0833; H04W 76/28

USPC ..... 455/434; 370/338

See application file for complete search history.

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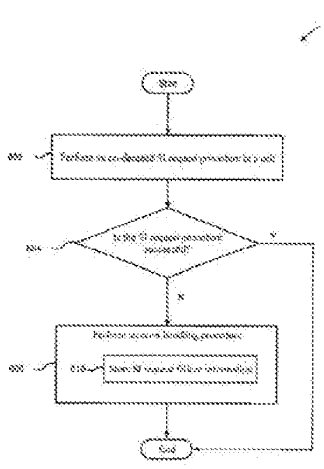
*Primary Examiner* — Marcos Batista
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

A method of wireless communications performed by a user equipment (UE) is provided. The method includes performing an on-demand system information (SI) request procedure in a cell; and performing an error handling procedure if the on-demand SI request procedure in the cell is unsuccessful. The error handling procedure includes storing SI request failure information.

**20 Claims, 7 Drawing Sheets**



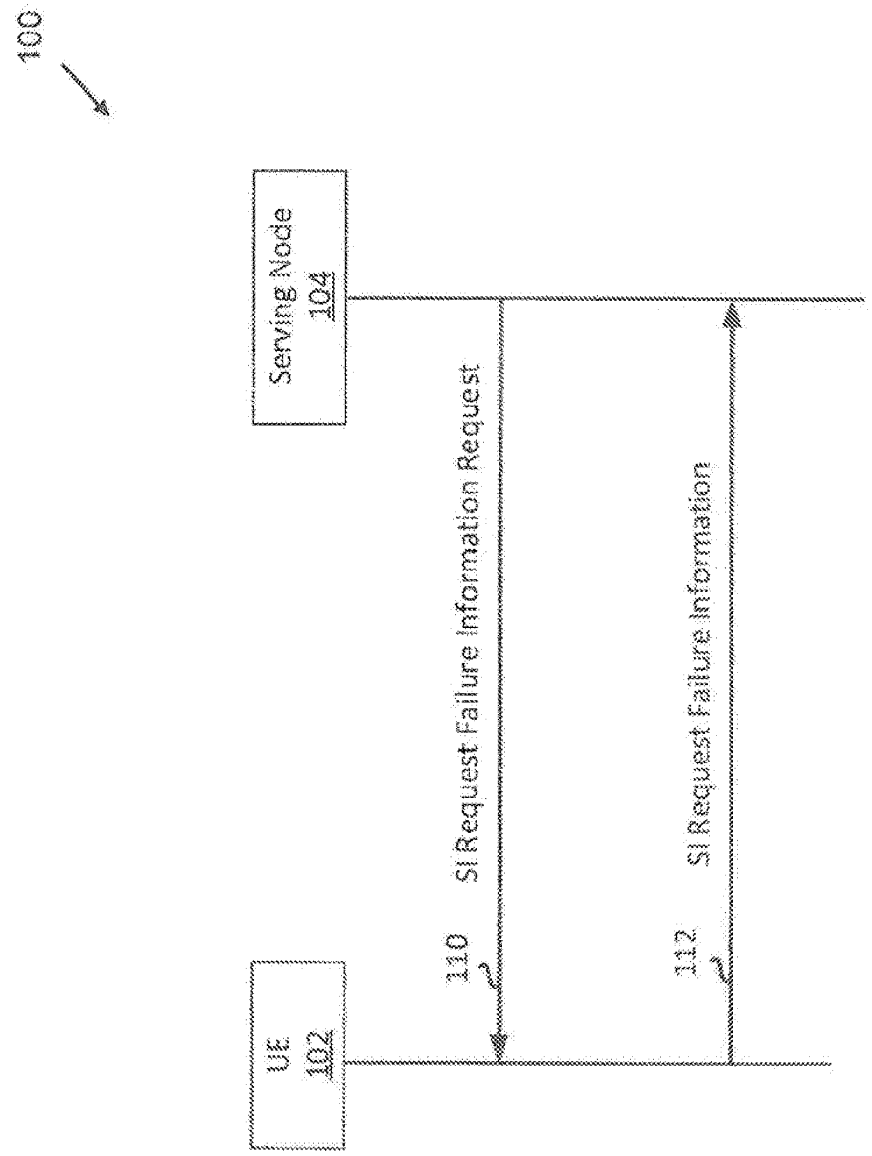

100
Serving Node
104
UE
102
SI Request Failure Information Request
110
SI Request Failure Information
112

FIG. 1

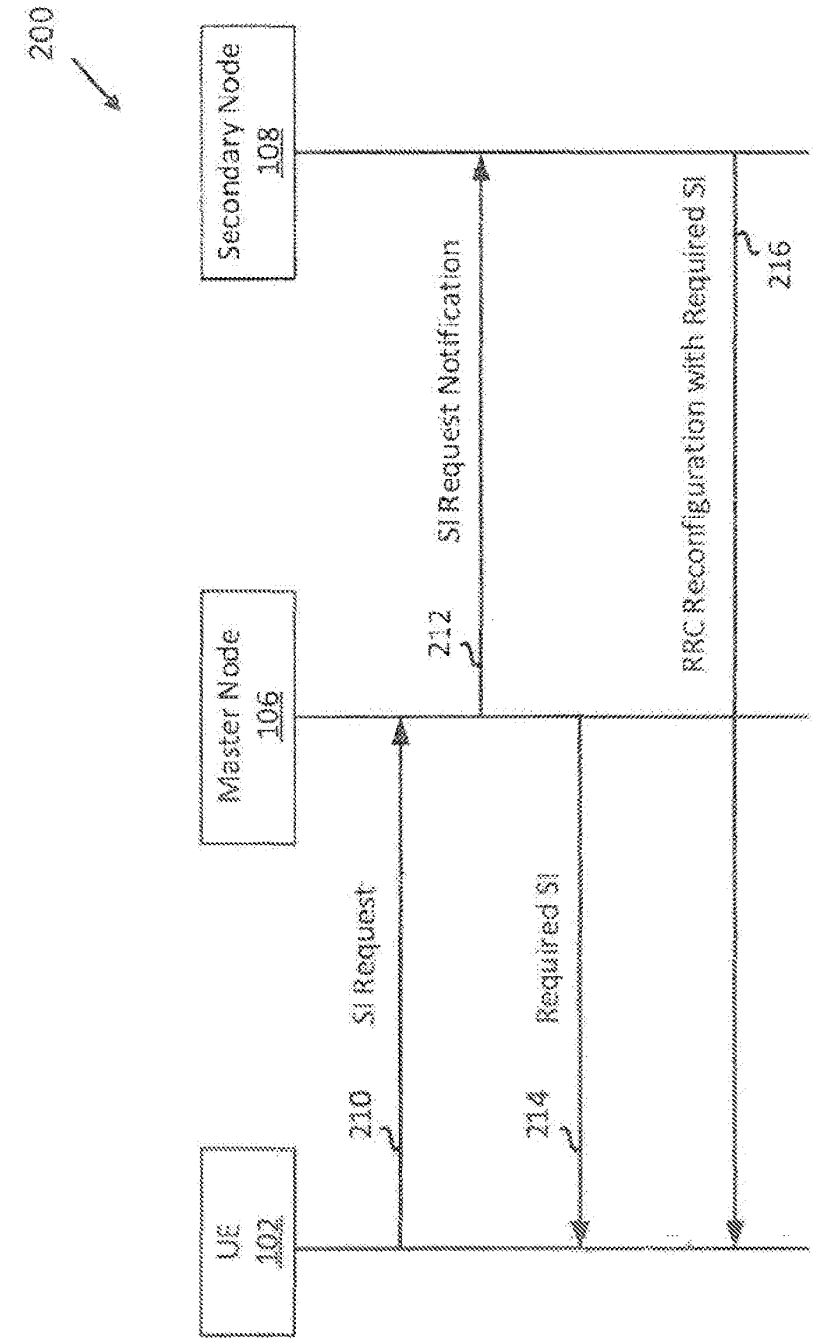

200
Secondary Node 108
Master Node 106
UE 102
SI Request Notification
212
RRC Reconfiguration with Required SI
216
SI Request
210
Required SI
214

FIG. 2

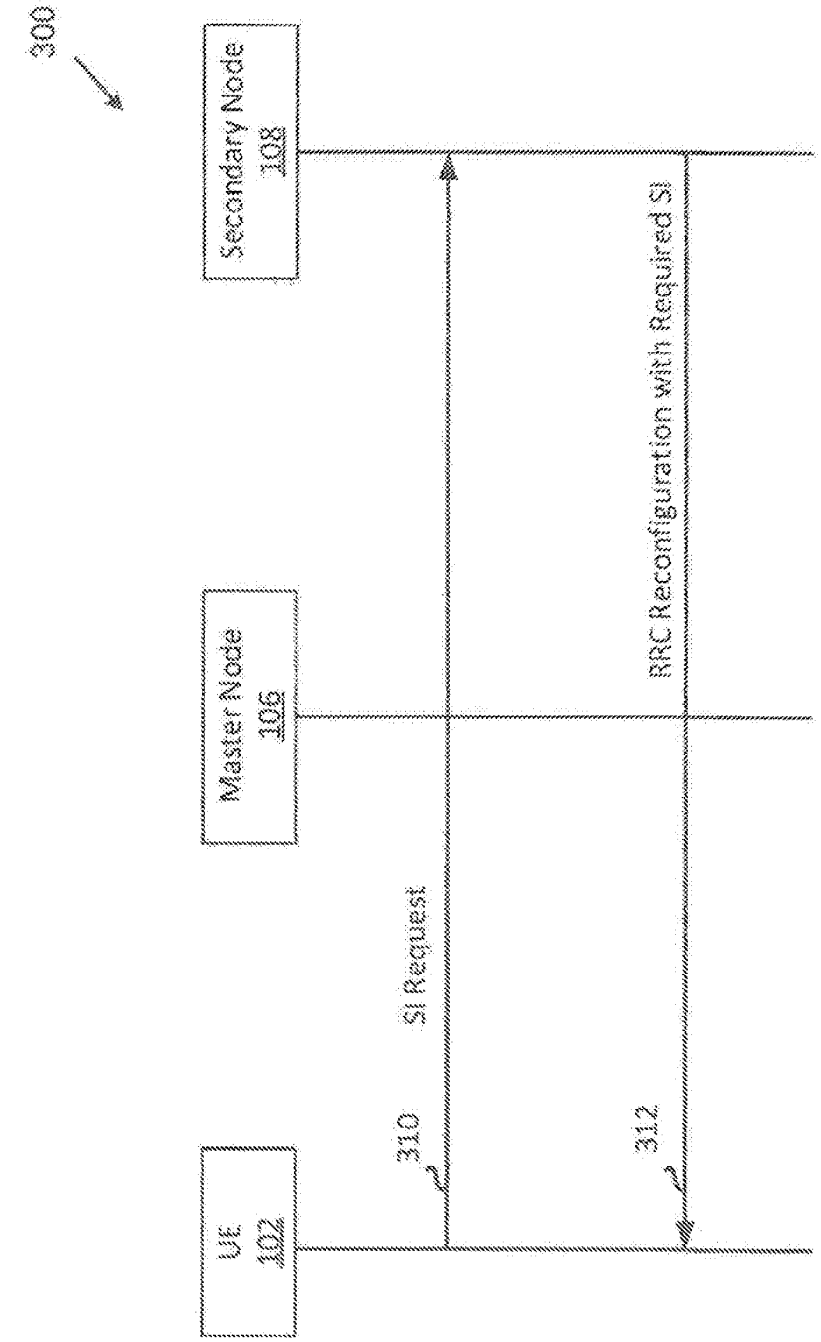

300
Secondary Node 108
Master Node 106
UE 102
SI Request
RRC Reconfiguration with Required SI
310
312

FIG. 3

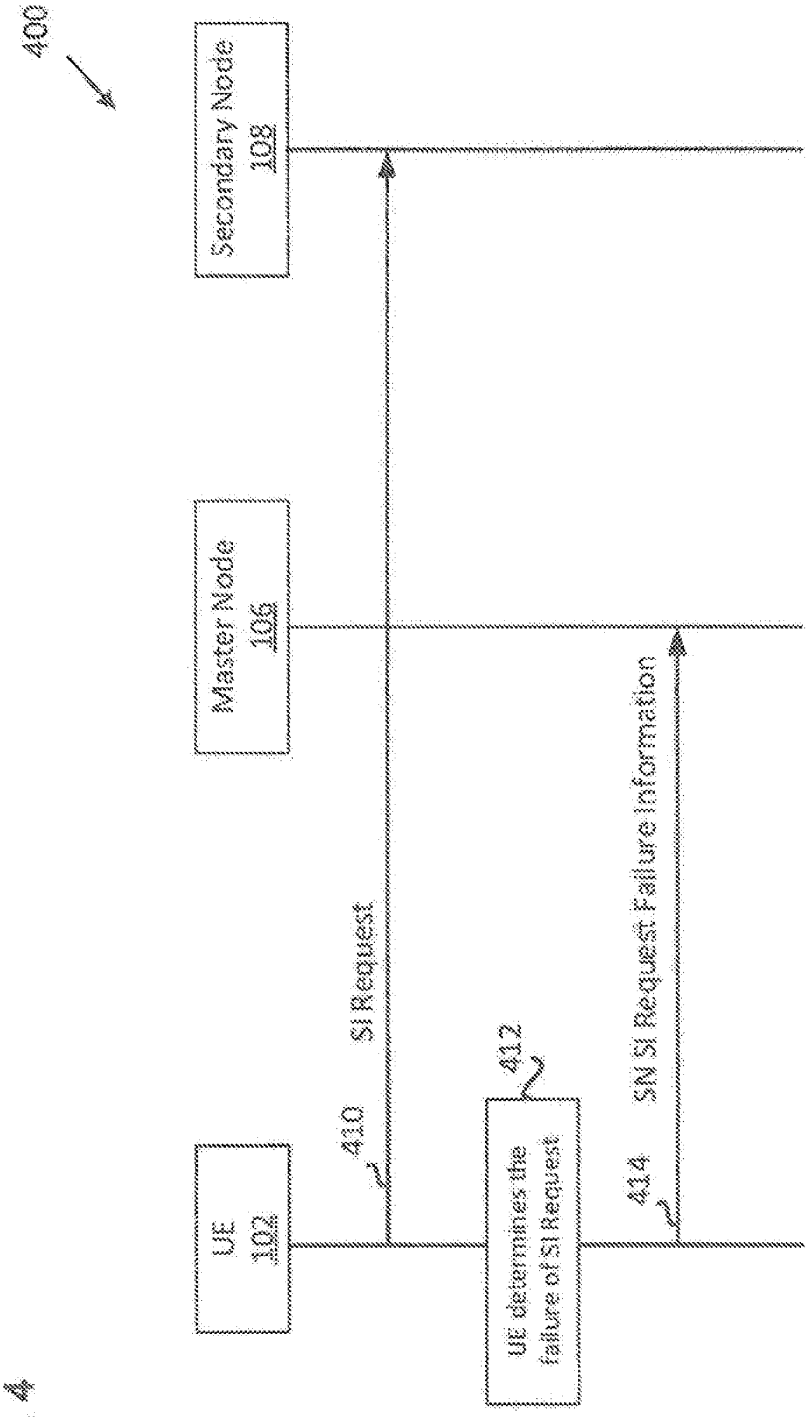

400
Secondary Node 108
Master Node 106
UE 102
410
SI Request
412
UE determines the failure of SI Request
414
SN SI Request Failure Information

FIG. 4

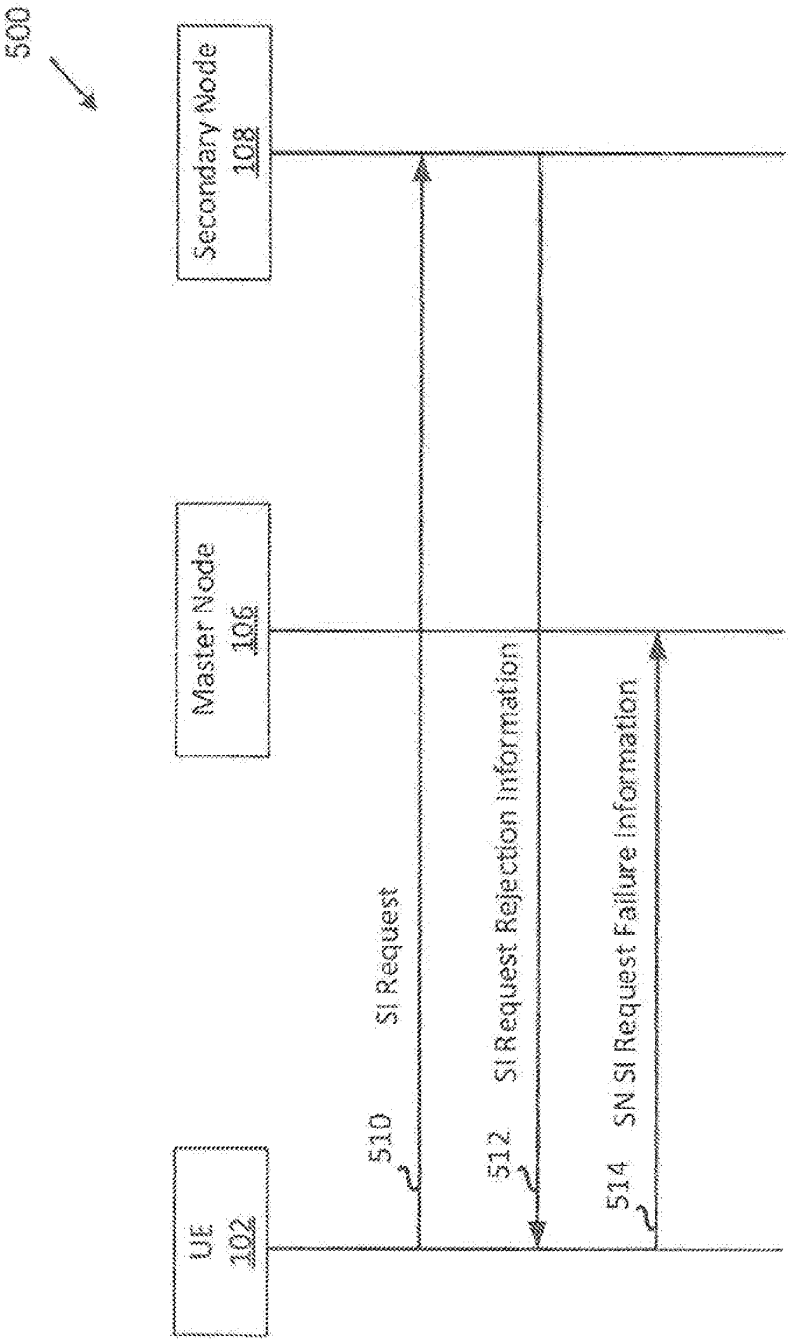
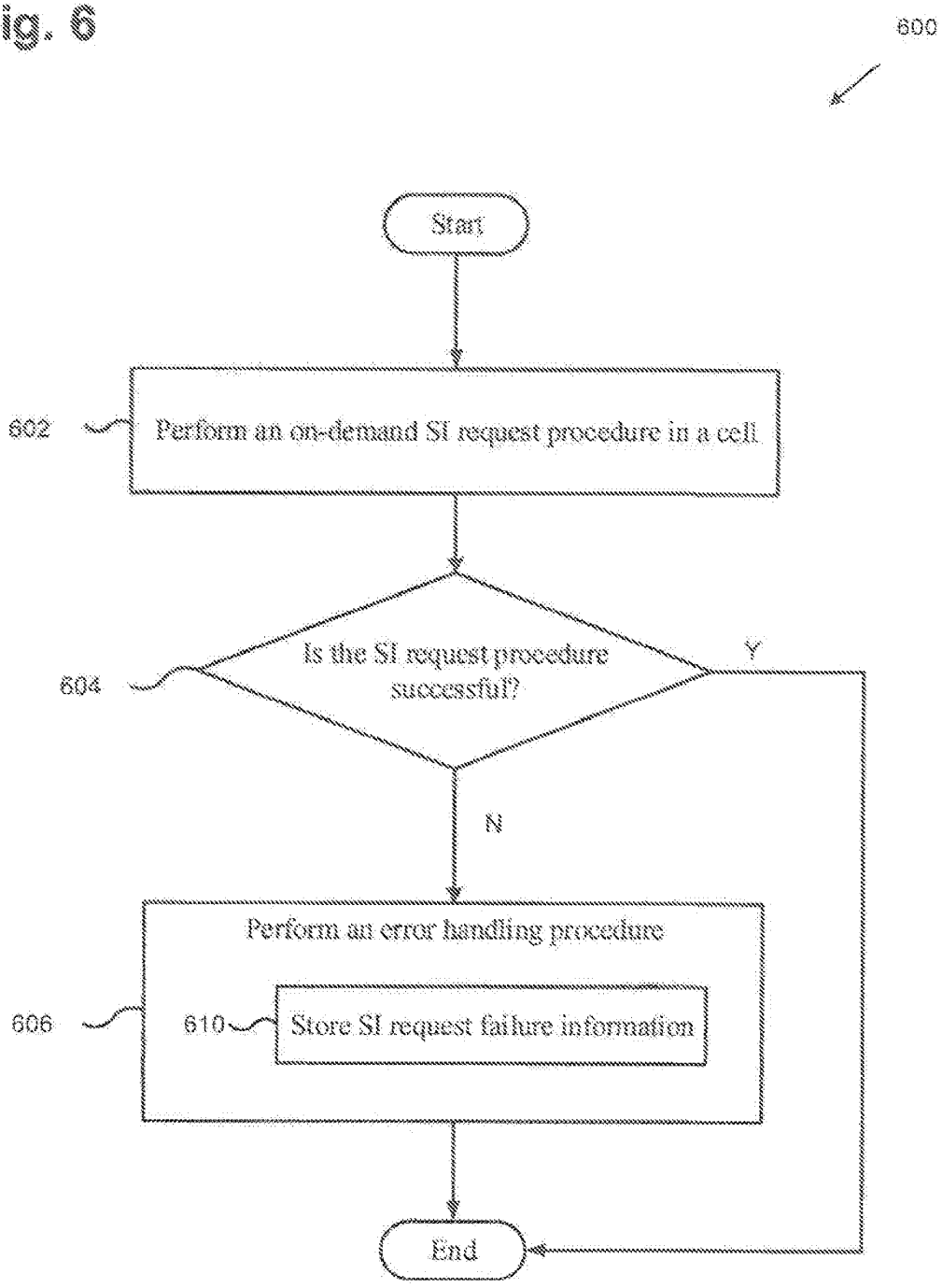

500
Secondary Node 108
Master Node 106
UE 102
510
SI Request
512
SI Request Rejection Information
514
SN SI Request Failure Information

FIG. 5

Fig. 6


600
Start
602
Perform an on-demand SI request procedure in a cell
604
Is the SI request procedure successful?
Y
N
606
Perform an error handling procedure
610
Store SI request failure information
End

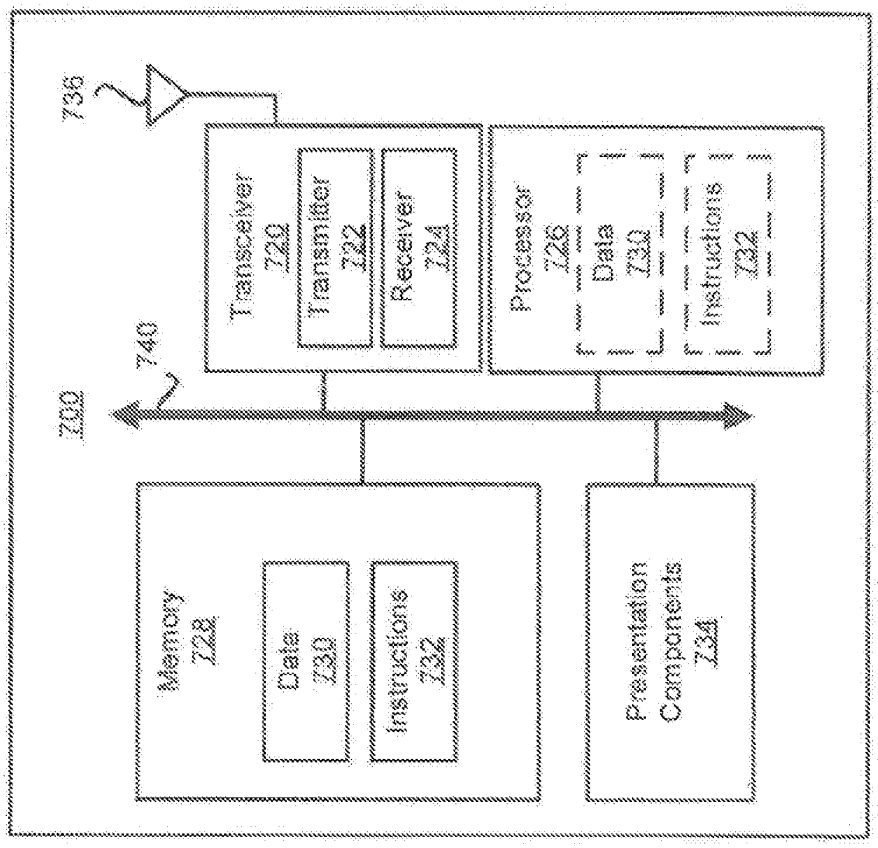

736
Transceiver
720
Transmitter
722
Receiver
724
Processor
726
Data
730
Instructions
732
740
700
Memory
728
Data
730
Instructions
732
Presentation
Components
734

FIG. 7

US010743238B2

(12) **United States Patent**
**Chen et al.**

(10) **Patent No.: US 10,743,238 B2**
(45) **Date of Patent: Aug. 11, 2020**

(54) **SYSTEM INFORMATION UPDATES IN BAND WIDTH PART (BWP) SWITCH OPERATION**

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(73) Assignee: **FG Innovation Company Limited**, Tuen Mun (HK)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(51) **Int. Cl.**

| | |
|---|---|
| ***H04W 4/00*** | (2018.01) |
| ***H04W 48/10*** | (2009.01) |
| *H04W 48/12* | (2009.01) |

(52) **U.S. Cl.**
CPC ..... ***H04W 48/10*** (2013.01); *H04W 48/12* (2013.01)

(58) **Field of Classification Search**
CPC ..... H04W 48/10; H04W 48/12
USPC ..... 370/328, 329, 330
See application file for complete search history.

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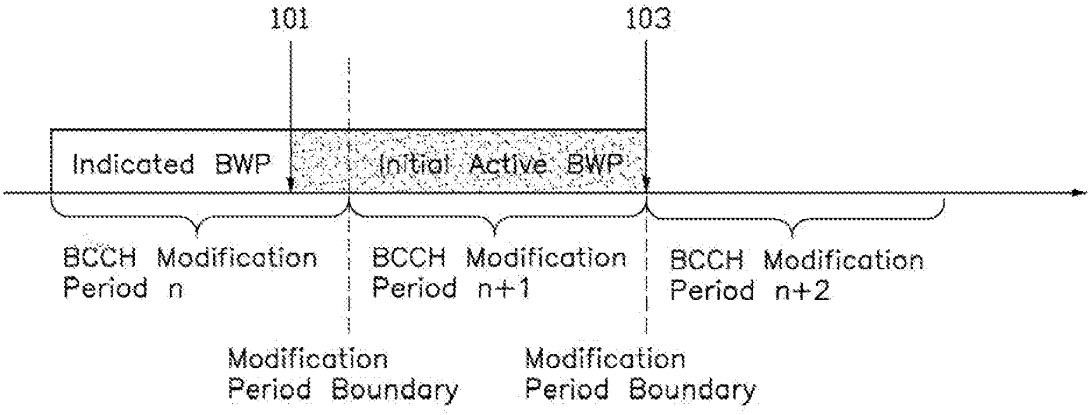
(57) **ABSTRACT**

A user equipment (UE) for wireless communication is configured to perform bandwidth part (BWP) switching operation in response to receiving a system information change indication. The UE receives the system information change indication via a currently active BWP in a BCCH modification period. The system information change indication notifies the UE that contents of system information have been changed. The UE switches from the currently active BWP to an initial active BWP to receive the changed contents of system information which are required for the UE. The UE receives the changed contents of system information via the initial active BWP in a next BCCH modification period that immediately follows the BCCH modification period. The UE updates the system information according to the changed contents.

**20 Claims, 10 Drawing Sheets**



# ON-DEMAND SYSTEM INFORMATION REQUEST PROCEDURE AND ERROR HANDLING

## CROSS-REFERENCE TO RELATED APPLICATION(S)

The present application claims the benefit of and priority to a provisional U.S. Patent Application Ser. No. 62/651,312, filed on Apr. 2, 2018, entitled "On-Demand System Information Request Procedure and Error Handling," (hereinafter referred to as "US73481 application"). The disclosure of the US73481 application is hereby incorporated fully by reference into the present application.

## FIELD

The present disclosure generally relates to wireless communication, and more particularly, to the on-demand system information (SI) request procedure for the next generation wireless communication networks.

## BACKGROUND

The concept of on-demand System Information (SI) request has been introduced in the next generation wireless network (e.g., a 5th generation (5G) new radio (NR) network). When a UE finds that a required SI message(s) is not broadcasted, based on information in the System Information Block Type 1 (SIB1) (e.g., a one-bit indicator that shows whether the corresponding SI message is currently broadcasted or not) and the mapping of the SIBs to SI messages, the UE may perform an on-demand SI request procedure to ask the network (also referred to as NW) to broadcast the required SIB(s) and/or SI message(s). However, the next generation wireless network lacks an efficient mechanism for error handling associated with the on-demand SI request procedure.

## SUMMARY

The present disclosure is directed to on-demand system information request procedure and the corresponding error handling procedure for the next generation wireless communication networks.

According to an aspect of the present disclosure, a method of wireless communications performed by a user equipment (UE) is provided. The method includes performing an on-demand system information (SI) request procedure in a first cell; and performing an error handling procedure if the on-demand SI request procedure in the first cell is unsuccessful. The error handling procedure includes storing SI request failure information.

According to another aspect of the present disclosure, a UE is provided. The UE includes one or more non-transitory computer-readable media having computer-executable instructions embodied thereon and at least one processor coupled to the one or more non-transitory computer-readable media. The at least one processor is configured to execute the computer-executable instructions to perform an on-demand system information (SI) request procedure in a first cell, and perform an error handling procedure if the on-demand SI request procedure in the first cell is unsuccessful. The error handling procedure includes storing SI request failure information.

## BRIEF DESCRIPTION OF THE DRAWINGS

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, dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. **1** is a sequence diagram illustrating the transmission of SI request failure information, according to an exemplary implementation of the present application.

FIG. **2** is a sequence diagram illustrating an example of an on-demand SI request being transmitted to an MN in the DC mode, according to an exemplary implementation of the present application.

FIG. **3** is a sequence diagram illustrating an example of an on-demand SI request being transmitted to an SN in the DC mode, according to an exemplary implementation of the present application.

FIG. **4** is a sequence diagram illustrating an example of a UE determining the failure of an SI request in the DC mode, according to an exemplary implementation of the present application.

FIG. **5** is a sequence diagram illustrating an example of a UE receiving SI request rejection information in the DC mode, according to an exemplary implementation of the present application.

FIG. **6** is a flowchart for a method of wireless communications performed by a UE, according to an example implementation of the present application.

FIG. **7** illustrates a block diagram of a node for wireless communication, in accordance with various aspects of the present application.

## DETAILED DESCRIPTION

The following description contains specific information pertaining to exemplary implementations in the present disclosure. The drawings in the present disclosure and their accompanying detailed description are directed to merely exemplary implementations. However, the present disclosure is not limited to merely these exemplary 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.

For the purpose of consistency and ease of understanding, like features are identified (although, in some examples, not shown) by numerals in the exemplary 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.

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."

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, system, architectures, and the like are omitted so as not to obscure the description with unnecessary details.

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 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 exemplary implementations described in this specification are oriented to software installed and executing on computer hardware, nevertheless, alternative exemplary implementations implemented as firmware or as hardware or combination of hardware and software are well within the scope of the present disclosure.

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.

A radio communication network architecture (e.g., a long term evolution (LTE) system, a LTE-Advanced (LTE-A) system, a LTE-Advanced Pro system, or a 5G New Radio (NR) Radio Access Network) typically includes at least one base station, at least one user equipment (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 radio access network (RAN) established by one or more base stations.

It should be noted that, in the present application, 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, 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.

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-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 connect to serve the one or more UEs through a radio interface to the network.

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 EDGE radio access Network (GERAN), General Packet Radio Service (GRPS), 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), New Radio (NR, often referred to as 5G), and/or LTE-A Pro. However, the scope of the present application should not be limited to the above mentioned protocols.

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 can 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) service. Each cell may have overlapped coverage areas with other cells.

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 communication 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.

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 resource may also be provided in a NR frame to support ProSe services or V2X services.

The 3rd Generation Partnership Project (3GPP) has introduced a new radio resource control (RRC) state (i.e., the RRC_INACTIVE state) for the next generation (e.g., 5th generation (5G)) wireless communication networks. The RRC_INACTIVE state (also referred to as inactive state in the following description) aims to achieve power saving with acceptable access latency, and is suitable especially for small data transmission, such as in machine type communications (MTC) scenarios. When a UE is in an inactive state, the 5G radio access network (5G-RAN) (e.g., the next generation radio access network (NG-RAN), other 3GPP/non-3GPP access network connected to a 5G core network)

and the UE store the "UE context" (which may include Access Stratum (AS) context and Non-Access Stratum (NAS) context of the UE) separately. In addition, when the UE is in the inactive state, the UE may not have an RRC connection with the 5G-RAN, although the 5G-RAN may keep a connection with the next generation core network (e.g., 5G Core Network (5GC)).

The on-demand SI request procedure may be implemented differently for the UEs that are in different Radio Resource Control (RRC) states. For example, in one implementation, for a UE that is in a connected state, the NW may deliver on-demand SI messages or SIB(s) via dedicated signaling to the UE after receiving an SI request from the UE. In some implementations, for a UE that is in an idle state or an inactive state, the NW may deliver on-demand SI messages or SIB(s) via broadcasting. In some implementations, the NW may control the message type for the on-demand SI request procedure. For example, the message type for the on-demand SI request procedure may include a Message 1 (MSG1) based approach and a Message 3 (MSG3) based approach.

In some of the present embodiments, if a Random Access (RA) preamble and/or a Physical Random Access Channel (PRACH) resource specific to each SIB or set of SIBs (which the UE needs to acquire) is included in the minimum SI (e.g., in the Master Information Block and the SIB1), the SI request may be indicated using an MSG 1-based approach.

In an MSG1-based SI request, in some implementations, the minimum granularity for a requested SI may be one SI message (for a set of SIBs, as in an LTE scenario). In some of such implementations, one RA preamble may be used to request for multiple SI messages. In some implementations, a Random Access Preamble Index (RAPID) may be included in a Message 2 (MSG2). Other fields, such as Timing Advance (TA), UL grant and Temporary Cell Radio Network Temporary Identifier (C-RNTI), may not be included in the MSG2 in some implementations.

In some of the present embodiments, an RA procedure for SI request may be considered successful when the UE receives an MSG2 that includes a RAPID corresponding to the transmitted preamble. The MSG2 reception may use an RA-RNTI that corresponds to the MSG1 transmitted by the UE.

In some of the present embodiments, the UE may retransmit the RA preamble according to an NR RA power ramping when the SI request is considered to be unsuccessful. The MSG1 for SI request re-transmission may be continued until reaching maximum preamble transmissions in some of the present embodiments. Thereafter, an RA problem may be indicated to the upper layer (e.g., RRC layer). In some of the present embodiments, a Back off mechanism may be applicable to the MSG1-based SI requests. In some of such embodiments, however, no special back off sub-header/procedure may be required.

In some of the present embodiments, if the RA preamble and/or the PRACH resource (or PRACH occasions) specific to each SIB or set of SIBs (which the UE needs to acquire) is not included in the minimum SI, the SI request may be included in an MSG3. The UE may determine whether the MSG3-based approach is successful or not based on a reception of the MSG4. The preamble(s) and/or the PRACH occasions for the SI request using the MSG3-based approach may not be reserved in some aspects of the present embodiments. RRC signaling may be used for the SI request in an MSG3-based approach. In some embodiments, the UE's ID may not be included in the MSG3.

In some of the present embodiments, a temporary C-RNTI received in the MSG2 may be used for an MSG4 reception. The UE may check the contention resolution Medium Access Control (MAC) Control Element (CE) against the transmitted request.

Specifically, based on the MSG1-based SI request procedure, a UE which transmits a preamble on a dedicated PRACH resource (or PRACH occasions) for the SI request may need to wait for a corresponding Random Access Response (RAR) within a configured RAR window. If no RAR that contains a RAPID corresponding to the transmitted preamble is received, the UE may retransmit the RA preamble until the corresponding RAR is received. The MSG1 for SI request re-transmission, in some of the present embodiments, may be continued until a maximum preamble transmission is reached. In some of such embodiments, an RA problem may be indicated to the upper layers. However, during the whole MSG1-based SI request procedure, the requested SIB(s) or SI message(s) may be broadcasted based on the NW decision or other UE's SI request(s). There may be a power consumption issue if the UE does not stop the ongoing MSG1-based SI request procedure when the required SIB(s) has been broadcasted.

As described above, based on the MSG1-based SI request procedure, a UE which transmits a preamble on a dedicated PRACH resource for the SI request may need to wait for the corresponding RAR within a configured RAR window. If no RAR that contains a RAPID corresponding to the transmitted preamble is received, the UE may retransmit the RA preamble until reaching a maximum preamble transmission, and then an RA problem may be indicated to upper layers. If the corresponding RAR is received, the UE may send an MSG3 to indicate the required SIB(s) and/or SI message(s). After sending the MSG3, the UE may need to wait for a period e.g., defined by a contention resolution timer) for receiving the MSG4 for contention resolution. If the contention resolution timer expires and no MSG4 is received, the UE may retransmit a preamble again. In some of the present embodiments, the MSG1 for the SI request re-transmission may be continued until a maximum preamble transmission is reached. In some aspects of the present embodiments, an RA problem may be indicated to the upper layers. Similarly, since contention resolution is also adopted for the MSG3-based SI request procedure, an RA problem may be indicated to the upper layers if the maximum preamble transmission is reached.

CASE 1: A UE's Behaviour when an On-Demand SI Request is Unsuccessful for the UE in an Idle State or an Inactive State:

When an MSG1-based SI request or an MSG3-based SI request procedure in a cell is failed, the UE may consider the cell as barred, or may consider that the required SIB(s) and/or SI message(s) are not available. In one implementation, the UE may consider the on-demand SI request procedure as unsuccessful when the number of times the UE transmits a random access preamble reaches a threshold (e.g., maximum allowable preamble transmissions), and/or the UE receives SI request rejection information (e.g., in a RAR) in some of the present embodiments.

If the UE considers that a cell is barred due to an SI request failure, the UE may consider the cell as barred for a configurable time period or a fixed time period (e.g., for 300 s). The UE may perform a cell reselection procedure to find another cell to camp on. The barring time period may be broadcasted to the UE in system information, carried in an MSG2 or MSG4, or may be predefined as a fixed value in some of the present embodiments.

If the UE considers that the required SIB(s) and/or SI message(s) are not available, the UE may not perform the SI request for the unavailable SIB(s) and/or SI message(s) again on the cell. In some of the present embodiments, when the UE considers that the required SIB(s) and/or SI message(s) are not available (e.g., when an RA procedure problem is reported, or when SI request rejection information is received), the UE may activate a prohibit timer. In some of such embodiments, the UE may avoid initiating another on-demand SI request procedure until the prohibit timer expires. In one implementation, the UE is forbidden to perform another on-demand SI request procedure until the prohibit timer expires. For example, the prohibit timer may start when an upper layer (e.g., the RRC layer) receives the SI request rejection information, or receives the RA problem due to an SI request failure from a lower layer (e.g., the MAC layer). After the prohibit timer expires, the UE may initiate another SI request procedure. The prohibit timer may be preconfigured or may be a fixed value in some of the present embodiments. The value of the prohibit timer may be broadcasted in system information, carried in an MSG2 or MSG4, or may be predefined as a fixed value in some embodiments.

In one implementation, if the prohibit timer is not present in the signaling from the NW, it is up to UE's implementation on when to start the SI request procedure again.

In one implementation, the UE may determine whether to perform a cell reselection procedure due to a failure of the MSG1-based SI request or the MSG3-based SI request. The UE may make such a determination based on whether the required SIB(s) and/or SI message(s) are essential for the UE (e.g. essential for the UE's targeting services) or based on some other predefined rules. For example, the UE may determine to perform a cell reselection procedure as a result of an unsuccessful SI request if the required SIB(s) and/or SI message(s) are essential.

The UE may perform a cell reselection procedure due to a failure of the MSG1-based SI request or the MSG3-based SI request. Specifically, when the UE performs a cell reselection procedure, the UE may consider the cell, for which the UE fails to request the required SIB(s) and/or SI messages(s), as barred or having a lower priority (e.g., by setting the priority of the frequency on which the barred cell is to a default value). In one implementation, the requested SIB(s) and/or SI messages(s) may be defined/considered as the essential SI for different UE categories or UE types. If the requested SIB(s) and/or SI messages(s) are not defined/considered as the essential SI for the category or type of the UE, the UE may decide whether to re-request the requested SIB(s) or SI messages(s) on the camped cell. In one implementation, if the requested SIB(s) or SI messages(s) are not defined/considered as the essential SI for the category or type of the UE, a prohibit timer may start when the upper layer (e.g., the RRC layer) receives the RA problem due to an SI request failure from the lower layer (e.g., the MAC layer). After the prohibit timer expires, the UE may perform the SI request procedure again. The prohibit timer may be preconfigured or be a fixed value. The value of the prohibit timer may be broadcasted in the system information, carried in an MSG2 or MSG4, or may be predefined as a fixed value.

CASE 2: A UE's Behaviour when the On-Demand SI Request is Unsuccessful for the UE in a Connected State:

A UE may also request the required SIB(s) or SI message(s) while the UE is in a connected state. Normally, the UE may receive the required SIB(s) or SI message(s) via dedicated signaling. If the UE does not receive the required SIB(s) or SI message(s) via dedicated signaling, (e.g., no response from the NW side to deliver the required SIB(s) or SI message(s), or receiving SI request rejection information), the UE may consider that there is an NW error and perform reestablishment to another qualified cell if there is another qualified cell with a valid UE context. If there is no such a qualified cell or if the reestablishment is rejected/failed, the UE may switch to an idle state and perform a cell reselection procedure by considering the cell as barred. In another implementation, the UE may directly switch to the idle state and then perform a cell reselection procedure by considering the cell as barred.

In one implementation, the NW may respond an SI request rejection message/information to the UE. After receiving the SI request rejection message/information, the UE may consider that the required SIB(s) or SI message(s) are not available and may not perform the SI request for the SIB(s) or SI message(s) again on the cell. In another implementation, a prohibit timer may be initiated when the UE receives the SI request rejection message/information. After the prohibit timer expires, the UE may perform an SI request procedure again. The prohibit timer may be preconfigured or may be a fixed value.

In one implementation, when the SI request procedure is unsuccessful, the UE may perform, at least, a reestablishment procedure, switch to an idle state for a cell reselection procedure, mark that the requested SIB(s) or SI message(s) are not available, etc.

In one implementation, the requested SIB(s) or SI messages(s) may be defined/considered as the essential SI for different UE categories or UE types. The UE may switch to the idle state and perform a cell reselection procedure when the SI request for essential SI is failed. The UE may consider the cell in which the SI request is failed as barred, or having a lower priority when performing a cell reselection procedure (e.g., by setting the priority of the frequency on which the barred cell is to a default value). The UE, in some of the present embodiments, may only mark that the requested SIB(s) or SI message(s) are not available when the SI request for non-essential SI is failed.

In the connected state, the NW may perform a handover (HO) procedure (e.g., from a source gNB to a target gNB) when receiving the SI request for required SIB(s) or SI message(s) that are not provided by the NW. The target gNB may provide the required SIB(s) or SI message(s) in the HO command (e.g., based on the SI request information provided in the HO Request message from the source gNB).

In the Dual Connectivity (DC) mode, the UE may inform the cause of a Secondary Node (SN) SI request failure, or the information related to the SI request failure to a Master Node (MN) when the on-demand SI request for the SIB(s) of the SN is rejected or failed. After the MN receives the cause of an SI request failure or the information related to the SI request failure, in some of the present embodiments, the MN may try to resolve the SN SI request rejection/failure problem. For example, in one aspect of the present embodiments, the MN may release the SN or change the SN to a new SN for the UE.

CASE 3: Store and Report the Information Related to the SI Request Failure:

An MSG1-based SI request or an MSG3-bsed SI request procedure may be failed when a lower layer (e.g., the MAC layer) informs an upper layer (e.g., the RRC layer) of an RA problem. Since the RRC layer knows the RA procedure is triggered for the SI request, the UE may store the SI request failure information. The SI request failure information may include one or more parameters used in the on-demand SI request procedure. The SI request failure information may

include at least one of the following: the on-demand SIB(s) requested by the UE, the on-demand SI message(s) requested by the UE, the cell ID (of the cell in which the UE has performed the SI procedure but has failed), SSB Index(s) (Synchronization Signal Block Index(s)) to perform the SI request procedure, the message type of the failed SI request procedure (e.g., MSG1-based or MSG3-based), the timestamp (e.g., when to perform the SI request procedure), etc. The SSB Index may indicate which SSB with RA resource (or RA occasions) is used for a preamble transmission. For example, for an MSG1-based approach, the dedicated RA resource (or RA occasions) for transmitting a preamble may be associated with an SSB. For an MSG3-based approach, the common RA resource (or RA occasions) for transmitting a preamble may be associated with an SSB. The UE may report such failure information to the NW when switching to a connected state later. The UE may mandatorily report the information of the SI request failure, according to the configuration, or upon an NW request. The content of the SI request failure information may be predefined, may be based on the required information indicated in the received SI request failure information message, or may be based on the configuration.

FIG. **1** is a sequence diagram illustrating the transmission of SI request failure information, according to an exemplary implementation of the present application. As shown in diagram **100**, in action **110**, serving node **104** (e.g., a gNB) may send a request to UE **102** to provide the information related to SI request failure. For example, serving node **104** may send an SI Request Failure Information Request message to UE **102** if UE **102** informs serving node **104** that such information is stored. In one implementation, UE **102** may set one bit in an RRC message (e.g., in the RRC Connection Setup Complete message or in the RRC Connection Resume message) to true (or '1') to inform serving node **104** that UE **102** supports storage of the SI request failure information and it has the SI request failure information stored. Serving node **104** may determine to request the SI request failure information after receiving such information from UE **102**. In action **112**, UE **102** may send a message including the SI request failure information to serving node **104**.

By utilizing the SI request failure information, serving node **104** may know how to adjust the SI request mechanism between the MSG1-based approach and the MSG3-based approach. For example, if UE **102** reports failure of an MSG3-based SI request procedure in a cell or a certain area, serving node **104** may consider adopting the MSG1-based SI request for the UEs in idle/inactive state to avoid an RA collision by using the dedicated RA resource(s) for SI request. Alternatively, serving node **104** may continue to adopt the MSG3-based SI request procedure when UE **102** reports the failure of the MSG3-based SI request procedure.

In one implementation, UE **102** may store the information related to the SI request failure when UE **102** considers the cell as barred and performs a cell reselection procedure. UE **102** may not store the information related to the SI request failure when UE **102** considers that the required SIB(s) or SI message(s) are not available.

When the SI request procedure for a UE that is in a connected state is failed (e.g., UE **102** does not receive the required SIB(s) or SI message(s) via dedicated signaling, or UE **102** receives the SI request rejection information), UE **102** may store the information of the SI request failure. In one implementation, when the SI request procedure is unsuccessful, UE **102** may perform re-establishment to another qualified cell, or UE **102** may switch to an idle state and then perform a cell reselection procedure by considering the cell as barred. The information of the SI request failure may include at least one of the following: the required SIB(s), the required SI message(s), the cell ID (of the cell in which the UE preforms SI procedure but failed), and the timestamp of the SI request procedure. UE **102** may report such failure information to the NW when switching to a connected state later. UE **102** may mandatorily report the information of the SI request failure, according to the configuration, or upon receiving an NW request. The content of the SI request failure information may be predefined, may be based on the required information indicated in the received SI request failure information message, or may be based on the configuration.

Similarly, UE **102** may store the SI request failure information when UE **102** is in a connected state if the SI request is unsuccessful (where SI request procedure may be an MSG1-based SI approach or an MSG3-based SI approach). The SI request failure information may include at least one of the following: the on-demand SIB(s) requested by UE **102**, the on-demand SI message(s) requested by UE **102**, the cell ID (of the cell which UE **102** preforms SI procedure but failed), SSB Index(s) (Synchronization Signal Block Index(s)) to perform the on-demand SI request procedure, the message type of the unsuccessful SI request procedure (e.g., MSG1-based or MSG3-based), and the timestamp (e.g., when to perform the SI request procedure). The UE may mandatorily report the SI request failure information, according to the configuration, or by an NW request (e.g., requested by serving node **104**). The content in the SI request failure information may be predefined, may be based on the required information indicated in the received SI Request Failure Information message, or may be based on the configuration.

It may be beneficial for the NW to know the information related to SI request failure. For example, the NW may determine which cell, SIB(s)/SI message(s), or the related dedicated preamble may have problems. As a result, the NW is likely to overcome the problem afterwards, or the NW may consider adopting another mechanism for serving the SI request.

In the DC mode, a UE may inform the cause of a Secondary Node (SN) SI request failure, or the information related to the SI request failure, to a Master Node (MN) when the on-demand SI request for the SIB(s) of the SN is rejected or failed. After MN receives the cause of the SI request failure or the information related to the SI request failure, the MN may try to resolve the SN's SI request rejection/failure problem. For example, the MN may release the SN or change the SN to a new SN for the UE.

CASE 4: Harmonization of the SI Request Messages in Idle, Inactive, and Connected States:

For an MSG3-bsed SI request procedure, the MSG3 may include an SI request message (which may be an RRC message) containing no UE ID. In an idle state, there may be no security key and/or security algorithm configured to the UE yet. Therefore, the SI request message transmitted in an idle state may be transmitted on Signaling Radio Bearer 0 (SRB0). Neither integrity protection, nor ciphering, apply to the SRB0 in some embodiments. In one implementation, the SI request message (which is an RRC message) may be the same for idle, inactive, and connected states, resulting in an RRC message harmonization. The SI request message may be transmitted on the SRB0 without integrity protection and ciphering, even if the UE is in a connected state, or in an inactive state, where integrity protection and ciphering may have been already applied.

in one implementation, the SI request message (which is an RRC message) that includes no UE ID may be the same for idle, inactive, and connected states. The UE may transmit the SI request message on the SRB0 when the UE is in an idle or an inactive state. The UE may transmit the SI request message on Signaling Radio Bearer 1 (SRB1) when the UE is in a connected state. Both integrity protection and ciphering may apply to the SRB1.

In one implementation, the SI Request message (which is an RRC message) may be the same for idle, inactive, and connected states. The UE may transmit the SI request message on the SRB0 when the UE is in an idle state. The UE may transmit the SI request message on the SRB1 when the UE is in an inactive or a connected state. Both integrity protection and ciphering may apply to the SRB1. In an inactive State, the UE may still have the UE context and the NW's configuration for integrity protection and ciphering.

In one implementation, whether the SI request message is transmitted on the SRB0 or the SRB1 for a UE in an inactive state may be determined based on the UE's implementation, the NW's preconfiguration, and/or whether the UE context for integrity protection and ciphering is stored/valid or not.

It may be beneficial to keep the commonality of the SI Request message with respect to the UEs in different states, which may lead to simplification of the overall system design in some of the present embodiments.

CASE 5: The Structure of an SI Request Message:

In one implementation, the SI request message in the MSG3 (e.g., in an MSG3-based SI request procedure) may be the same for idle, inactive, and connected states. Different minimum granularity of the requested SI (e.g., SIB-based or SI message-based) may be considered in connection with the SI request message. For example, it may be beneficial for the SI request message to use SI message-based granularity (e.g., the UE indicates which SI message(s) is requested) in the MSG3-based SI request procedure, since there is a one-bit indicator in the NR SIB1 to show whether the corresponding SI message is currently broadcasted or not, and the number of SI messages may be much less than the number of SIBs. However, the SI message-based granularity may not provide sufficient information to the NW in regards to which SIB(s) needs to be broadcasted and/or whether the mapping of the SIB(s) and the SI message(s), and the associated periodicity may need to be re-arranged based on the UE's requirements. The UE in connected state may receive the required SI via dedicated signaling. Therefore, in one implementation, the SIB-based granularity may be used, e.g., by the UE indicating which SIB(s) is requested.

Different implementations regarding the different SIB-based granularities will be discussed next:

CASE 5-1:

In the SI Request message, there may be a choice structure in which the UE may choose to use the SI message-based granularity or the SIB-based granularity. The UE may consider the signaling overhead to select which granularity to use. In one implementation, the UE may use a first bitmap to indicate which SI message(s) is requested and a second bitmap to indicate which SIB(s) is requested. In one implementation, there may be a common bitmap for the UE to indicate which SI message(s) is requested or which SIB ID(s) is requested.

CASE 5-2:

In the SI Request message, there may be a choice structure in which the UE may choose to use the SI message-based granularity or the SIB-based granularity. The UE may select one of the two types of granularity based on the NW configuration. The NW configuration may be delivered to the UE via dedicated signaling or via broadcasting. In one implementation, the UE may use a first bitmap to indicate which SI message(s) is requested and a second bitmap to indicate which SIB(s) is requested. In one implementation, there may be a common bitmap for the UE to indicate which SI message(s) is requested or which SIB ID(s) is requested.

CASE 5-3:

In the SI Request message, in some of the present embodiments, the UE may request one or more SI messages together with one or more SIBs. For example, both SI message-based granularity and SIB-based granularity may be potentially used in the SI Request message. Specifically, a UE may send an SI Request message that only uses the SI message-based granularity, only uses the SIB-based granularity, or uses both SI message-based granularity and SIB-based granularity. The UE may use a first bitmap to indicate which SI message(s) is requested and a second bitmap to indicate which SIB(s) is requested. In one implementation, there may be a common bitmap for the UE to indicate which SI message(s) is requested or which SIB ID(s) is requested.

CASE 5-4:

In some of the present embodiments, the UE may use a two-level bitmap for the SI request messages. In some of such embodiments, the first level bitmap may be used for the SI-based granularity, which may be mandatorily appended in the SI request message. The second level bitmap may be used for the SIB-based granularity, which may be optionally appended in the SI request message if the corresponding SI bit is set to "1" in the first level bitmap. As an example, in which there are 5 SI messages, and the SI message#3 includes SIB#7, SIB#8, SIB#9 and SIB#10, when the UE wants to request SIB#9, the first level bitmap of the UE's SI request message may be "0100" (which indicates SI message#3), and the UE may further optionally append the second level bitmap "0100" (which indicates the third SIB in the SI message#3). Consequently, a gNB may provide SIB#9 specifically in response to such an SI request message. In one implementation, if the second bitmap does not appear, the gNB may provide the complete SI message#3.

CASE 6: On-Demand SI Request Procedure in an NR-NR DC Scenario:

A UE in an NR-NR Dual Connectivity (DC) mode may request one or more required SIBs or one or more SI messages for certain purpose(s) or certain service(s). Several implementations are described below regarding how the UE may request and receive the required SIB(s) from a secondary node (SN) or the serving cells in a secondary cell group (SCG).

CASE 6-1:

When a UE is in an NR-NR DC mode and one or more SIBs or one or more SI messages are required, the UE may be only allowed to send the SI request message to the master node (MN) in some of the present embodiments.

FIG. **2** is a sequence diagram illustrating an example of an on-demand SI request being transmitted to an MN in the DC mode, according to an exemplary implementation of the present application. As shown in diagram **200**, in action **210**, UE **102** may transmit an SI request message to MN **106** when UE **102** requires on-demand system information of a cell belonging to MN **106** or a cell belonging to SN **108**. In action **212**, MN **106** may inform SN **108** to provide the required SIB(s) or SI message(s) to UE **102** based on the SI request message. For example, MN **106** may use a signaling message between two base stations (e.g., X2-AP message or Xn-AP message) with fields indicating the requested SIB(s) or SI message(s). When SN **108** receives the SI request from MN **106**, SN **108** may transmit the required SIB(s) or SI

message(s) to UE **102** by initiating serving cell release and addition action in the same RRC reconfiguration message to update the SIB(s) or SI message(s) for certain, or all, serving cell(s). As shown in diagram **200**, this RRC reconfiguration may be transmitted via MN **106** or transmitted via Signaling Radio Bearer 3 (SRB3), if configured.

When the UE requires on-demand system information of a cell belonging to MN **106**, if the requested SI message or SIB is not broadcasted, in action **214**, MN **106** may transmit the required SI to UE **102**. When the UE requires on-demand system information of a cell belonging to SN **108**, if the requested SI message or SIB is not provided before, in action **216**, SN **108** may transmit RRC Reconfiguration with the required SI to UE **102** (e.g., via the SRB3). In one implementation, SN **108** may transmit RRC reconfiguration with required SI (e.g., action **216**) only when SN **108** receives the SI Request Notification from MN **106** (e.g., action **212**).

In one implementation, SN **108** may directly transmit the modified SIB(s) or SI messages(s) to UE **102** without taking cell release and addition action, when MN **106** sends the SI Request Notification to SN **108**. SN **108** may transmit the modified SIB(s) or SI messages(s) directly to UE **102** only when receiving the SI Request Notification from MN **106**.

In one implementation, UE **102** is only allowed to send the SI request message to MN **106**. The UE may indicate in the SI request message that the SI Request is for the SIB(s) or the SI message(s) on MN **106** or SN **108**. If the SI Request message is marked for MN **106**, MN **106** may be responsible for this SI Request message. On the other hand, if the SI Request message is marked for SN **108**, MN **106** may forward this message to SN **108** and SN **108** may be responsible for this SI Request message. It should be noted that UE **102** may follow the minimum SI's indication (e.g., SI transmission period) of MN **106** or SN **108** to receive the SI while the SI request message is marked to MN **106** or SN **108**, respectively. In another implementation, UE **102** may not mark the SI request toward MN **106** or SN **108**, and MN **106** may provide all (MN **106** and SN **108**) relative SI to UE **102** in a unicast approach.

If some or all of the serving cells in the SCG do not provide the requested SIB(s) or SI message(s), SN **108** may inform MN **106** that the SCG, or some serving cells in the SCG, does not provide the requested SIB(s) or SI message(s). MN **106** may decide whether to perform the SCG change action or release SN **108** for UE **102**.

CASE 6-2:

When a UE in the NR-NR DC mode and one or more SIBs or SI messages are required, the UE may send the SI request message to the MN and/or the SN when required.

FIG. **3** is a sequence diagram illustrating an example of the on-demand SI request being transmitted to an SN in the DC mode, according to an exemplary implementation of the present application. As shown in diagram **300**, in action **310**, UE **102** may transmit the SI request message to SN **108** (e.g., via SRB3, if configured). In action **312**, SN **108** may transmit RRC Reconfiguration with the required SI to UE **102** via SRB3. If SRB3 is not configured, UE **102** may transmit the SI request message to MN **106** and let MN **106** forward the SI request message to SN **108**.

When some or all of the serving cells in the SCG cannot provide the required SIB(s) or SI message(s), SN **108** may inform MN **106** that the SCG, or some serving cells in the SCG, does not provide the requested SIB(s) or SI message(s). MN **106** may decide whether to perform the SCG change action or release SN **108** for UE **102**.

FIG. **4** is a sequence diagram illustrating an example of the UE determining the failure of an SI request in the DC mode, according to an exemplary implementation of the present application. As shown in diagram **400**, in action **410**, UE **102** sends an SI request message to SN **108**. In action **412**, UE **102** determines the failure of the SI request, e.g., when the number of times UE **102** transmits the random access preamble reaches a threshold. After determining the on-demand SI request procedure is unsuccessful, UE **102** may store the SI request failure information related to SN **108**. In action **414**, UE **102** may transmit the SN SI request failure information to MN **106**.

FIG. **5** is a sequence diagram illustrating an example of the UE receiving SI request rejection information in the DC mode, according to an exemplary implementation of the present application. As shown in diagram **500**, in action **510**, UE **102** sends an SI request message to SN **108**. In action **512**, UE **102** receives the SI request rejection information from SN **108**. After determining the on-demand SI request procedure is unsuccessful, UE **102** may store the SI request failure information related to SN **108**. In action **514**, UE **102** may send the SN SI request failure information to MN **106**.

If UE **102** determines that the SI request procedure on SN **108** has failed (e.g., action **412** in diagram **400** or action **512** in diagram **500**), UE **102** may inform MN **106** of the cause of SN SI request failure or the information related to SN SI request failure (e.g., by sending an SN SI Request Failure Information when the on-demand SI request for the SIB(s) of SN **108** is rejected or failed, e.g., in action **414** of diagram **400**, or action **514** of diagram **500**). The information of the SI request failure may include at least one of the following: the required SIB(s), the required SI message(s), the cell ID (of the cell which the UE performs SI procedure but failed), SSB Index(s) (Synchronization Signal Block Index(s)) to perform SI request, the failed SI request procedure type (e.g., MSG1-based or MSG3-based), or the timestamp (e.g., when to perform the SI request procedure). After MN **106** receives the cause of the SI request failure or the information related to the SI request failure, MN **106** may resolve the SN SI request rejection/failure problem. For example, MN **106** may release SN **108** or change SN **108** to a new SN for UE **102**.

CASE 7: An RA Problem Caused by the MSG1-Based/MSG3-Based SI Request Procedure:

A UE in connected state may be allowed to apply an MSG1-based SI request procedure and/or an MSG3-based SI request procedure. In one implementation, if the RA problem is caused by the MSG1-based or the MSG3-bsed SI request procedures, the UE's operation in connected state is not affected if the requested SI message(s) or SIB(s) is not essential for the UE to perform the targeting services.

In one implementation, the UE may still be fine even if the requested SIB(s) or SI message(s) is not received from the serving node (e.g., in a single connectivity mode) or the MN (e.g., in dual connectivity mode) (e.g., the requested SIB or SI message may not be essential). In this scenario, the UE may not consider the RA problem as a normal radio link failure, and the UE may not perform a re-establishment procedure, or enter into an idle state.

In one implementation, the UE may still be fine even if the requested SIB(s) or SI message(s) is not received from the SN (e.g., in a dual connectivity mode). In this scenario, the UE may not consider the RA problem as a normal radio link failure, and the UE may report the SI failure information to the MN. For example, when the RA problem is reported and the upper layer (e.g., the RRC layer) knows that the problem is caused by an SI request, the UE may initiate a transmis-

sion of the SI failure information report to the MN. In this implementation, the UE may not suspend all of the SCG data radio bearers (DRBs) or SCG transmission for the split DRBs or the duplication DRBs. Also, the UE may not reset the MAC entity associated with the SCG (or SN).

In one implementation, the UE may still be fine even if the requested SIB(s) or SI message(s) is not received from the SN (e.g., in a dual connectivity mode). In this scenario, the UE may not consider the RA problem as a normal radio link failure, and the UE may not report the SI failure information to the MN. For example, when the RA problem is reported and the upper layer (e.g., RRC layer) knows that the problem is caused by an SI request, the UE may not initiate a transmission of the SI failure Information report to the MN. In this implementation, the UE may not suspend all of the SCG DRBs or SCG transmission for the split DRBs or the duplication DRBs. Also, the UE may not reset the MAC entity associated with the SCG (or SN). When the upper layer (e.g., the RRC layer) receives the RA problem caused by the SI request from the lower layer (e.g., the MAC layer), it may also inform the NAS layer (or the application layer) so that the NAS layer (or the application layer) does not trigger the SI request procedure for one or more required SIBS on the same cell, or not trigger the SI request procedure for a while (which may follow the NW configuration or a predefined period). How to handle the SI request failure condition may depend on the UE's implementation, if the NAS layer (or the application layer) is informed about the SI request failure.

In one implementation, whether the SN initiates the transmission of the SI failure information report to the MN may depend on the NW configuration.

FIG. **6** is a flowchart for a method of wireless communications performed by a UE, according to an example implementation of the present application. In FIG. **6**, the process/method **600** includes actions **602**, **604**, **606**, and **610**.

In action **602**, the UE may perform an on-demand system information request procedure in a cell. The UE may be in idle, inactive, or connected state. In addition, the UE may be in a single connectivity mode or a dual connectivity mode.

In action **604**, the UE may determine whether the on-demand SI request procedure is successful. In one implementation, the on-demand SI request procedure is considered unsuccessful when the number of times the UE transmits a random access preamble reaches a threshold, and/or the UE receives the SI request rejection information. If the process **600** determines, in action **604**, that the SI request procedure is unsuccessful, the UE may proceed to action **606**. On the other hand, if the request procedure is successful, the process **600** may end.

In action **606**, the UE may perform an error handling procedure corresponding to the on-demand SI request procedure. There may be several implementations regarding the error handling procedure in different implementations. In one implementation, the error handling procedure may include action **610**, in which the UE may store the SI request failure information. For example, the SI request failure information may include one or more parameters used in the on-demand SI request procedure. In one implementation, the error handling procedure may further include at least one of following: a prohibit timer activation, a cell re-selection procedure, and a re-establishment procedure.

FIG. **7** illustrates a block diagram of a node for wireless communication, in accordance with various aspects of the present application. As shown in FIG. **7**, node **700** may include transceiver **720**, processor **726**, memory **728**, one or more presentation components **734**, and at least one antenna **736**. Node **700** 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 FIG. **7**). Each of these components may be in communication with each other, directly or indirectly, over one or more buses **740**.

Transceiver **720** having transmitter **722** and receiver **724** may be configured to transmit and/or receive time and/or frequency resource partitioning information. In some implementations, transceiver **720** 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 **720** may be configured to receive data and control channels.

Node **700** may include a variety of computer-readable media. Computer-readable media can be any available media that can be accessed by node **700** 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.

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.

Memory **728** may include computer-storage media in the form of volatile and/or non-volatile memory. Memory **728** 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 FIG. **7**, memory **728** may store computer-readable, computer-executable instructions **732** (e.g., software codes) that are configured to, when executed, cause processor **726** to perform various functions described herein, for example, with reference to FIGS. **1** through **6**. Alternatively, instructions **732** may not be directly executable by processor **726** but be configured to cause node **700** (e.g., when compiled and executed) to perform various functions described herein.

Processor **726** may include an intelligent hardware device, e.g., a central processing unit (CPU), a microcontroller, an ASIC, and etc. Processor **726** may include memory. Processor **726** may process data **730** and instructions **732** received from memory **728**, and information through transceiver **720**, the base band communications module, and/or the network communications module. Processor **726** may also process information to be sent to

transceiver **720** for transmission through antenna **736**, to the network communications module for transmission to a core network.

One or more presentation components **734** presents data indications to a person or other device. Exemplary one or more presentation components **734** include a display device, speaker, printing component, vibrating component, and etc.

From the above description, it is manifest that various techniques can be used for implementing the concepts described in the present application 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 application 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.

What is claimed is:

**1**. A method of an on-demand system information (SI) request procedure performed by a user equipment (UE), the method comprising:

transmitting a first SI request message to a base station (BS) after determining that the UE is in a connected state, the first SI request message including at least one requested system information block (SIB);

activating a prohibit timer; and

transmitting a second SI request message to the BS only when the at least one requested SIB is not received and the prohibit timer expires.

**2**. The method of claim **1**, wherein the on-demand SI request procedure is unsuccessful when one of the following conditions is met:

a number of times the UE transmits a random access preamble reaches a threshold; and

the UE receives SI request rejection information.

**3**. The method of claim **1**, wherein when the UE is in a dual connectivity mode, the method further comprises:

transmitting a third SI request message to a master node when the UE requires on-demand system information of a cell belonging to a secondary node.

**4**. The method of claim **1**, wherein the first SI request message is transmitted on signaling radio bearer **1** (SRB1).

**5**. The method of claim **1**, further comprising:

receiving, from the BS, the at least one requested SIB via dedicated signaling that is transmitted in response to the first SI request message.

**6**. The method of claim **1**, further comprising:

transmitting a fourth SI request message to the BS after determining that the UE is not in the connected state, the fourth SI request message including at least one requested SI message.

**7**. The method of claim **6**, wherein the fourth SI request message is transmitted on signaling radio bearer 0 (SRB0).

**8**. The method of claim **1**, further comprising:

storing SI request failure information after determining that the on-demand SI request procedure is unsuccessful.

**9**. The method of claim **8**, wherein the SI request failure information comprises at least one of the following:

the at least one requested SIB;

the at least one requested SI message;

a cell identifier (ID) associated with the BS;

a synchronization signal block (SSB) index for performing the on-demand SI request procedure;

a message type of the on-demand SI request procedure; and

a timestamp for performing the on-demand SI request procedure.

**10**. The method of claim **8**, further comprising:

transmitting the SI request failure information;

wherein the SI request failure information is transmitted to a master node when the UE is in a dual connectivity mode.

**11**. A user equipment (UE), comprising:

one or more non-transitory computer-readable media having computer-executable instructions embodied thereon; 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 perform operations for an on-demand system information (SI) request procedure, the operations comprising:

transmitting a first SI request message to a base station (BS) after determining that the UE is in a connected state, the first SI request message including at least one requested system information block (SIB);

activating a prohibit timer; and

transmitting a second SI request message to the BS only when the at least one requested SIB is not received and the prohibit timer expires.

**12**. The UE of claim **11**, wherein the on-demand SI request procedure is unsuccessful when one of the following conditions is met:

a number of times the UE transmits a random access preamble reaches a threshold; and

the UE receives SI request rejection information.

**13**. The UE of claim **11**, wherein when the UE is in a dual connectivity mode, the operations further comprise:

transmitting a third SI request message to a master node when the UE requires on-demand system information of a cell belonging to a secondary node.

**14**. The UE of claim **11**, wherein the first SI request message is transmitted on signaling radio bearer 1 (SRB1).

**15**. The UE of claim **11**, wherein the operations further comprise:

receiving, from the BS, the at least one requested SIB via dedicated signaling that is transmitted in response to the first SI request message.

**16**. The UE of claim **11**, wherein the operations further comprise:

transmitting a fourth SI request message to the BS after determining that the UE is not in the connected state, the fourth SI request message including at least one requested SI message.

**17**. The UE of claim **16**, wherein the fourth SI request message is transmitted on signaling radio bearer 0 (SRB0).

**18**. The UE of claim **11**, wherein the operations further comprise:

storing SI request failure information after determining that the on-demand SI request procedure is unsuccessful.

**19**. The UE of claim **18**, wherein the SI request failure information comprises at least one of the following:

the at least one requested SIB;

the at least one requested SI message;

a cell identifier (ID) associated with the BS;

a synchronization signal block (SSB) index for performing the on-demand SI request procedure;

a message type of the on-demand SI request procedure; and

a timestamp for performing the on-demand SI request procedure.

**20**. The UE of claim **18**, wherein the operations further comprise:

transmitting the SI request failure information;

wherein the SI request failure information is transmitted to a master node when the UE is in a dual connectivity mode.

* * * * *

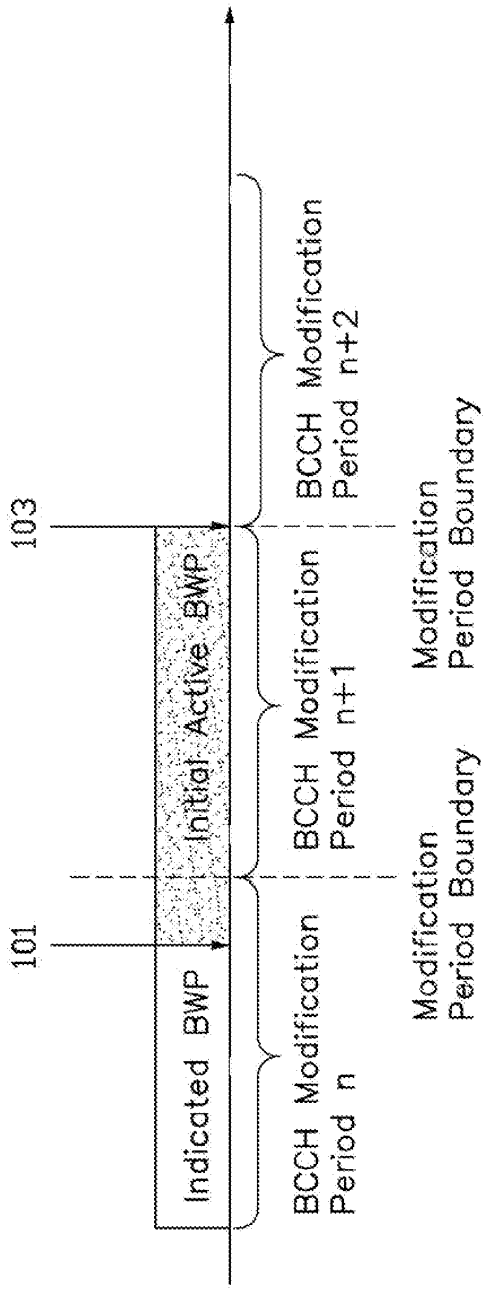

101
103
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 1

# Exhibit 3

US010972972B2

(12) **United States Patent**
**Cheng et al.**

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(54) **METHODS AND APPARATUSES FOR OPERATING MULTIPLE ANTENNA PANELS**

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| | |
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| ***H04W 76/28*** | (2018.01) |
| ***H04W 52/02*** | (2009.01) |
| ***H04B 17/309*** | (2015.01) |
| ***H04W 24/10*** | (2009.01) |
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See application file for complete search history.

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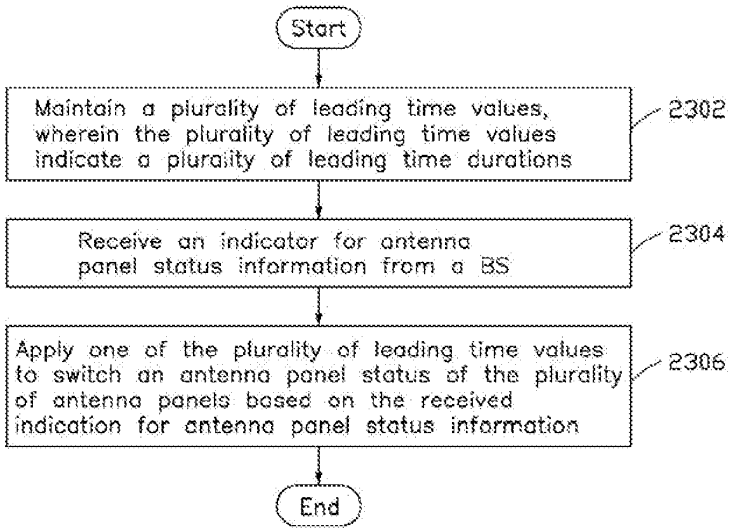
(57) **ABSTRACT**

Methods and apparatuses for operating multiple antenna panels are provided. The wireless communication device includes a plurality of antenna panels and a processor coupled to the antenna panels. The processor is configured to maintain a plurality of leading time values. The plurality of leading time values may indicate a plurality of leading time durations. The processor is further configured to receive an indicator for antenna panel status information from a base station, and apply one of the plurality of leading time values to switch an antenna panel status of the plurality of antenna panels based on the indicator for antenna panel status information.

**28 Claims, 27 Drawing Sheets**



(56) **References Cited**

OTHER PUBLICATIONS

3GPP TSF RAN; NR; Medium Access Control (MAC) protocol specification; TS 38.321 V15.2.0 (Jun. 2018) (Year: 2018).*
MediaTek Inc. ("Discussion on NR UE Feature List", 3GPP TSG RAN WG1 Meeting #93, R1-1806792, May 21-25, 2018) (Year: 2018).*
Samsung Discussion on group-based beam reporting 3GPP TSG RAN WG1 Meeting #90 R1-1714511 Jun. 25, 2017 (Jun. 25, 2017) the whole document.

* cited by examiner

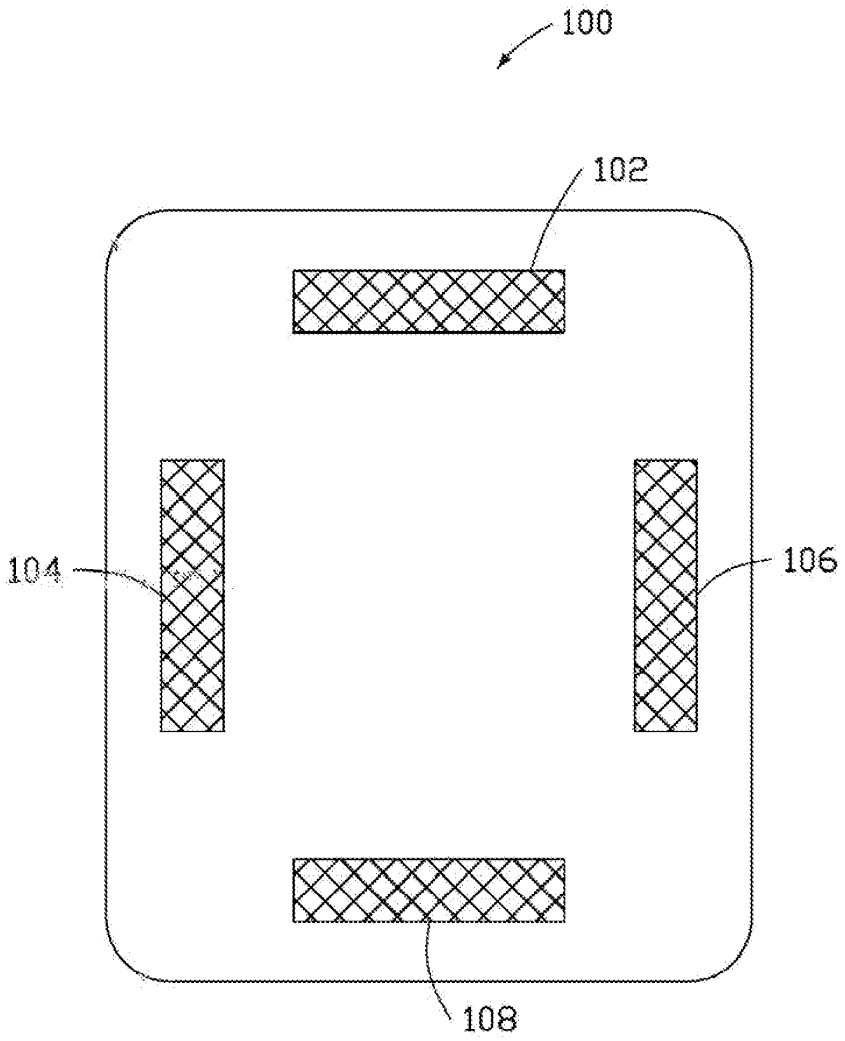



FIG. 1

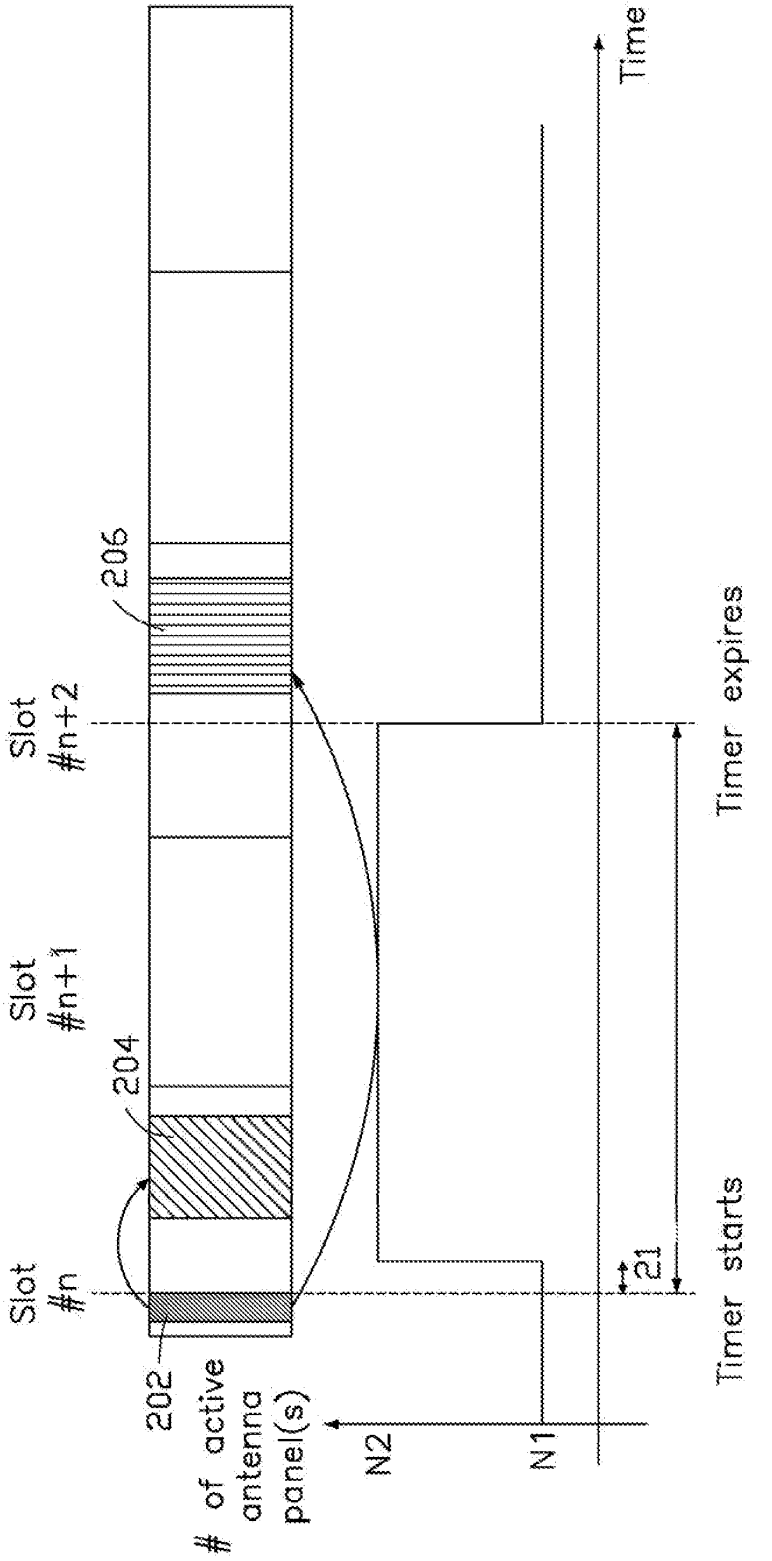

Time
206
Slot #n+2
Timer expires
Slot #n+1
204
Slot #n
Timer starts
21
202
# of active antenna panel(s)
N2
N1

FIG. 2

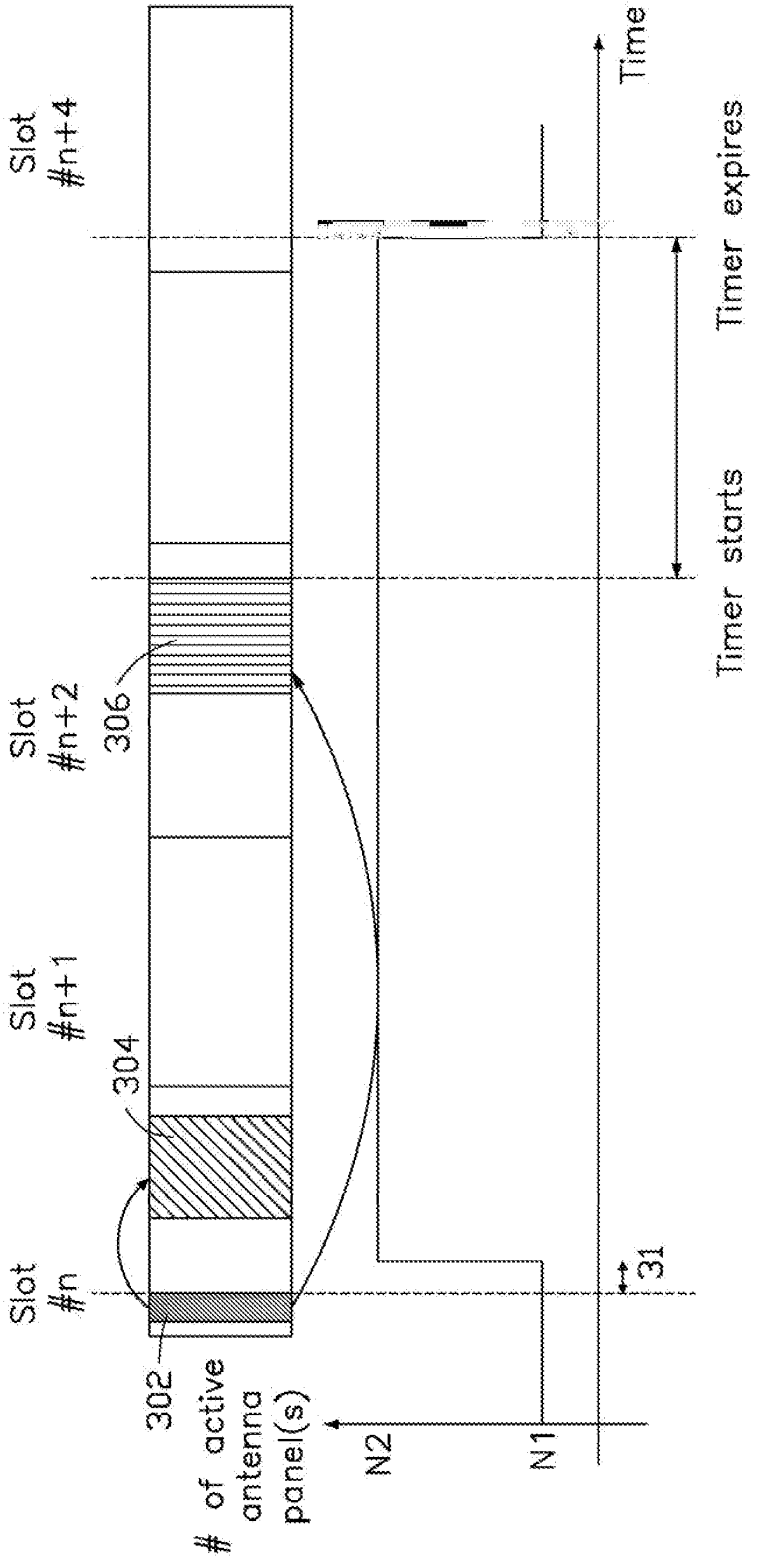

Time
Timer expires
Timer starts
Slot #n+4
Slot #n+2
306
Slot #n+1
304
Slot #n
31
302
# of active antenna panel(s)
N2
N1

FIG. 3

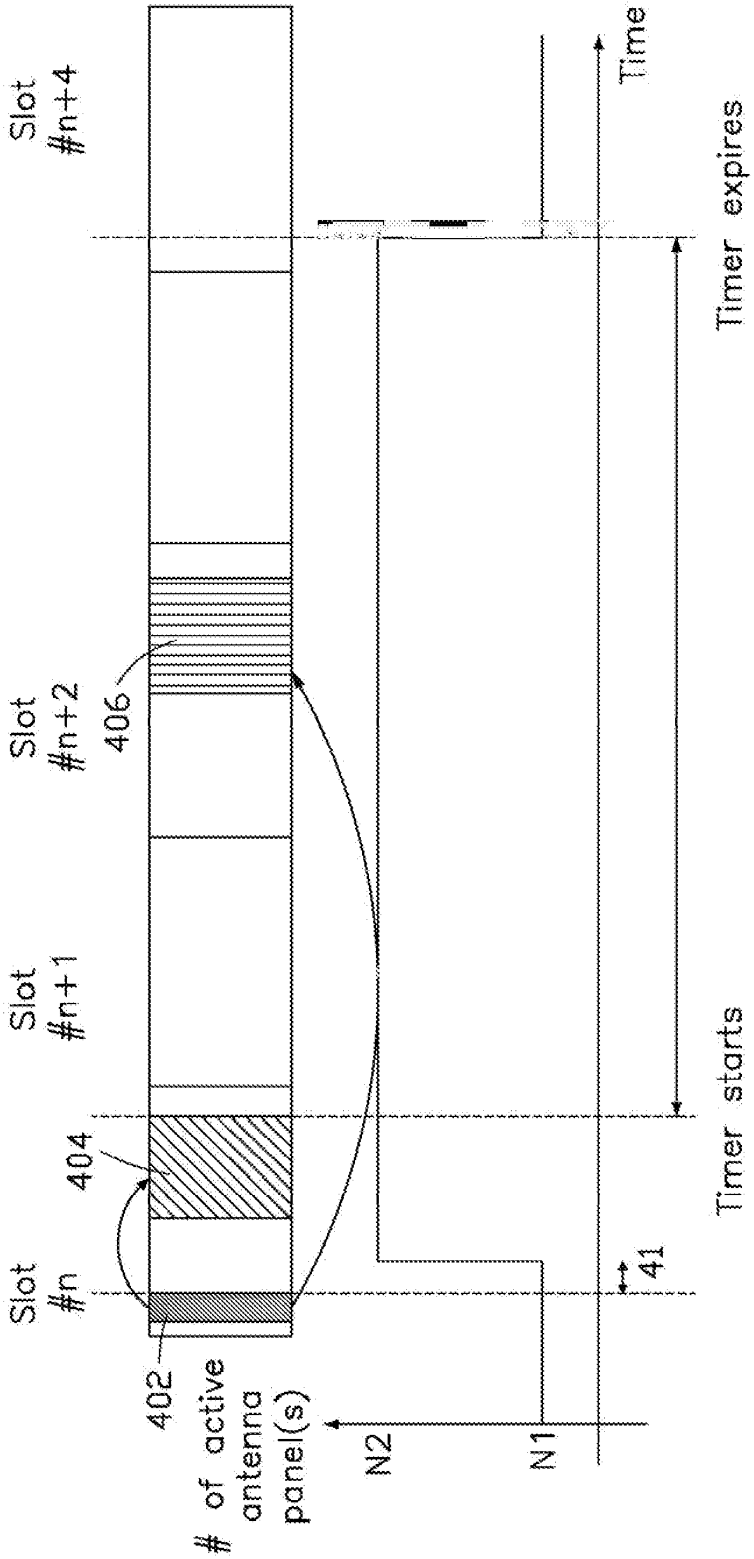

Slot #n+4
Slot #n+2
406
Slot #n+1
Slot #n
404
402
# of active antenna panel(s)
N2
N1
41
Time
Timer expires
Timer starts

FIG. 4

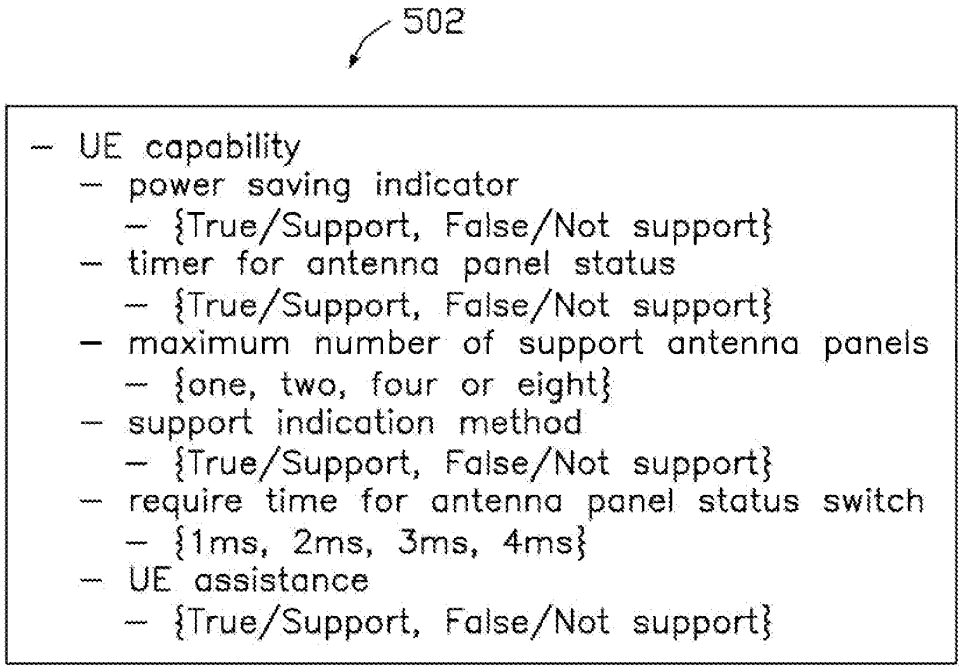

502
– UE capability
– power saving indicator
– {True/Support, False/Not support}
– timer for antenna panel status
– {True/Support, False/Not support}
– maximum number of support antenna panels
– {one, two, four or eight}
– support indication method
– {True/Support, False/Not support}
– require time for antenna panel status switch
– {1ms, 2ms, 3ms, 4ms}
– UE assistance
– {True/Support, False/Not support}

FIG. 5

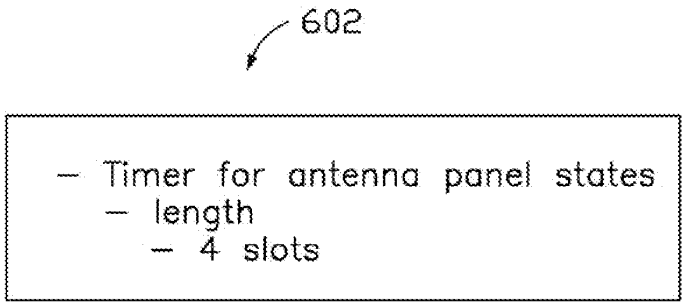



FIG. 6

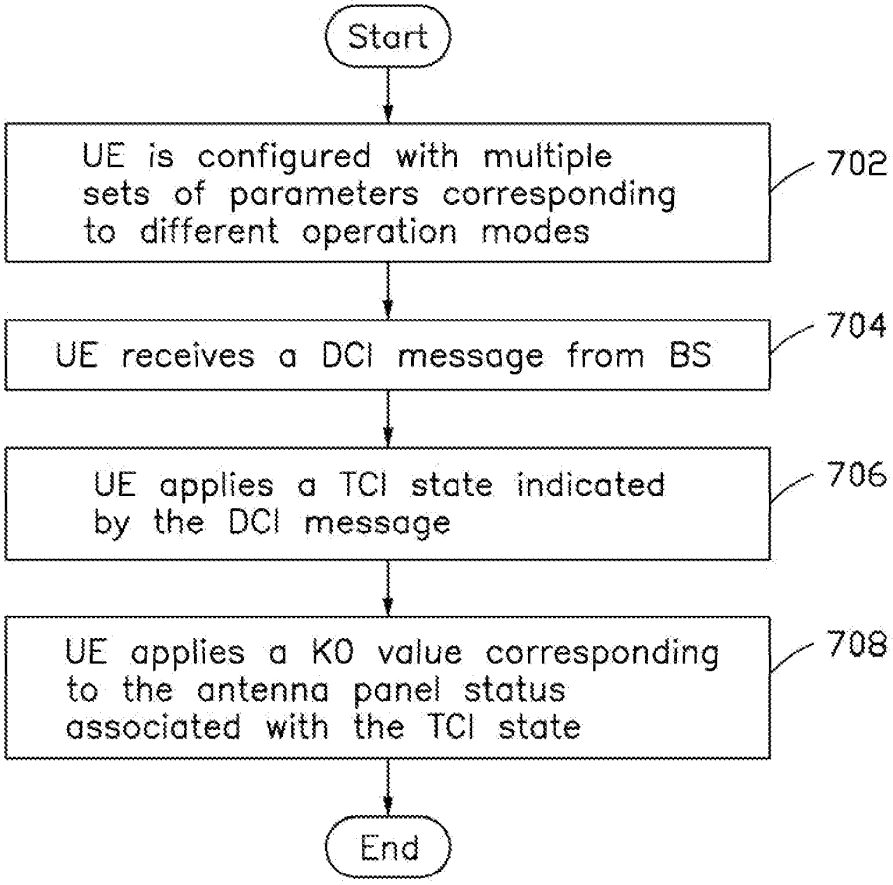

Start
UE is configured with multiple sets of parameters corresponding to different operation modes
702
UE receives a DCI message from BS
704
UE applies a TCI state indicated by the DCI message
706
UE applies a K0 value corresponding to the antenna panel status associated with the TCI state
708
End

FIG. 7

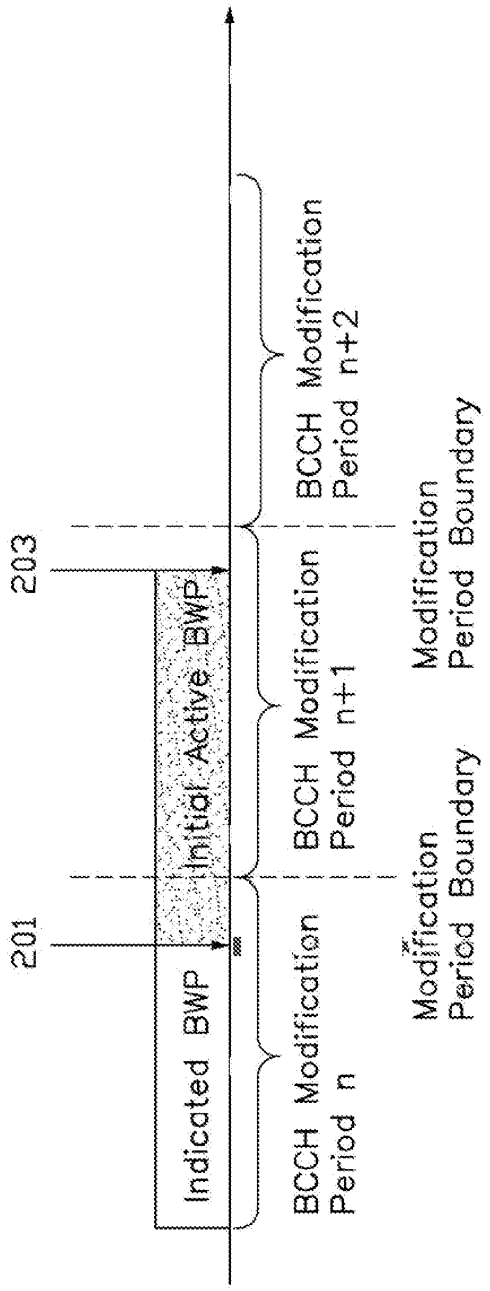

201
203
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 2

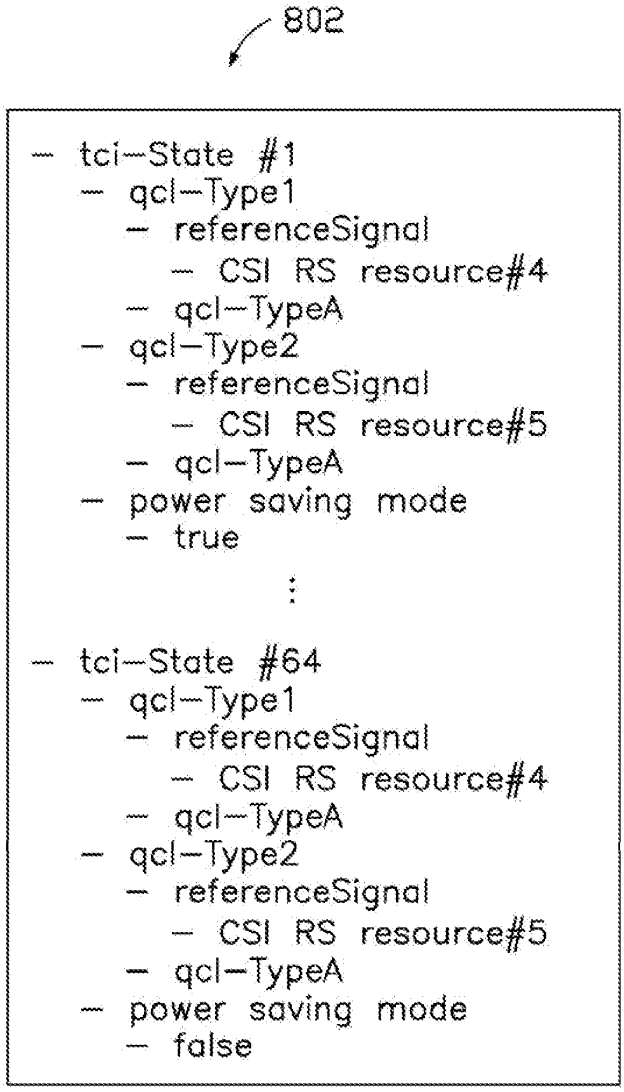

802
– tci–State #1
– qcl–Type1
– referenceSignal
– CSI RS resource#4
– qcl–TypeA
– qcl–Type2
– referenceSignal
– CSI RS resource#5
– qcl–TypeA
– power saving mode
– true
⋮
– tci–State #64
– qcl–Type1
– referenceSignal
– CSI RS resource#4
– qcl–TypeA
– qcl–Type2
– referenceSignal
– CSI RS resource#5
– qcl–TypeA
– power saving mode
– false

FIG. 8

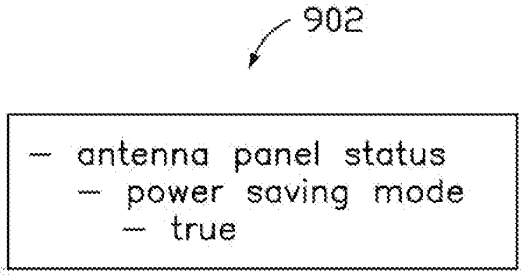



FIG. 9

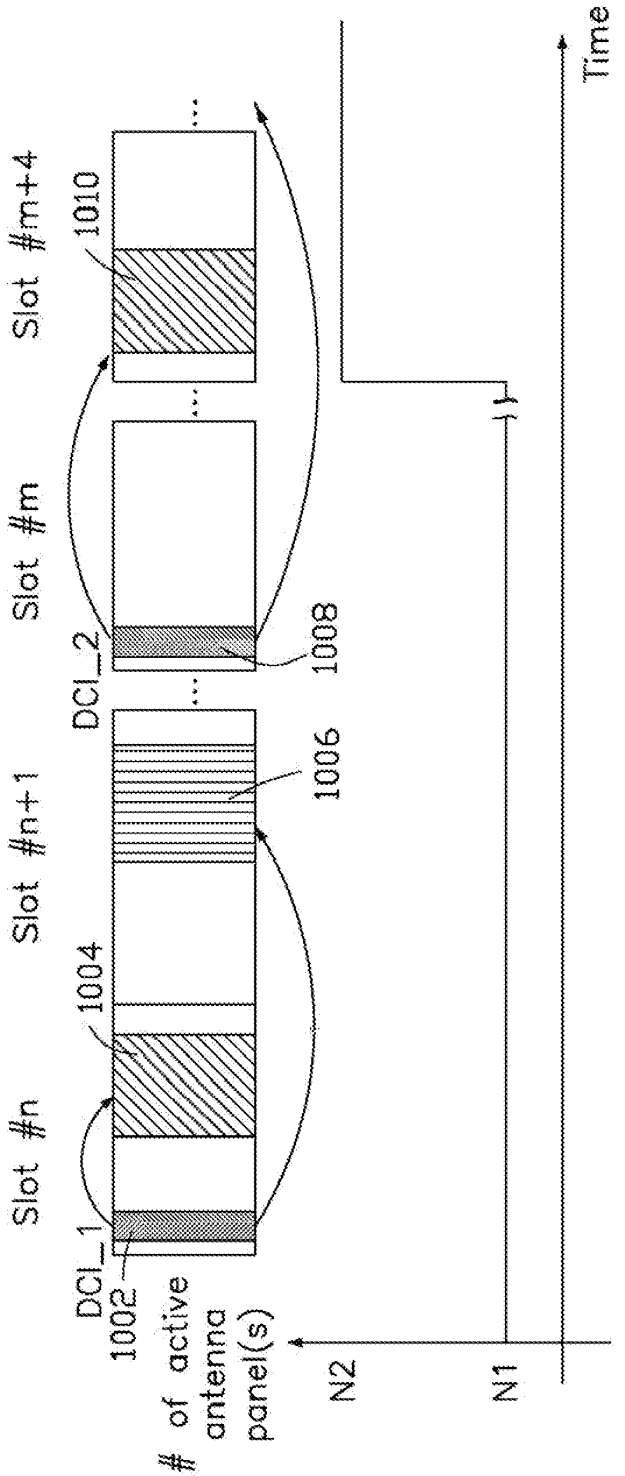

Time
Slot #n
Slot #n+1
Slot #m
Slot #m+4
1004
1006
1008
1010
DCI_1
DCI_2
1002
# of active antenna panel(s)
N2
N1

FIG. 10A

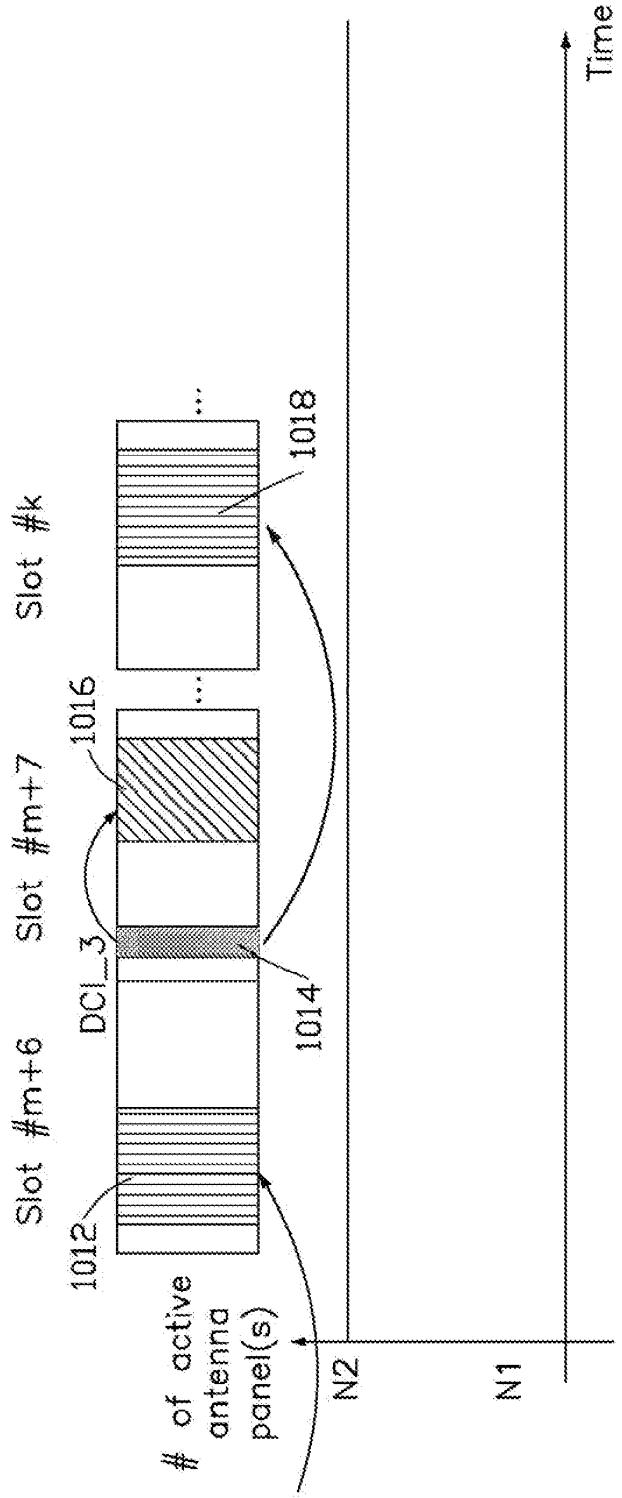

Time
Slot #k
Slot #m+7
Slot #m+6
1018
1016
1014
1012
DCI_3
# of active antenna panel(s)
N2
N1

FIG. 10B

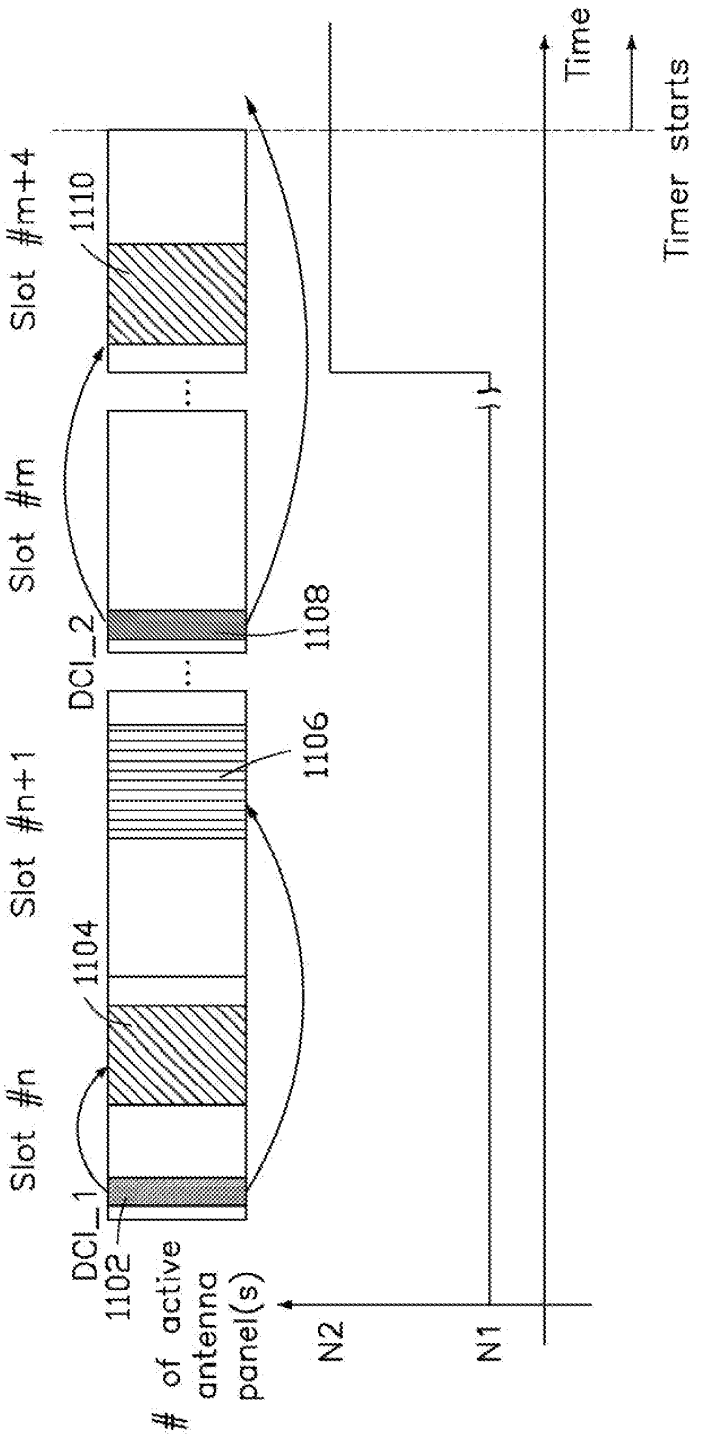

Time
Timer starts
Slot #m+4
Slot #m
Slot #n+1
Slot #n
1110
1108
1106
1104
1102
DCI_2
DCI_1
# of active antenna panel(s)
N2
N1

FIG. 11A

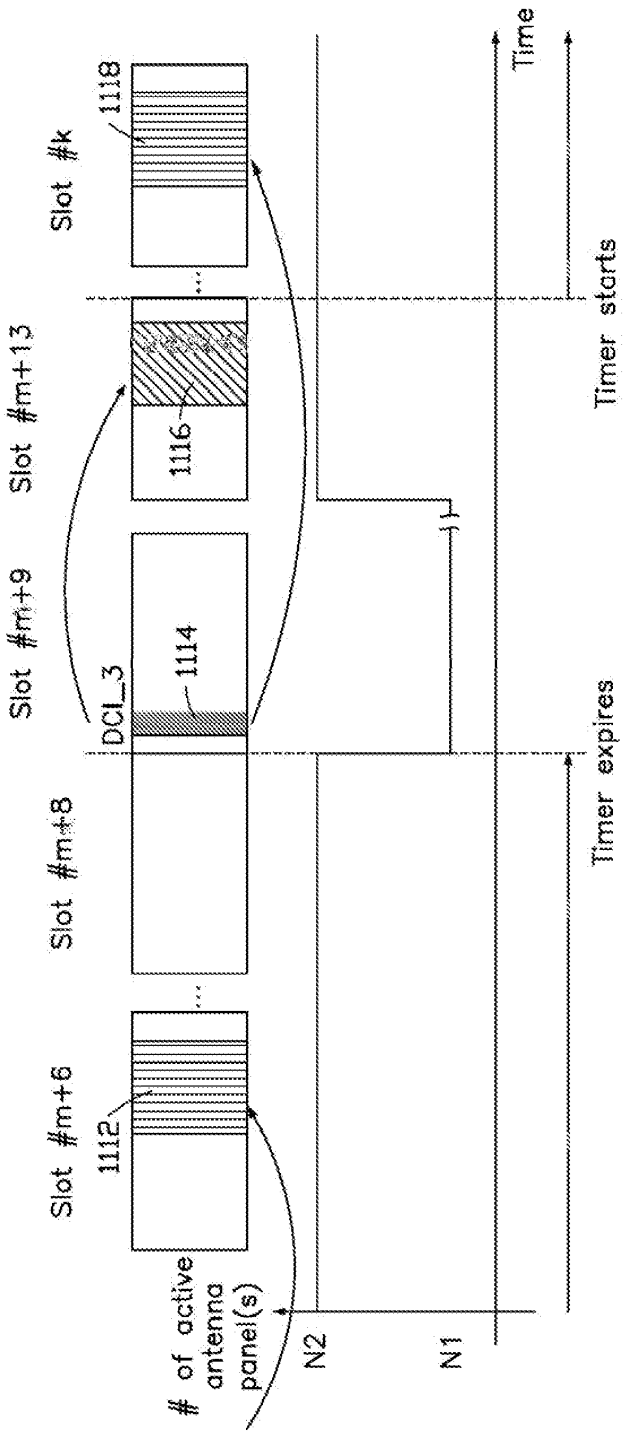

Time
Slot #k
1118
Slot #m+13
1116
Timer starts
Slot #m+9
DCI_3
1114
Slot #m+8
Timer expires
Slot #m+6
1112
# of active antenna panel(s)
N2
N1

FIG. 11B

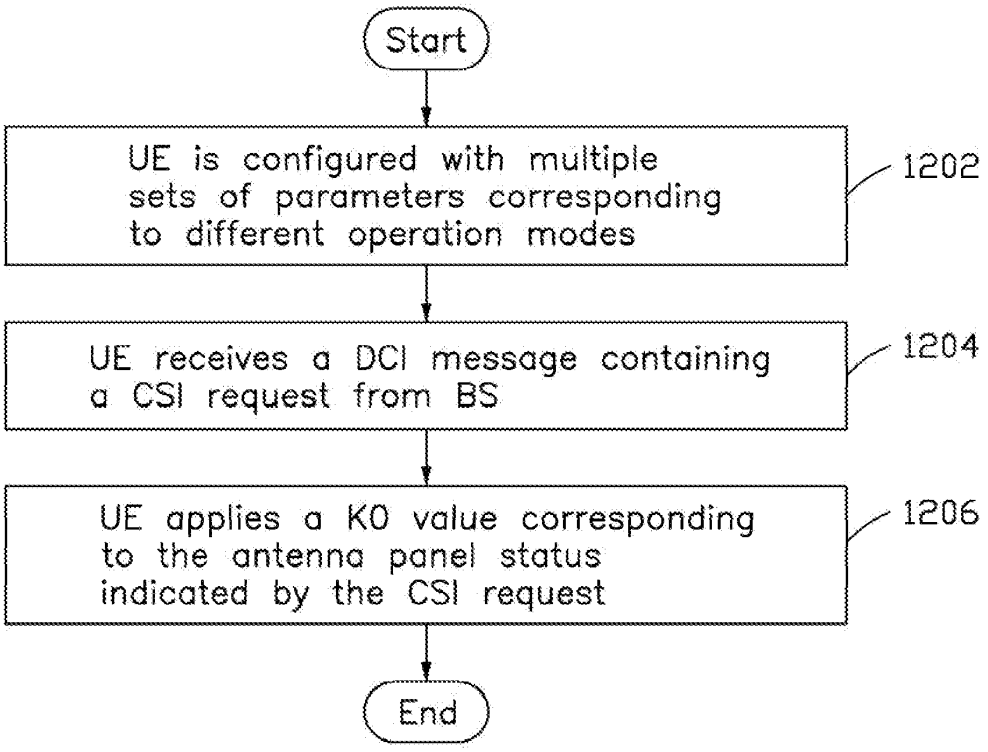

Start
UE is configured with multiple sets of parameters corresponding to different operation modes
1202
UE receives a DCI message containing a CSI request from BS
1204
UE applies a K0 value corresponding to the antenna panel status indicated by the CSI request
1206
End

FIG. 12

1302

- NZP-CSI-RS-ResourceSet
  - aperiodicTriggeringOffset
    - index:10

1304

| Row index | K0(normal,long) |
|---|---|
| 00 | (0 slot, 4 slots) |
| 01 | (1 slot, 4 slots) |
| 10 | (2 slot, 6 slots) |
| 11 | (3 slot, 7 slots) |

FIG. 13

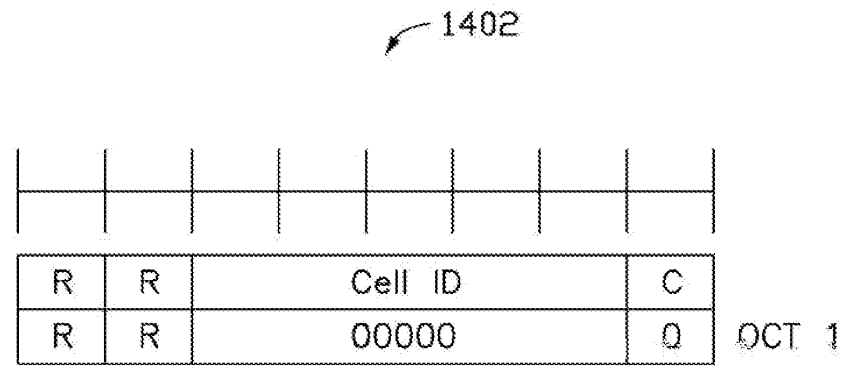



FIG. 14

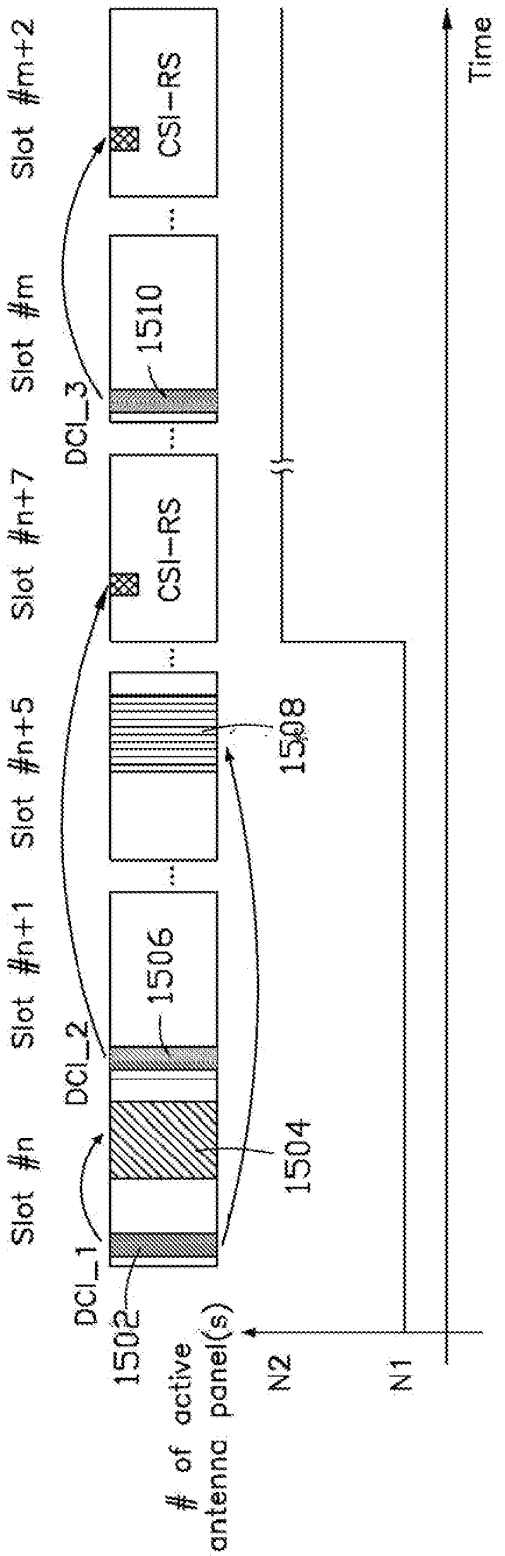

Slot #n
Slot #n+1
Slot #n+5
Slot #n+7
Slot #m
Slot #m+2
Time
DCI_1
DCI_2
DCI_3
1502
1504
1506
1508
1510
CSI-RS
CSI-RS
# of active antenna panel(s)
N2
N1

FIG. 15

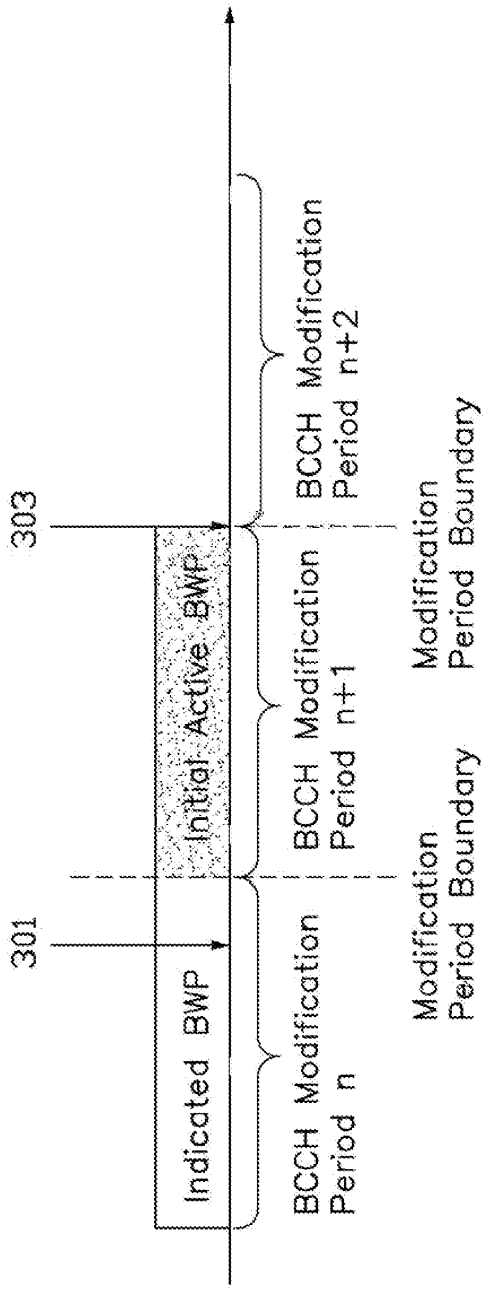

301
303
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 3

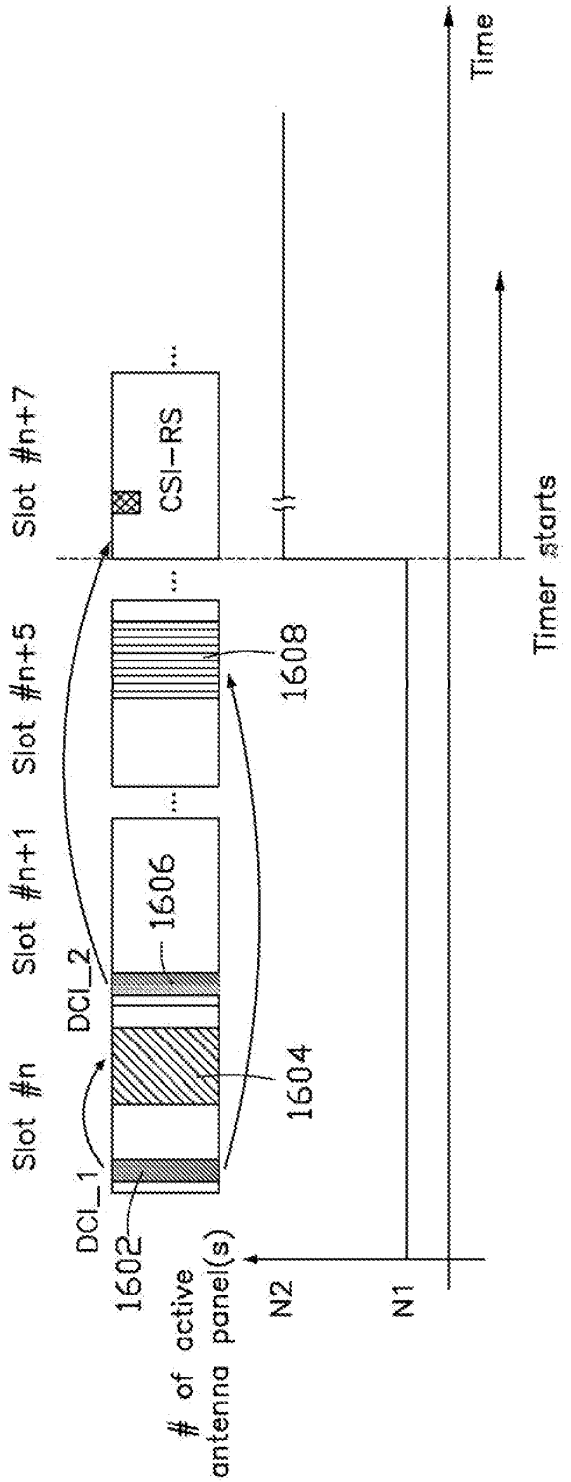

Time
Slot #n+7
CSI-RS
Slot #n+5
Slot #n+1
Slot #n
DCI_2
DCI_1
1606
1608
1604
1602
Timer starts
# of active antenna panel(s)
N2
N1

FIG. 16A

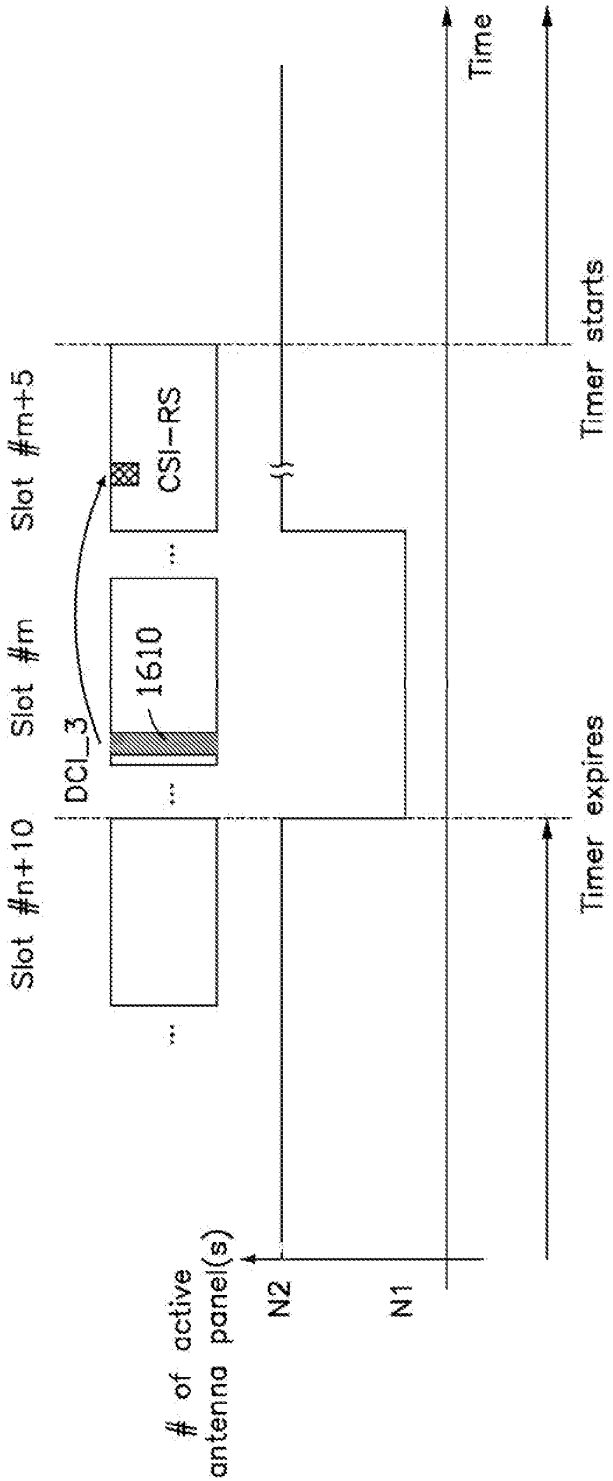

Time
Timer starts
Timer expires
Slot #n+10
Slot #m
Slot #m+5
DCI_3
1610
CSI-RS
# of active antenna panel(s)
N2
N1

FIG. 16B

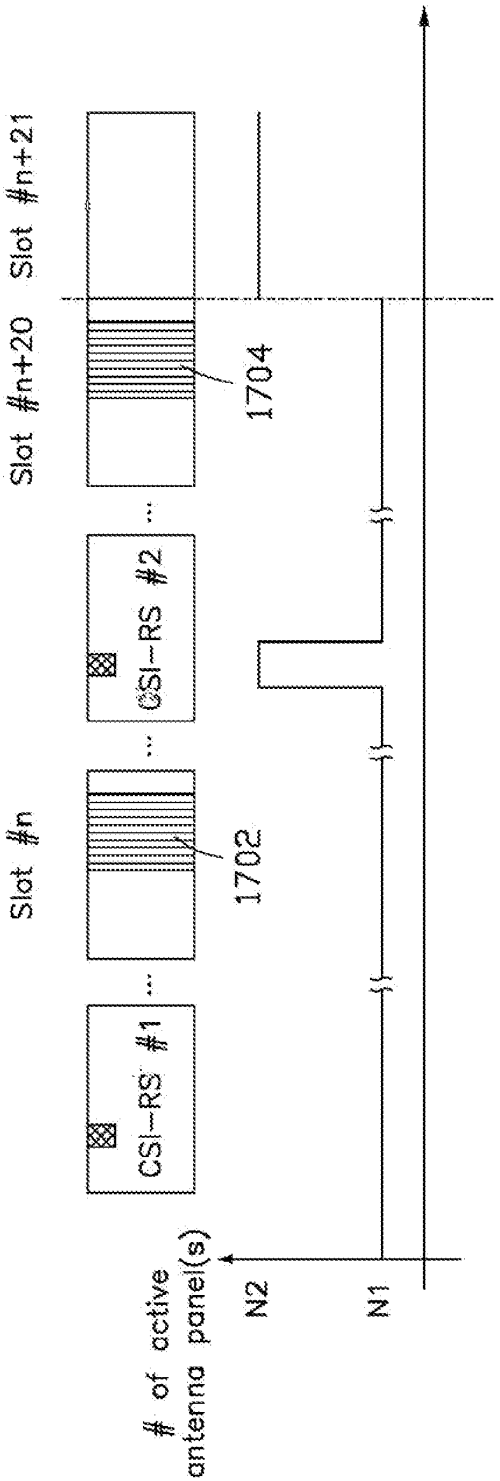

Slot #n
Slot #n+20
Slot #n+21
CSI-RS #1
CSI-RS #2
1702
1704
# of active antenna panel(s)
N2
N1

FIG. 17

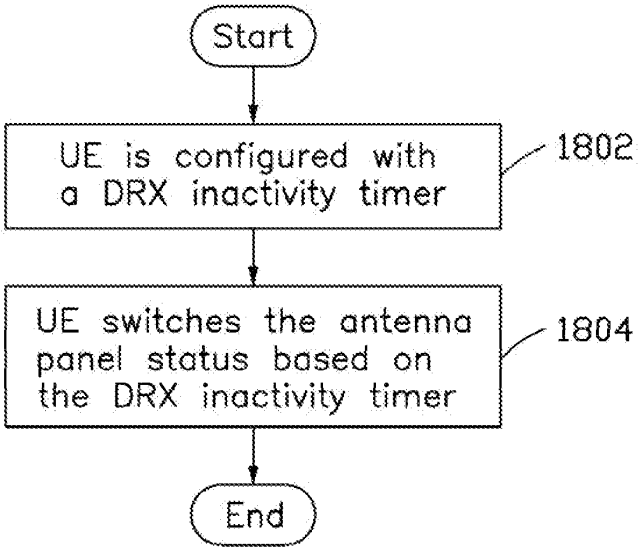

Start
UE is configured with a DRX inactivity timer
1802
UE switches the antenna panel status based on the DRX inactivity timer
1804
End

FIG. 18

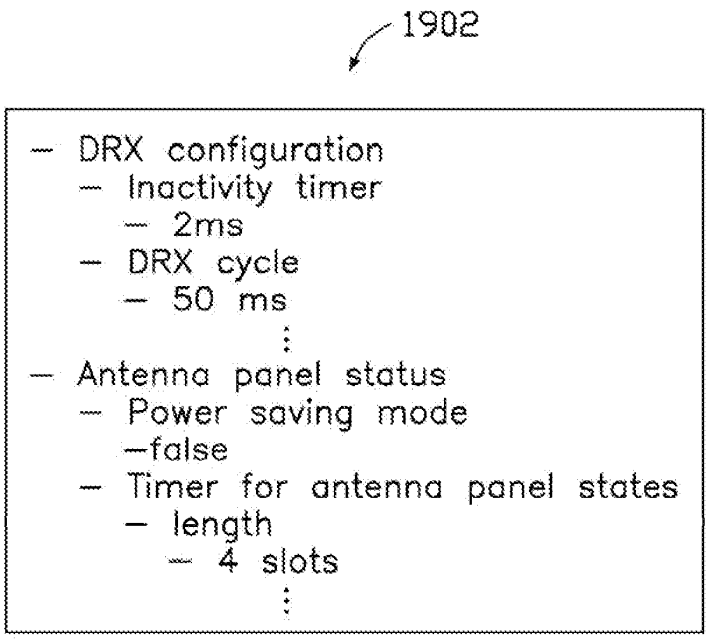

1902
– DRX configuration
– Inactivity timer
– 2ms
– DRX cycle
– 50 ms
– Antenna panel status
– Power saving mode
–false
– Timer for antenna panel states
– length
– 4 slots

FIG. 19

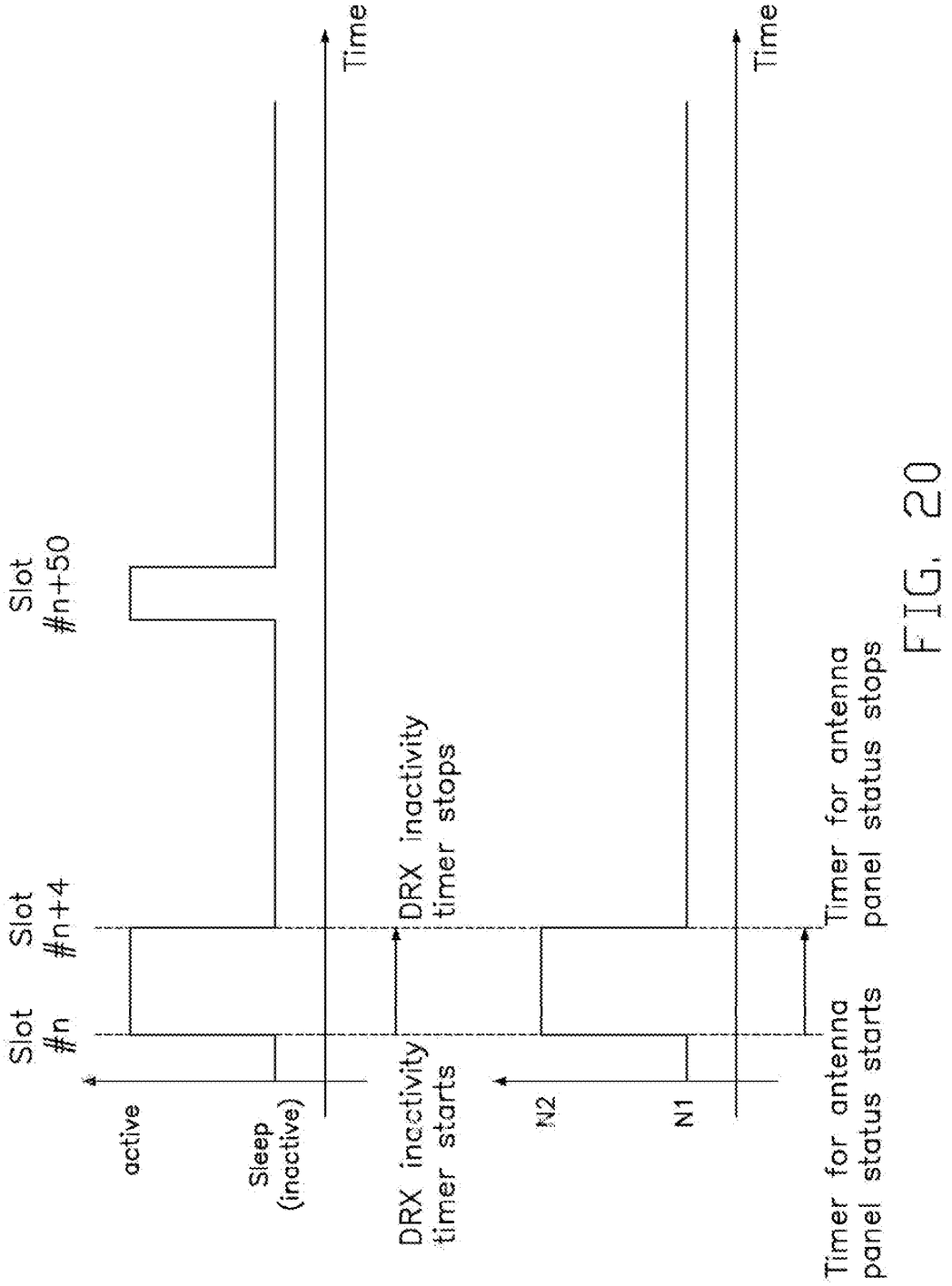

Slot #n
Slot #n+4
Slot #n+50
Time
active
Sleep (inactive)
DRX inactivity timer starts
DRX inactivity timer stops
Timer for antenna panel status starts
N2
N1
Time
Timer for antenna panel status stops

FIG. 20

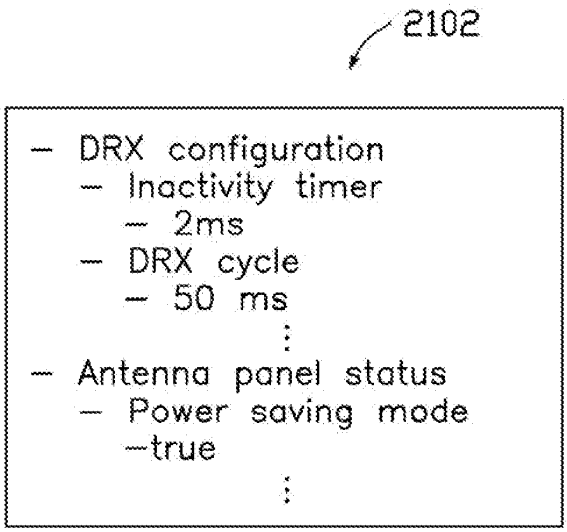

2102
– DRX configuration
– Inactivity timer
– 2ms
– DRX cycle
– 50 ms
– Antenna panel status
– Power saving mode
–true

FIG. 21

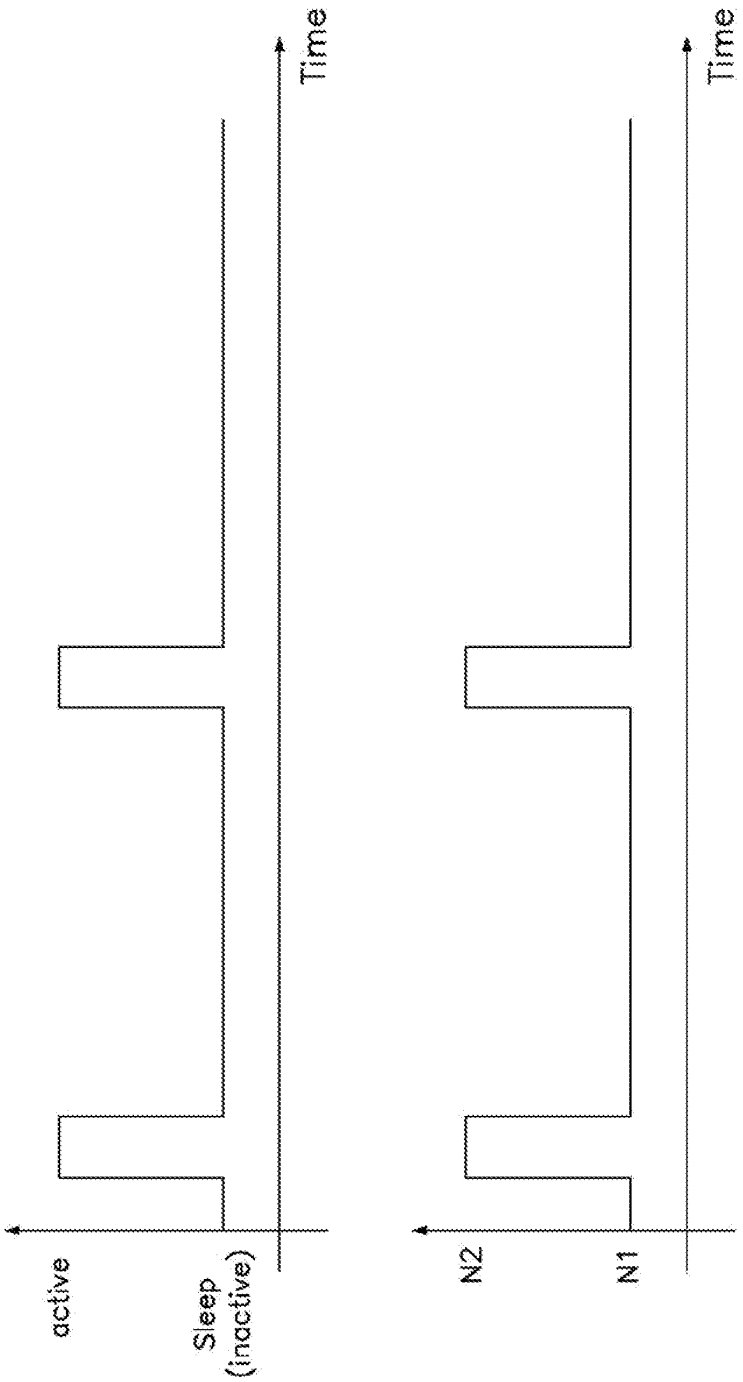



FIG. 22

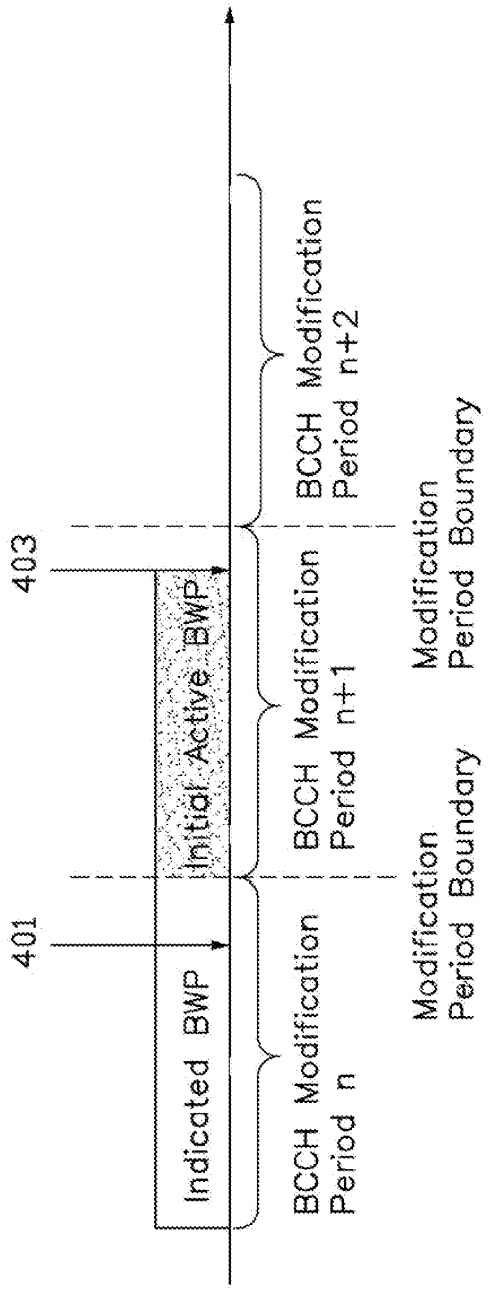

401
403
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 4

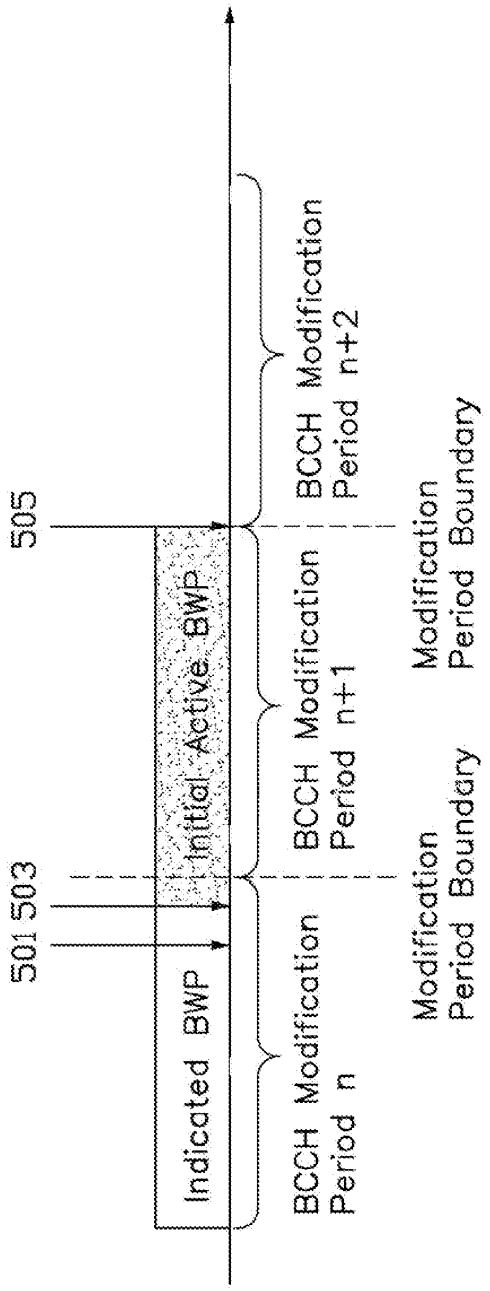

501
503
505
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 5

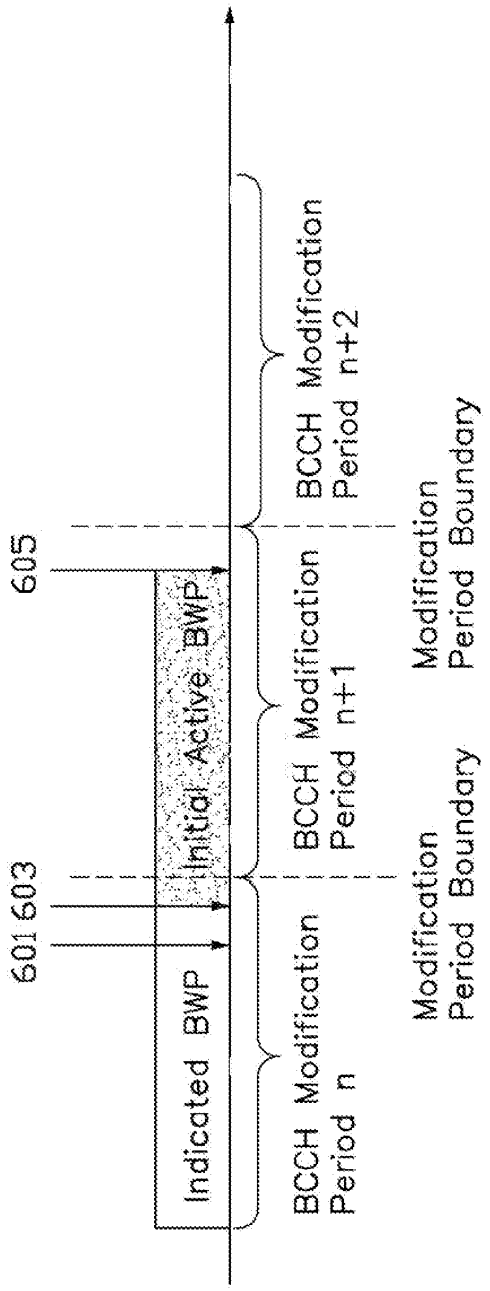

601
603
605
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 6

AO 120 (Rev. 08/10)

| TO: | Mail Stop 8<br>Director of the U.S. Patent and Trademark Office<br>P.O. Box 1450<br>Alexandria, VA 22313-1450 | REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK |
|---|---|---|

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of Texas on the following

☐ Trademarks or ☑ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

| DOCKET NO. | DATE FILED | U.S. DISTRICT COURT |
|---|---|---|
| 6:22-cv-328 | 3/28/2022 | Western District of Texas |

| PLAINTIFF | DEFENDANT |
|---|---|
| TOGAIL TECHNOLOGIES LTD. | SAMSUNG ELECTRONICS CO., LTD., SAMSUNG ELECTRONICS AMERICA, INC. |

| | PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
|---|---|---|---|
| 1 | 10,743,238 | 8/11/2020 | TOGAIL TECHNOLOGIES LTD. |
| 2 | 10,791,502 | 9/29/2020 | TOGAIL TECHNOLOGIES LTD. |
| 3 | 10,972,972 | 4/6/2021 | TOGAIL TECHNOLOGIES LTD. |
| 4 | 11,115,165 | 9/7/2021 | TOGAIL TECHNOLOGIES LTD. |
| 5 | | | |

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

| DATE INCLUDED | INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading | | |
|---|---|---|---|
| | PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

In the above—entitled case, the following decision has been rendered or judgement issued:

| DECISION/JUDGEMENT |
|---|
| 8/10/22 - Order Dismissing Case - Doc #17 |

| CLERK | (BY) DEPUTY CLERK | DATE |
|---|---|---|
| Philip J. Devlin | Suzanne Miles | 8/10/2022 |

**Copy 1—Upon initiation of action, mail this copy to Director** **Copy 3—Upon termination of action, mail this copy to Director**
**Copy 2—Upon filing document adding patent(s), mail this copy to Director** **Copy 4—Case file copy**

Print Save As... Reset

AO 120 (Rev. 08/10)

| TO: | Mail Stop 8<br>Director of the U.S. Patent and Trademark Office<br>P.O. Box 1450<br>Alexandria, VA 22313-1450 | REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK |
|---|---|---|

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Northern District of Illinois on the following

☐ Trademarks or ☑ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

| DOCKET NO. | DATE FILED | U.S. DISTRICT COURT |
|---|---|---|
| 1:22-cv-02176 | 4/26/2022 | Northern District of Illinois |

| PLAINTIFF | DEFENDANT |
|---|---|
| Togail Technologies Ltd. | Motorola Mobility LLC |

| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
|---|---|---|
| 1 | | See attached |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

| DATE INCLUDED | INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading | |
|---|---|---|
| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |

In the above—entitled case, the following decision has been rendered or judgement issued:

| DECISION/JUDGEMENT |
|---|
| |

| CLERK | (BY) DEPUTY CLERK | DATE |
|---|---|---|
| Thomas G. Bruton | Jennifer Kuldanek | 4/27/2022 |

**Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director**
**Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy**

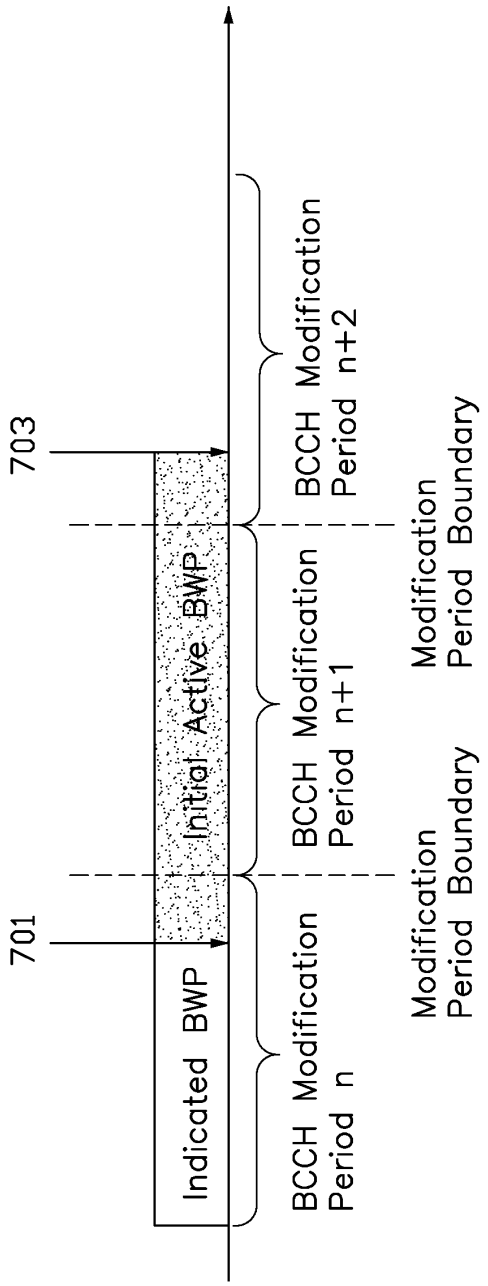

703
701
Initial Active BWP
Indicated BWP
BCCH Modification Period n+2
BCCH Modification Period n+1
BCCH Modification Period n
Modification Period Boundary
Modification Period Boundary

FIG. 7

In some of the present implementations, the BS may indicate at least one sTRP resource set to the UE through at least one of the configuration of the sTRP, the predetermined resource(s) associated with the sTRP ID, and the best compatible channel quality in terms of the pTRP determined by the BS or UE.

In some of the present implementations, the UE may identify different resource(s)/resource set(s) from different TRPs via at least one of the information of QCL assumption(s), the target RS port group(s), and reference RS correlation indication.

For example, the network/BS may indicate target RSs to the UE in terms of two reference RS resource sets. According to the TCI state configuration, the target DMRS may be spatially quasi co-located with the reference RS from a TRP. The DMRS ports may be in different target DMRS port groups. In some other implementations, the UE may be configured with an information element of correlation information, and the UE may use it to determine whether two or more resources are from the same TRP. In this case, a low correlation means that the reference RS resources may have a rich spatial multiplexing/diversity and come from different TRPs, and a high correlation may mean that the reference RS resources may come from the same TRP.

FIG. **6** is a block diagram illustrating a node for wireless communication, in accordance with various aspects of the present disclosure. As shown in FIG. **6**, a node **600** may include a transceiver **620**, a processor **628**, a memory **634**, one or more presentation components **638**, and at least one antenna **636**. The node **600** may also include an RF spectrum band module, a BS 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 FIG. **6**). Each of these components may be in communication with each other, directly or indirectly, over one or more buses **640**. In one implementation, the node **600** may be a UE or a BS that performs various functions described herein, for example, with reference to FIGS. **1** through **5**.

The transceiver **620** having a transmitter **622** (e.g., transmitting/transmission circuitry) and a receiver **624** (e.g., receiving/reception circuitry) may be configured to transmit and/or receive time and/or frequency resource partitioning information. In some implementations, the transceiver **620** 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. The transceiver **620** may be configured to receive data and control channels.

The node **600** may include a variety of computer-readable media. Computer-readable media may be any available media that may be accessed by the node **600** 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 data.

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.

The memory **634** may include computer-storage media in the form of volatile and/or non-volatile memory. The memory **634** may be removable, non-removable, or a combination thereof. Example memory includes solid-state memory, hard drives, optical-disc drives, and etc. As illustrated in FIG. **6**, The memory **634** may store computer-readable, computer-executable instructions **632** (e.g., software codes) that are configured to, when executed, cause the processor **628** to perform various functions described herein, for example, with reference to FIGS. **1** through **5**. Alternatively, the instructions **632** may not be directly executable by the processor **628** but be configured to cause the node **600** (e.g., when compiled and executed) to perform various functions described herein.

The processor **628** (e.g., having processing circuitry) may include an intelligent hardware device, e.g., a Central Processing Unit (CPU), a microcontroller, an ASIC, and etc. The processor **628** may include memory. The processor **628** may process the data **630** and the instructions **632** received from the memory **634**, and information through the transceiver **620**, the base band communications module, and/or the network communications module. The processor **628** may also process information to be sent to the transceiver **620** for transmission through the antenna **636**, to the network communications module for transmission to a core network.

One or more presentation components **638** presents data indications to a person or other device. Examples of presentation components **638** may include a display device, speaker, printing component, vibrating component, etc.

From the above description, it is manifested that various techniques may be used for implementing the concepts described in the present application 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 may 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 application 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.

What is claimed is:

**1**. A user equipment (UE) comprising:

one or more non-transitory computer-readable media having computer-executable instructions embodied thereon; 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, in a Physical Download Control Channel (PDCCH), Transmission Configuration Indicator (TCI) state data for determining a plurality of Physical Downlink Shared Channels (PDSCHs), the TCI state data

being associated with a plurality of Demodulation Reference Signal (DMRS) port groups; and

obtain a plurality of Quasi Co-Location (QCL) assumptions for receiving the plurality of PDSCHs based on the plurality of DMRS port groups associated with the TCI state data, wherein:

each of the plurality of QCL assumptions corresponds to one of the plurality of DMRS port groups,

the TCI state data corresponds to a TCI state configuration that includes a plurality of QCL Reference Signal (RS) sets, and

each of the plurality of QCL RS sets corresponds to one of the plurality of DMRS port groups.

**2**. The UE of claim **1**, wherein the at least one processor is further configured to execute the computer-executable instructions to:

identify a plurality of Transmit/Receive Points (TRPs) based on the plurality of QCL assumptions.

**3**. The UE of claim **1**, wherein the at least one processor is further configured to execute the computer-executable instructions to:

receive an instruction for indicating a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups via Medium Access Control (MAC) Control Element (CE) signaling.

**4**. The UE of claim **1**, wherein the at least one processor is further configured to execute the computer-executable instructions to:

indicate a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups when a timer configured for the UE expires.

**5**. The UE of claim **1**, wherein the at least one processor is further configured to execute the computer-executable instructions to:

receive the plurality of DMRS port groups via Radio Resource Control (RRC) signaling, wherein the plurality of DMRS port groups is associated with the plurality of PDSCHs.

**6**. The UE of claim **1**, wherein each of the plurality of QCL assumptions includes at least one of a time-domain QCL parameter, a frequency-domain QCL parameter, and a spatial-domain QCL parameter.

**7**. A method of wireless communications by a user equipment (UE), the method comprising:

receiving, in a Physical Download Control Channel (PDCCH) Transmission Configuration Indicator (TCI) state data for determining a plurality of Physical Downlink Shared Channels (PDSCHs), the TCI state data being associated with a plurality of Demodulation Reference Signal (DMRS) port groups; and

obtaining a plurality of Quasi Co-Location (QCL) assumptions for receiving the plurality of PDSCHs based on the plurality of DMRS port groups associated with the TCI state data, wherein:

each of the plurality of QCL assumptions corresponds to one of the plurality of DMRS port groups,

the TCI state data corresponds to a TCI state configuration that includes a plurality of QCL Reference Signal (RS) sets, and

each of the plurality of QCL RS sets corresponds to one of the plurality of DMRS port groups.

**8**. The method of claim **7**, further comprising:

identifying a plurality of Transmit/Receive Points (TRPs) based on the plurality of QCL assumptions.

**9**. The method of claim **7**, further comprising:

receiving an instruction for indicating a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups via Medium Access Control (MAC) Control Element (CE) signaling.

**10**. The method of claim **7**, further comprising:

indicating a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups when a timer configured for the UE expires.

**11**. The method of claim **7**, further comprising:

receiving the plurality of DMRS port groups via Radio Resource Control (RRC) signaling, wherein the plurality of DMRS port groups is associated with the plurality of PDSCHs.

**12**. The method of claim **7**, wherein each of the plurality of QCL assumptions includes at least one of a time-domain QCL parameter, a frequency-domain QCL parameter, and a spatial-domain QCL parameter.

* * * * *

# EXHIBIT 5

# U.S. Patent No. 10,743,238 ("'238 Patent")

Defendant's Accused Products, including those which comply with 3GPP Standard TS 38.311 V15.15.0, 3GPP Standard TS 38.331 V16.6.0, 3GPP Standard TS 38.212 V.16.7, 3GPP Standard TS 38.213 V.16.7, and 3GPP Standard TS 38.214 V.16.7, infringe at least claim of the '238 patent as set forth below, which Plaintiff provides without the benefit of information about the Accused Products obtained through discovery.

## Claim 1

| Claim 1 | Accused Products |
|---|---|
| **Element a**<br>A method for a user equipment (UE) of a connected state, the method comprising: | |
| **Element b**<br>receiving a system information (SI) change indication broadcasted by a paging via a currently active bandwidth part (BWP) during a modification period; | **TS 38.331 V15.15.0 (2021-09)**<br>**Section 5.2.2.2.2 SI change indication and PWS notification**<br>A modification period is used, i.e. updated SI (other than for ETWS and CMAS) is broadcasted in the modification period following the one where SI change indication is transmitted. The modification period boundaries are defined by SFN values for which SFN mod m = 0, where m is th number of radio frames comprising the modification period. The modification period is configured by system information. The UE receives indications about SI modifications and/or PWS notifications using Short Message transmitted with P-RNTI over DCI (see clause 6.5). Repetitions of SI change indication may occur within preceding modification period.<br>For Short Message reception in a paging occasion, the UE monitors the PDCCH monitoring occasion(s) for paging as specified in TS 38.304 [20] and TS 38.213 [13]. If the UE receives a Short Message, the UE shall:<br>1> if the UE is ETWS capable or CMAS capable, the *etwsAndCmasIndication* bit of Short Message is set, and the UE is provided with *searchSpaceOtherSystemInformation* on the active BWP or the initial BWP:<br>2> immediately re-acquire the *SIB1*;<br>2> if the UE is ETWS capable and *si-SchedulingInfo* includes scheduling information for *SIB6*:<br>3> acquire *SIB6*, as specified in sub-clause 5.2.2.3.2, |

| Claim 1 | Accused Products |
|---|---|
| | immediately;<br>2> if the UE is ETWS capable and *si-SchedulingInfo* includes scheduling information for *SIB7*:<br>3> acquire *SIB7*, as specified in sub-clause 5.2.2.3.2,<br>immediately;<br>2> if the UE is CMAS capable and *si-SchedulingInfo* includes scheduling information for *SIB8*:<br>3> acquire *SIB8*, as specified in sub-clause 5.2.2.3.2,<br>immediately;<br>NOTE: In case *SIB6*, *SIB7*, or *SIB8* overlap with a measurement gap it is left to UE implementation how to immediately acquire *SIB6*, *SIB7*, or *SIB8*.<br>1> if the *systemInfoModification* bit of Short Message is set:<br>2> apply the SI acquisition procedure as defined in sub-clause 5.2.2.3 from the start of the next modification period. |
| **Element c**<br>in response to receiving the SI change indication, switching from the currently active BWP to an initial active BWP for an SI update; | **TS 38.331 (V15.15.0)**<br>**Section 5.2.2.3 Acquisition of System Information**<br>5.2.2.3.1 Acquisition of *MIB* and *SIB1*<br>The UE shall:<br>1> apply the specified BCCH configuration defined in 9.1.1.1;<br>1> if the UE is in RRC_IDLE or in RRC_INACTIVE; or<br>1> if the UE is in RRC_CONNECTED while T311 is running:<br>2> acquire the *MIB*, which is scheduled as specified in TS 38.213 [13]; 2> if the UE is unable to acquire the *MIB*;<br>3> perform the actions as specified in clause 5.2.2.5;<br>2> else:<br>3> perform the actions specified in clause 5.2.2.4.1.<br>1> if the UE is in RRC_CONNECTED with an active BWP with common search space configured by *searchSpaceSIB1* and *pagingSearchSpace* and has received an indication about change of system information; or<br>1> if the UE is in RRC_IDLE or in RRC_INACTIVE; or<br>1> if the UE is in RRC_CONNECTED while T311 is running:<br>2> if *ssb-SubcarrierOffset* indicates *SIB1* is transmitted in the cell (TS 38.213 |

| Claim 1 | Accused Products |
|---|---|
| | [13]) and if *SIB1* acquisition is required for the UE:<br>3> acquire the *SIB1*, which is scheduled as specified in TS 38.213<br>[13]; 3> if the UE is unable to acquire the *SIB1*:<br>4> perform the actions as specified in clause 5.2.2.5;<br>3> else:<br>4> upon acquiring *SIB1*, perform the actions specified in clause 5.2.2.4.2.<br>2> else if *SIB1* acquisition is required for the UE and *ssb-SubcarrierOffset* indicates that *SIB1* is not scheduled in the cell:<br>3> perform the actions as specified in clause 5.2.2.5.<br>NOTE: The UE in RRC_CONNECTED is only required to acquire broadcasted *SIB1* if the UE can acquire it without disrupting unicast data reception, i.e. the broadcast and unicast beams are quasi co-located.<br><br>**Section 5.2.2.4.2 Actions upon reception of the *SIB1***<br>Upon receiving the *SIB1* the UE shall:<br>.....<br>4> if the UE has not stored a valid version of a SIB, in accordance with sub- clause 5.2.2.2.1, of one or several required SIB(s), in accordance with sub- clause 5.2.2.1:<br>5> for the SI message(s) that, according to the *si-SchedulingInfo*, contain at least one required SIB and for which *si-BroadcastStatus* is set to broadcasting:<br>6> acquire the SI message(s) as defined in sub-clause 5.2.2.3.2;<br>– ***PDCCH-ConfigCommon***<br>The IE *PDCCH-ConfigCommon* is used to configure cell specific PDCCH parameters provided in SIB as well as in dedicated signalling.<br>***PDCCH-ConfigCommon* information element**<br>-- ASN1START<br>-- TAG-PDCCH-CONFIGCOMMON-START<br>PDCCH-ConfigCommon ::= SEQUENCE {<br>controlResourceSetZero ControlResourceSetZero |



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| Claim 1 | Accused Products |
|---|---|
| | OPTIONAL, -- Cond InitialBWP-Only<br>commonControlResourceSet ControlResourceSet<br>OPTIONAL, -- Need R<br>searchSpaceZero SearchSpaceZero<br>OPTIONAL, -- Cond InitialBWP-Only<br>commonSearchSpaceList SEQUENCE (SIZE(1..4)) OF SearchSpace<br>OPTIONAL, -- Need R<br>searchSpaceSIB1 SearchSpaceId<br>OPTIONAL, -- Need S<br>searchSpaceOtherSystemInformation SearchSpaceId<br>OPTIONAL, -- Need S<br>pagingSearchSpace SearchSpaceId<br>OPTIONAL, -- Need S<br>ra-SearchSpace SearchSpaceId<br>OPTIONAL, -- Need S<br>...,<br>[[<br>firstPDCCH-MonitoringOccasionOfPO CHOICE {<br>sCS15KHZoneT SEQUENCE<br>(SIZE (1..maxPO-perPF)) OF INTEGER (0..139),<br>sCS30KHZoneT-SCS15KHZhalfT<br>SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..279),<br>sCS60KHZoneT-SCS30KHZhalfT-SCS15KHZquarterT<br>SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..559),<br>sCS120KHZoneT-SCS60KHZhalfT-SCS30KHZquarterT-<br>SCS15KHZoneEighthT<br>SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..1119),<br>sCS120KHZhalfT-SCS60KHZquarterT-SCS30KHZoneEighthT-<br>SCS15KHZoneSixteenthT SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER<br>(0..2239),<br>sCS120KHZquarterT-SCS60KHZoneEighthT-SCS30KHZoneSixteenthT<br>SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..4479), |

| Claim 1 | Accused Products |
|---|---|
| | sCS120KHZoneEighthT-SCS60KHZoneSixteenthT<br>SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..8959),<br>sCS120KHZoneSixteenthT<br>SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..17919)<br>}<br>OPTIONAL -- Cond OtherBWP<br>]]<br>}<br><br>-- TAG-PDCCH-CONFIGCOMMON-STOP<br>-- ASN1STOP<br><br>***searchSpaceSIB1***<br>ID of the search space for *SIB1* message. In the initial DL BWP of the UE's PCell, the network sets this field to 0. If the field is absent, the UE does not receive *SIB1* in this BWP. (see TS 38.213 [13], clause 10) |
| **Element d**<br>receiving remaining minimum SI (RMSI) via the initial active BWP during a next modification period that immediately follows the modification period wherein the RMSI includes information associated with changed system information blocks (SIBs), | **TS 38.331 (V15.15.0)**<br>**Section 5.2.2.2.2 SI change indication and PWS notification**<br>A modification period is used, i.e. updated SI (other than for ETWS and CMAS) is broadcast in the next modification period. Within the cell where SI change indication is transmitted. The modification period boundaries are defined by SFN values for which SFN mod m = 0, where m is th number of radio frames comprising the modification period. The modification period is configured by system information. The UE receives indications about SI modifications and/or PWS notifications using Short Message transmitted with P-RNTI over DCI (see clause 6.5). Repetitions of SI change indication may occur within preceding modification period.<br><br>**Section 5.2.2.3.1 Acquisition of *MIB* and *SIB1***<br>The UE shall:<br>1> apply the specified BCCH configuration defined in 9.1.1.1;<br>1> if the UE is in RRC_IDLE or in RRC_INACTIVE; or<br>1> if the UE is in RRC_CONNECTED while T311 is running: |

| Claim 1 | Accused Products |
|---|---|
| | 2> acquire the *MIB*, which is scheduled as specified in TS 38.213 [13]; 2> if the UE is unable to acquire the *MIB*;<br>3> perform the actions as specified in clause 5.2.2.5;<br>2> else:<br>3> perform the actions specified in clause 5.2.2.4.1.<br>1> if the UE is in RRC_CONNECTED with an active BWP with common search space configured by *searchSpaceSIB1* and *pagingSearchSpace* and has received an indication about change of system information; or<br>1> if the UE is in RRC_IDLE or in RRC_INACTIVE; or<br>1> if the UE is in RRC_CONNECTED while T311 is running:<br>2> if *ssb-SubcarrierOffset* indicates *SIB1* is transmitted in the cell (TS 38.213 [13]) and if *SIB1* acquisition is required for the UE:<br>3> acquire the *SIB1*, which is scheduled as specified in TS 38.213 [13]; 3> if the UE is unable to acquire the *SIB1*:<br>4> perform the actions as specified in clause 5.2.2.5;<br>3> else:<br>4> upon acquiring *SIB1*, perform the actions specified in clause 5.2.2.4.2.<br>2> else if *SIB1* acquisition is required for the UE and *ssb-SubcarrierOffset* indicates that *SIB1* is not scheduled in the cell:<br>3> perform the actions as specified in clause 5.2.2.5.<br>NOTE: The UE in RRC_CONNECTED is only required to acquire broadcasted *SIB1* if the UE can acquire it without disrupting unicast data reception, i.e. the broadcast and unicast beams are quasi co-located.<br><br>**Section 5.2.2.4.2 Actions upon reception of the *SIB1***<br>Upon receiving the *SIB1* the UE shall:<br>.....<br>4> if the UE has not stored a valid version of a SIB, in accordance with sub- clause 5.2.2.2.1, of one or several required SIB(s), in accordance with sub- clause 5.2.2.1:<br>5> for the SI message(s) that, according to the [redacted] contain at least one required SIB and for which *si-BroadcastStatus* |

| Claim 1 | Accused Products |
|---|---|
| | is set to broadcasting:<br>6> acquire the SI message(s) as defined in sub-clause 5.2.2.3.2;<br><br>***SIB1***<br>*SIB1* contains information relevant when evaluating if a UE is allowed to access a cell and defines the scheduling of other system information. It also contains radio resource configuration information that is common for all UEs and barring information applied to the unified access control.<br>Signalling radio bearer: N/A<br>RLC-SAP: TM<br>Logical channels: BCCH<br>Direction: Network to UE<br><br>SIB1 message<br><br>-- ASN1START<br>-- TAG-SIB1-START<br><br>SIB1 ::= SEQUENCE {<br>cellSelectionInfo SEQUENCE {<br>q-RxLevMin Q-RxLevMin,<br>q-RxLevMinOffset INTEGER (1..8)<br>OPTIONAL, -- Need S<br>q-RxLevMinSUL Q-RxLevMin<br>OPTIONAL, -- Need R<br>q-QualMin Q-QualMin<br>OPTIONAL, -- Need S<br>q-QualMinOffset INTEGER (1..8)<br>OPTIONAL -- Need S<br>}<br>OPTIONAL, -- Cond Standalone<br>cellAccessRelatedInfo CellAccessRelatedInfo,<br>connEstFailureControl ConnEstFailureControl |

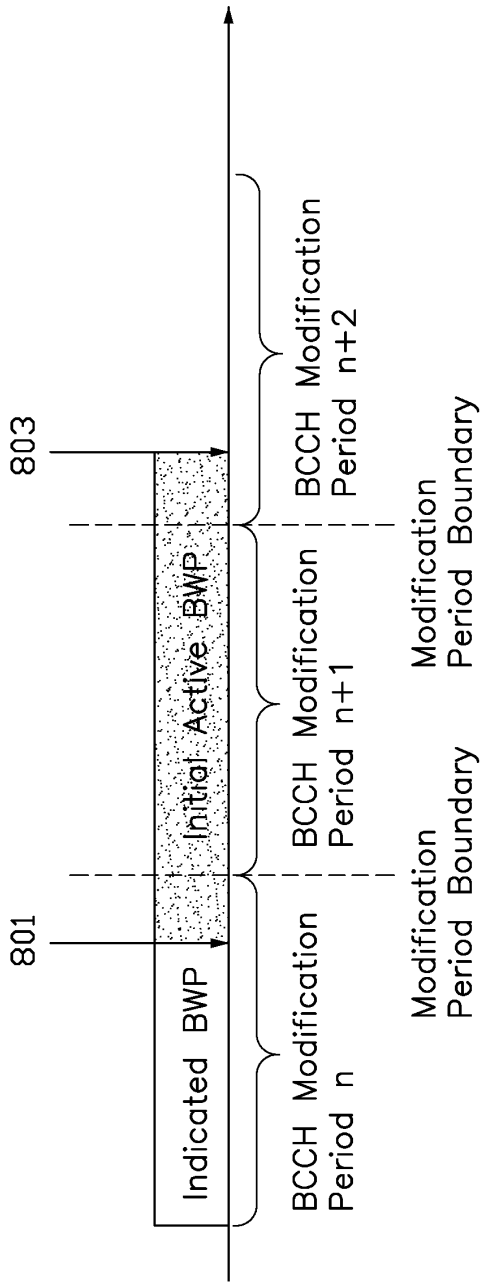
803
801
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 8

| Claim 1 | Accused Products |
|---|---|
| | OPTIONAL, -- Need R<br><br>OPTIONAL, -- Need R<br>servingCellConfigCommon ServingCellConfigCommonSIB<br>OPTIONAL, -- Need R<br>ims-EmergencySupport ENUMERATED {true}<br>OPTIONAL, -- Need R<br>eCallOverIMS-Support ENUMERATED {true}<br>OPTIONAL, -- Cond Absent<br>ue-TimersAndConstants UE-TimersAndConstants<br>OPTIONAL, -- Need R<br><br>uac-BarringInfo SEQUENCE {<br>uac-BarringForCommon UAC-BarringPerCatList<br>OPTIONAL, -- Need S<br>uac-BarringPerPLMN-List UAC-BarringPerPLMN-List<br>OPTIONAL, -- Need S<br>uac-BarringInfoSetList UAC-BarringInfoSetList, uac-AccessCategory1-SelectionAssistanceInfo CHOICE {<br>plmnCommon UAC-AccessCategory1-SelectionAssistanceInfo,<br>individualPLMNList SEQUENCE (SIZE (2..maxPLMN)) OF UAC-AccessCategory1-SelectionAssistanceInfo<br>}<br>OPTIONAL -- Need S<br>}<br>OPTIONAL, -- Need R<br><br>useFullResumeID ENUMERATED {true}<br>OPTIONAL, -- Need R<br><br>lateNonCriticalExtension OCTET STRING |



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| Claim 1 | Accused Products |
|---|---|
| | OPTIONAL,<br>nonCriticalExtension SEQUENCE{}<br>OPTIONAL<br>}<br><br>*SI-SchedulingInfo*<br>The IE *SI-SchedulingInfo* contains information needed for acquisition of SI message<br>***SI-SchedulingInfo* information element**<br>-- ASN1START<br>-- TAG-SI-SCHEDULINGINFO-START<br><br>SI-SchedulingInfo ::= SEQUENCE {<br>schedulingInfoList SEQUENCE (SIZE (1..maxSI-Message)) OF SchedulingInfo,<br>si-WindowLength ENUMERATED {s5, s10, s20, s40, s80, s160, s320, s640, s1280},<br>si-RequestConfig SI-RequestConfig OPTIONAL, -- CondMSG-1<br>si-RequestConfigSUL SI-RequestConfig OPTIONAL, -- Cond SUL-MSG-1<br>systemInformationAreaID BIT STRING (SIZE (24)) OPTIONAL, -- Need R<br>...<br>}<br>SchedulingInfo ::= SEQUENCE {<br>si-BroadcastStatus ENUMERATED {broadcasting, notBroadcasting},<br>si-Periodicity ENUMERATED {rf8, rf16, rf32, rf64, rf128, rf256, rf512},<br>sib-MappingInfo SIB-Mapping<br>} |

| Claim 1 | Accused Products |
|---|---|
| | SIB-Mapping ::= SEQUENCE (SIZE (1..maxSIB)) OF SIB-TypeInfo<br>SIB-TypeInfo ::= SEQUENCE {<br>type ENUMERATED {sibType2, sibType3, sibType4, sibType5, sibType6, sibType7, sibType8, sibType9, spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1,... },<br>valueTag INTEGER (0..31) OPTIONAL, -- Cond SIB-TYPE<br>areaScope ENUMERATED {true} OPTIONAL -- Need S<br>}<br>-- Configuration for Msg1 based SI Request<br>SI-RequestConfig ::= SEQUENCE {<br>rach-OccasionsSI SEQUENCE {<br>rach-ConfigSI RACH-ConfigGeneric,<br>ssb-perRACH-Occasion ENUMERATED {oneEighth, oneFourth, oneHalf, one, two, four, eight, sixteen}<br>} OPTIONAL, -- Need R<br>si-RequestPeriod ENUMERATED {one, two, four, six, eight, ten, twelve, sixteen} OPTIONAL, -- Need R<br>si-RequestResources SEQUENCE (SIZE (1..maxSI-Message)) OF SI-RequestResources<br>}<br>SI-RequestResources ::= SEQUENCE {<br>ra-PreambleStartIndex INTEGER (0..63),<br>ra-AssociationPeriodIndex INTEGER (0..15) OPTIONAL, -- Need R<br>ra-ssb-OccasionMaskIndex INTEGER (0..15) OPTIONAL -- Need R<br>}<br>-- TAG-SI-SCHEDULINGINFO-STOP |



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| Claim 1 | Accused Products |
|---|---|
| | -- ASN1STOP |
| **Element e**<br>determining which of the changed SIBs is required to be updated for the UE according to the received RMSI; | **TS 38.331 (V15.15.0)**<br>**Section 5.2.2.4.2 Actions upon reception of the *SIB1***<br>Upon receiving the *SIB1* the UE shall:<br>.....<br>4> if the UE has not stored a valid version of a SIB, in accordance with sub- clause 5.2.2.2.1, of one or several required SIB(s), in accordance with sub- clause 5.2.2.1:<br>5> for the SI message(s) that, according to the *si-SchedulingInfo*, contain at least one required SIB and for which *si-BroadcastStatus* is set to broadcasting:<br>6> acquire the SI message(s) as defined in sub-clause 5.2.2.3.2;<br><br>5.2.2.2.1 SIB validity<br>The UE shall apply the SI acquisition procedure as defined in clause 5.2.2.3 upon cell selection (e.g. upon power on), cell-reselection, return from out of coverage, after reconfiguration with sync completion, after entering the network from another RAT, upon receiving an indication that the system information has changed, upon receiving a PWS notification; and whenever the UE does not have a valid version of a stored SIB.<br>The UE shall:<br>1> delete any stored version of a SIB after 3 hours from the moment it was successfully confirmed as valid;<br>1> for each stored version of a SIB:<br>2> if the *areaScope* is associated and its value for the stored version of the SIB is the same as the value received in the *si-SchedulingInfo* for that SIB from the serving cell:<br>3> if the first *PLMN-Identity* included in the *PLMN-IdentityInfoList*, the *systemInformationAreaID* and the *valueTag* that are included in the *si-SchedulingInfo* for the SIB received from the serving cell are identical to |



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| Claim 1 | Accused Products |
|---|---|
| | the *PLMN-Identity*, the *systemInformationAreaID* and the *valueTag* associated<br>with the stored version of that SIB:<br>4> consider the stored SIB as valid for the cell;<br>2> if the *areaScope* is not present for the stored version of the SIB and the *areaScope* value is not included in the *si-SchedulingInfo* for that SIB from the serving cell:<br>3> if the first *PLMN-Identity* in the *PLMN-IdentityInfoList*, the *cellIdentity* and<br>*valueTag* that are included in the *si-SchedulingInfo* for the SIB received from the serving cell are identical to the *PLMN-Identity*, the *cellIdentity* and the *valueTag* associated with the stored version of that SIB:<br>4> consider the stored SIB as valid for the cell;<br><br>***SI-SchedulingInfo***<br>The IE *SI-SchedulingInfo* contains information needed for acquisition of SI messages.<br>***SI-SchedulingInfo* information element**<br>-- ASN1START<br>-- TAG-SI-SCHEDULINGINFO-START<br>SI-SchedulingInfo ::= SEQUENCE {<br>schedulingInfoList SEQUENCE (SIZE (1..maxSI-Message)) OF SchedulingInfo,<br>si-WindowLength ENUMERATED {s5, s10, s20, s40, s80, s160, s320, s640, s1280},<br>si-RequestConfig SI-RequestConfig OPTIONAL, -- Cond MSG-1<br>si-RequestConfigSUL SI-RequestConfig OPTIONAL, -- Cond SUL-MSG-1<br>systemInformationAreaID BIT STRING (SIZE (24)) OPTIONAL, -- Need R<br>...<br>} |



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| Claim 1 | Accused Products |
|---|---|
| | SchedulingInfo ::= SEQUENCE {<br>si-BroadcastStatus ENUMERATED {broadcasting, notBroadcasting},<br>si-Periodicity ENUMERATED {rf8, rf16, rf32, rf64, rf128, rf256, rf512},<br>sib-MappingInfo SIB-Mapping<br>}<br>SIB-Mapping ::= SEQUENCE (SIZE (1..maxSIB)) OF SIB-TypeInfo<br>SIB-TypeInfo ::= SEQUENCE {<br>type ENUMERATED {sibType2, sibType3, sibType4, sibType5, sibType6, sibType7, sibType8, sibType9, spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1,... },<br>valueTag INTEGER (0..31) OPTIONAL, -- Cond SIB-TYPE<br>areaScope ENUMERATED {true} OPTIONAL -- Need S<br>}<br>-- Configuration for Msg1 based SI Request<br>SI-RequestConfig ::= SEQUENCE {<br>rach-OccasionsSI SEQUENCE {<br>rach-ConfigSI RACH-ConfigGeneric,<br>ssb-perRACH-Occasion ENUMERATED {oneEighth, oneFourth, oneHalf, one, two, four, eight, sixteen}<br>} OPTIONAL, -- Need R<br>si-RequestPeriod ENUMERATED {one, two, four, six, eight, ten, twelve, sixteen} OPTIONAL, -- Need R<br>si-RequestResources SEQUENCE (SIZE (1..maxSI-Message)) OF SI-RequestResources<br>}<br>SI-RequestResources ::= SEQUENCE { |

| Claim 1 | Accused Products |
|---|---|
| | ra-PreambleStartIndex INTEGER (0..63),<br>ra-AssociationPeriodIndex INTEGER (0..15)<br>OPTIONAL, -- Need R<br>ra-ssb-OccasionMaskIndex INTEGER (0..15)<br>OPTIONAL -- Need R<br>}<br>-- TAG-SI-SCHEDULINGINFO-STOP<br>-- ASN1STOP |
| **Element f**<br>and receiving content of the required changed SIBs based on the determination | **TS 38.331 (V15.15.0)**<br><br>**Section 5.2.2.4.2 Actions upon reception of the *SIB1***<br>Upon receiving the *SIB1* the UE shall:<br>……<br><br>4> if the UE has not stored a valid version of a SIB, in accordance with sub- clause 5.2.2.2.1, of one or several required SIB(s), in accordance with sub- clause 5.2.2.1:<br><br>5> for the SI message(s) that, according to the *si-SchedulingInfo*, contain at least one required SIB and for which *si-BroadcastStatus* is set to broadcasting:<br>6> [redacted] as defined in sub-clause 5.2.2.3.2; |

# EXHIBIT 6

# U.S. Patent No. 10,791,502 ("'502 Patent")

Defendant's Accused Products, including those which comply with 3GPP Standard TS 38.311 V15.15.0, 3GPP Standard TS 38.331 V16.6.0, 3GPP Standard TS 38.212 V.16.7, 3GPP Standard TS 38.213 V.16.7, and 3GPP Standard TS 38.214 V.16.7, infringe at least claim of the '502 patent as set forth below, which Plaintiff provides without the benefit of information about the Accused Products obtained through discovery.

## Claim 1

| Claim 1 | Accused Products |
|---|---|
| **Element a**<br>A method of an on-demand system information (SI) request procedure performed by a user equipment (UE), the method comprising: | **TS 38.331 (v16.6.0)**<br>**Section 5.2.2.3.5** Request for on demand system information **in RRC_CONNECTED**<br>The UE shall:<br>1> if the UE is in RRC_CONNECTED with an active BWP not configured with common search space with the field *searchSpaceOtherSystemInformation* and the UE has not stored a valid version of a SIB, in accordance with sub-clause 5.2.2.2.1, of one or several required SIB(s), in accordance with sub-clause 5.2.2.1 or if requested by upper layers:<br>2> for the SI message(s) that, according to the *si-SchedulingInfo* or *posSI-SchedulingInfo* in the stored SIB1, contain at least one required SIB or requested posSIB:<br>3> if *onDemandSIB-Request* is configured and timer T350 is not running:<br>4> initiate transmission of the DedicatedSIBRequest message in accordance with 5.2.2.3.6;<br>4> start timer T350 with the timer value set to the *onDemandSIB-RequestProhibitTimer*;<br>1> else if the UE is in RRC_CONNECTED with an active BWP configured with common search space with the field *searchSpaceOtherSystemInformation* and the UE has not stored a valid version of a SIB, in accordance with sub-clause 5.2.2.2.1, of one or several required SIB(s), in accordance with sub-clause |
| **Element b**<br>transmitting a first SI request message to a base station (BS) after determining that the UE is in a connected state, the first SI request message including at least one requested system information block (SIB); | |

| Claim 1 | Accused Products |
|---|---|
| | 5.2.2.1 or if requested by upper layers:<br>2> for the SI message(s) that, according to the *si-SchedulingInfo* in the stored SIB1, contain at least one required SIB and for which *si-BroadcastStatus* is set to *broadcasting*:<br>3> acquire the SI message(s) as defined in sub-clause 5.2.2.3.2;<br>> for the SI message(s) that, according to the *si-SchedulingInfo* in the stored SIB1, contain at least one required SIB and for which *si-BroadcastStatus* is set to *notBroadcasting*:<br>3> if *onDemandSIB-Request* is configured and timer T350 is not running:<br>4> initiate transmission of the *DedicatedSIBRequest* message in accordance with 5.2.2.3.6;<br>4> start timer T350 with the timer value set to the *onDemandSIB-RequestProhibitTimer*;<br>3> acquire the requested SI message(s) corresponding to the requested SIB(s) as defined in sub-clause 5.2.2.3.2.<br><br>**Section 5.2.2.3.6 Actions related to transmission of DedicatedSIBRequest message**<br><br>The UE shall set the contents of *DedicatedSIBRequest* message as follows: 1> if the procedure is triggered to request the required SIB(s):<br>2> include *requestedSIB-List* in the *onDemandSIB-RequestList* to indicate the requested SIB(s); |

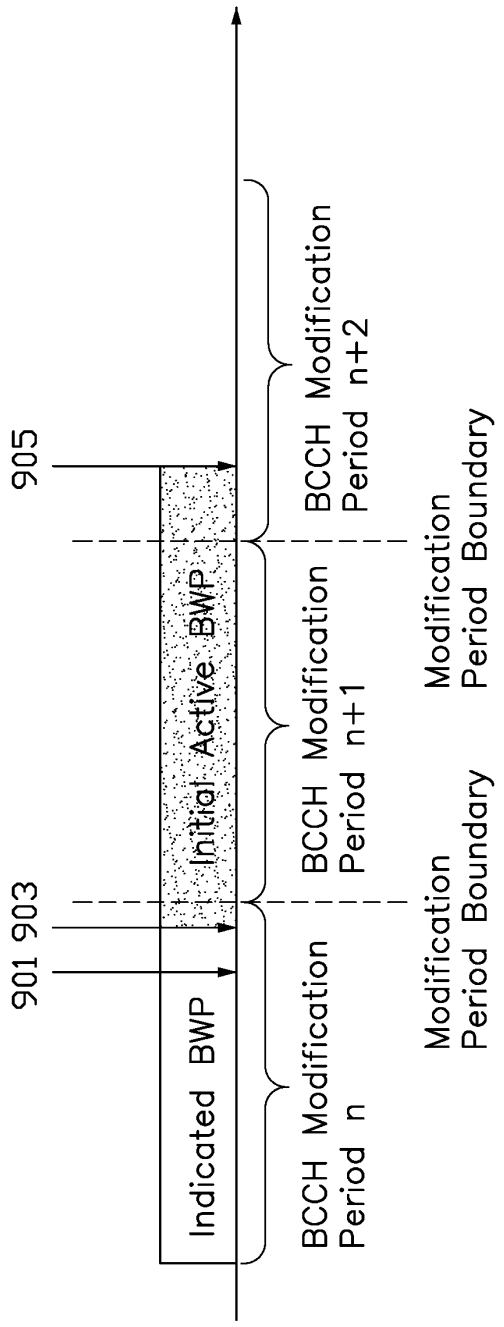
905
901
903
Initial Active BWP
Indicated BWP
BCCH Modification Period n+2
BCCH Modification Period n+1
BCCH Modification Period n
Modification Period Boundary
Modification Period Boundary

FIG. 9

| Claim 1 | Accused Products |
|---|---|
| | 1> if the procedure is triggered to request the required posSIB(s):<br><br>2> include *requestedPosSIB-List* in the *onDemandSIB-RequestList* to indicate the requested posSIB(s).<br><br>**Section 6.2.2 Message definitions**<br>– ***DedicatedSIBRequest***<br><br>The *DedicatedSIBRequest* message is used to request SIB(s) required by the UE in RRC_CONNECTED as specified in clause 5.2.2.3.5.<br>Signalling radio bearer: SRB1 RLC-SAP: AM<br><br>Logical channel: DCCH<br><br>Direction: UE to Network<br><br>***DedicatedSIBRequest message***<br><br>`-- ASN1START`<br>`-- TAG-DEDICATEDSIBREQUEST-START`<br><br>`DedicatedSIBRequest-r16 ::=`<br>`SEQUENCE`<br>`{ criticalExtensions CHOICE {`<br>`dedicatedSIBRequest-r16 DedicatedSIBRequest-`<br>`r16-IEs, criticalExtensionsFuture SEQUENCE`<br>`{}`<br>`}`<br><br>`}`<br><br>`DedicatedSIBRequest-r16-IEs ::=`<br>`SEQUENCE { onDemandSIB-` |

| Claim 1 | Accused Products |
|---|---|
| | RequestList-r16 SEQUENCE {<br><br>requestedSIB-List-r16 SEQUENCE (SIZE (1..maxOnDemandSIB-r16)) OF SIB-ReqInfo-r16 OPTIONAL,<br>requestedPosSIB-List-r16 SEQUENCE (SIZE (1..maxOnDemandPosSIB- r16)) OF PosSIB-ReqInfo-r16 OPTIONAL<br>} OPTIONAL,<br>lateNonCriticalExtension OCTET STRING OPTIONAL,<br>nonCriticalExtension SEQUENCE {} OPTIONAL<br>}<br><br>SIB-ReqInfo-r16 ::= ENUMERATED { sib12, sib13, sib14, spare6, spare5, spare4, spare3, spare2, spare1 }<br><br>PosSIB-ReqInfo-r16 ::= SEQUENCE {<br>gnss-id-r16 GNSS-ID-r16 OPTIONAL,<br>sbas-id-r16 SBAS-ID-r16 OPTIONAL,<br>posSibType-r16 ENUMERATED { posSibType1-1, posSibType1-2, posSibType1-3, posSibType1-4, posSibType1-5, posSibType1-6, posSibType1-7, posSibType1-8, posSibType2-1, posSibType2-2, posSibType2-3, posSibType2-4, posSibType2-5, posSibType2-6, posSibType2-7, posSibType2-8, posSibType2-9, posSibType2-10, posSibType2-11, posSibType2-12, posSibType2-13, posSibType2-14, posSibType2-15, posSibType2-16, posSibType2-17, posSibType2-18, posSibType2-19, |

| Claim 1 | Accused Products |
|---|---|
| | posSibType2-20,<br>posSibType2-21,<br>posSibType2-22, posSibType2-23, posSibType3-1,<br>posSibType6-1,<br>posSibType6-2, posSibType6-3,... }<br><br>-- TAG-DEDICATEDSIBREQUEST-STOP<br>-- ASN1STOP<br><br>***DedicatedSIBRequest field descriptions***<br>***requestedSIB-List***<br>Contains a list of SIB(s) the UE requests while in RRC_CONNECTED.<br>***requestedPosSIB-List***<br>Contains a list of posSIB(s) the UE requests while in RRC_CONNECTED. |
| **Element c**<br>activating a prohibit timer, and transmitting a second SI request message to the BS only when the at least one requested SIB is not received and the prohibit timer expires | **TS 38.331 (v16.6.0)**<br>**Section 5.2.2.3.5 Request for on demand system information in RRC_CONNECTED**<br><br>The UE shall:<br><br>1> if the UE is in RRC_CONNECTED with an active BWP not configured with common search space with the field *searchSpaceOtherSystemInformation* and the UE has not stored a valid version of a SIB, in accordance with sub-clause 5.2.2.2.1, of one or several required SIB(s), in accordance with sub-clause 5.2.2.1 or if requested by upper layers:<br><br>2> for the SI message(s) that, according to the *si-SchedulingInfo* or *posSI-SchedulingInfo* in the stored SIB1, contain at least one required SIB or requested posSIB:<br><br>3> if *onDemandSIB-Request* is configured and timer T[xxx] is not running: |



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| Claim 1 | Accused Products |
|---|---|
| | 4> initiate transmission of the DedicatedSIBRequest message in accordance with 5.2.2.3.6;<br><br>4> start timer T350 with the timer value set to the *onDemandSIB-RequestProhibitTimer*;<br><br>1> else if the UE is in RRC_CONNECTED with an active BWP configured with common search space with the field *searchSpaceOtherSystemInformation* and the UE has not stored a valid version of a SIB, in accordance with sub-clause 5.2.2.2.1, of one or several required SIB(s), in accordance with sub-clause 5.2.2.1 or if requested by upper layers:<br><br>2> for the SI message(s) that, according to the *si-SchedulingInfo* in the stored SIB1, contain at least one required SIB and for which *si-BroadcastStatus* is set to *broadcasting*:<br><br>3> acquire the SI message(s) as defined in sub-clause 5.2.2.3.2;<br><br>2> for the SI message(s) that, according to the *si-SchedulingInfo* in the stored SIB1, contain at least one required SIB and for which *si-BroadcastStatus* is set to *notBroadcasting*:<br>3> if *onDemandSIB-Request* is configured and timer T350 is not running:<br>4> initiate transmission of the *DedicatedSIBRequest* message in accordance with 5.2.2.3.6;<br><br>4> start timer T350 with the timer value set to the *onDemandSIB-RequestProhibitTimer*;<br>3> acquire the requested SI message(s) corresponding to the requested SIB(s) as defined in sub-clause 5.2.2.3.2. |

# Exhibit 7

# U.S. Patent No. 10,972,972 ("'972 Patent")

Defendant's Accused Products, including those which comply with 3GPP Standard TS 38.311 V15.15.0, 3GPP Standard TS 38.331 V16.6.0, 3GPP Standard TS 38.212 V.16.7, 3GPP Standard TS 38.213 V.16.7, and 3GPP Standard TS 38.214 V.16.7, infringe at least claim of the '972 patent as set forth below, which Plaintiff provides without the benefit of information about the Accused Products obtained through discovery.

## Claim 1

| Claim 1 | Accused Products |
|---|---|
| **Element a**<br><br>A wireless communication device comprising: a plurality of antenna panels; a processor coupled to the plurality of antenna panels and configured to: | Each of the Accused Products are wireless communication devices comprising a plurality of antenna panels and a processor coupled to the plurality of antenna panels. |
| **Element b**<br><br>maintain a plurality of leading time values, the plurality of leading time values indicating a plurality of leading time durations; receive an indicator for antenna panel status information from a base station (BS); | **TS 38.214 (v16.7)**<br>**Section 5.3.1 Application delay of the minimum scheduling offset restriction**<br>When the UE is scheduled with DCI format 0_1 or 1_1 with a '*Minimum applicable scheduling offset indicator*' field in slot *n*, it shall determine the $K0$min and $K2$min values, if configured respectively, to be applied, while the previously applied $K0$min and/or $K2$min values are applied until the new values take effect. If the DCI in slot *n* also indicates an active DL (UL) BWP change for a serving cell, the indicated $K0$min ($K2$min) value in the new active DL (UL) BWP, if configured, is applied from the slot indicated by the slot offset value of the time domain resource assignment field in the DCI. Otherwise, change of applied minimum scheduling offset restriction indication carried by DCI in slot *n*, shall be applied in slot *n*+*X* of the scheduling cell. The UE does not expect to be scheduled with DCI format 0_1 or 1_1 with '*Minimum applicable scheduling offset indicator*' field indicating another change to $K0$min or $K2$min for the same active BWP of the scheduled cell before slot *n*+*X* of the scheduling cell.<br>When the DCI format 0_1 or 1_1 with '*Minimum applicable scheduling offset indicator*' |

| Claim 1 | Accused Products |
|---|---|
| | field indicating a change to the applied $K0_{min}$ or $K2_{min}$ is contained within the first three symbols of slot $n$, the value of application delay $X$ is determined by, $X = \max(\lceil K0_{minOld} \cdot 2^{\mu PDCCH} / 2^{\mu PDSCH} \rceil, Z_{\mu})$ where $K$ is the currently applied $K$ value of the active DL BWP in the scheduled cell and is zero, if *minimumSchedulingOffsetK0* is not configured for the active DL BWP in the scheduled cell, $Z_{\mu}$ is determined by the subcarrier spacing of the active DL BWP in the scheduling cell in slot $n$, and given in Table 5.3.1-1, and $\mu$PDCCH and $\mu$PDSCH are the sub-carrier spacing configurations for PDCCH of the active DL BWP in the scheduling cell and PDSCH of the active DL BWP in the scheduled cell, respectively, in slot $n$. |
| **Element c**<br>apply one of the plurality of leading time values to switch an antenna panel status of the plurality of antenna panels based on the indicator for antenna panel status information; receive a scheduling offset value from the BS, the scheduling offset value comprising at least one of a K0 parameter for a Downlink (DL) channel and a K2 parameter for an Uplink (UL) channel; | **TS 38.312 (v16.7)**<br><br>**Section 7.3.1.1.2 Format 0_1**<br><br>Bandwidth part indicator – 0, 1 or 2 bits as determined by the number of UL BWPs $n_{BWP,RRC}$ configured by higher layers, excluding the initial UL bandwidth part. The bitwidth for this field is determined as $\lceil \log_2(n_{BWP}) \rceil$ bits, where<br><br>- $n_{BWP} = n_{BWP,RRC} + 1$ if $n_{BWP,RRC} \leq 3$, in which case the bandwidth part indicator is equivalent to the ascending order of the higher layer parameter *BWP-Id*;<br><br>- otherwise $n_{BWP} = n_{BWP,RRC}$, in which case the bandwidth part indicator is defined in Table 7.3.1.1.2-1;<br><br>Minimum applicable scheduling offset indicator – 0 or 1 bit<br><br>- 0 bit if higher layer parameter *minimumSchedulingOffsetK2* is not configured; |

| Claim 1 | Accused Products |
|---|---|
| | 1 bit if higher layer parameter *minimumSchedulingOffsetK2* is configured. The 1 bit indication is used to determine the minimum applicable K2 for the active UL BWP and the minimum applicable K0 value for the active DL BWP, if configured respectively, according to Table 7.3.1.1.2-33. If the minimum applicable K0 is indicated, the minimum applicable value of the aperiodic CSI-RS triggering offset for an active DL BWP shall be the same as the minimum applicable K0 value.<br><br>**TS 38.331 (v16.6)**<br><br>**PDSCH-Config**<br><br>The PDSCH-Config IE is used to configure the UE specific PDSCH parameters.<br><br>minimumSchedulingOffsetK0-r16 SetupRelease { MinSchedulingOffsetK0-Values-r16 } OPTIONAL, --Need M<br><br>minimumSchedulingOffsetK0<br><br>List of minimum K0 values.Minimum K0 parameter denotes minimum applicable value(s) for the TDRA table for PDSCH and for A-CSI RS triggering Offset(s) (see TS 38.214 [19], clause 5.3.1).<br><br>**PUSCH-Config**<br><br>The IE PUSCH-Config is used to configure the UE specific PUSCH parameters applicable to a particular BWP.<br><br>...<br><br>minimumSchedulingOffsetK2-r16 SetupRelease { MinSchedulingOffsetK2- |

| Claim 1 | Accused Products |
|---|---|
| | Values-r16 } OPTIONAL, --NeedM<br><br>minimumSchedulingOffsetK2<br>List of minimum K2 values.Minimum K2 parameter denotes minimum applicable value(s) for the Time domain resource assignment table for PUSCH (see TS 38.214 [19], clause 6.1.2.1). |
| **Element d**<br><br>and determine that the scheduling offset value is invalid, when a time duration indicated by the scheduling offset value is less than a leading time duration indicated by the applied leading time value. | **TS 38.214 (v16.7)**<br>**Section 5.1.2.1 Resource allocation in time domain**<br>When the UE is configured with *minimumSchedulingOffsetK0* in an active DL BWP it applies a minimum scheduling offset restriction indicated by the 'Minimum applicable scheduling offset indicator' field in DCI format 1_1 or DCI format 0_1 if the same field is available. When the UE is configured with *minimumSchedulingOffsetK0* in an active DL BWP and it has not received 'Minimum applicable scheduling offset indicator' field in DCI format 0_1 or 1_1, the UE shall apply a minimum scheduling offset restriction indicated based on 'Minimum applicable scheduling offset indicator' value '0'. When the minimum scheduling offset restriction is applied the UE is not expected to be scheduled with a DCI in slot *n* to receive a PDSCH scheduled with C-RNTI, CS-RNTI or MCS-C-RNTI with $K_0$ smaller than $\left[K_{0min} \cdot \frac{2^{\mu'}}{2^{\mu}}\right]$, where $K_{0min}$ and $\mu$ are the applied minimum scheduling offset restriction and the numerology of the active DL BWP of the scheduled cell when receiving the DCI in slot *n*, respectively, and $\mu'$ is the numerology of the new active DL BWP in case of active DL BWP change in the scheduled cell and is equal to $\mu$, otherwise. |

# Exhibit 8

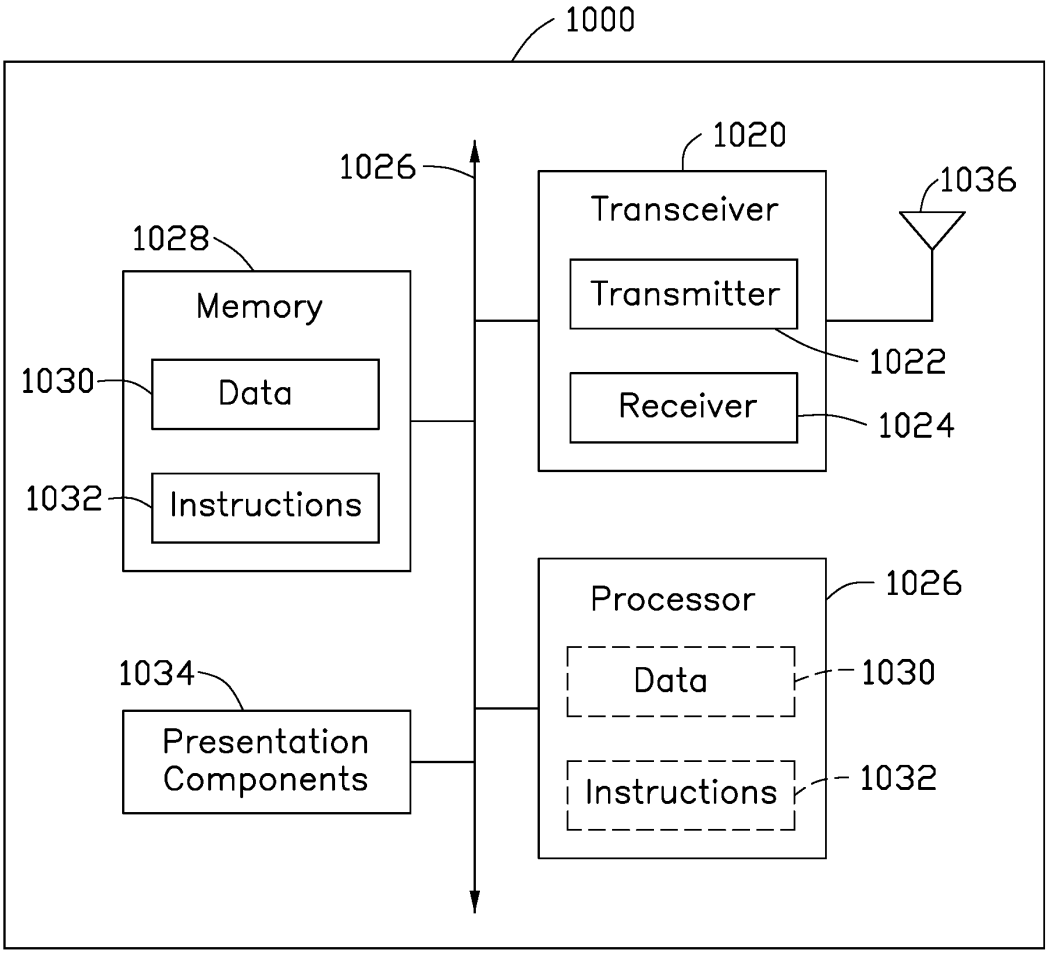
1000
1026
1020
Transceiver
1036
1028
Memory
Transmitter
1022
1030
Data
Receiver
1024
1032
Instructions
Processor
1026
1034
Data
1030
Presentation Components
Instructions
1032

FIG. 10

# U.S. Patent No. 11,115,165 ("'165 Patent")

Defendant's Accused Products, including those which comply with 3GPP Standard TS 38.311 V15.15.0, 3GPP Standard TS 38.331 V16.6.0, 3GPP Standard TS 38.212 V.16.7, 3GPP Standard TS 38.213 V.16.7, and 3GPP Standard TS 38.214 V.16.7, infringe at least claim of the '165 patent as set forth below, which Plaintiff provides without the benefit of information about the Accused Products obtained through discovery.

## Claim 1

| Claim 1 | Accused Products |
|---|---|
| **Element a**<br><br>A user equipment (UE) comprising: one or more non- transitory computer-readable media having computer-executable instructions embodied thereon; 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: | The Accused Products include a user equipment (UE) comprising one or more non-transitory computer-readable media having computer- executable instructions embodied thereon; and at least one processor coupled to the one or more non-transitory computer-readable media, and configured to execute the computer-executable instructions. |
| **Element b**<br><br>receive, in a Physical Download Control Channel (PDCCH), Transmission Configuration Indicator (TCI) state data for determining a plurality of Physical Downlink Shared Channels (PDSCHs), the TCI state data being associated with a plurality of Demodulation Reference Signal (DMRS) port groups; | **TS 38.212 (v16.7)**<br><br>**Section 7.3.1.2.2 Format 1_1**<br><br>DCI format 1_1 is used for the scheduling of PDSCH in one cell.<br>- Antenna port(s) – 4, 5, or 6 bits as defined by Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2- 1A/2A/3A/4A, where the number of CDM groups without data of values 1, 2, and 3 refers to CDM groups {0}, {0,1}, and {0, 1,2} respectively. The antenna ports {p0,...,pv−1} shall be determined according to the ordering of DMRS port(s) given by Tables 7.3.1.2.2-1/2/3/4 or Tables 7.3.1.2.2-1A/2A/3A/4A. When a UE receives an activation command that maps at least one codepoint of DCI field 'Transmission Configuration Indication' to two TCI states, the UE shall use Table 7.3.1.2.2-1A/2A/3A/4A; otherwise, it |

| Claim 1 | Accused Products |
|---|---|
| | shall use Tables 7.3.1.2.2- 1/2/3/4. The UE can receive an entry with DMRS ports equals to 1000, 1002, 1003 when two TCI states are indicated in a codepoint of DCI field 'Transmission Configuration Indication'.<br><br>**TS 38.214 (v16.7)**<br><br>**Section 5.1.5 Antenna ports quasi co-location**<br><br>When a UE supports two TCI states in a codepoint of the DCI field 'Transmission Configuration Indication' the UE<br><br>may receive an activation command, as described in clause 6.1.3.24 of [10, TS 38.321], the activation command is used<br>to map up to 8 combinations of one or two TCI states to the codepoints of the DCI field 'Transmission Configuration Indication'. The UE is not expected to receive more than 8 TCI states in the activation command. |
| **Element c**<br><br>and obtain a plurality of Quasi Co-Location (QCL) assumptions for receiving the plurality of PDSCHs based on the plurality of DMRS port groups associated with the TCI state data, | **TS 38.213 (v16.7)**<br><br>**Section 5 Radio link monitoring**<br><br>if the active TCI state for PDCCH reception includes two RS, the UE expects that one RS is configured with qcl-Typeset to 'typeD' [6, TS 38.214] and the UE uses the RS configured with qcl-Typeset to 'typeD' for radio link monitoring; the UE does not expect both RS to be configured with qcl-Type set to 'typeD'<br><br>**TS 38.214 (v16.7)**<br><br>**Section 5.1.5 Antenna ports quasi co-location**<br>The UE can be configured with a list of up to M TCI-State configurations within the higher layer parameter PDSCHConfig to decode PDSCH according to a detected PDCCH with DCI intended for the UE and the given serving cell, where M depends on the UE capability maxNumberConfiguredTCIstates PerCC. Each TCI-State contains parameters for configuring a quasi co-location relationship |

| Claim 1 | Accused Products |
|---|---|
| | between one or two downlink reference signals and the DM-RS ports of the PDSCH, the DM-RS port of PDCCH or the CSI-RS port(s) of a CSI-RS resource. The quasi co-location relationship is configured by the higher layer parameter qcl-Type1 for the first DL RS, and qcl-Type2 for the second DL RS (if configured). For the case of two DL RSs, the QCL types shall not be the same, regardless of whether the references are to the same DL RS or different DL RSs. The quasi co-location types corresponding to each DL RS are given by the higher layer parameter qcl-Type in QCL-Info and may take one of the following values: - 'typeA': {Doppler shift, Doppler spread, average delay, delay spread} - 'typeB': {Doppler shift, Doppler spread} - 'typeC':{Doppler shift, average delay} - 'typeD': {Spatial Rx parameter} |
| **Element d**<br><br>wherein: each of the plurality of QCL assumptions corresponds to one of the plurality of DMRS port groups, the TCI state data corresponds to a TCI state configuration that includes a plurality of QCL Reference Signal (RS) sets, and each of the plurality of QCL RS sets corresponds to one of the plurality of DMRS port groups | **TS 38.214 (v16.7)**<br><br>**Section 5.1.5 Antenna ports quasi co-location**<br><br>The UE can be configured with a list of up to M TCI-State configurations within the higher layer parameter PDSCHConfig to decode PDSCH according to a detected PDCCH with DCI intended for the UE and the given serving cell, where M depends on the UE capability maxNumberConfiguredTCIstates PerCC. Each TCI-State contains parameters for configuring a quasi co-location relationship between one or two downlink reference signals and the DM-RS ports of the PDSCH, the DM-RS port of PDCCH or the CSI-RS port(s) of a CSI-RS resource. The quasi co-location relationship is configured by the higher layer parameter qcl-Type1 for the first DL RS, and qcl-Type2 for the second DL RS (if configured). For the case of two DL RSs, the QCL types shall not be the same, regardless of whether the references are to the same DL RS or different DL RSs. The quasi co-location types corresponding to each DL RS are given by the higher layer parameter qcl-Type in QCL-Info and may take one of the following values: - 'typeA': {Doppler shift, Doppler spread, average delay, delay spread} - 'typeB': {Doppler shift, Doppler spread} - 'typeC': {Doppler shift, average delay} - 'typeD': {Spatial Rx parameter} |

| Claim 1 | Accused Products |
|---|---|
| | **TS 38.331 (v16.6)**<br><br>TCI-State<br><br>The IE TCI-State associates one or two DL reference signals with a corresponding quasi- colocation (QCL) type. TCI-State information element<br><br>TCI-State ::= SEQUENCE {<br>tci-StateId TCI-StateId, qcl-Type1 QCL-Info,<br>qcl-Type2 QCL-Info OPTIONAL, -- Need R<br><br>...<br><br>}<br><br>QCL-Info ::= SEQUENCE {<br><br>cell ServCellIndex OPTIONAL, -- Need R<br><br>bwp-Id BWP-Id OPTIONAL, -- Cond CSI-RS-<br><br>Indicated referenceSignal CHOICE {<br><br>csi-rs NZP-CSI-RS-ResourceId,<br><br>ssb SSB-Index<br><br>},<br><br>qcl-Type ENUMERATED {typeA, typeB, typeC, typeD}, |

# SYSTEM INFORMATION UPDATES IN BAND WIDTH PART (BWP) SWITCH OPERATION

## CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and priority to U.S. Provisional Application No. 62/586,598 filed on Nov. 15, 2017 and entitled "SYSTEM INFORMATION UPDATE IN BWP SWITCH OPERATION," (hereinafter referred to as "US72315 application"). The disclosure of the US72315 application is hereby incorporated fully by reference into the present disclosure.

## TECHNICAL FIELD

The present disclosure generally relates to a method for bandwidth part switching operations performed by a user equipment and user equipment performing the same.

## BACKGROUND

In a cellular network, a UE-specific serving cell may configure one or more bandwidth parts (BWPs) in downlink and uplink respectively for a UE by dedicated RRC signaling. One the other hand, a UE may be allocated to with at most one active DL BWP and one active UL BWP at a given time by the cell. A single scheduled downlink control information (DCI) may be applied to switching from one active BWP to another for an operating UE.

For a UE, an initial active DL BWP is defined as the frequency location and bandwidth dedicated for broadcasting remaining minimum SI (RMSI). When the NW sends to a Connected_UE a system information (SI) change indication that notifies of system information change, the Connected_UE may have to switch from the currently active BWP to the initial active BWP for accessing the RMSI and updating to the changed SI if there is no SI broadcasting on the currently active BWP. Furthermore, the Connected_UE may not successfully complete SI update if there is no clear UE behavior defined for BWP switching. As a result of BWP switching inability problem, the UE may not be able to update system information.

## SUMMARY

The present disclosure is directed to bandwidth part (BWP) switching operations in conjunction with system information updates for a user equipment.

In one aspect of the present disclosure, a method for bandwidth part (BWP) operations performed by a user equipment (UE) of a connected state is provided. The method comprises receiving a system information (SI) change indication broadcasted by a paging via a currently active bandwidth part (BWP) during a modification period; switching from the currently active bandwidth part (BWP) for data transmission to an initial active BWP for an SI update; receiving remaining minimum SI (RMSI) via the initial active BWP during a next modification period that immediately follows the modification period, the RMSI including information associated with changed system information blocks (SIBs); determining which of the changed SIBs is required to be updated for the UE; and receiving content of the required changed SIBs based on the determination.



In one aspect of the present disclosure, a user equipment (UE) of a connected state is configured to receive a system information (SI) change indication broadcasted by a paging via a currently active bandwidth part (BWP) during a modification period; to switch from the currently active bandwidth part (BWP) for data transmission to an initial active BWP for an SI update; to receive remaining minimum SI (RMSI) via the initial active BWP during a next modification period that immediately follows the modification period, the RMSI including information associated with changed system information blocks (SIBs); to determine which of the changed SIBs is required to be updated for the UE; and to receive content of the required changed SIBs based on the determination.

## BRIEF DESCRIPTION OF THE DRAWINGS

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, dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. **1** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **2** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **3** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **4** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **5** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **6** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving an SI change indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **7** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving a public warning system (PWS) notification indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **8** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving a public warning system (PWS) notification indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **9** is a schematic diagram illustrating a BWP switching operation for a Connected_UE due to receiving a public warning system (PWS) notification indication in accordance with one exemplary embodiment of the present disclosure.

FIG. **10** is a block diagram of a device for wireless communication in accordance with various embodiments of the present disclosure.

## DETAILED DESCRIPTION

The following description contains specific information pertaining to exemplary implementations in the present disclosure. The drawings in the present disclosure and their

accompanying detailed description are directed to merely exemplary implementations. However, the present disclosure is not limited to merely these exemplary 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.

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.

It is noted that the term "and/or" includes any and all combinations of one or more of the associated listed items. It will also be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, parts and/or sections, these elements, components, regions, parts and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, part or section from another element, component, region, layer or section. Thus, a first element, component, region, part or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present disclosure.

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 personal digital assistant (PDA), or a television display 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.

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-A, a radio network controller (RNC) as in the UMTS, a base station controller (BSC) as in the GSM/GERAN, an NG-eNB as in an E-UTRA base station in connection with the 5GC, a next generation node B (gNB) as in the 5G Access Network (5G-AN), and any other apparatus capable of controlling radio communication with cellular positioning technology and managing radio resources within a cell. The base station may connect to serve the one or more UEs through a radio interface to the network.

In one embodiment of the present disclosure, a Connected_UE may implicitly switch to an initial active BWP upon receiving a system information (SI) change indication broadcasted by paging from cellular network (NW). The SI change indication indicates a SI change/modification and notifies the UE to update to the changed SI if required by the UE. This results in reduction of redundant L1 signaling for switching from a currently active BWP to the initial active BWP for the UE. In FIG. **1**, a BWP switching operation for a Connected_UE due to receiving an SI change indication is illustrated. In DL, the UE may operate on an indicated BWP as currently active DL BWP for DL data transmission (e.g., based on RRC configuration, DCI control or the behavior for BWP inactivity timer) or operate on an initial active DL BPW able to receive the content of changed SI required for the UE SI update. The UE may also have an uplink (UL) BWP for UL data transmission and an initial active UL BWP. Within $n^{th}$ broadcast control channel modification period (denoted as BCCH modification period n), the UE may operate on the indicated BWP as the currently active BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE operates on the indicated BWP. Specifically, the UE receives indications about SI modifications and/or PWS notifications using Short Message transmitted with P-RNTI over downlink control information (DCI). At **101**, upon receiving the SI change indication, UE may switch immediately to the initial active BWP from the indicated BWP during BCCH modification period n. The SI change indication is used to inform the UE that there is a system information change(s) or update(s), and may be carried as part of the Short Message. Then, RRC sublayer of the NW may inform the PHY sublayer that the paging has been sent to the UE and the switching of the UE to the initial active BWP has been performed. So, the NW may stop sending to the UE any other L1 signaling (e.g., DCI) for BWP switching operations.

After switching to the initial active BWP, the UE may continue to stay on the initial active BWP until BCCH modification period n+1 ends. The BCCH modification period n+1 immediately follows the BCCH modification period n in time sequence. Although the UE has switched to the initial active BWP at certain timing (e.g., at **101**) within BCCH modification period n, it is in the next BCCH modification period n+1 that the UE performs the system information acquisition to update to changed system information. In modification period n+1, the UE may receive broadcast remaining minimum system information (RMSI) carrying information associated with changed system information blocks (SIBs) via the initial active BWP and perform the SI update(s) according to the information. The RMSI is also known as SIB1 (system information block 1). The UE may receive the RMSI at certain time point in modification period n+1 (e.g., at the start time point of the modification period n+1). After receiving the RMSI, the UE may determine which of the changed SIB(s) is (or are) required for the SI update(s) according to the received information. For example, the UE may identify one or more of the changed SIB(s) that the UE requires for the SI update(s). Then the UE may receive the content(s) of the changed SIBs which are identified as being required for the SI update(s) based on the determination. For another example, the UE may identify none of the changed SIBs is required to update and may not perform any SI update(s). The UE may not update the changed SIB(s) based on the identification within BCCH modification period n+1.

After the UE completes the SI update(s), the NW may re-take control over the BWP switching of the UE on the end of BCCH modification period n+1.

In this case, since the NW may know the UE by default will complete the SI update within modification period n+1, the PHY sublayer may re-take control over the BWP switching after BCCH modification period n+1 ends. Therefore, at **103** on the ending boundary of modification period n+1 the NW re-takes the BWP switching operations by sending L1 signaling to switch the initial active BWP to a BWP for subsequent data transmission.

In one embodiment, the currently active BWP happens to be the initial active BWP. In this case, it is not necessary that a BWP switching operation is involved for updating the SI

when receiving the SI change indication. For example, the Connected UE has already been on the initial active BWP as currently active BWP because of certain on-going services in modification period n and will stay on the initial active BWP to perform system information acquisition to conduct the SI update in BCCH modification period n+1. The PHY sublayer of the NW may consider the completeness of the SI update in the next BCCH modification period n+1. Then, the PHY sublayer of the NW may re-take control over the BWP switching operation on the end of BCCH modification period n+1.

In one embodiment, the UE may be only permitted to receive the Short Message of the paging on the initial active BWP. For example, based on the paging frame and paging occasion derived from an associated UE ID and per-configured parameters, the Short Message cannot be broadcasted on other BWPs but the initial active BWP. On occasions, the UE may switch to the initial active BWP automatically to detect whether there is a Short Message and receiving the Short Message. If receiving the SI change indication carried in the Short Message, the UE may stay on the initial active BWP for the subsequent SI update without the need for additional BWP switching. If receiving no Short Message or no SI change indication carried in the Short Message, the UE may switch back to the previous active BWP without involvement of the NW. Alternatively, the UE may not switch back but stay on the initial active BWP after modification period n+1 ends, waiting for next L1 signaling from the NW (e.g., DCI) for BWP switching.

In one embodiment of the present disclosure, the Connected UE may feedback to the NW while the SI update is completed, and the NW may re-take control over the BWP switching immediately upon receiving the feedback. In FIG. **2**, a BWP switching operation for an RRC_connected UE due to receiving an SI change indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operate on the indicated BWP. At **201**, upon receiving the SI change indication, UE may switch to the initial active BWP immediately from the indicated BWP in BCCH modification period n. The SI change indication is used to inform the UE that there is SI change(s) or update(s), and may be carried as part of Short Message in the paging. Then, RRC sublayer of the NW may inform the PHY sublayer that the paging has been sent to the UE and the switching of the UE to the initial active BWP has been performed. So, the NW may stop sending to the UE any other L1 signaling for BWP switching operations, and wait for the UE feedback indicating the completeness of the SI update.

After switching to the initial active BWP, the UE may continue to stay on the initial active BWP until the update to SI is completed. At **203**, the UE completed the SI update if required and feedback to the NW that the system information update is completed by sending an SI update complete indication. Upon receiving the SI update complete indication as the UE feedback, the PHY sublayer of the NW may re-take control over the BWP switching operation immediately. Although the UE has to operate on the initial active BWP for the SI update in DL, the NW may be still able to schedule data transmission on the initial active BWP.

The UE feedback of SI update complete may be sent by L1 signaling (via PUCCH) or by MAC-CE transmission on an uplink (UL) BWP paired with the initial active DL BWP. If using L1 signaling, the upper sublayer (e.g., RRC) of the UE may inform PHY sublayer that the SI update is completed, and the UE PHY sublayer may feedback it to the NW. The NW may re-take control over the BWP switching after receiving the feedback in NW PHY sublayer. Alternatively, if using MAC-CE transmission, the upper sublayer of the UE may inform MAC sublayer that the system information update is completed, and the UE MAC sublayer may feedback it to the NW. The NW may re-take control over the BWP switching once receiving the feedback in NW MAC sublayer.

In one embodiment of the present disclosure, upon receiving the SI change indication, the UE may not switch to the initial active BPW until the current BCCH modification period ends. In FIG. **3**, a BWP switching operation for an RRC_connected UE due to receiving an SI change indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operate on the indicated BWP. At **301**, upon receiving the SI change indication, UE may continue to stay on the indicated BWP instead of switching immediately to the initial active BWP. Then, the UE switches to the initial active BWP automatically on the ending boundary of BCCH modification period n. The BWP switching operation(s) for the UE could be still performed for certain required services before the automatic switching to the initial active BWP takes place on the end of BCCH modification period n.

In this case, PHY sublayer of the NW may know that the UE switches to the initial active BWP automatically on the end of BCCH modification period n, and may stop sending to the UE any other L1 signaling for BWP switching operations after modification period n ends. The PHY sublayer of the NW may know the UE by default will complete the SI update within the next modification period n+1, the PHY sublayer may re-take control over the BWP switching after BCCH modification period n+1 ends. Therefore, at **303** on the ending boundary of modification period n+1 the NW re-takes the BWP switching operations by sending L1 signaling to switch the initial active BWP to a BWP for data transmission.

After switching to the initial active BWP on the end of modification period n, the UE may wait to receive, via the initial active BWP, broadcast information required for updating to the changed SI in a next BCCH modification period directly following modification period n. Therefore, within BCCH modification period n+1 (the next BCCH modification period as shown in FIG. **3**), the UE performs the system information acquisition to update the changed system information if required.

In this case, since the NW may know the UE by default will complete the SI update within the next modification period n+1, the PHY sublayer may re-take control over the BWP switching after BCCH modification period n+1 ends. Therefore, at **303** on the ending boundary of modification period n+1 the NW re-takes the BWP switching operations by sending L1 signaling to switch the initial active BWP to a BWP for data transmission.

In one embodiment of the present disclosure, the Connected UE may feedback to the NW while the SI update is completed, and the NW may take control over the BWP switching immediately upon receiving the feedback. In FIG. **4**, a BWP switching operation for an RRC_connected UE due to receiving an SI change indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operate on the indicated BWP. At **401**, upon receiving the SI change indication, UE may continue to stay on the indicated BWP instead of switching immediately to the initial active BWP. Then, the UE switches to the initial active BWP automatically on the ending boundary of BCCH modification period n. The BWP switching operation(s) for the UE could be still performed for certain required services before the automatic switching to the initial active BWP takes place on the end of modification period n. In this case, PHY sublayer of the NW may know that the UE switches to the initial active BWP automatically on the end of BCCH modification period n, and may stop sending to the UE any other L1 signaling for BWP switching operations after period n ends.

After switching to the initial active BWP on the end of modification period n, the UE may continue to stay on the initial active BWP until the update of the required SI change(s) is completed. At **403**, the UE complete the SI update and feedback to the NW that the system information update is completed by sending an SI update complete indication. Upon receiving the SI update complete indication as the UE feedback, the PHY sublayer of the NW may re-take control over the BWP switching operation at **403**. Although the UE has to operate on the initial active BWP for the SI update in DL, the NW may be still able to schedule data transmission on the initial active BWP.

The UE feedback of SI update complete may be sent by L1 signaling (via PUCCH) or by MAC-CE transmission on an uplink (UL) BWP paired with the initial active DL BWP. If using L1 signaling, the upper sublayer (e.g., RRC) of the UE may inform PHY sublayer that the SI update is completed, and the UE PHY sublayer may feedback it to the NW. The NW may re-take control over the BWP switching after receiving the feedback in NW PHY sublayer. Alternatively, if using MAC-CE transmission, the upper sublayer of the UE may inform MAC sublayer that the system information update is completed, and the UE MAC sublayer may feedback it to the NW. The NW may re-take control over the BWP switching once receiving the feedback in NW MAC sublayer.

In one embodiment of the present disclosure, after receiving an SI change indication the UE may not switch to an initial active BWP until an L1 signaling is received from the NW. In FIG. **5**, a BWP switching operation for an RRC_connected UE due to receiving an SI change indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The SI change indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operates on the indicated BWP in BCCH modification period n. At **501**, upon receiving the SI change indication, the UE may not switch to the initial active BWP but continue to stay on the indicated BWP. On the NW side, the RRC sublayer may inform the PHY sublayer that the SI change indication is sent to the UE. The SI change indication may be carried as part of the Short Message in the paging. In response to the UE reception of the SI change indication, the PHY sublayer of the NW may schedule the L1 signaling and decide when to send the L1 signaling to switch the UE to the initial active BWP. After sending the SI change indication, the NW may perform the L1 signaling before BCCH modification period n ends.

At **503**, the UE switches to the initial active BWP in response to receiving the L1 signaling sent from the NW in BCCH modification period n, and the NW may also stop sending to the UE any other L1 signaling for BWP switching operations. In this case, the PHY sublayer of the NW may know the UE by default will complete the SI update within the next modification period (i.e., BCCH modification period n+1 as shown in FIG. **5**), and the PHY sublayer may re-take control over the BWP switching after BCCH modification period n+1 ends.

Thus, at **505** the NW re-takes control over the BWP switching operations on the ending boundary of modification period n+1 by sending L1 signaling to switch the initial active BWP to a BWP for data transmission.

Alternatively, the NW may re-take control over the BWP switching operations upon receiving a feedback from the UE indicating the SI update is complete before BCCH modification period n+1 ends. In FIG. **6**, the UE receives a L1 signaling for switching to the initial active BWP at **603** after receiving the SI change indication at **601** in modification period n, followed by the SI update operations in modification period n+1. Once the UE completes the SI update at **605**, the UE feedback of SI update complete (e.g., an SI update completeness indication) may be sent by another L1 signaling (via PUCCH) or by MAC-CE transmission on an uplink (UL) BWP paired with the initial active DL BWP. If using L1 signaling, the upper sublayer (e.g., RRC) of the UE may inform PHY sublayer that the SI update is completed, and the UE PHY sublayer may feedback it to the NW. The NW may re-take control over the BWP switching after receiving the feedback in NW PHY sublayer. If using MAC-CE transmission, the upper sublayer of the UE may inform MAC sublayer that the system information update is completed, and the UE MAC sublayer may feedback it to the NW. The NW may re-take control over the BWP switching once receiving the feedback in NW MAC sublayer.

In one embodiment of the present disclosure, the UE may receive a public warning system (PWS) notification indication for ETWS indication or CMAS indication carried in Short Message of a paging. The PWS notification indication notifies the UE of immediate reception of a PWS notification. When a Connected UE receives a PWS notification indication broadcasted by paging of the NW, the RRC sublayer of the UE may inform the PHY sublayer that a PWS notification reception is required immediately.

If the UE receives the PWS notification indication(s) of a paging from the NW, the UE has to immediately start receiving the PWS notification(s) according to the scheduling information in RMSI. The PWS notification indication may trigger the UE to perform re-acquisition of the scheduling information in RMSI for checking scheduling changes for the SIBs associated with the PWS notification(s). Once the SIB(s) associated with the corresponding PWS notification(s) is no longer scheduled, the UE could stop receives the SIB(s).

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In FIG. **7**, a BWP switching operation for an RRC_connected UE due to receiving a PWS notification indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP as the current active BWP for data transmission according to L1 signaling.

The PWS notification indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE operates on the indicated BWP. At **701**, upon receiving the PWS notification indication, UE may switch automatically to the initial active BWP from the indicated BWP in BCCH modification period n. The PWS notification indication may be carried as part of Short Message in the paging. Then, RRC sublayer of the NW may inform the PHY sublayer that the paging has been sent to the UE. So, the PHY sublayer of the NW knows successful automatic switching to the initial active BWP and may stop sending to the UE any other L1 signaling for BWP switching operations. The PHY sublayer of the NW would wait for the information from upper layer(s) indicating the stop of broadcasting PWS notification(s) at a certain time point, e.g. at **703** in BBCH modification period n+2. Then, the PHY sublayer in the NW could re-start to take control over BWP switching operation(s).

In another embodiment of the present disclosure, the Connected UE may feedback to the NW while the PWS notification is no longer scheduled, and the NW may re-take control over the BWP switching immediately upon receiving the feedback. In FIG. **8**, a BWP switching operation for an RRC_connected UE due to receiving a PWS notification indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The PWS notification indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operates on the indicated BWP. At **801**, upon receiving the PWS notification indication, UE may switch to the initial active BWP automatically from the indicated BWP in BCCH modification period n. The PWS notification indication may be carried as part of Short Message in the paging. Then, RRC sublayer of the NW may inform the PHY sublayer that the paging has been sent to the UE and the switching of the UE to the initial active BWP has been performed. So, the NW may stop sending to the UE any other L1 signaling for BWP switching operations, and wait for the UE feedback indicating the PWS notification is no longer scheduled.

At **803**, the UE may inform the NW of the stopping broadcast of the PWS notification(s) by a feedback that indicates the PWS notification is no longer scheduled.

In one embodiment of the present disclosure, after receiving a PWS notification indication the UE may not switch to an initial active BWP until an L1 signaling is received from the NW. Since the PWS notification is for emergence, the L1 signalling for switching the UE to the initial active BWP shall be transmitted as fast as possible. In FIG. **9**, a BWP switching operation for an RRC_connected UE due to receiving a PWS notification indication is illustrated. The UE may operate on an indicated BWP as currently active BWP for data transmission or operate on an initial active BPW able to receive the content of changed SI required for the UE SI update. Within BCCH modification period n, the UE may operate on the indicated BWP for data transmission according to L1 signaling.

The PWS notification indication is sent to the UE by paging (e.g., a Short Message) from the NW while the UE may operate on the indicated BWP in BCCH modification period n. At **901**, upon receiving the PWS notification indication, the UE may not switch to the initial active BWP but continue to stay on the indicated BWP until an L1 signaling from the NW is received. At **903**, the UE switches to the initial active BWP in response to receiving the L1 signaling sent from the NW in BCCH modification period n, and the NW may also stop sending to the UE any other L1 signaling for BWP switching operations. At **905**, the PHY sublayer of the NW would wait for the information from upper layer(s) indicating the stop of broadcasting PWS notification(s) at a certain time point, e.g. in BCCH modification period n+2. Then, the PHY sublayer in the NW could re-start to take control over BWP switching operation(s).

Alternatively, the UE may inform the NW of the stopping broadcast of the PWS notification(s) by a feedback that indicates the PWS notification is no longer scheduled in this case.

In some embodiments of the present disclosure, a BWP inactivity timer is introduced to switch an ongoing indicated BWP (or the currently active BWP) to a default BWP after a certain inactive time. The BWP inactivity timer may start to run for an inactive time period immediately after the UE switches off the default BWP. In other words, no matter what BWPs the Connected_UE currently operates on, the UE may switch back to the default BWP immediately after the BWP inactivity timer expires.

If the initial active BWP is the default BWP, the currently running BWP inactivity timer would stop after receiving Short Message on the configured active BWP. The UE may switch to another BWP after SI acquisition in response to receiving an L1 signalling, and the BWP inactivity timer would reset with the configured value and start running.

If the initial active BWP is not the default BWP, the currently running BWP inactivity timer may keep running. In some embodiments, the BWP inactivity timer would restart with the configured value and start running. It is noted that the configured value may be different from the normal one (i.e., the normal one is not used for SI acquisition upon switching to the initial active BWP). For example, gNB(s) may configure the BWP inactivity timer with two values, one is 5 ms, the other is 40 ms (e.g., equal to the duration of one BCCH modification period), and UE will automatically apply the second one when the UE needs to perform SI acquisition after receiving the SI change indication carried in the Short Message.

In one embodiment of the present application, if the BWP inactivity timer expires but the SI update is not complete, the UE may keep staying on the initial active BWP until the next L1 signalling (e.g., DCI) controls the UE to perform another BWP switching. The NW may need the timing of the SI update completeness by an NW control mechanism (e.g., waiting for the whole BCCH modification period for SI updated as introduced in the above embodiments) or an UE control mechanism (e.g., by waiting for the UE feedback as introduced in the above embodiments). The BWP inactivity timer would then reset and restart while the UE is switched to another BWP, which is not the default BWP. On the other hand, if the BWP inactivity timer is expired but the PWS notification receiving is not complete, the UE would keep staying on the initial active BWP until the next L1 signalling

(e.g., DCI) controls the UE to perform another BWP switch. The NW would need the timing of the SI complete by an NW control mechanism (e.g., waiting for the whole BCCH modification period for SI updated as introduced in the embodiments) or an UE control mechanism (e.g., by waiting for the UE feedback as introduced in the embodiment). The BWP inactivity timer may then reset and restart while the UE switches to another BWP, which is not the default BWP. If there is no system information change indication or Public Warning System (PWS) notification indication indicating that the following SI update or PWS notification receiving procedure is required, once the BWP inactivity timer expires, the UE would automatically switch to the default BWP without L1 signalling.

FIG. **10** illustrates a block diagram of a device for wireless communication, according to various exemplary implementations of the present disclosure. As shown in FIG. **10**, device **1000** may include transceiver **1020**, processor **1026**, memory **1028**, one or more presentation components **1034**, and at least one antenna **1036**. Device **1000** may also include an 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 FIG. **10**). Each of these components may be in communication with each other, directly or indirectly, over one or more buses **1026**.

Transceiver **1020** having transmitter **1022** and receiver **1024** may be configured to transmit and/or receive time and/or frequency resource partitioning information. In some implementations, transceiver **1020** 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 **1020** may be configured to receive data and control channels.

Device **1000** may include a variety of computer-readable media. Computer-readable media can be any available media that can be accessed by device **1000** 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.

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.

Memory **1028** may include computer-storage media in the form of volatile and/or non-volatile memory. Memory **1028** 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 FIG. **10**, memory **1028** may store computer-readable, computer-executable instructions **1032** (e.g., software codes) that are configured to, when executed, cause processor **1026** to perform various functions described herein, for example, with reference to FIGS. **1** through **9**. Alternatively, instructions **1032** may not be directly executable by processor **1026** but be configured to cause device **1000** (e.g., when compiled and executed) to perform various functions described herein.

Processor **1026** may include an intelligent hardware device, e.g., a central processing unit (CPU), a microcontroller, an ASIC, and etc. Processor **1026** may include memory. Processor **1026** may process data **1030** and instructions **1032** received from memory **1028**, and information through transceiver **1020**, the base band communications module, and/or the network communications module. Processor **1026** may also process information to be sent to transceiver **1020** for transmission through antenna **1036**, to the network communications module for transmission to a core network.

One or more presentation components **1034** presents data indications to a person or other device. Exemplary one or more presentation components **1034** include a display device, speaker, printing component, vibrating component, and etc.

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 would 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.

What is claimed is:

**1**. A method for a user equipment (UE) of a connected state, the method comprising:

receiving a system information (SI) change indication broadcasted by a paging via a currently active bandwidth part (BWP) during a modification period;

in response to receiving the SI change indication, switching from the currently active BWP to an initial active BWP for an SI update;

receiving remaining minimum SI (RMSI) via the initial active BWP during a next modification period that immediately follows the modification period, wherein the RMSI includes information associated with changed system information blocks (SIBs);

determining which of the changed SIBs is required to be updated for the UE according to the received RMSI; and

receiving content of the required changed SIBs based on the determination.

**2**. The method of claim **1**, wherein the currently active BWP is switched to the initial active BWP automatically on the end of the modification period.

**3**. The method of claim **1**, wherein the currently active BWP is switched to the initial active BWP immediately upon receiving the SI change indication.

# Exhibit 1

4. The method of claim 1, wherein the currently active BWP is switched to the initial active BWP in response to receiving downlink control information (DCI).

5. The method of claim 1, further comprising:

completing the SI update of the required changed SIBs within the next modification period in response to receiving the content of the required changed SIBs.

6. The method of claim 1, further comprising:

sending an SI update complete indication as a feedback indicating completeness of the SI update via an uplink BWP.

7. The method of claim 1, wherein the UE is pre-configured with a default BWP and a BWP inactivity timer for the connected state, and wherein the UE starts the BWP inactivity timer after switching off the default BWP and switches back to the default BWP after the BWP inactivity timer expires.

8. The method of claim 7, wherein the BWP inactivity timer stops after the currently active BWP for data transmission is switched to an initial active BWP in response to receiving the SI change indication.

9. The method of claim 7, wherein the BWP inactivity timer is further configured to have a short period and a long period, and wherein the UE selects the long period for the BWP inactivity timer upon receiving the SI change indication.

10. The method of claim 7, wherein the UE stays on the initial active BWP in order to complete the SI update after the BWP inactivity timer expires.

11. A user equipment (UE) for wireless communication, comprising:

a non-transitory machine-readable medium storing computer-executable instructions;

a processor coupled to the non-transitory computer-readable medium, and configured to execute the computer-executable instructions to cause the UE of a connected state to perform operations comprising:

receiving a system information (SI) change indication broadcasted by a paging via a currently active bandwidth part (BWP) during a modification period;

in response to receiving the SI change indication, switching from currently active BWP to an initial active BWP for an SI update; and

receiving remaining minimum SI (RMSI) via the initial active BWP during a next modification period that immediately follows the modification period, wherein the RMSI includes information associated with changed system information block (SIB);

determining which of the changed SIBs is required to be updated for the UE according to the received RMSI; and

receiving content of the required changed SIBs based on the determination.



12. The UE of claim 11, wherein the currently active BWP is switched to the initial active BWP automatically on the end of the modification period.

13. The UE of claim 11, wherein the currently active BWP is switched to the initial active BWP immediately upon receiving the SI change indication.

14. The UE of claim 11, wherein the currently active BWP is switched to the initial active BWP in response to receiving downlink control information (DCI).

15. The UE of claim 11, wherein the processor is further configured to execute the computer-executable instructions to cause the UE of a connected state to perform operations comprising:

completing the SI update of the required changed SIBs within the next modification period in response to receiving the content of the required changed SIBs.

16. The UE of claim 15, wherein the processor is further configured to execute the computer-executable instructions to cause the UE of a connected state to perform operations comprising:

sending an SI update complete indication as a feedback indicating completeness of the SI update via an uplink BWP.

17. The UE of claim 11, wherein the UE is pre-configured with a default BWP and a BWP inactivity timer for the connected state, and wherein the UE starts the BWP inactivity timer after switching off the default BWP and switches back to the default after the BWP inactivity timer expires.

18. The UE of claim 17, wherein the BWP inactivity timer stops after the currently active BWP for data transmission is switched to an initial active BWP in response to receiving the SI change indication.

19. The UE of claim 17, wherein the BWP inactivity timer is further configured to have a short period and a long period, and wherein the UE selects the long period for the BWP inactivity timer upon receiving the SI change indication.

20. The UE of claim 17, wherein the UE stays on the initial active BWP in order to complete the SI update after the BWP inactivity timer expires.

* * * * *

# Exhibit 2

US010791502B2

(12) **United States Patent**
**Chen et al.**

(10) **Patent No.: US 10,791,502 B2**
(45) **Date of Patent: Sep. 29, 2020**

(54) **ON-DEMAND SYSTEM INFORMATION REQUEST PROCEDURE AND ERROR HANDLING**

(71) Applicant: **FG Innovation Company Limited**, Tuen Mun (HK)

(72) Inventors: **Hung-Chen Chen**, Hsinchu (TW); **Chie-Ming Chou**, Hsinchu (TW); **Yung-Lan Tseng**, Hsinchu (TW)

(73) Assignee: **FG Innovation Company Limited**, Tuen Mun (HK)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/372,389**

(22) Filed: **Apr. 1, 2019**

(65) **Prior Publication Data**

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**Related U.S. Application Data**

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(51) **Int. Cl.**

| | |
|---|---|
| ***H04W 4/00*** | (2018.01) |
| ***H04W 48/14*** | (2009.01) |
| ***H04W 48/16*** | (2009.01) |
| ***H04W 76/18*** | (2018.01) |
| ***H04W 36/30*** | (2009.01) |
| ***H04W 76/15*** | (2018.01) |
| ***H04W 36/08*** | (2009.01) |
| *H04W 74/08* | (2009.01) |
| *H04W 76/28* | (2018.01) |

(52) **U.S. Cl.**
CPC ..... ***H04W 48/14*** (2013.01); ***H04W 36/08*** (2013.01); ***H04W 36/305*** (2018.08); ***H04W 48/16*** (2013.01); ***H04W 76/15*** (2018.02); ***H04W 76/18*** (2018.02); *H04W 74/0833* (2013.01); *H04W 76/28* (2018.02)

(58) **Field of Classification Search**
CPC ..... H04W 48/14; H04W 48/16; H04W 76/18; H04W 36/305; H04W 76/15; H04W 36/08; H04W 74/0833; H04W 76/28
USPC ..... 455/434; 370/338
See application file for complete search history.

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| 2019/0215858 | A1* | 7/2019 | Ishii | H04W 76/25 |

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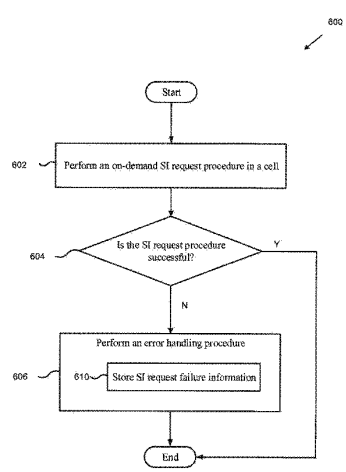
*Primary Examiner* — Marcos Batista
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

A method of wireless communications performed by a user equipment (UE) is provided. The method includes performing an on-demand system information (SI) request procedure in a cell; and performing an error handling procedure if the on-demand SI request procedure in the cell is unsuccessful. The error handling procedure includes storing SI request failure information.

**20 Claims, 7 Drawing Sheets**



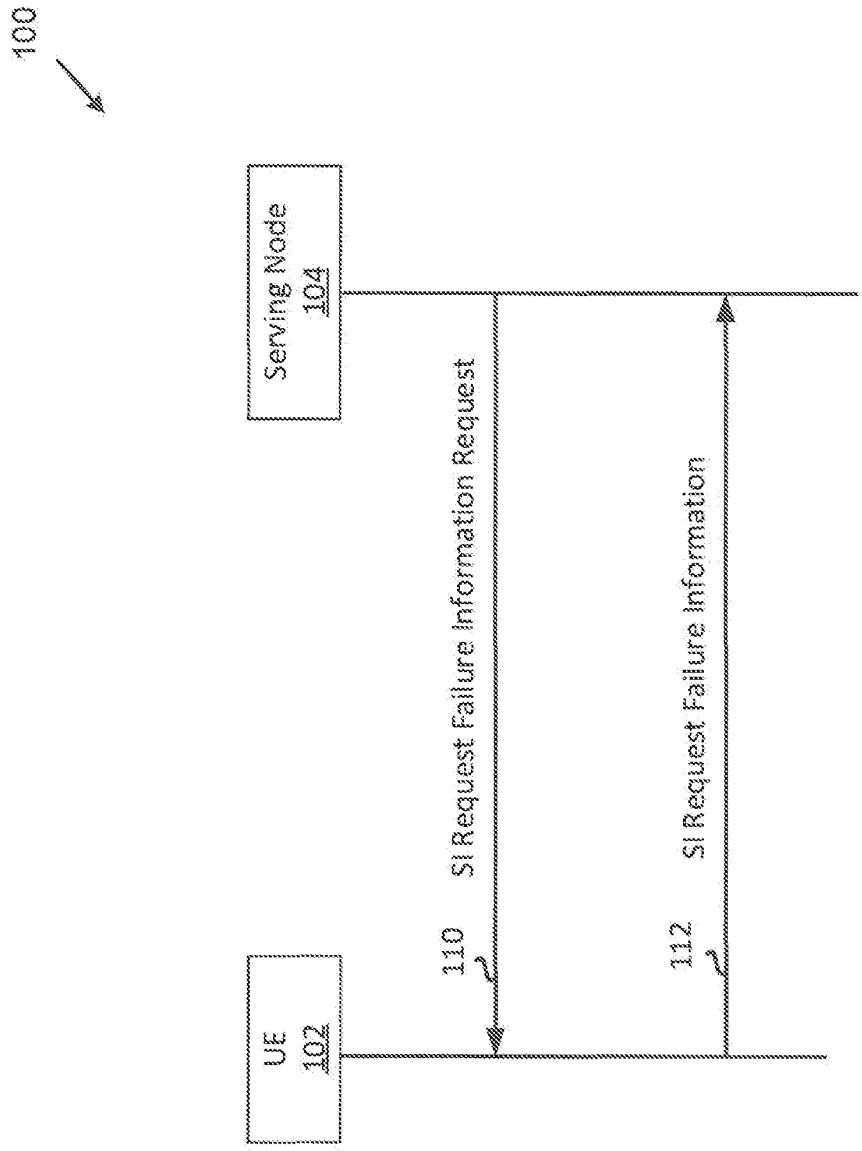

100
Serving Node
104
SI Request Failure Information Request
SI Request Failure Information
110
112
UE
102

FIG. 1

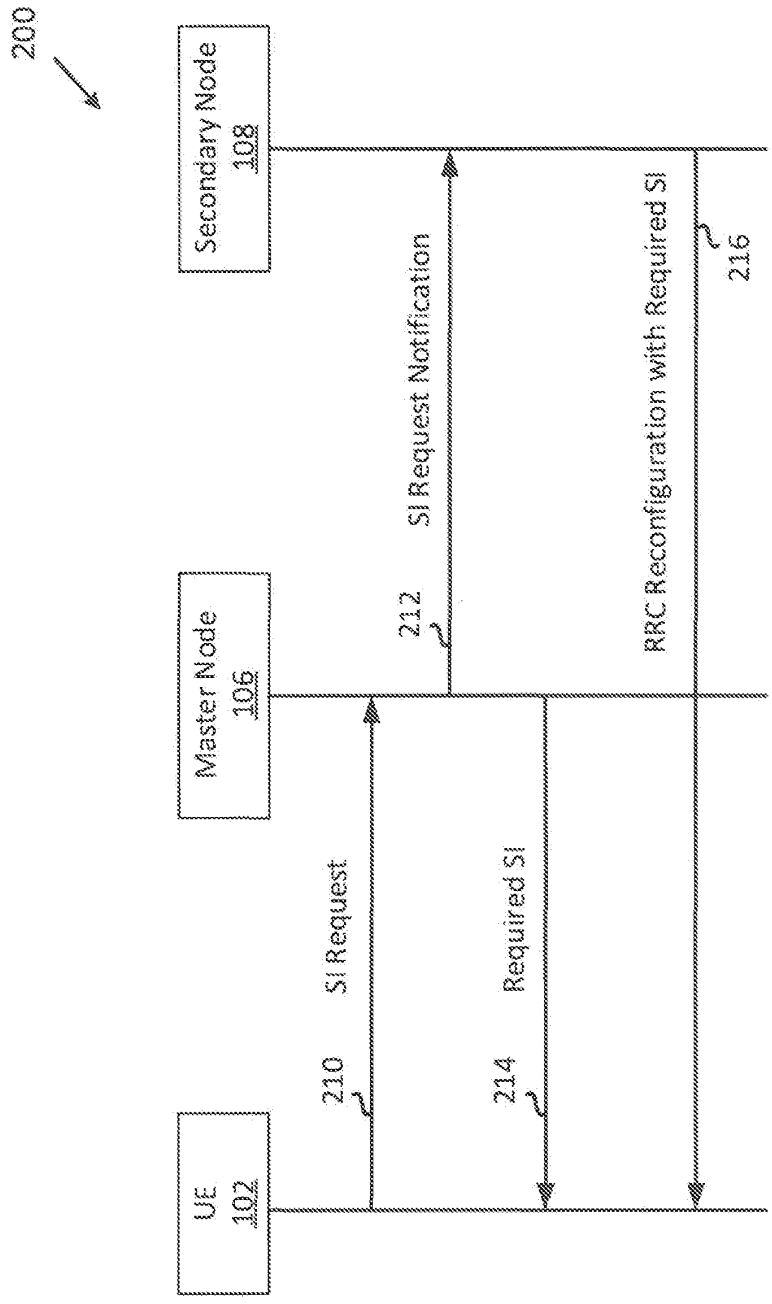

200
Secondary Node 108
Master Node 106
UE 102
SI Request Notification
212
RRC Reconfiguration with Required SI
216
SI Request
210
Required SI
214

FIG. 2

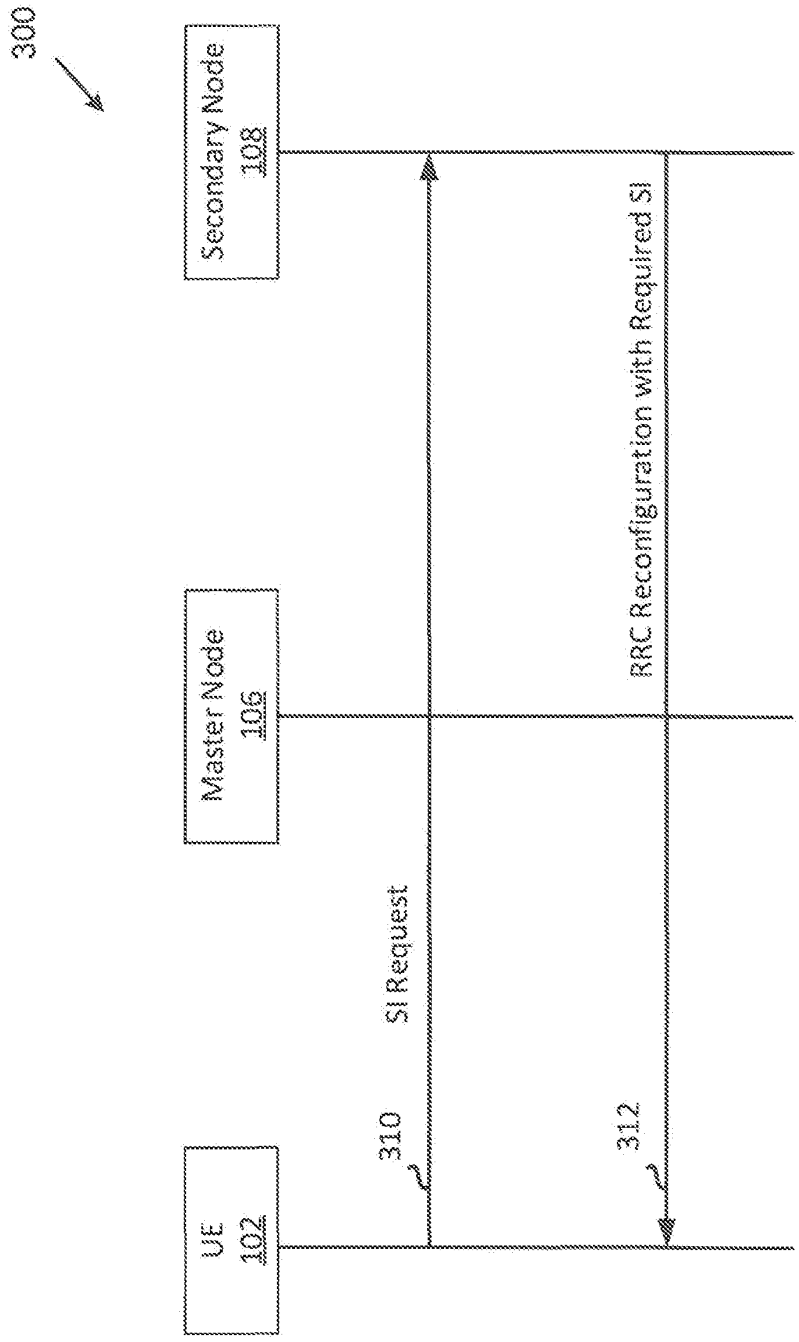

300
Secondary Node
108
Master Node
106
UE
102
SI Request
310
RRC Reconfiguration with Required SI
312

FIG. 3

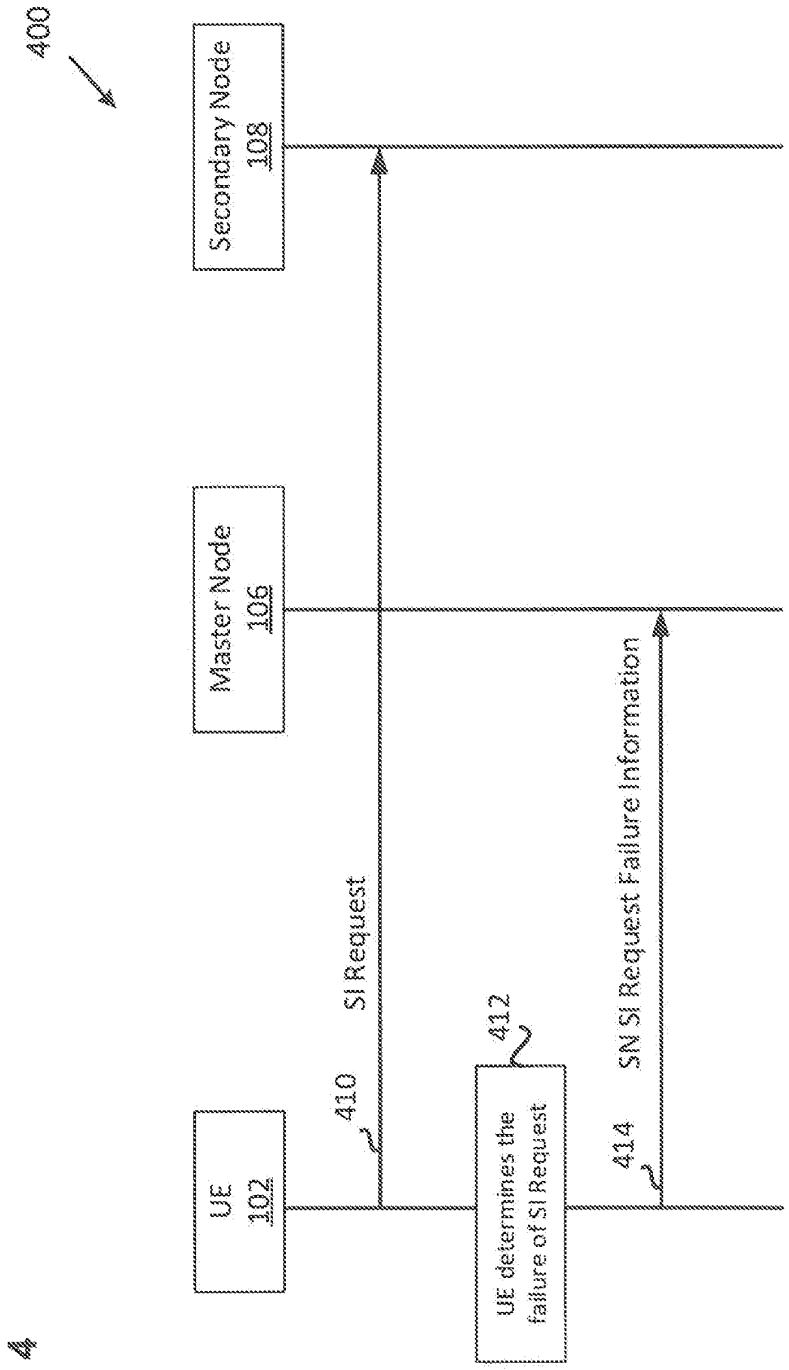

400
Secondary Node 108
Master Node 106
UE 102
410
SI Request
412
UE determines the failure of SI Request
414
SN SI Request Failure Information

FIG. 4

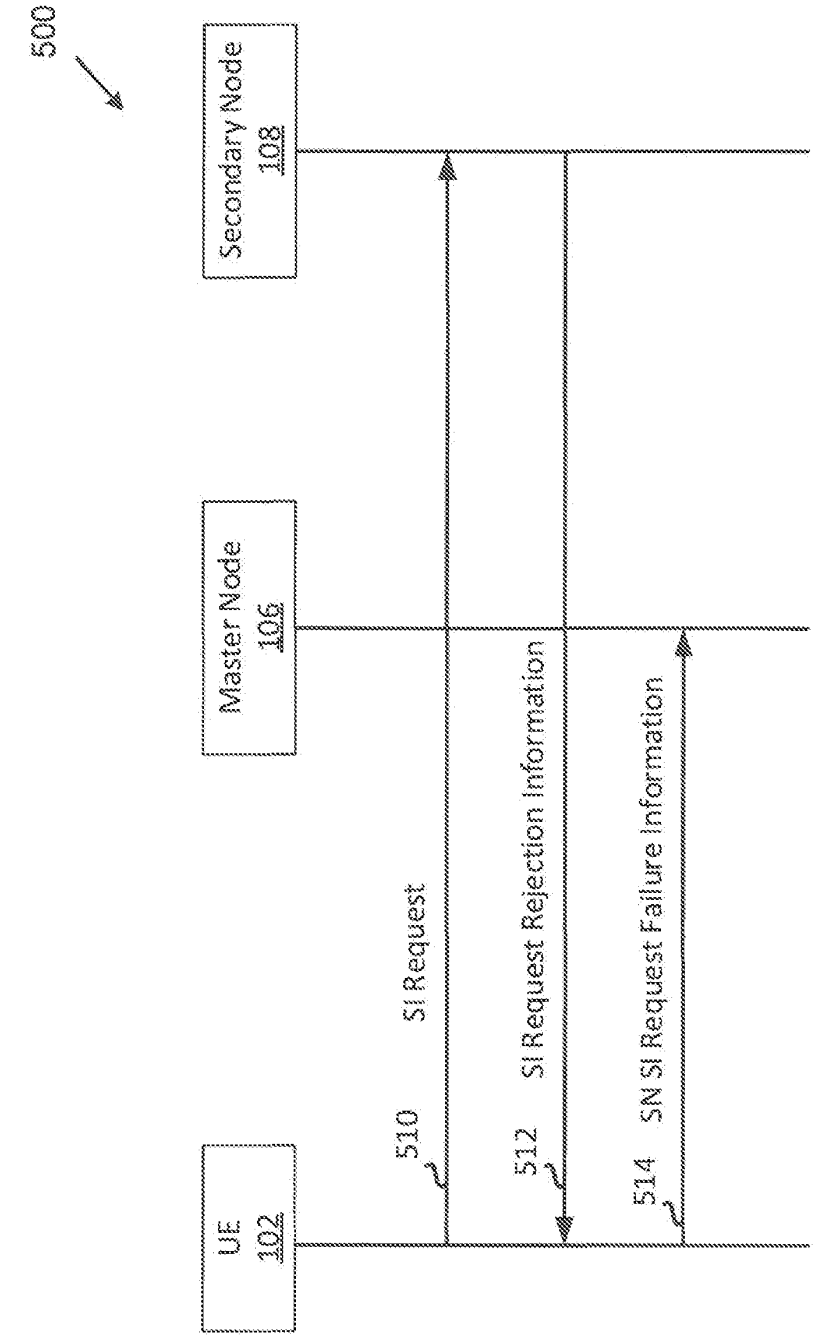
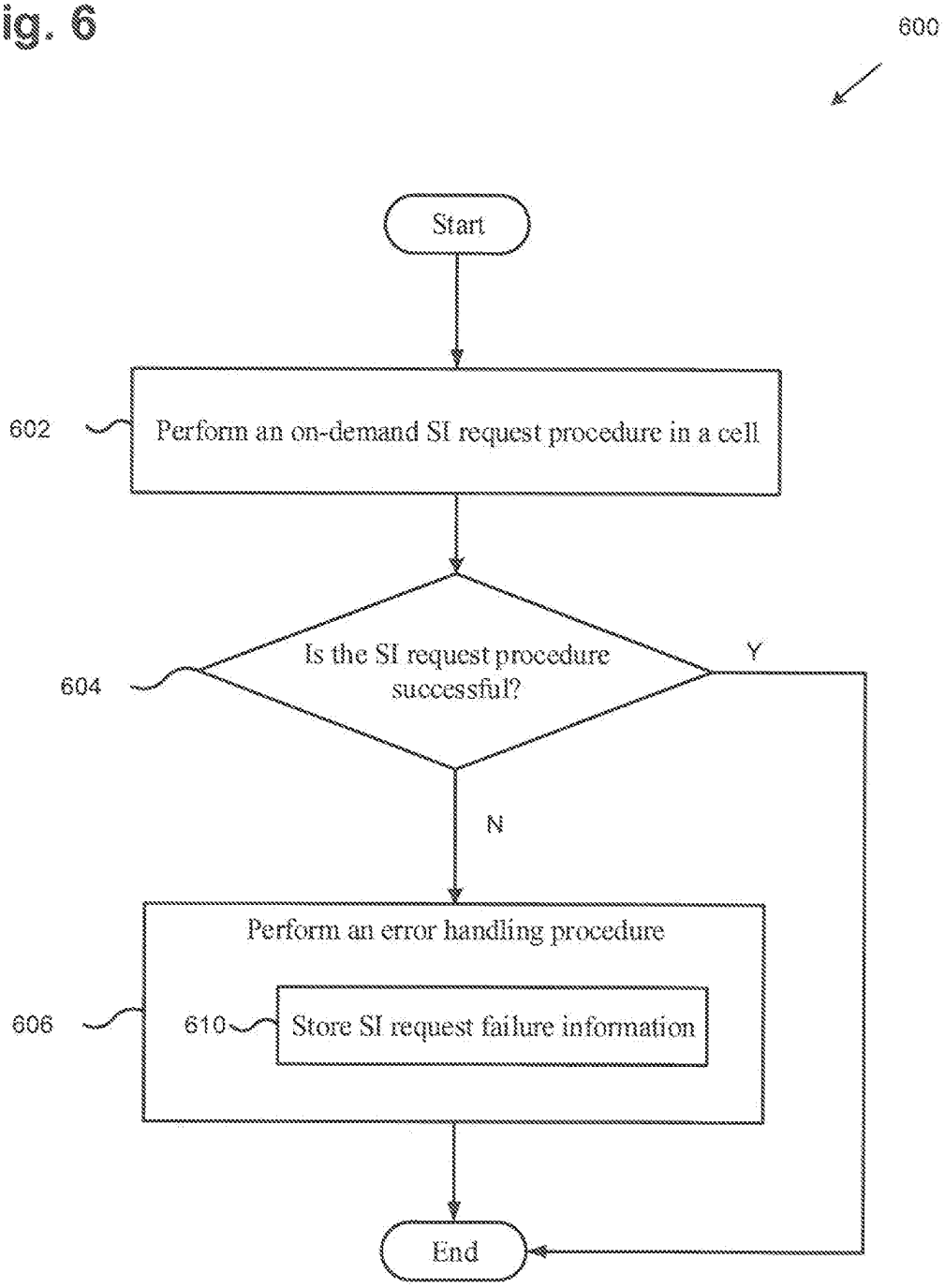

500
Secondary Node
108
Master Node
106
UE
102
SI Request
SI Request Rejection Information
SN SI Request Failure Information
510
512
514

FIG. 5

Fig. 6


600
Start
602
Perform an on-demand SI request procedure in a cell
604
Is the SI request procedure successful?
Y
N
Perform an error handling procedure
606
610
Store SI request failure information
End

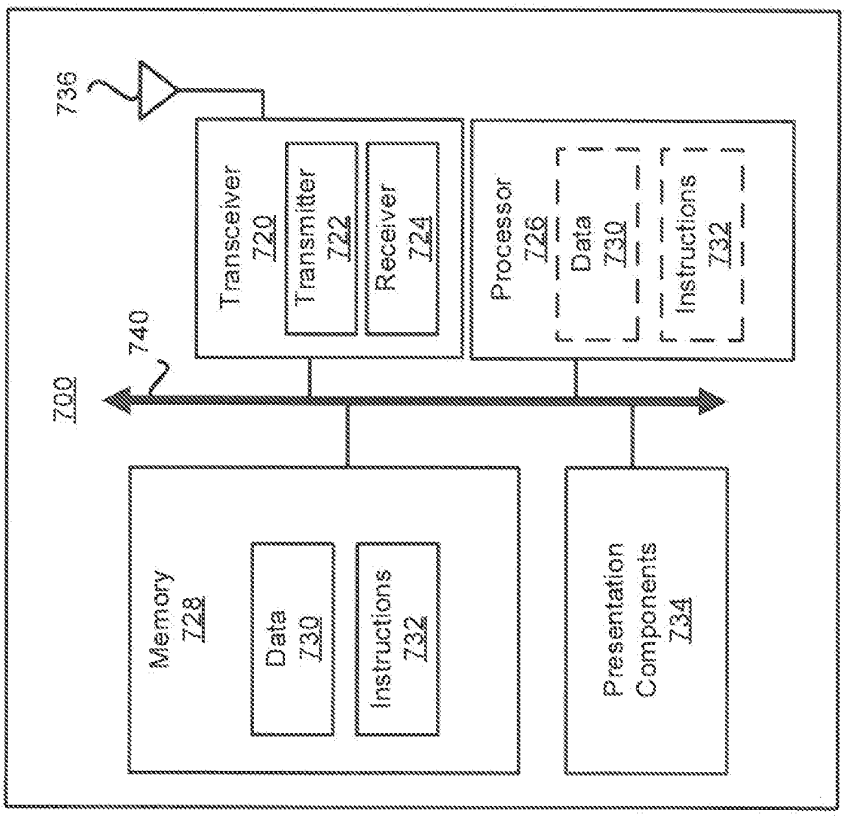

736
Transceiver
720
Transmitter
722
Receiver
724
Processor
726
Data
730
Instructions
732
740
700
Memory
728
Data
730
Instructions
732
Presentation
Components
734

FIG. 7

US010743238B2

(12) **United States Patent**
**Chen et al.**

(10) **Patent No.: US 10,743,238 B2**
(45) **Date of Patent: Aug. 11, 2020**

(54) **SYSTEM INFORMATION UPDATES IN BAND WIDTH PART (BWP) SWITCH OPERATION**

(71) Applicant: **FG Innovation Company Limited**, Tuen Mun (HK)

(72) Inventors: **Hung-Chen Chen**, Hsinchu (TW); **Chie-Ming Chou**, Hsinchu (TW)

(73) Assignee: **FG Innovation Company Limited**, Tuen Mun (HK)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/191,465**

(22) Filed: **Nov. 15, 2018**

(65) **Prior Publication Data**

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**Related U.S. Application Data**

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(51) **Int. Cl.**

| | |
|---|---|
| ***H04W 4/00*** | (2018.01) |
| ***H04W 48/10*** | (2009.01) |
| *H04W 48/12* | (2009.01) |

(52) **U.S. Cl.**
CPC ..... ***H04W 48/10*** (2013.01); *H04W 48/12* (2013.01)

(58) **Field of Classification Search**
CPC ..... H04W 48/10; H04W 48/12
USPC ..... 370/328, 329, 330
See application file for complete search history.

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*Primary Examiner* — Chuong T Ho
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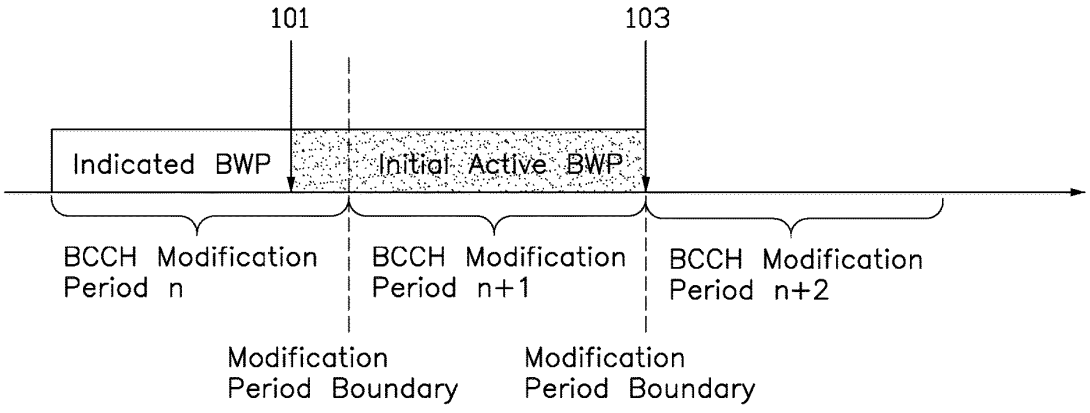
(57) **ABSTRACT**

A user equipment (UE) for wireless communication is configured to perform bandwidth part (BWP) switching operation in response to receiving a system information change indication. The UE receives the system information change indication via a currently active BWP in a BCCH modification period. The system information change indication notifies the UE that contents of system information have been changed. The UE switches from the currently active BWP to an initial active BWP to receive the changed contents of system information which are required for the UE. The UE receives the changed contents of system information via the initial active BWP in a next BCCH modification period that immediately follows the BCCH modification period. The UE updates the system information according to the changed contents.

**20 Claims, 10 Drawing Sheets**



# ON-DEMAND SYSTEM INFORMATION REQUEST PROCEDURE AND ERROR HANDLING

## CROSS-REFERENCE TO RELATED APPLICATION(S)

The present application claims the benefit of and priority to a provisional U.S. Patent Application Ser. No. 62/651,312, filed on Apr. 2, 2018, entitled "On-Demand System Information Request Procedure and Error Handling," (hereinafter referred to as "US73481 application"). The disclosure of the US73481 application is hereby incorporated fully by reference into the present application.

## FIELD

The present disclosure generally relates to wireless communication, and more particularly, to the on-demand system information (SI) request procedure for the next generation wireless communication networks.

## BACKGROUND

The concept of on-demand System Information (SI) request has been introduced in the next generation wireless network (e.g., a $5^{th}$ generation (5G) new radio (NR) network). When a UE finds that a required SI message(s) is not broadcasted, based on information in the System Information Block Type 1 (SIB1) (e.g., a one-bit indicator that shows whether the corresponding SI message is currently broadcasted or not) and the mapping of the SIBs to SI messages, the UE may perform an on-demand SI request procedure to ask the network (also referred to as NW) to broadcast the required SIB(s) and/or SI message(s). However, the next generation wireless network lacks an efficient mechanism for error handling associated with the on-demand SI request procedure.

## SUMMARY

The present disclosure is directed to on-demand system information request procedure and the corresponding error handling procedure for the next generation wireless communication networks.

According to an aspect of the present disclosure, a method of wireless communications performed by a user equipment (UE) is provided. The method includes performing an on-demand system information (SI) request procedure in a first cell; and performing an error handling procedure if the on-demand SI request procedure in the first cell is unsuccessful. The error handling procedure includes storing SI request failure information.

According to another aspect of the present disclosure, a UE is provided. The UE includes one or more non-transitory computer-readable media having computer-executable instructions embodied thereon and at least one processor coupled to the one or more non-transitory computer-readable media. The at least one processor is configured to execute the computer-executable instructions to perform an on-demand system information (SI) request procedure in a first cell, and perform an error handling procedure if the on-demand SI request procedure in the first cell is unsuccessful. The error handling procedure includes storing SI request failure information.

## BRIEF DESCRIPTION OF THE DRAWINGS

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, dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. **1** is a sequence diagram illustrating the transmission of SI request failure information, according to an exemplary implementation of the present application.

FIG. **2** is a sequence diagram illustrating an example of an on-demand SI request being transmitted to an MN in the DC mode, according to an exemplary implementation of the present application.

FIG. **3** is a sequence diagram illustrating an example of an on-demand SI request being transmitted to an SN in the DC mode, according to an exemplary implementation of the present application.

FIG. **4** is a sequence diagram illustrating an example of a UE determining the failure of an SI request in the DC mode, according to an exemplary implementation of the present application.

FIG. **5** is a sequence diagram illustrating an example of a UE receiving SI request rejection information in the DC mode, according to an exemplary implementation of the present application.

FIG. **6** is a flowchart for a method of wireless communications performed by a UE, according to an example implementation of the present application.

FIG. **7** illustrates a block diagram of a node for wireless communication, in accordance with various aspects of the present application.

## DETAILED DESCRIPTION

The following description contains specific information pertaining to exemplary implementations in the present disclosure. The drawings in the present disclosure and their accompanying detailed description are directed to merely exemplary implementations. However, the present disclosure is not limited to merely these exemplary 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.

For the purpose of consistency and ease of understanding, like features are identified (although, in some examples, not shown) by numerals in the exemplary 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.

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."

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, system, architectures, and the like are omitted so as not to obscure the description with unnecessary details.

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 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 exemplary implementations described in this specification are oriented to software installed and executing on computer hardware, nevertheless, alternative exemplary implementations implemented as firmware or as hardware or combination of hardware and software are well within the scope of the present disclosure.

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.

A radio communication network architecture (e.g., a long term evolution (LTE) system, a LTE-Advanced (LTE-A) system, a LTE-Advanced Pro system, or a 5G New Radio (NR) Radio Access Network) typically includes at least one base station, at least one user equipment (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 radio access network (RAN) established by one or more base stations.

It should be noted that, in the present application, 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, 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.

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-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 connect to serve the one or more UEs through a radio interface to the network.



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 EDGE radio access Network (GERAN), General Packet Radio Service (GRPS), 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), New Radio (NR, often referred to as 5G), and/or LTE-A Pro. However, the scope of the present application should not be limited to the above mentioned protocols.

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 can 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) service. Each cell may have overlapped coverage areas with other cells.

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 communication 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.

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 resource may also be provided in a NR frame to support ProSe services or V2X services.

The 3rd Generation Partnership Project (3GPP) has introduced a new radio resource control (RRC) state (i.e., the RRC_INACTIVE state) for the next generation (e.g., 5th generation (5G)) wireless communication networks. The RRC_INACTIVE state (also referred to as inactive state in the following description) aims to achieve power saving with acceptable access latency, and is suitable especially for small data transmission, such as in machine type communications (MTC) scenarios. When a UE is in an inactive state, the 5G radio access network (5G-RAN) (e.g., the next generation radio access network (NG-RAN), other 3GPP/non-3GPP access network connected to a 5G core network)

and the UE store the "UE context" (which may include Access Stratum (AS) context and Non-Access Stratum (NAS) context of the UE) separately. In addition, when the UE is in the inactive state, the UE may not have an RRC connection with the 5G-RAN, although the 5G-RAN may keep a connection with the next generation core network (e.g., 5G Core Network (5GC)).

The on-demand SI request procedure may be implemented differently for the UEs that are in different Radio Resource Control (RRC) states. For example, in one implementation, for a UE that is in a connected state, the NW may deliver on-demand SI messages or SIB(s) via dedicated signaling to the UE after receiving an SI request from the UE. In some implementations, for a UE that is in an idle state or an inactive state, the NW may deliver on-demand SI messages or SIB(s) via broadcasting. In some implementations, the NW may control the message type for the on-demand SI request procedure. For example, the message type for the on-demand SI request procedure may include a Message 1 (MSG1) based approach and a Message 3 (MSG3) based approach.

In some of the present embodiments, if a Random Access (RA) preamble and/or a Physical Random Access Channel (PRACH) resource specific to each SIB or set of SIBs (which the UE needs to acquire) is included in the minimum SI (e.g., in the Master Information Block and the SIB1), the SI request may be indicated using an MSG 1-based approach.

In an MSG1-based SI request, in some implementations, the minimum granularity for a requested SI may be one SI message (for a set of SIBs, as in an LTE scenario). In some of such implementations, one RA preamble may be used to request for multiple SI messages. In some implementations, a Random Access Preamble Index (RAPID) may be included in a Message 2 (MSG2). Other fields, such as Timing Advance (TA), UL grant and Temporary Cell Radio Network Temporary Identifier (C-RNTI), may not be included in the MSG2 in some implementations.

In some of the present embodiments, an RA procedure for SI request may be considered successful when the UE receives an MSG2 that includes a RAPID corresponding to the transmitted preamble. The MSG2 reception may use an RA-RNTI that corresponds to the MSG1 transmitted by the UE.

In some of the present embodiments, the UE may retransmit the RA preamble according to an NR RA power ramping when the SI request is considered to be unsuccessful. The MSG1 for SI request re-transmission may be continued until reaching maximum preamble transmissions in some of the present embodiments. Thereafter, an RA problem may be indicated to the upper layer (e.g., RRC layer). In some of the present embodiments, a Back off mechanism may be applicable to the MSG1-based SI requests. In some of such embodiments, however, no special back off sub-header/procedure may be required.

In some of the present embodiments, if the RA preamble and/or the PRACH resource (or PRACH occasions) specific to each SIB or set of SIBs (which the UE needs to acquire) is not included in the minimum SI, the SI request may be included in an MSG3. The UE may determine whether the MSG3-based approach is successful or not based on a reception of the MSG4. The preamble(s) and/or the PRACH occasions for the SI request using the MSG3-based approach may not be reserved in some aspects of the present embodiments. RRC signaling may be used for the SI request in an MSG3-based approach. In some embodiments, the UE's ID may not be included in the MSG3.

In some of the present embodiments, a temporary C-RNTI received in the MSG2 may be used for an MSG4 reception. The UE may check the contention resolution Medium Access Control (MAC) Control Element (CE) against the transmitted request.

Specifically, based on the MSG1-based SI request procedure, a UE which transmits a preamble on a dedicated PRACH resource (or PRACH occasions) for the SI request may need to wait for a corresponding Random Access Response (RAR) within a configured RAR window. If no RAR that contains a RAPID corresponding to the transmitted preamble is received, the UE may retransmit the RA preamble until the corresponding RAR is received. The MSG1 for SI request re-transmission, in some of the present embodiments, may be continued until a maximum preamble transmission is reached. In some of such embodiments, an RA problem may be indicated to the upper layers. However, during the whole MSG1-based SI request procedure, the requested SIB(s) or SI message(s) may be broadcasted based on the NW decision or other UE's SI request(s). There may be a power consumption issue if the UE does not stop the ongoing MSG1-based SI request procedure when the required SIB(s) has been broadcasted.

As described above, based on the MSG1-based SI request procedure, a UE which transmits a preamble on a dedicated PRACH resource for the SI request may need to wait for the corresponding RAR within a configured RAR window. If no RAR that contains a RAPID corresponding to the transmitted preamble is received, the UE may retransmit the RA preamble until reaching a maximum preamble transmission, and then an RA problem may be indicated to upper layers. If the corresponding RAR is received, the UE may send an MSG3 to indicate the required SIB(s) and/or SI message(s). After sending the MSG3, the UE may need to wait for a period e.g., defined by a contention resolution timer) for receiving the MSG4 for contention resolution. If the contention resolution timer expires and no MSG4 is received, the UE may retransmit a preamble again. In some of the present embodiments, the MSG1 for the SI request re-transmission may be continued until a maximum preamble transmission is reached. In some aspects of the present embodiments, an RA problem may be indicated to the upper layers. Similarly, since contention resolution is also adopted for the MSG3-based SI request procedure, an RA problem may be indicated to the upper layers if the maximum preamble transmission is reached.

CASE 1: A UE's Behaviour when an On-Demand SI Request is Unsuccessful for the UE in an Idle State or an Inactive State:

When an MSG1-based SI request or an MSG3-based SI request procedure in a cell is failed, the UE may consider the cell as barred, or may consider that the required SIB(s) and/or SI message(s) are not available. In one implementation, the UE may consider the on-demand SI request procedure as unsuccessful when the number of times the UE transmits a random access preamble reaches a threshold (e.g., maximum allowable preamble transmissions), and/or the UE receives SI request rejection information (e.g., in a RAR) in some of the present embodiments.

If the UE considers that a cell is barred due to an SI request failure, the UE may consider the cell as barred for a configurable time period or a fixed time period (e.g., for 300 s). The UE may perform a cell reselection procedure to find another cell to camp on. The barring time period may be broadcasted to the UE in system information, carried in an MSG2 or MSG4, or may be predefined as a fixed value in some of the present embodiments.

If the UE considers that the required SIB(s) and/or SI message(s) are not available, the UE may not perform the SI request for the unavailable SIB(s) and/or SI message(s) again on the cell. In some of the present embodiments, when the UE considers that the required SIB(s) and/or SI message(s) are not available (e.g., when an RA procedure problem is reported, or when SI request rejection information is received), the UE may activate a prohibit timer. In some of such embodiments, the UE may avoid initiating another on-demand SI request procedure until the prohibit timer expires. In one implementation, the UE is forbidden to perform another on-demand SI request procedure until the prohibit timer expires. For example, the prohibit timer may start when an upper layer (e.g., the RRC layer) receives the SI request rejection information, or receives the RA problem due to an SI request failure from a lower layer (e.g., the MAC layer). After the prohibit timer expires, the UE may initiate another SI request procedure. The prohibit timer may be preconfigured or may be a fixed value in some of the present embodiments. The value of the prohibit timer may be broadcasted in system information, carried in an MSG2 or MSG4, or may be predefined as a fixed value in some embodiments.

In one implementation, if the prohibit timer is not present in the signaling from the NW, it is up to UE's implementation on when to start the SI request procedure again.

In one implementation, the UE may determine whether to perform a cell reselection procedure due to a failure of the MSG1-based SI request or the MSG3-bsed SI request. The UE may make such a determination based on whether the required SIB(s) and/or SI message(s) are essential for the UE (e.g. essential for the UE's targeting services) or based on some other predefined rules. For example, the UE may determine to perform a cell reselection procedure as a result of an unsuccessful SI request if the required SIB(s) and/or SI message(s) are essential.

The UE may perform a cell reselection procedure due to a failure of the MSG1-based SI request or the MSG3-based SI request. Specifically, when the UE performs a cell reselection procedure, the UE may consider the cell, for which the UE fails to request the required SIB(s) and/or SI messages(s), as barred or having a lower priority (e.g., by setting the priority of the frequency on which the barred cell is to a default value). In one implementation, the requested SIB(s) and/or SI messages(s) may be defined/considered as the essential SI for different UE categories or UE types. If the requested SIB(s) and/or SI messages(s) are not defined/considered as the essential SI for the category or type of the UE, the UE may decide whether to re-request the requested SIB(s) or SI messages(s) on the camped cell. In one implementation, if the requested SIB(s) or SI messages(s) are not defined/considered as the essential SI for the category or type of the UE, a prohibit timer may start when the upper layer (e.g., the RRC layer) receives the RA problem due to an SI request failure from the lower layer (e.g., the MAC layer). After the prohibit timer expires, the UE may perform the SI request procedure again. The prohibit timer may be preconfigured or be a fixed value. The value of the prohibit timer may be broadcasted in the system information, carried in an MSG2 or MSG4, or may be predefined as a fixed value.

CASE 2: A UE's Behaviour when the On-Demand SI Request is Unsuccessful for the UE in a Connected State:

A UE may also request the required SIB(s) or SI message(s) while the UE is in a connected state. Normally, the UE may receive the required SIB(s) or SI message(s) via dedicated signaling. If the UE does not receive the required SIB(s) or SI message(s) via dedicated signaling, (e.g., no response from the NW side to deliver the required SIB(s) or SI message(s), or receiving SI request rejection information), the UE may consider that there is an NW error and perform reestablishment to another qualified cell if there is another qualified cell with a valid UE context. If there is no such a qualified cell or if the reestablishment is rejected/failed, the UE may switch to an idle state and perform a cell reselection procedure by considering the cell as barred. In another implementation, the UE may directly switch to the idle state and then perform a cell reselection procedure by considering the cell as barred.

In one implementation, the NW may respond an SI request rejection message/information to the UE. After receiving the SI request rejection message/information, the UE may consider that the required SIB(s) or SI message(s) are not available and may not perform the SI request for those SIB(s) or SI message(s) again on the cell. In another implementation, a prohibit timer may be initiated when the UE receives the SI request rejection message/information. After the prohibit timer expires, the UE may perform an SI request procedure again. The prohibit timer may be preconfigured or may be a fixed value.

In one implementation, when the SI request procedure is unsuccessful, the UE may perform, at least, a reestablishment procedure, switch to an idle state for a cell reselection procedure, mark that the requested SIB(s) or SI message(s) are not available, etc.

In one implementation, the requested SIB(s) or SI messages(s) may be defined/considered as the essential SI for different UE categories or UE types. The UE may switch to the idle state and perform a cell reselection procedure when the SI request for essential SI is failed. The UE may consider the cell in which the SI request is failed as barred, or having a lower priority when performing a cell reselection procedure (e.g., by setting the priority of the frequency on which the barred cell is to a default value). The UE, in some of the present embodiments, may only mark that the requested SIB(s) or SI message(s) are not available when the SI request for non-essential SI is failed.

In the connected state, the NW may perform a handover (HO) procedure (e.g., from a source gNB to a target gNB) when receiving the SI request for required SIB(s) or SI message(s) that are not provided by the NW. The target gNB may provide the required SIB(s) or SI message(s) in the HO command (e.g., based on the SI request information provided in the HO Request message from the source gNB).

In the Dual Connectivity (DC) mode, the UE may inform the cause of a Secondary Node (SN) SI request failure, or the information related to the SI request failure to a Master Node (MN) when the on-demand SI request for the SIB(s) of the SN is rejected or failed. After the MN receives the cause of an SI request failure or the information related to the SI request failure, in some of the present embodiments, the MN may try to resolve the SN SI request rejection/failure problem. For example, in one aspect of the present embodiments, the MN may release the SN or change the SN to a new SN for the UE.

CASE 3: Store and Report the Information Related to the SI Request Failure:

An MSG1-based SI request or an MSG3-bsed SI request procedure may be failed when a lower layer (e.g., the MAC layer) informs an upper layer (e.g., the RRC layer) of an RA problem. Since the RRC layer knows the RA procedure is triggered for the SI request, the UE may store the SI request failure information. The SI request failure information may include one or more parameters used in the on-demand SI request procedure. The SI request failure information may

include at least one of the following: the on-demand SIB(s) requested by the UE, the on-demand SI message(s) requested by the UE, the cell ID (of the cell in which the UE has performed the SI procedure but has failed), SSB Index(s) (Synchronization Signal Block Index(s)) to perform the SI request procedure, the message type of the failed SI request procedure (e.g., MSG1-based or MSG3-based), the timestamp (e.g., when to perform the SI request procedure), etc. The SSB Index may indicate which SSB with RA resource (or RA occasions) is used for a preamble transmission. For example, for an MSG1-based approach, the dedicated RA resource (or RA occasions) for transmitting a preamble may be associated with an SSB. For an MSG3-based approach, the common RA resource (or RA occasions) for transmitting a preamble may be associated with an SSB. The UE may report such failure information to the NW when switching to a connected state later. The UE may mandatorily report the information of the SI request failure, according to the configuration, or upon an NW request. The content of the SI request failure information may be predefined, may be based on the required information indicated in the received SI request failure information message, or may be based on the configuration.

FIG. **1** is a sequence diagram illustrating the transmission of SI request failure information, according to an exemplary implementation of the present application. As shown in diagram **100**, in action **110**, serving node **104** (e.g., a gNB) may send a request to UE **102** to provide the information related to SI request failure. For example, serving node **104** may send an SI Request Failure Information Request message to UE **102** if UE **102** informs serving node **104** that such information is stored. In one implementation, UE **102** may set one bit in an RRC message (e.g., in the RRC Connection Setup Complete message or in the RRC Connection Resume message) to true (or '1') to inform serving node **104** that UE **102** supports storage of the SI request failure information and it has the SI request failure information stored. Serving node **104** may determine to request the SI request failure information after receiving such information from UE **102**. In action **112**, UE **102** may send a message including the SI request failure information to serving node **104**.

By utilizing the SI request failure information, serving node **104** may know how to adjust the SI request mechanism between the MSG1-based approach and the MSG3-based approach. For example, if UE **102** reports failure of an MSG3-based SI request procedure in a cell or a certain area, serving node **104** may consider adopting the MSG1-based SI request for the UEs in idle/inactive state to avoid an RA collision by using the dedicated RA resource(s) for SI request. Alternatively, serving node **104** may continue to adopt the MSG3-based SI request procedure when UE **102** reports the failure of the MSG3-based SI request procedure.

In one implementation, UE **102** may store the information related to the SI request failure when UE **102** considers the cell as barred and performs a cell reselection procedure. UE **102** may not store the information related to the SI request failure when UE **102** considers that the required SIB(s) or SI message(s) are not available.

When the SI request procedure for a UE that is in a connected state is failed (e.g., UE **102** does not receive the required SIB(s) or SI message(s) via dedicated signaling, or UE **102** receives the SI request rejection information), UE **102** may store the information of the SI request failure. In one implementation, when the SI request procedure is unsuccessful, UE **102** may perform re-establishment to another qualified cell, or UE **102** may switch to an idle state and then perform a cell reselection procedure by considering the cell as barred. The information of the SI request failure may include at least one of the following: the required SIB(s), the required SI message(s), the cell ID (of the cell in which the UE preforms SI procedure but failed), and the timestamp of the SI request procedure. UE **102** may report such failure information to the NW when switching to a connected state later. UE **102** may mandatorily report the information of the SI request failure, according to the configuration, or upon receiving an NW request. The content of the SI request failure information may be predefined, may be based on the required information indicated in the received SI request failure information message, or may be based on the configuration.

Similarly, UE **102** may store the SI request failure information when UE **102** is in a connected state if the SI request is unsuccessful (where SI request procedure may be an MSG1-based SI approach or an MSG3-based SI approach). The SI request failure information may include at least one of the following: the on-demand SIB(s) requested by UE **102**, the on-demand SI message(s) requested by UE **102**, the cell ID (of the cell which UE **102** preforms SI procedure but failed), SSB Index(s) (Synchronization Signal Block Index(s)) to perform the on-demand SI request procedure, the message type of the unsuccessful SI request procedure (e.g., MSG1-based or MSG3-based), and the timestamp (e.g., when to perform the SI request procedure). The UE may mandatorily report the SI request failure information, according to the configuration, or by an NW request (e.g., requested by serving node **104**). The content in the SI request failure information may be predefined, may be based on the required information indicated in the received SI Request Failure Information message, or may be based on the configuration.

It may be beneficial for the NW to know the information related to SI request failure. For example, the NW may determine which cell, SIB(s)/SI message(s), or the related dedicated preamble may have problems. As a result, the NW is likely to overcome the problem afterwards, or the NW may consider adopting another mechanism for serving the SI request.

In the DC mode, a UE may inform the cause of a Secondary Node (SN) SI request failure, or the information related to the SI request failure, to a Master Node (MN) when the on-demand SI request for the SIB(s) of the SN is rejected or failed. After MN receives the cause of the SI request failure or the information related to the SI request failure, the MN may try to resolve the SN's SI request rejection/failure problem. For example, the MN may release the SN or change the SN to a new SN for the UE.

CASE 4: Harmonization of the SI Request Messages in Idle, Inactive, and Connected States:

For an MSG3-bsed SI request procedure, the MSG3 may include an SI request message (which may be an RRC message) containing no UE ID. In an idle state, there may be no security key and/or security algorithm configured to the UE yet. Therefore, the SI request message transmitted in an idle state may be transmitted on Signaling Radio Bearer 0 (SRB0). Neither integrity protection, nor ciphering, apply to the SRB0 in some embodiments. In one implementation, the SI request message (which is an RRC message) may be the same for idle, inactive, and connected states, resulting in an RRC message harmonization. The SI request message may be transmitted on the SRB0 without integrity protection and ciphering, even if the UE is in a connected state, or in an inactive state, where integrity protection and ciphering may have been already applied.

In one implementation, the SI request message (which is an RRC message) that includes no UE ID may be the same for idle, inactive, and connected states. The UE may transmit the SI request message on the SRB0 when the UE is in an idle or an inactive state. The UE may transmit the SI request message on Signaling Radio Bearer 1 (SRB1) when the UE is in a connected state. Both integrity protection and ciphering may apply to the SRB1.

In one implementation, the SI Request message (which is an RRC message) may be the same for idle, inactive, and connected states. The UE may transmit the SI request message on the SRB0 when the UE is in an idle state. The UE may transmit the SI request message on the SRB1 when the UE is in an inactive or a connected state. Both integrity protection and ciphering may apply to the SRB1. In an inactive State, the UE may still have the UE context and the NW's configuration for integrity protection and ciphering.

In one implementation, whether the SI request message is transmitted on the SRB0 or the SRB1 for a UE in an inactive state may be determined based on the UE's implementation, the NW's preconfiguration, and/or whether the UE context for integrity protection and ciphering is stored/valid or not.

It may be beneficial to keep the commonality of the SI Request message with respect to the UEs in different states, which may lead to simplification of the overall system design in some of the present embodiments.

CASE 5: The Structure of an SI Request Message:

In one implementation, the SI request message in the MSG3 (e.g., in an MSG3-based SI request procedure) may be the same for idle, inactive, and connected states. Different minimum granularity of the requested SI (e.g., SIB-based or SI message-based) may be considered in connection with the SI request message. For example, it may be beneficial for the SI request message to use SI message-based granularity (e.g., the UE indicates which SI message(s) is requested) in the MSG3-based SI request procedure, since there is a one-bit indicator in the NR SIB1 to show whether the corresponding SI message is currently broadcasted or not, and the number of SI messages may be much less than the number of SIBs. However, the SI message-based granularity may not provide sufficient information to the NW in regards to which SIB(s) needs to be broadcasted and/or whether the mapping of the SIB(s) and the SI message(s), and the associated periodicity may need to be re-arranged based on the UE's requirements. The UE in connected state may receive the required SI via dedicated signaling. Therefore, in one implementation, the SIB-based granularity may be used, e.g., by the UE indicating which SIB(s) is requested.

Different implementations regarding the different SIB-based granularities will be discussed next:

CASE 5-1:

In the SI Request message, there may be a choice structure in which the UE may choose to use the SI message-based granularity or the SIB-based granularity. The UE may consider the signaling overhead to select which granularity to use. In one implementation, the UE may use a first bitmap to indicate which SI message(s) is requested and a second bitmap to indicate which SIB(s) is requested. In one implementation, there may be a common bitmap for the UE to indicate which SI message(s) is requested or which SIB ID(s) is requested.

CASE 5-2:

In the SI Request message, there may be a choice structure in which the UE may choose to use the SI message-based granularity or the SIB-based granularity. The UE may select one of the two types of granularity based on the NW configuration. The NW configuration may be delivered to the UE via dedicated signaling or via broadcasting. In one implementation, the UE may use a first bitmap to indicate which SI message(s) is requested and a second bitmap to indicate which SIB(s) is requested. In one implementation, there may be a common bitmap for the UE to indicate which SI message(s) is requested or which SIB ID(s) is requested.

CASE 5-3:

In the SI Request message, in some of the present embodiments, the UE may request one or more SI messages together with one or more SIBs. For example, both SI message-based granularity and SIB-based granularity may be potentially used in the SI Request message. Specifically, a UE may send an SI Request message that only uses the SI message-based granularity, only uses the SIB-based granularity, or uses both SI message-based granularity and SIB-based granularity. The UE may use a first bitmap to indicate which SI message(s) is requested and a second bitmap to indicate which SIB(s) is requested. In one implementation, there may be a common bitmap for the UE to indicate which SI message(s) is requested or which SIB ID(s) is requested.

CASE 5-4:

In some of the present embodiments, the UE may use a two-level bitmap for the SI request messages. In some of such embodiments, the first level bitmap may be used for the SI-based granularity, which may be mandatorily appended in the SI request message. The second level bitmap may be used for the SIB-based granularity, which may be optionally appended in the SI request message if the corresponding SI bit is set to "1" in the first level bitmap. As an example, in which there are 5 SI messages, and the SI message#3 includes SIB#7, SIB#8, SIB#9 and SIB#10, when the UE wants to request SIB#9, the first level bitmap of the UE's SI request message may be "0100" (which indicates SI message#3), and the UE may further optionally append the second level bitmap "0100" (which indicates the third SIB in the SI message#3). Consequently, a gNB may provide SIB#9 specifically in response to such an SI request message. In one implementation, if the second bitmap does not appear, the gNB may provide the complete SI message#3.

CASE 6: On-Demand SI Request Procedure in an NR-NR DC Scenario:

A UE in an NR-NR Dual Connectivity (DC) mode may request one or more required SIBs or one or more SI messages for certain purpose(s) or certain service(s). Several implementations are described below regarding how the UE may request and receive the required SIB(s) from a secondary node (SN) or the serving cells in a secondary cell group (SCG).

CASE 6-1:

When a UE is in an NR-NR DC mode and one or more SIBs or one or more SI messages are required, the UE may be only allowed to send the SI request message to the master node (MN) in some of the present embodiments.

FIG. **2** is a sequence diagram illustrating an example of an on-demand SI request being transmitted to an MN in the DC mode, according to an exemplary implementation of the present application. As shown in diagram **200**, in action **210**, UE **102** may transmit an SI request message to MN **106** when UE **102** requires on-demand system information of a cell belonging to MN **106** or a cell belonging to SN **108**. In action **212**, MN **106** may inform SN **108** to provide the required SIB(s) or SI message(s) to UE **102** based on the SI request message. For example, MN **106** may use a signaling message between two base stations (e.g., X2-AP message or Xn-AP message) with fields indicating the requested SIB(s) or SI message(s). When SN **108** receives the SI request from MN **106**, SN **108** may transmit the required SIB(s) or SI

message(s) to UE **102** by initiating serving cell release and addition action in the same RRC reconfiguration message to update the SIB(s) or SI message(s) for certain, or all, serving cell(s). As shown in diagram **200**, this RRC reconfiguration may be transmitted via MN **106** or transmitted via Signaling Radio Bearer 3 (SRB3), if configured.

When the UE requires on-demand system information of a cell belonging to MN **106**, if the requested SI message or SIB is not broadcasted, in action **214**, MN **106** may transmit the required SI to UE **102**. When the UE requires on-demand system information of a cell belonging to SN **108**, if the requested SI message or SIB is not provided before, in action **216**, SN **108** may transmit RRC Reconfiguration with the required SI to UE **102** (e.g., via the SRB3). In one implementation, SN **108** may transmit RRC Reconfiguration with required SI (e.g., action **216**) only when SN **108** receives the SI Request Notification from MN **106** (e.g., action **212**).

In one implementation, SN **108** may directly transmit the modified SIB(s) or SI messages(s) to UE **102** without taking cell release and addition action, when MN **106** sends the SI Request Notification to SN **108**. SN **108** may transmit the modified SIB(s) or SI messages(s) directly to UE **102** only when receiving the SI Request Notification from MN **106**.

In one implementation, UE **102** is only allowed to send the SI request message to MN **106**. The UE may indicate in the SI request message that the SI Request is for the SIB(s) or the SI message(s) on MN **106** or SN **108**. If the SI Request message is marked for MN **106**, MN **106** may be responsible for this SI Request message. On the other hand, if the SI Request message is marked for SN **108**, MN **106** may forward this message to SN **108** and SN **108** may be responsible for this SI Request message. It should be noted that UE **102** may follow the minimum SI's indication (e.g., SI transmission period) of MN **106** or SN **108** to receive the SI while the SI request message is marked to MN **106** or SN **108**, respectively. In another implementation, UE **102** may not mark the SI request toward MN **106** or SN **108**, and MN **106** may provide all (MN **106** and SN **108**) relative SI to UE **102** in a unicast approach.

If some or all of the serving cells in the SCG do not provide the requested SIB(s) or SI message(s), SN **108** may inform MN **106** that the SCG, or some serving cells in the SCG, does not provide the requested SIB(s) or SI message(s). MN **106** may decide whether to perform the SCG change action or release SN **108** for UE **102**.

CASE 6-2:

When a UE in the NR-NR DC mode and one or more SIBs or SI messages are required, the UE may send the SI request message to the MN and/or the SN when required.

FIG. **3** is a sequence diagram illustrating an example of the on-demand SI request being transmitted to an SN in the DC mode, according to an exemplary implementation of the present application. As shown in diagram **300**, in action **310**, UE **102** may transmit the SI request message to SN **108** (e.g., via SRB3, if configured). In action **312**, SN **108** may transmit RRC Reconfiguration with the required SI to UE **102** via SRB3. If SRB3 is not configured, UE **102** may transmit the SI request message to MN **106** and let MN **106** forward the SI request message to SN **108**.

When some or all of the serving cells in the SCG cannot provide the required SIB(s) or SI message(s), SN **108** may inform MN **106** that the SCG, or some serving cells in the SCG, does not provide the requested SIB(s) or SI message(s). MN **106** may decide whether to perform the SCG change action or release SN **108** for UE **102**.

FIG. **4** is a sequence diagram illustrating an example of the UE determining the failure of an SI request in the DC mode, according to an exemplary implementation of the present application. As shown in diagram **400**, in action **410**, UE **102** sends an SI request message to SN **108**. In action **412**, UE **102** determines the failure of the SI request, e.g., when the number of times UE **102** transmits the random access preamble reaches a threshold. After determining the on-demand SI request procedure is unsuccessful, UE **102** may store the SI request failure information related to SN **108**. In action **414**, UE **102** may transmit the SN SI request failure information to MN **106**.

FIG. **5** is a sequence diagram illustrating an example of the UE receiving SI request rejection information in the DC mode, according to an exemplary implementation of the present application. As shown in diagram **500**, in action **510**, UE **102** sends an SI request message to SN **108**. In action **512**, UE **102** receives the SI request rejection information from SN **108**. After determining the on-demand SI request procedure is unsuccessful, UE **102** may store the SI request failure information related to SN **108**. In action **514**, UE **102** may send the SN SI request failure information to MN **106**.

If UE **102** determines that the SI request procedure on SN **108** has failed (e.g., action **412** in diagram **400** or action **512** in diagram **500**), UE **102** may inform MN **106** of the cause of SN SI request failure or the information related to SN SI request failure (e.g., by sending an SN SI Request Failure Information when the on-demand SI request for the SIB(s) of SN **108** is rejected or failed, e.g., in action **414** of diagram **400**, or action **514** of diagram **500**). The information of the SI request failure may include at least one of the following: the required SIB(s), the required SI message(s), the cell ID (of the cell which the UE preforms SI procedure but failed), SSB Index(s) (Synchronization Signal Block Index(s)) to perform SI request, the failed SI request procedure type (e.g., MSG1-based or MSG3-based), or the timestamp (e.g., when to perform the SI request procedure). After MN **106** receives the cause of the SI request failure or the information related to the SI request failure, MN **106** may resolve the SN SI request rejection/failure problem. For example, MN **106** may release SN **108** or change SN **108** to a new SN for UE **102**.

CASE 7: An RA Problem Caused by the MSG1-Based/MSG3-Based SI Request Procedure:

A UE in connected state may be allowed to apply an MSG1-based SI request procedure and/or an MSG3-based SI request procedure. In one implementation, if the RA problem is caused by the MSG1-based or the MSG3-bsed SI request procedures, the UE's operation in connected state is not affected if the requested SI message(s) or SIB(s) is not essential for the UE to perform the targeting services.

In one implementation, the UE may still be fine even if the requested SIB(s) or SI message(s) is not received from the serving node (e.g., in a single connectivity mode) or the MN (e.g., in dual connectivity mode) (e.g., the requested SIB or SI message may not be essential). In this scenario, the UE may not consider the RA problem as a normal radio link failure, and the UE may not perform a re-establishment procedure, or enter into an idle state.

In one implementation, the UE may still be fine even if the requested SIB(s) or SI message(s) is not received from the SN (e.g., in a dual connectivity mode). In this scenario, the UE may not consider the RA problem as a normal radio link failure, and the UE may report the SI failure information to the MN. For example, when the RA problem is reported and the upper layer (e.g., the RRC layer) knows that the problem is caused by an SI request, the UE may initiate a transmis-

sion of the SI failure information report to the MN. In this implementation, the UE may not suspend all of the SCG data radio bearers (DRBs) or SCG transmission for the split DRBs or the duplication DRBs. Also, the UE may not reset the MAC entity associated with the SCG (or SN).

In one implementation, the UE may still be fine even if the requested SIB(s) or SI message(s) is not received from the SN (e.g., in a dual connectivity mode). In this scenario, the UE may not consider the RA problem as a normal radio link failure, and the UE may not report the SI failure information to the MN. For example, when the RA problem is reported and the upper layer (e.g., RRC layer) knows that the problem is caused by an SI request, the UE may not initiate a transmission of the SI failure Information report to the MN. In this implementation, the UE may not suspend all of the SCG DRBs or SCG transmission for the split DRBs or the duplication DRBs. Also, the UE may not reset the MAC entity associated with the SCG (or SN). When the upper layer (e.g., the RRC layer) receives the RA problem caused by the SI request from the lower layer (e.g., the MAC layer), it may also inform the NAS layer (or the application layer) so that the NAS layer (or the application layer) does not trigger the SI request procedure for one or more required SIBS on the same cell, or not trigger the SI request procedure for a while (which may follow the NW configuration or a predefined period). How to handle the SI request failure condition may depend on the UE's implementation, if the NAS layer (or the application layer) is informed about the SI request failure.

In one implementation, whether the SN initiates the transmission of the SI failure information report to the MN may depend on the NW configuration.

FIG. **6** is a flowchart for a method of wireless communications performed by a UE, according to an example implementation of the present application. In FIG. **6**, the process/method **600** includes actions **602**, **604**, **606**, and **610**.

In action **602**, the UE may perform an on-demand system information request procedure in a cell. The UE may be in idle, inactive, or connected state. In addition, the UE may be in a single connectivity mode or a dual connectivity mode.

In action **604**, the UE may determine whether the on-demand SI request procedure is successful. In one implementation, the on-demand SI request procedure is considered unsuccessful when the number of times the UE transmits a random access preamble reaches a threshold, and/or the UE receives the SI request rejection information. If the process **600** determines, in action **604**, that the SI request procedure is unsuccessful, the UE may proceed to action **606**. On the other hand, if the request procedure is successful, the process **600** may end.

In action **606**, the UE may perform an error handling procedure corresponding to the on-demand SI request procedure. There may be several implementations regarding the error handling procedure in different implementations. In one implementation, the error handling procedure may include action **610**, in which the UE may store the SI request failure information. For example, the SI request failure information may include one or more parameters used in the on-demand SI request procedure. In one implementation, the error handling procedure may further include at least one of following: a prohibit timer activation, a cell re-selection procedure, and a re-establishment procedure.

FIG. **7** illustrates a block diagram of a node for wireless communication, in accordance with various aspects of the present application. As shown in FIG. **7**, node **700** may include transceiver **720**, processor **726**, memory **728**, one or more presentation components **734**, and at least one antenna **736**. Node **700** 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 FIG. **7**). Each of these components may be in communication with each other, directly or indirectly, over one or more buses **740**.

Transceiver **720** having transmitter **722** and receiver **724** may be configured to transmit and/or receive time and/or frequency resource partitioning information. In some implementations, transceiver **720** 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 **720** may be configured to receive data and control channels.

Node **700** may include a variety of computer-readable media. Computer-readable media can be any available media that can be accessed by node **700** 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.

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.

Memory **728** may include computer-storage media in the form of volatile and/or non-volatile memory. Memory **728** 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 FIG. **7**, memory **728** may store computer-readable, computer-executable instructions **732** (e.g., software codes) that are configured to, when executed, cause processor **726** to perform various functions described herein, for example, with reference to FIGS. **1** through **6**. Alternatively, instructions **732** may not be directly executable by processor **726** but be configured to cause node **700** (e.g., when compiled and executed) to perform various functions described herein.

Processor **726** may include an intelligent hardware device, e.g., a central processing unit (CPU), a microcontroller, an ASIC, and etc. Processor **726** may include memory. Processor **726** may process data **730** and instructions **732** received from memory **728**, and information through transceiver **720**, the base band communications module, and/or the network communications module. Processor **726** may also process information to be sent to

transceiver **720** for transmission through antenna **736**, to the network communications module for transmission to a core network.

One or more presentation components **734** presents data indications to a person or other device. Exemplary one or more presentation components **734** include a display device, speaker, printing component, vibrating component, and etc.

From the above description, it is manifest that various techniques can be used for implementing the concepts described in the present application 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 application 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.

What is claimed is:

**1**. A method of an on-demand system information (SI) request procedure performed by a user equipment (UE), the method comprising:

transmitting a first SI request message to a base station (BS) after determining that the UE is in a connected state, the first SI request message including at least one requested system information block (SIB);

activating a prohibit timer; and

transmitting a second SI request message to the BS only when the at least one requested SIB is not received and the prohibit timer expires.

**2**. The method of claim **1**, wherein the on-demand SI request procedure is unsuccessful when one of the following conditions is met:

a number of times the UE transmits a random access preamble reaches a threshold; and

the UE receives SI request rejection information.

**3**. The method of claim **1**, wherein when the UE is in a dual connectivity mode, the method further comprises:

transmitting a third SI request message to a master node when the UE requires on-demand system information of a cell belonging to a secondary node.

**4**. The method of claim **1**, wherein the first SI request message is transmitted on signaling radio bearer **1** (SRB1).

**5**. The method of claim **1**, further comprising:

receiving, from the BS, the at least one requested SIB via dedicated signaling that is transmitted in response to the first SI request message.

**6**. The method of claim **1**, further comprising:

transmitting a fourth SI request message to the BS after determining that the UE is not in the connected state, the fourth SI request message including at least one requested SI message.

**7**. The method of claim **6**, wherein the fourth SI request message is transmitted on signaling radio bearer 0 (SRB0).

**8**. The method of claim **1**, further comprising:

storing SI request failure information after determining that the on-demand SI request procedure is unsuccessful.

**9**. The method of claim **8**, wherein the SI request failure information comprises at least one of the following:

the at least one requested SIB;

the at least one requested SI message;

a cell identifier (ID) associated with the BS;

a synchronization signal block (SSB) index for performing the on-demand SI request procedure;

a message type of the on-demand SI request procedure; and

a timestamp for performing the on-demand SI request procedure.

**10**. The method of claim **8**, further comprising:

transmitting the SI request failure information;

wherein the SI request failure information is transmitted to a master node when the UE is in a dual connectivity mode.

**11**. A user equipment (UE), comprising:

one or more non-transitory computer-readable media having computer-executable instructions embodied thereon; 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 perform operations for an on-demand system information (SI) request procedure, the operations comprising:

transmitting a first SI request message to a base station (BS) after determining that the UE is in a connected state, the first SI request message including at least one requested system information block (SIB);

activating a prohibit timer; and

transmitting a second SI request message to the BS only when the at least one requested SIB is not received and the prohibit timer expires.

**12**. The UE of claim **11**, wherein the on-demand SI request procedure is unsuccessful when one of the following conditions is met:

a number of times the UE transmits a random access preamble reaches a threshold; and

the UE receives SI request rejection information.

**13**. The UE of claim **11**, wherein when the UE is in a dual connectivity mode, the operations further comprise:

transmitting a third SI request message to a master node when the UE requires on-demand system information of a cell belonging to a secondary node.

**14**. The UE of claim **11**, wherein the first SI request message is transmitted on signaling radio bearer 1 (SRB1).

**15**. The UE of claim **11**, wherein the operations further comprise:

receiving, from the BS, the at least one requested SIB via dedicated signaling that is transmitted in response to the first SI request message.

**16**. The UE of claim **11**, wherein the operations further comprise:

transmitting a fourth SI request message to the BS after determining that the UE is not in the connected state, the fourth SI request message including at least one requested SI message.

**17**. The UE of claim **16**, wherein the fourth SI request message is transmitted on signaling radio bearer 0 (SRB0).

**18**. The UE of claim **11**, wherein the operations further comprise:

storing SI request failure information after determining that the on-demand SI request procedure is unsuccessful.

**19**. The UE of claim **18**, wherein the SI request failure information comprises at least one of the following:

the at least one requested SIB;

the at least one requested SI message;

a cell identifier (ID) associated with the BS;

a synchronization signal block (SSB) index for performing the on-demand SI request procedure;

a message type of the on-demand SI request procedure; and

a timestamp for performing the on-demand SI request procedure.

**20**. The UE of claim **18**, wherein the operations further comprise:

transmitting the SI request failure information;

wherein the SI request failure information is transmitted to a master node when the UE is in a dual connectivity mode.

* * * * *

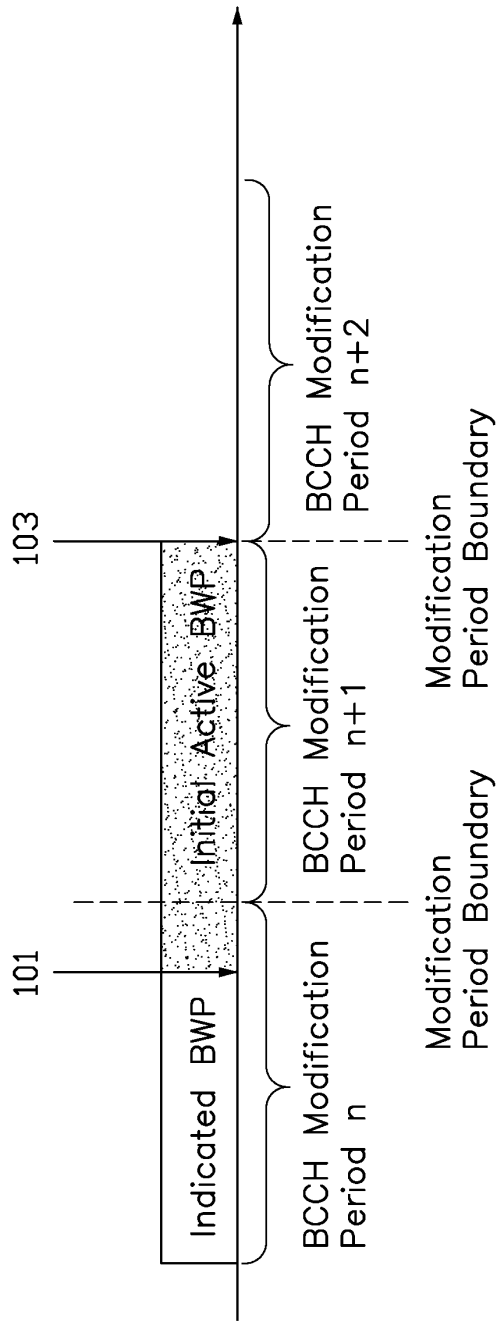

101
103
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 1

# Exhibit 3

(12) **United States Patent**
**Cheng et al.**

(10) **Patent No.: US 10,972,972 B2**
(45) **Date of Patent: Apr. 6, 2021**

(54) **METHODS AND APPARATUSES FOR OPERATING MULTIPLE ANTENNA PANELS**

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(73) Assignee: **FG Innovation Company Limited**, Tuen Mun (HK)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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**Related U.S. Application Data**

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(51) **Int. Cl.**

| | |
|---|---|
| ***H04W 48/20*** | (2009.01) |
| ***H04W 76/28*** | (2018.01) |
| ***H04W 52/02*** | (2009.01) |
| ***H04B 17/309*** | (2015.01) |
| ***H04W 24/10*** | (2009.01) |
| ***H04W 72/04*** | (2009.01) |

(52) **U.S. Cl.**

CPC ..... ***H04W 48/20*** (2013.01); ***H04B 17/309*** (2015.01); ***H04W 24/10*** (2013.01); ***H04W 52/0216*** (2013.01); ***H04W 72/042*** (2013.01); ***H04W 76/28*** (2018.02)

(58) **Field of Classification Search**

CPC ..... H04W 48/20; H04W 76/28; H04W 24/10; H04W 52/0216; H04W 72/042; H04B 17/309

See application file for complete search history.

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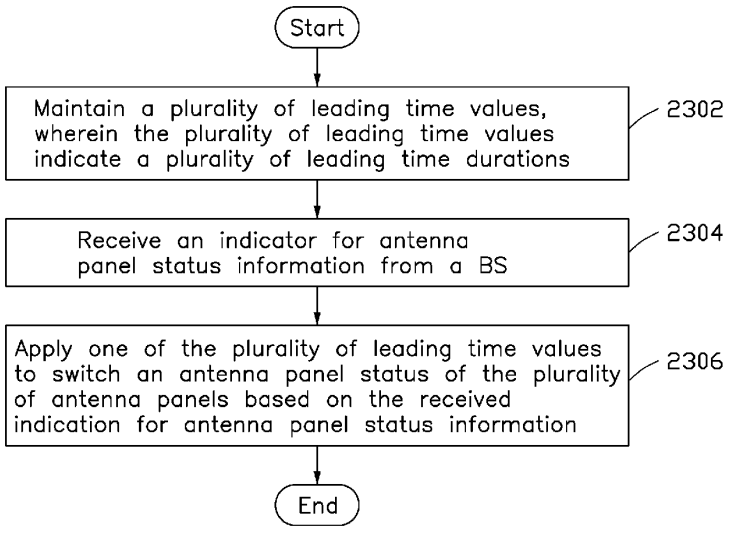
(57) **ABSTRACT**

Methods and apparatuses for operating multiple antenna panels are provided. The wireless communication device includes a plurality of antenna panels and a processor coupled to the antenna panels. The processor is configured to maintain a plurality of leading time values. The plurality of leading time values may indicate a plurality of leading time durations. The processor is further configured to receive an indicator for antenna panel status information from a base station, and apply one of the plurality of leading time values to switch an antenna panel status of the plurality of antenna panels based on the indicator for antenna panel status information.

**28 Claims, 27 Drawing Sheets**



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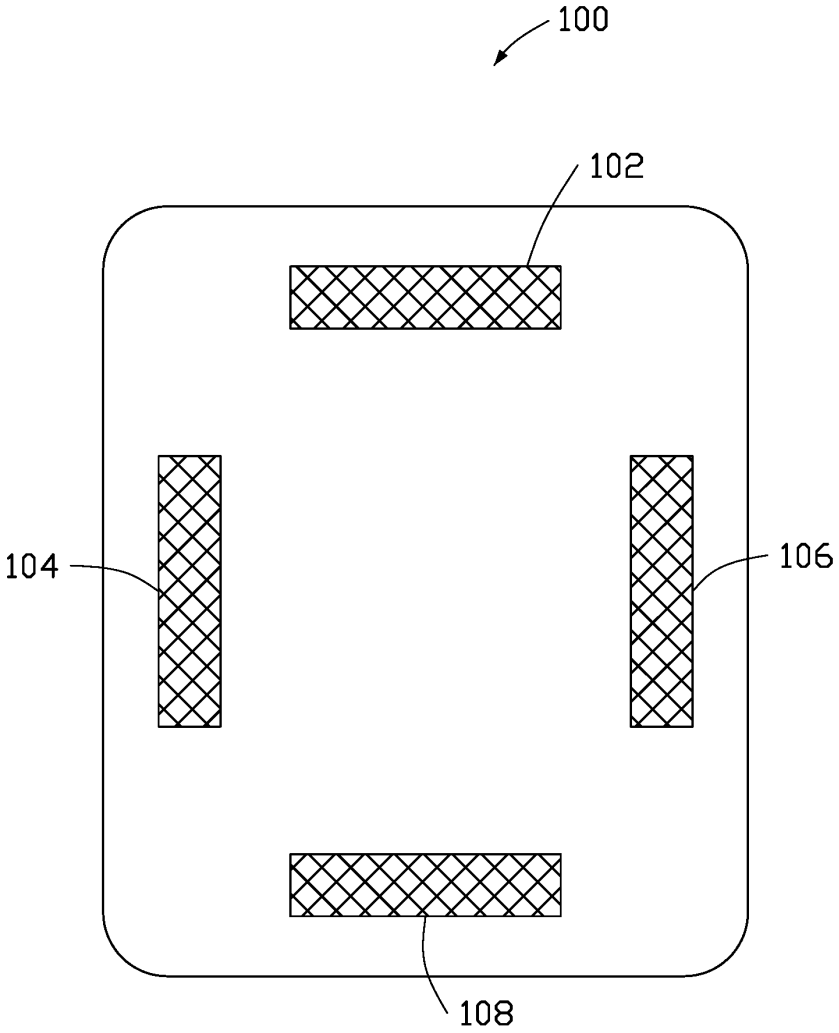


FIG. 1

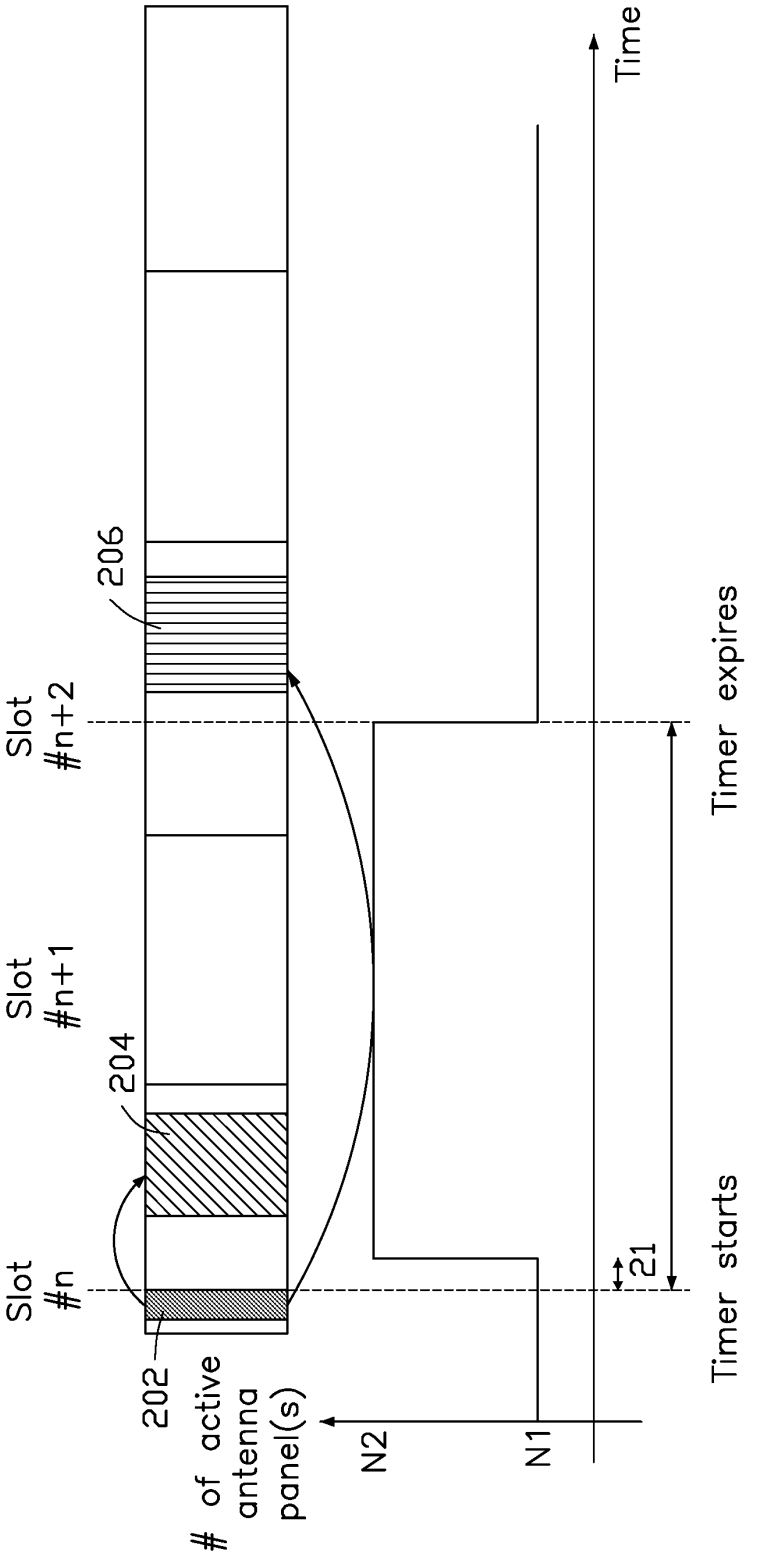
Time
206
Slot #n+2
Timer expires
Slot #n+1
204
Slot #n
Timer starts
21
202
# of active antenna panel(s)
N2
N1

FIG. 2

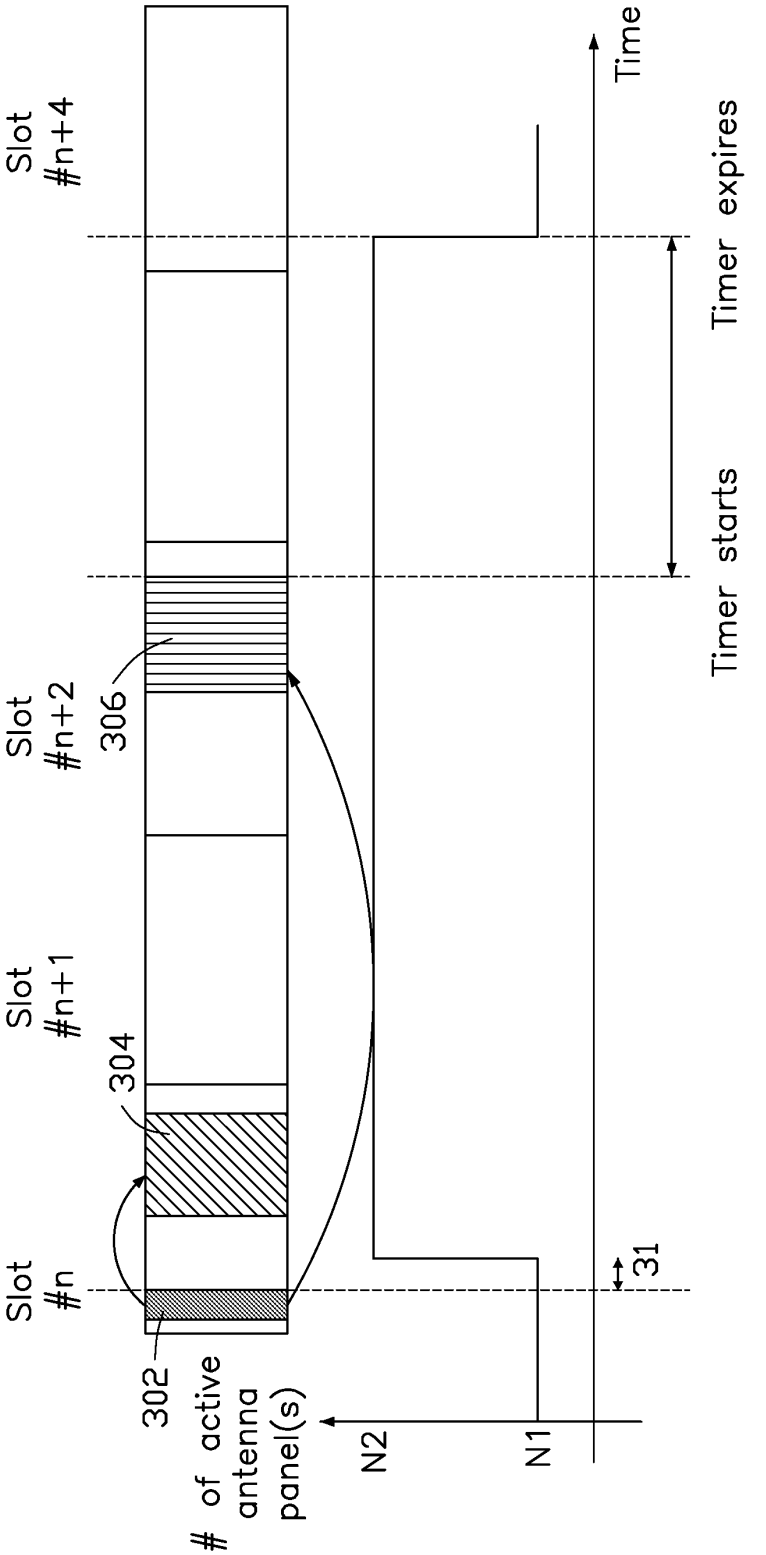
Time
Slot #n+4
Slot #n+2
Slot #n+1
Slot #n
Timer expires
Timer starts
306
304
302
31
# of active antenna panel(s)
N2
N1

FIG. 3

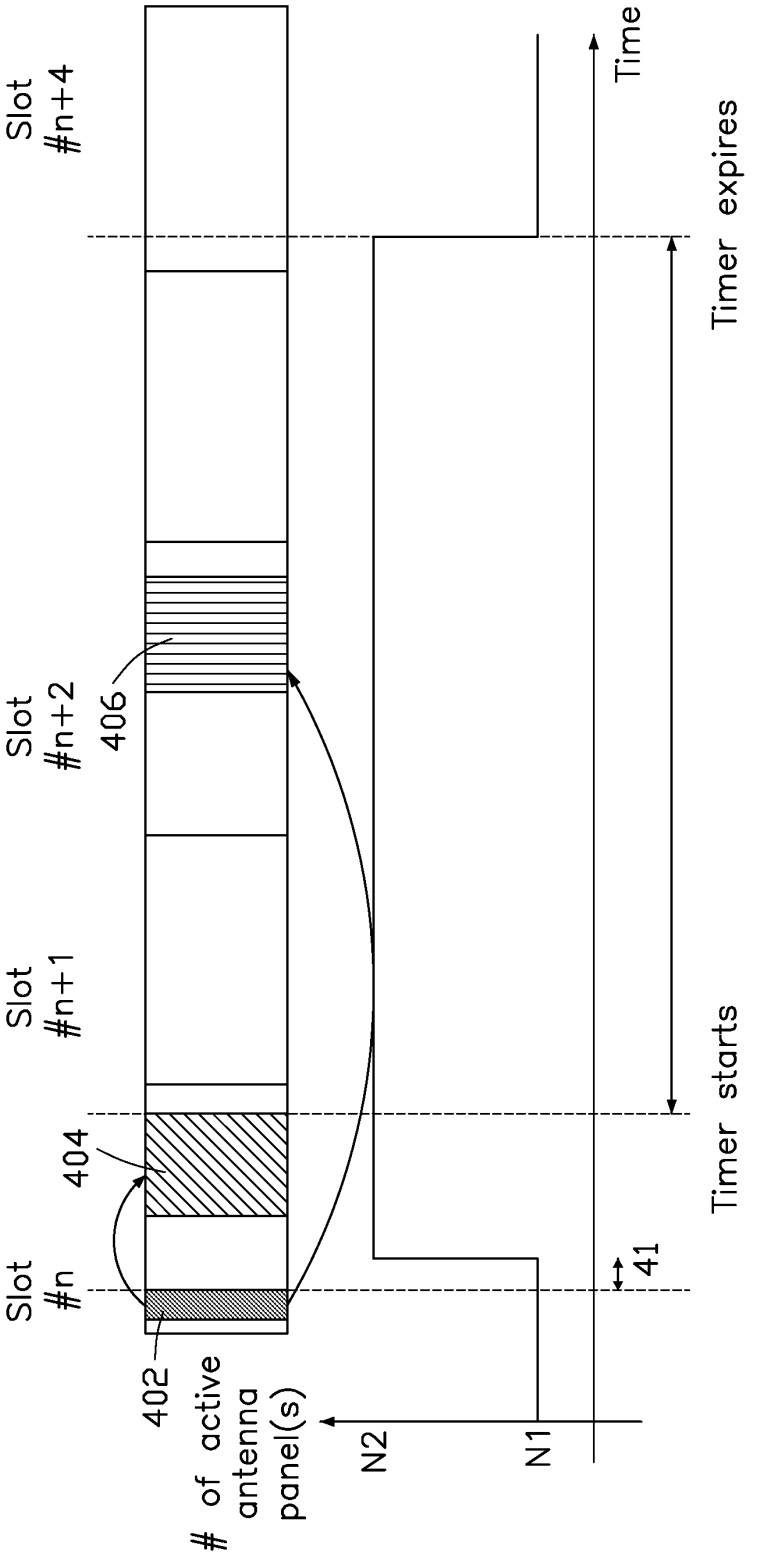
Slot #n+4
Slot #n+2
406
Slot #n+1
Slot #n
404
402
# of active antenna panel(s)
N2
N1
Time
Timer expires
Timer starts
41

FIG. 4

502

- UE capability
  - power saving indicator
    - {True/Support, False/Not support}
  - timer for antenna panel status
    - {True/Support, False/Not support}
  - maximum number of support antenna panels
    - {one, two, four or eight}
  - support indication method
    - {True/Support, False/Not support}
  - require time for antenna panel status switch
    - {1ms, 2ms, 3ms, 4ms}
  - UE assistance
    - {True/Support, False/Not support}

FIG. 5

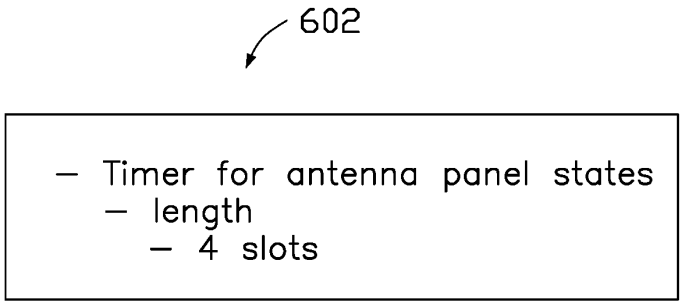


FIG. 6

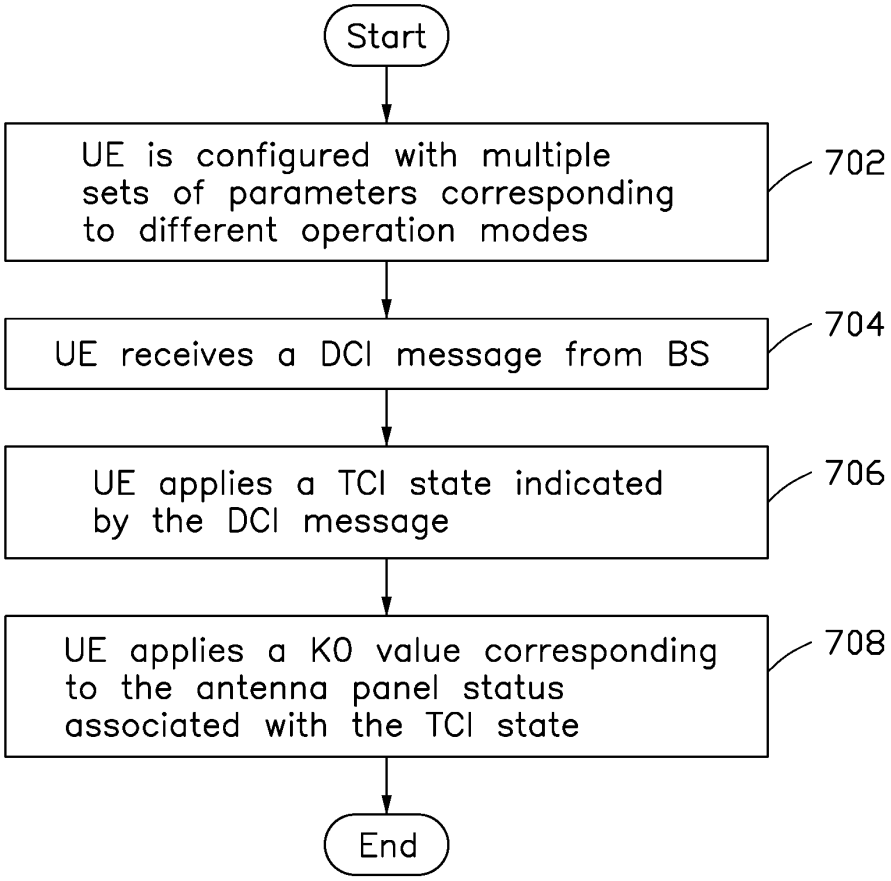
Start
UE is configured with multiple sets of parameters corresponding to different operation modes
702
UE receives a DCI message from BS
704
UE applies a TCI state indicated by the DCI message
706
UE applies a K0 value corresponding to the antenna panel status associated with the TCI state
708
End

FIG. 7

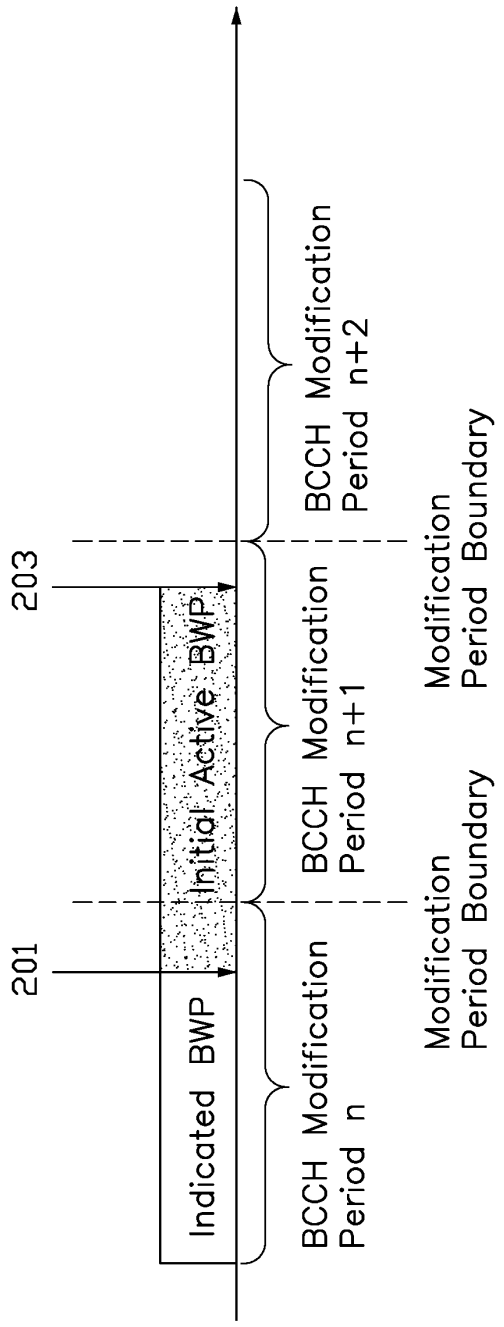
201
203
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 2

- tci-State #1
  - qcl-Type1
    - referenceSignal
      - CSI RS resource#4
    - qcl-TypeA
  - qcl-Type2
    - referenceSignal
      - CSI RS resource#5
    - qcl-TypeA
  - power saving mode
    - true

⋮

- tci-State #64
  - qcl-Type1
    - referenceSignal
      - CSI RS resource#4
    - qcl-TypeA
  - qcl-Type2
    - referenceSignal
      - CSI RS resource#5
    - qcl-TypeA
  - power saving mode
    - false

FIG. 8

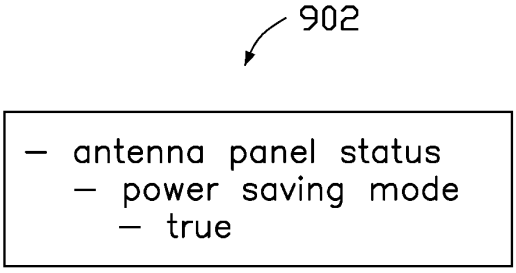


FIG. 9

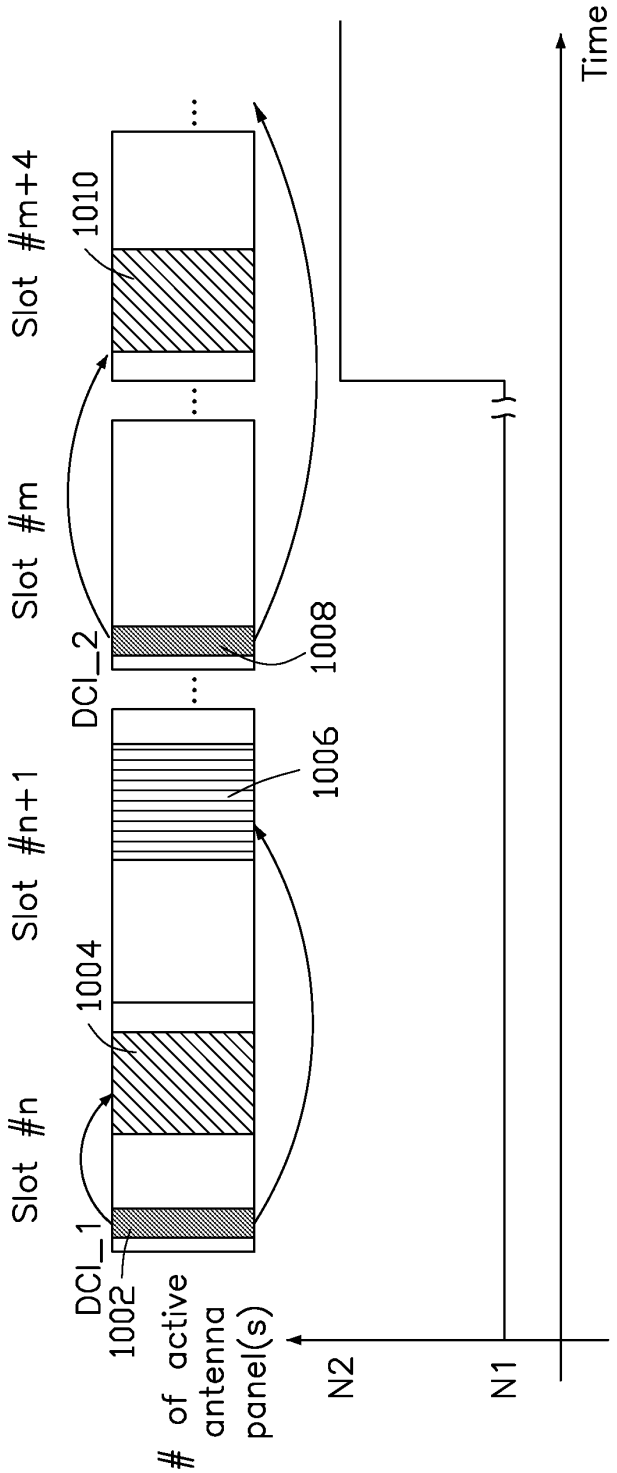
Time
Slot #n
Slot #n+1
Slot #m
Slot #m+4
1004
1006
1008
1010
DCI_1
1002
DCI_2
# of active antenna panel(s)
N2
N1

FIG. 10A

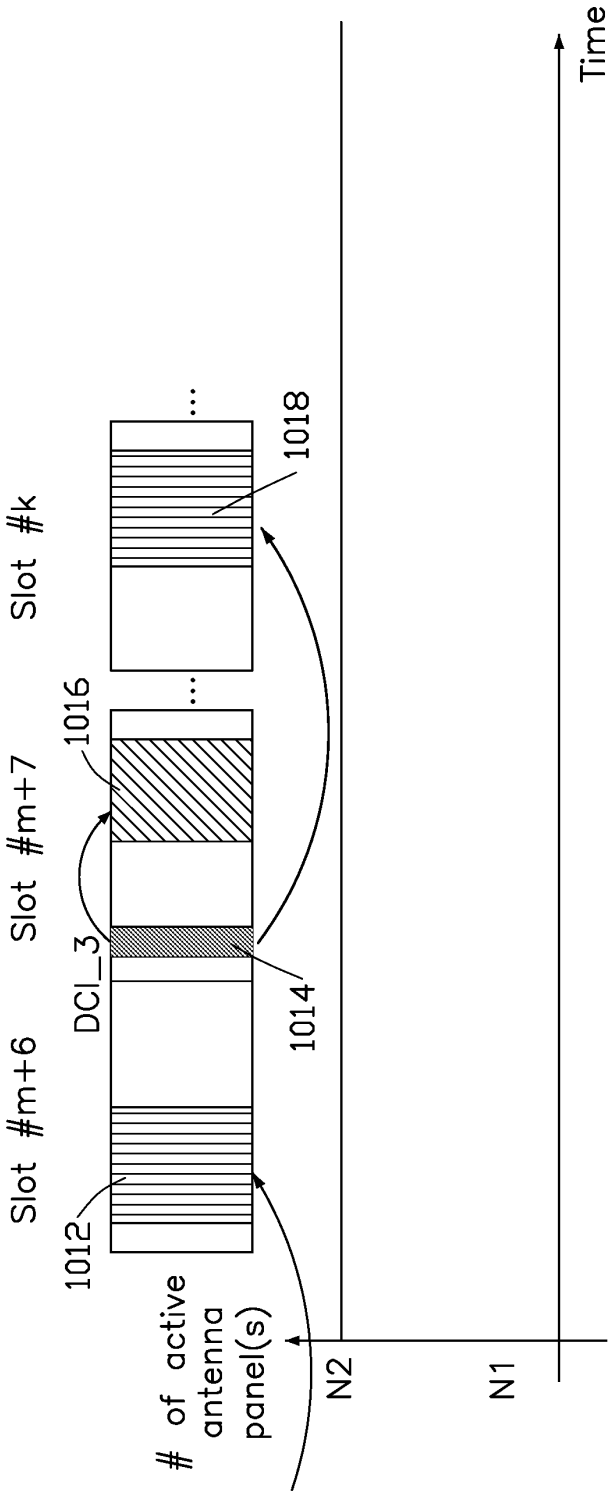
Time
Slot #k
Slot #m+7
Slot #m+6
1018
1016
1014
1012
DCI_3
# of active antenna panel(s)
N2
N1

FIG. 10B

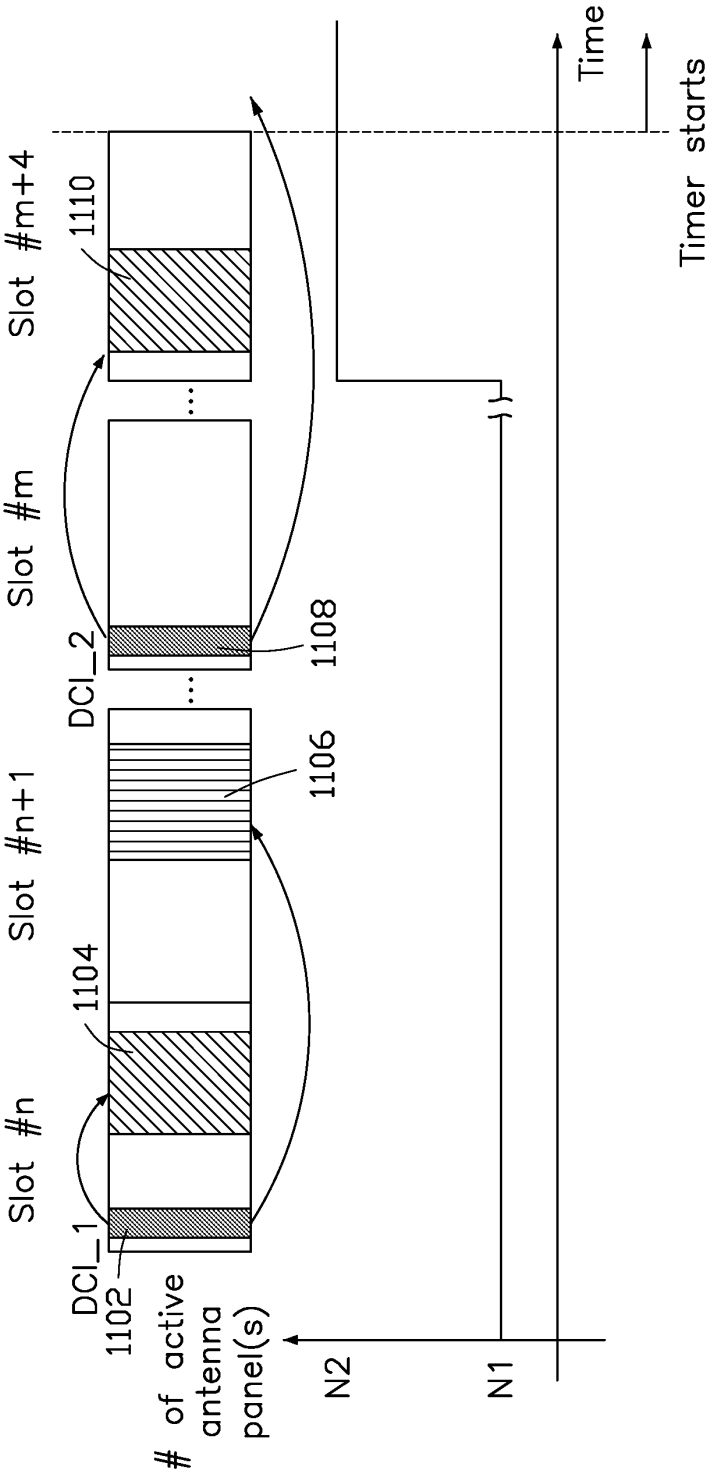
Time
Timer starts
Slot #m+4
Slot #m
Slot #n+1
Slot #n
1110
1108
1106
1104
1102
DCI_2
DCI_1
# of active antenna panel(s)
N2
N1

FIG. 11A

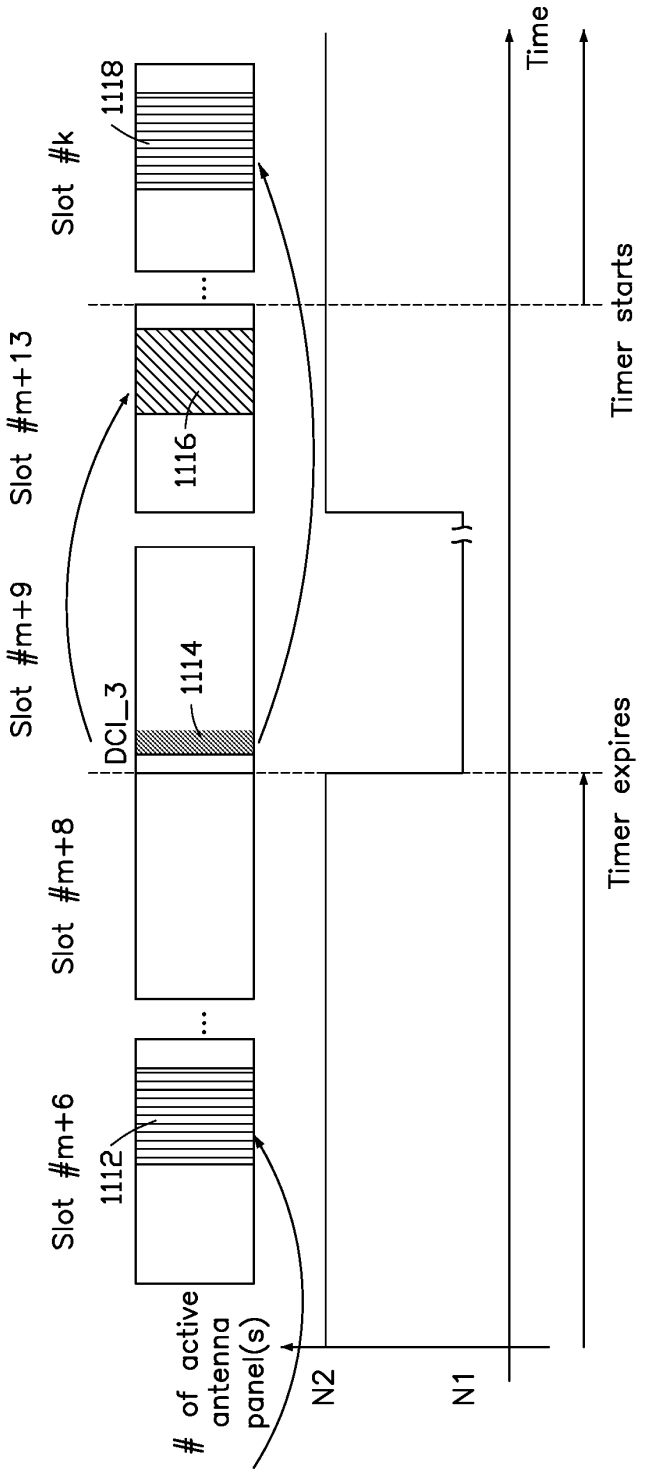
Time
Slot #k
1118
Slot #m+13
1116
Slot #m+9
DCI_3
1114
Slot #m+8
Slot #m+6
1112
# of active antenna panel(s)
N2
N1
Timer starts
Timer expires

FIG. 11B

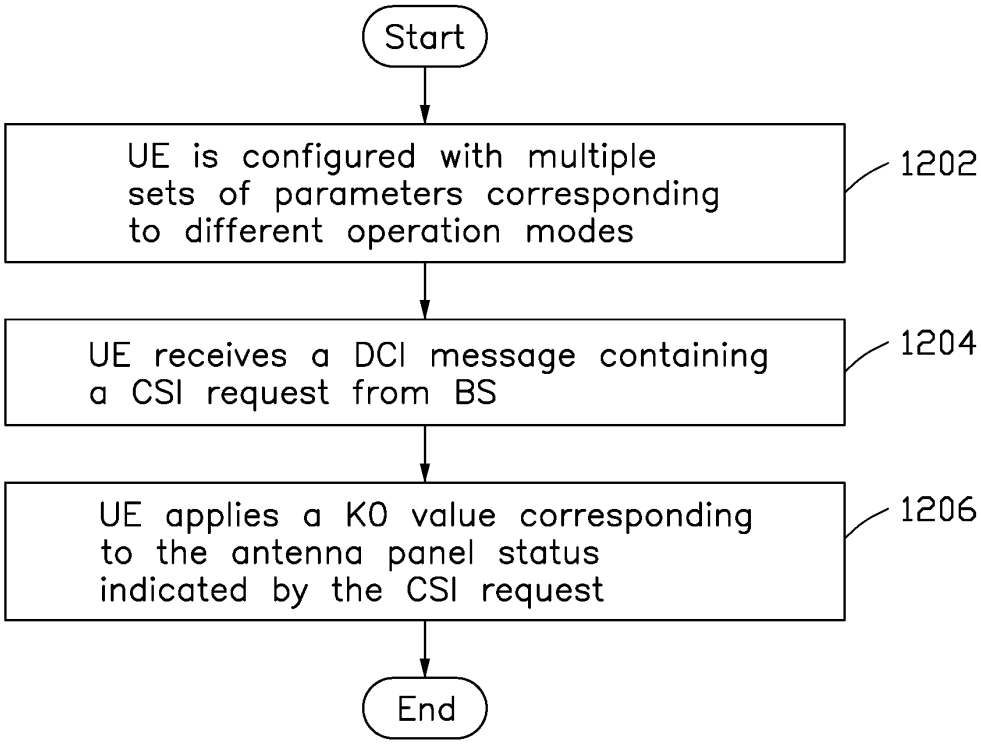
Start
UE is configured with multiple sets of parameters corresponding to different operation modes
1202
UE receives a DCI message containing a CSI request from BS
1204
UE applies a K0 value corresponding to the antenna panel status indicated by the CSI request
1206
End

FIG. 12

1302

- NZP-CSI-RS-ResourceSet
  - aperiodicTriggeringOffset
    - index:10

1304

| Row index | K0(normal,long) |
|---|---|
| 00 | (0 slot, 4 slots) |
| 01 | (1 slot, 4 slots) |
| 10 | (2 slot, 6 slots) |
| 11 | (3 slot, 7 slots) |

FIG. 13

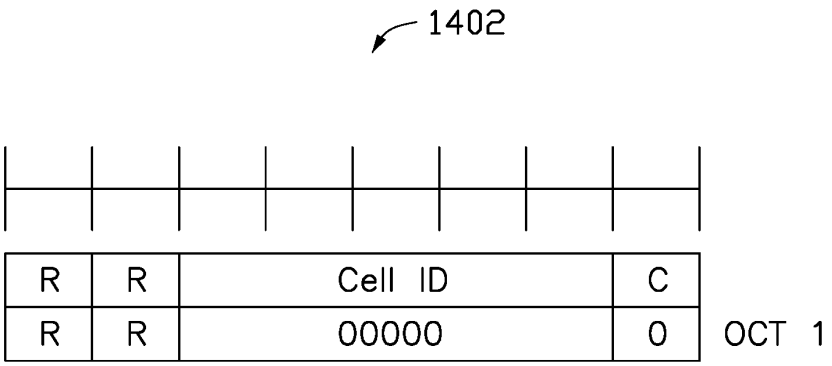


FIG. 14

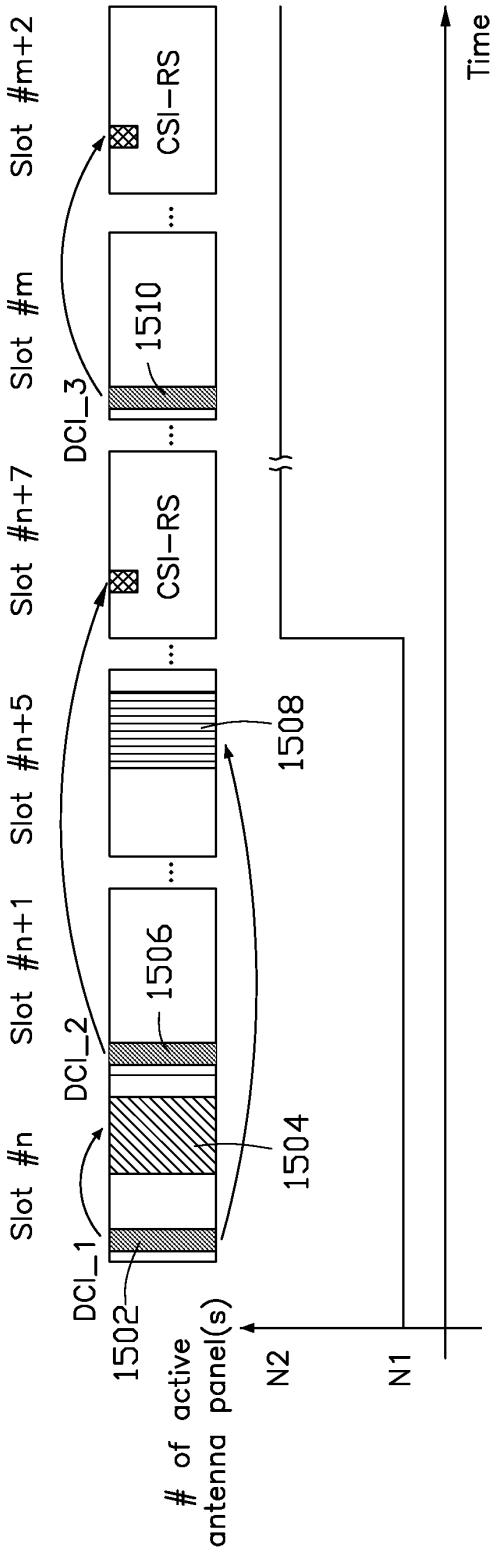
Slot #n
Slot #n+1
Slot #n+5
Slot #n+7
Slot #m
Slot #m+2
Time
DCI_1
DCI_2
DCI_3
1502
1504
1506
1508
1510
CSI-RS
CSI-RS
# of active antenna panel(s)
N2
N1

FIG. 15

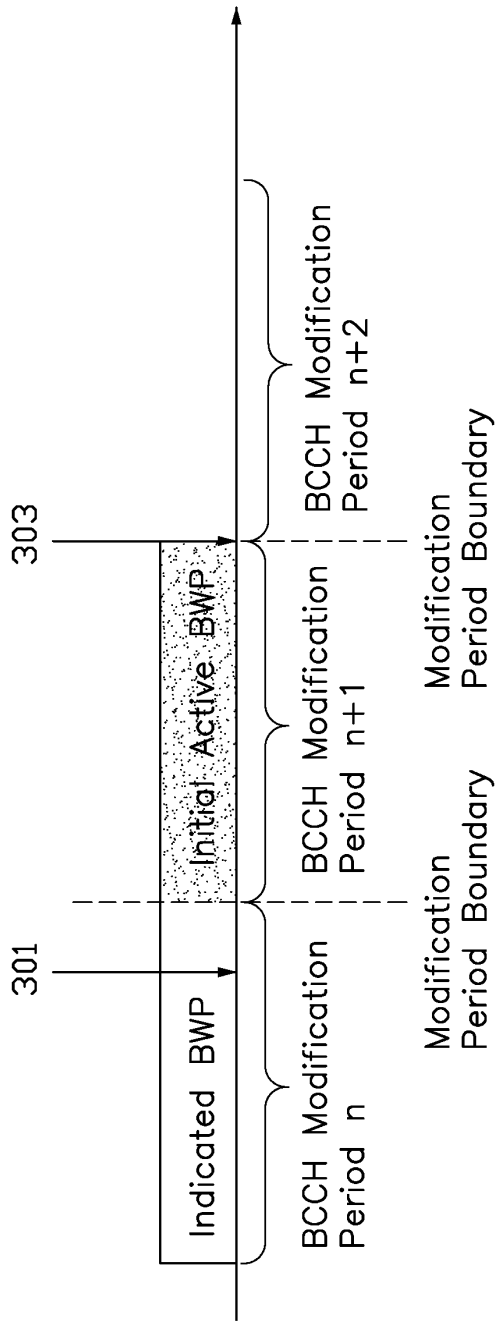
301
303
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 3

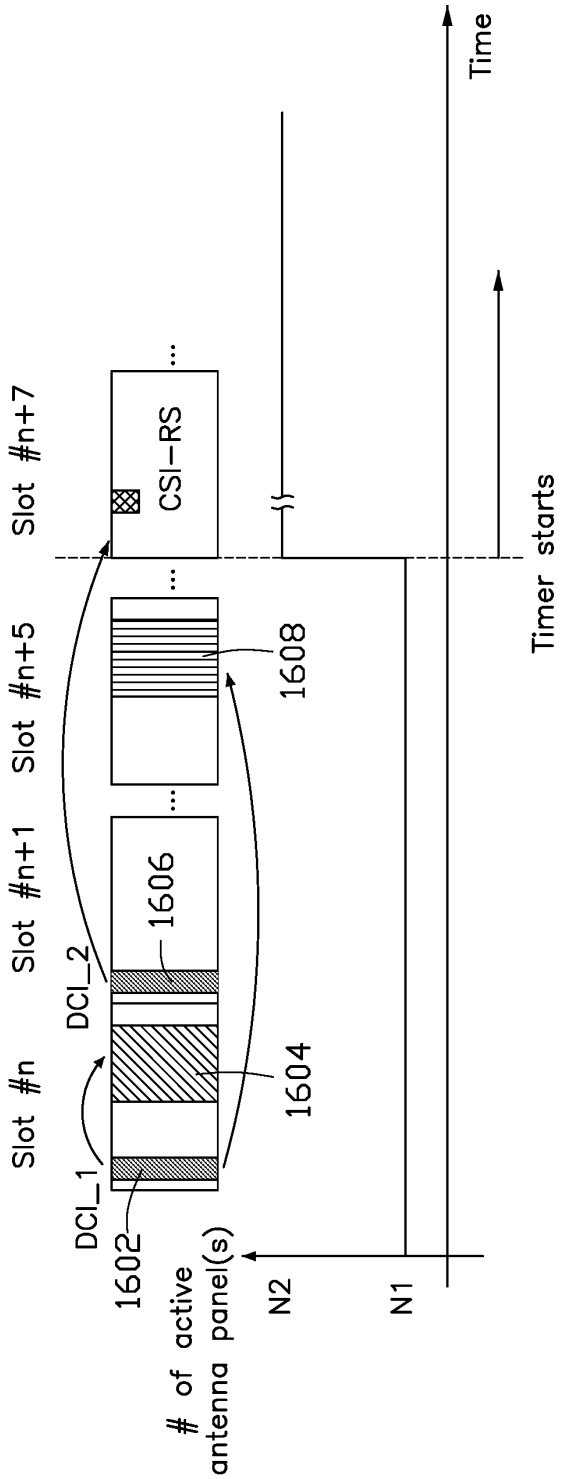
Time
Slot #n+7
CSI-RS
Slot #n+5
1608
Timer starts
Slot #n+1
1606
DCI_2
Slot #n
1604
DCI_1
1602
# of active antenna panel(s)
N2
N1

FIG. 16A

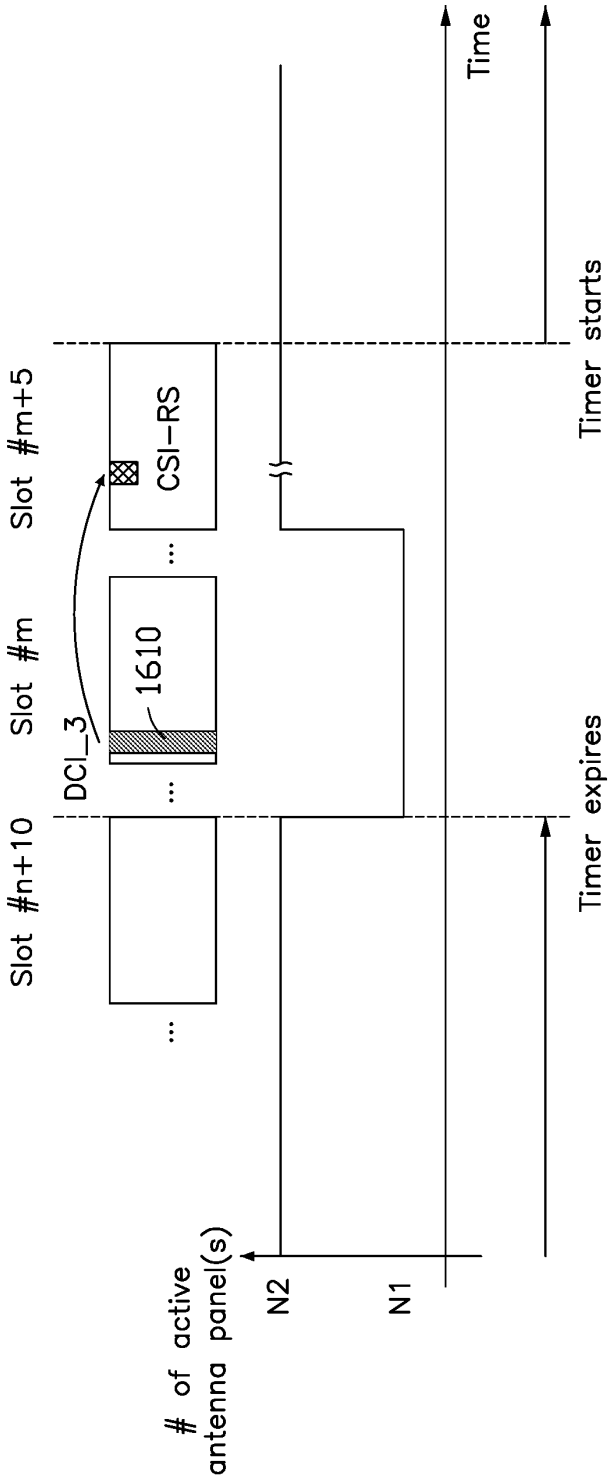
Time
Timer starts
Timer expires
Slot #n+10
Slot #m
Slot #m+5
DCI_3
1610
CSI-RS
N2
N1
# of active antenna panel(s)

FIG. 16B

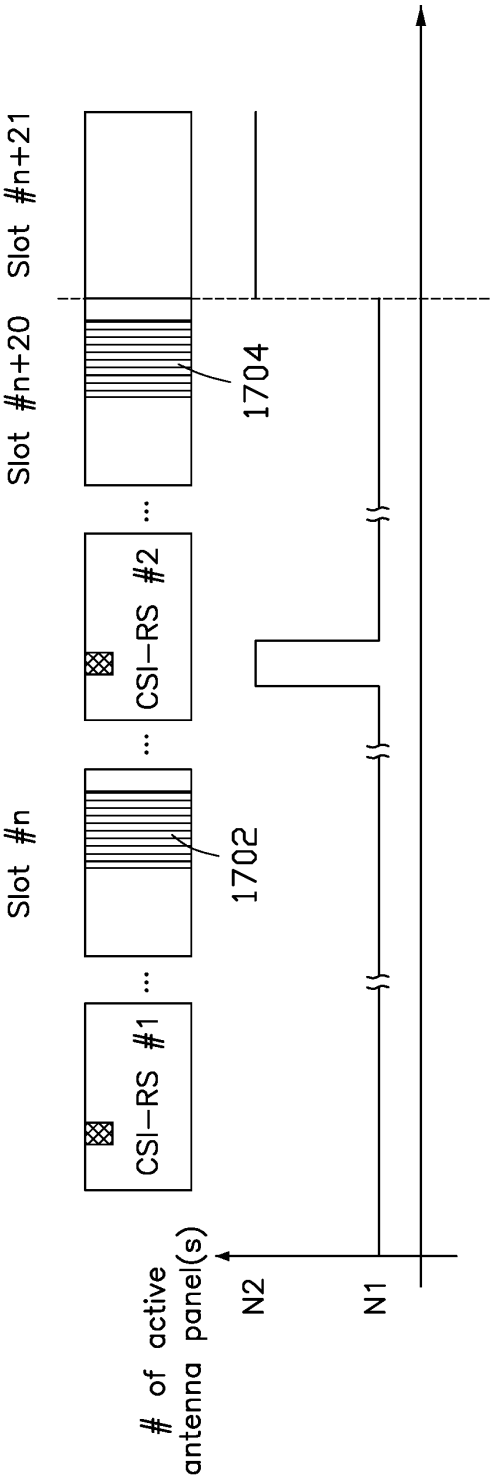
Slot #n
Slot #n+20
Slot #n+21
CSI-RS #1
CSI-RS #2
1702
1704
# of active antenna panel(s)
N1
N2

FIG. 17

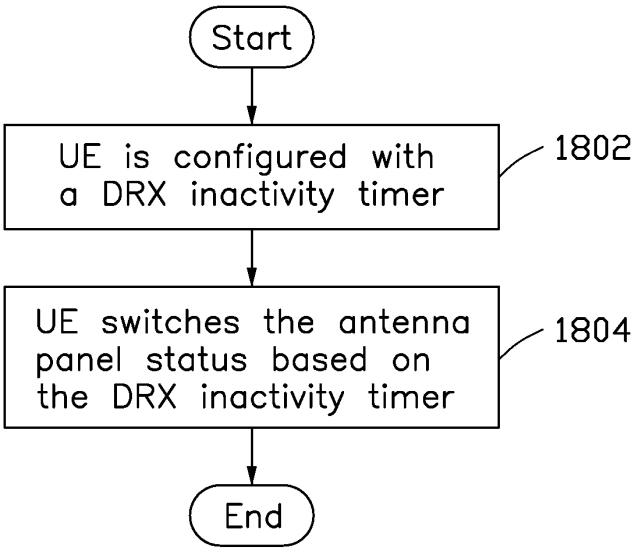
Start
UE is configured with a DRX inactivity timer
1802
UE switches the antenna panel status based on the DRX inactivity timer
1804
End

FIG. 18

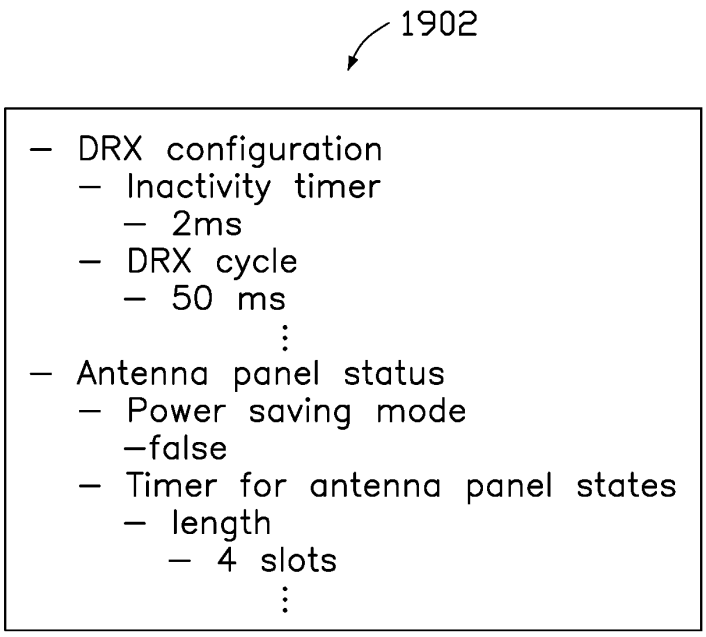
1902
– DRX configuration
– Inactivity timer
– 2ms
– DRX cycle
– 50 ms
– Antenna panel status
– Power saving mode
–false
– Timer for antenna panel states
– length
– 4 slots

FIG. 19

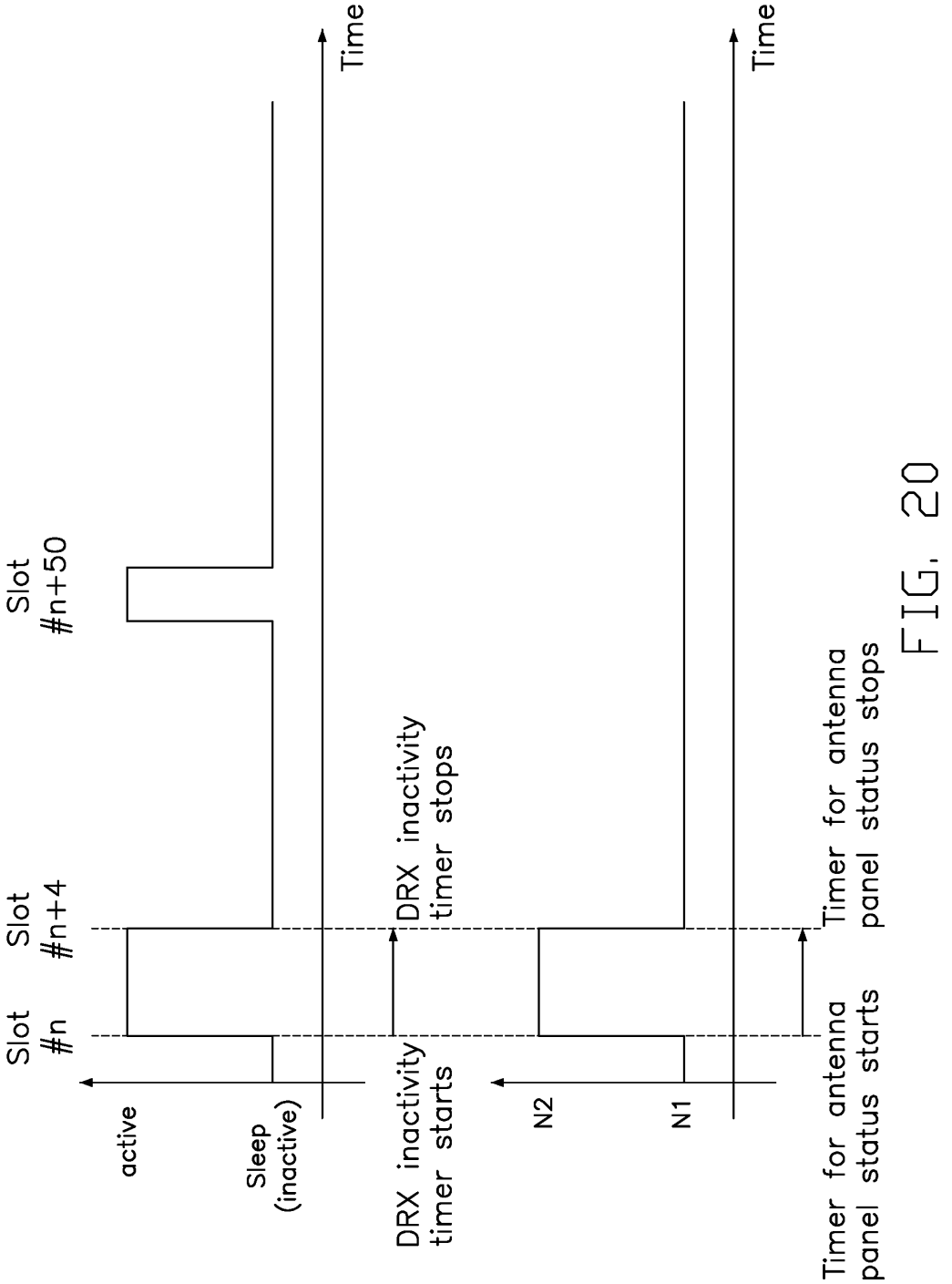
Slot #n
Slot #n+4
Slot #n+50
Time
active
Sleep (inactive)
DRX inactivity timer starts
DRX inactivity timer stops
N2
N1
Time
Timer for antenna panel status starts
Timer for antenna panel status stops

FIG. 20

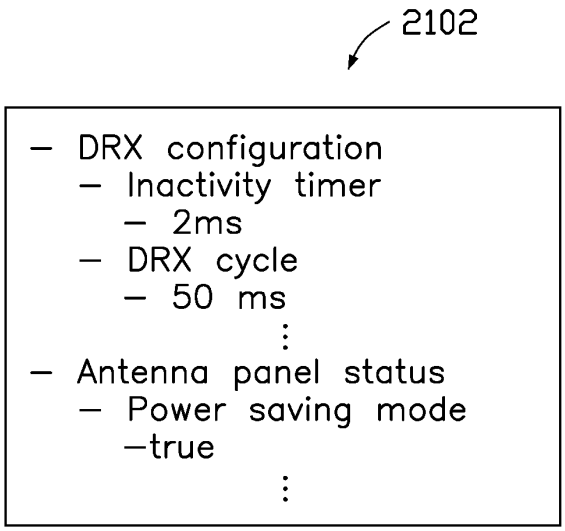
2102
– DRX configuration
– Inactivity timer
– 2ms
– DRX cycle
– 50 ms
⋮
– Antenna panel status
– Power saving mode
–true
⋮

FIG. 21

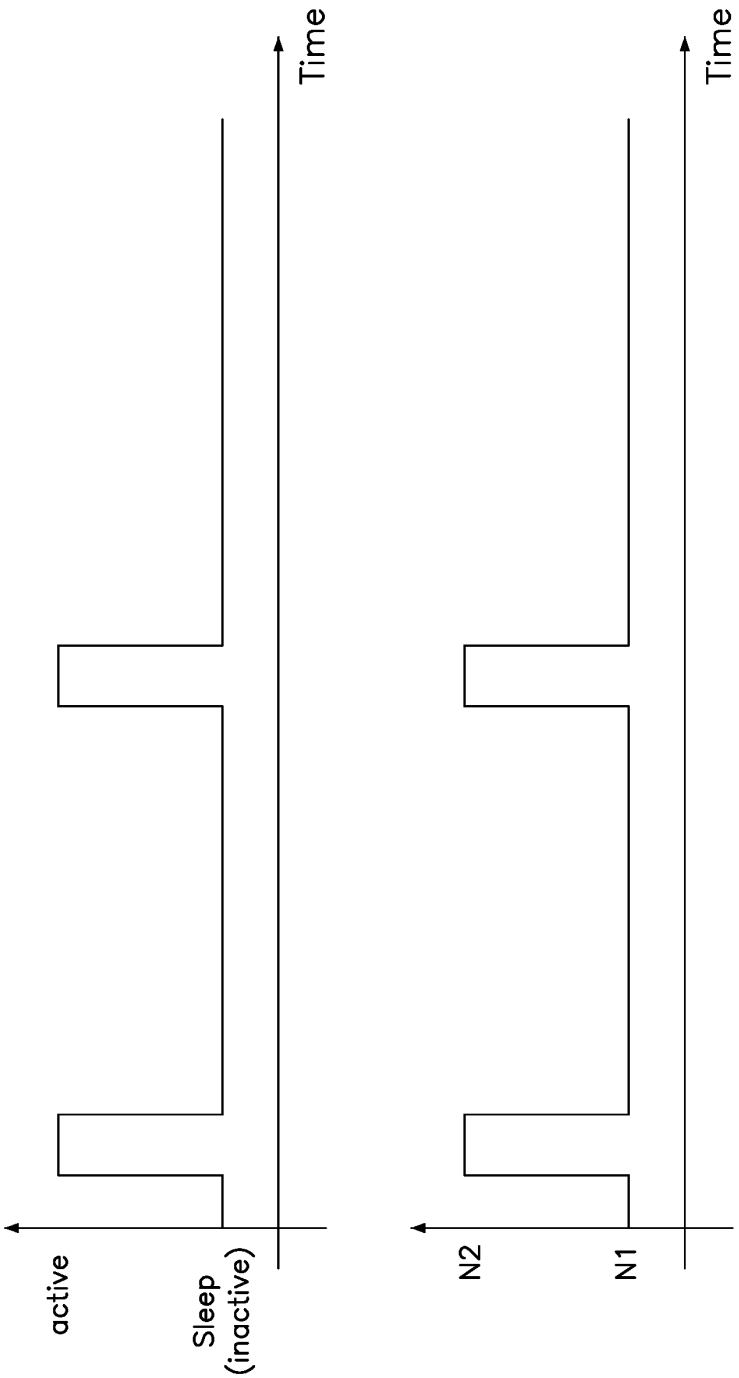


FIG. 22

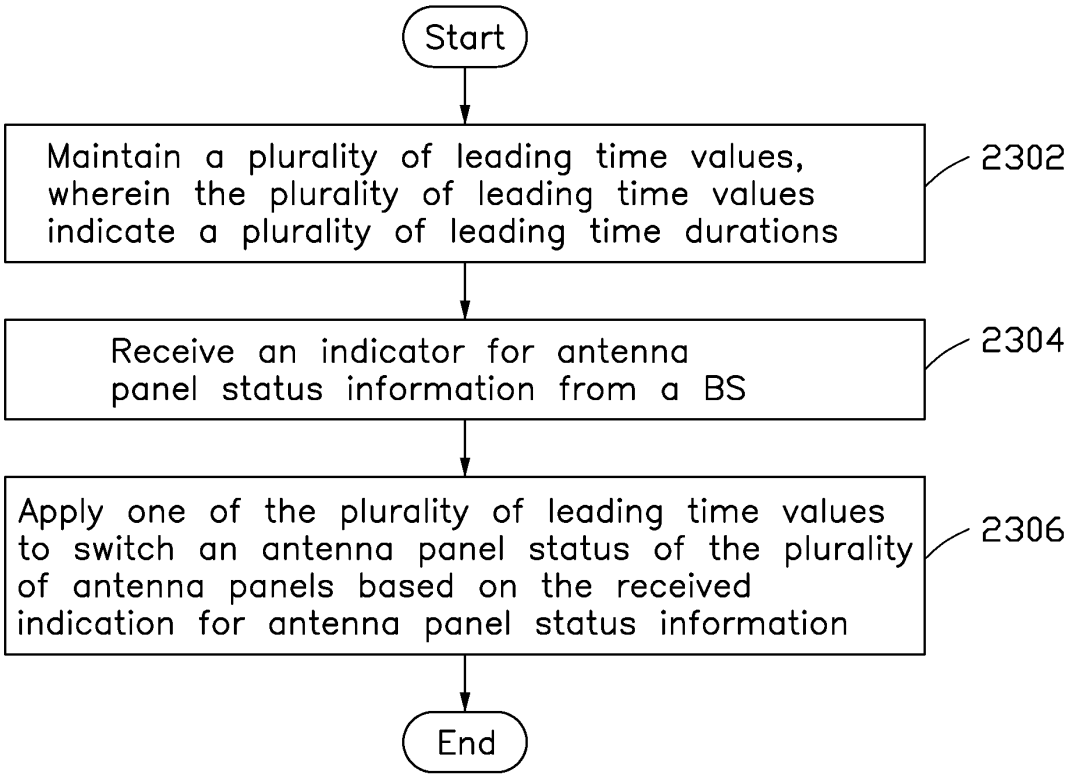
Start
Maintain a plurality of leading time values, wherein the plurality of leading time values indicate a plurality of leading time durations
2302
Receive an indicator for antenna panel status information from a BS
2304
Apply one of the plurality of leading time values to switch an antenna panel status of the plurality of antenna panels based on the received indication for antenna panel status information
2306
End

FIG. 23

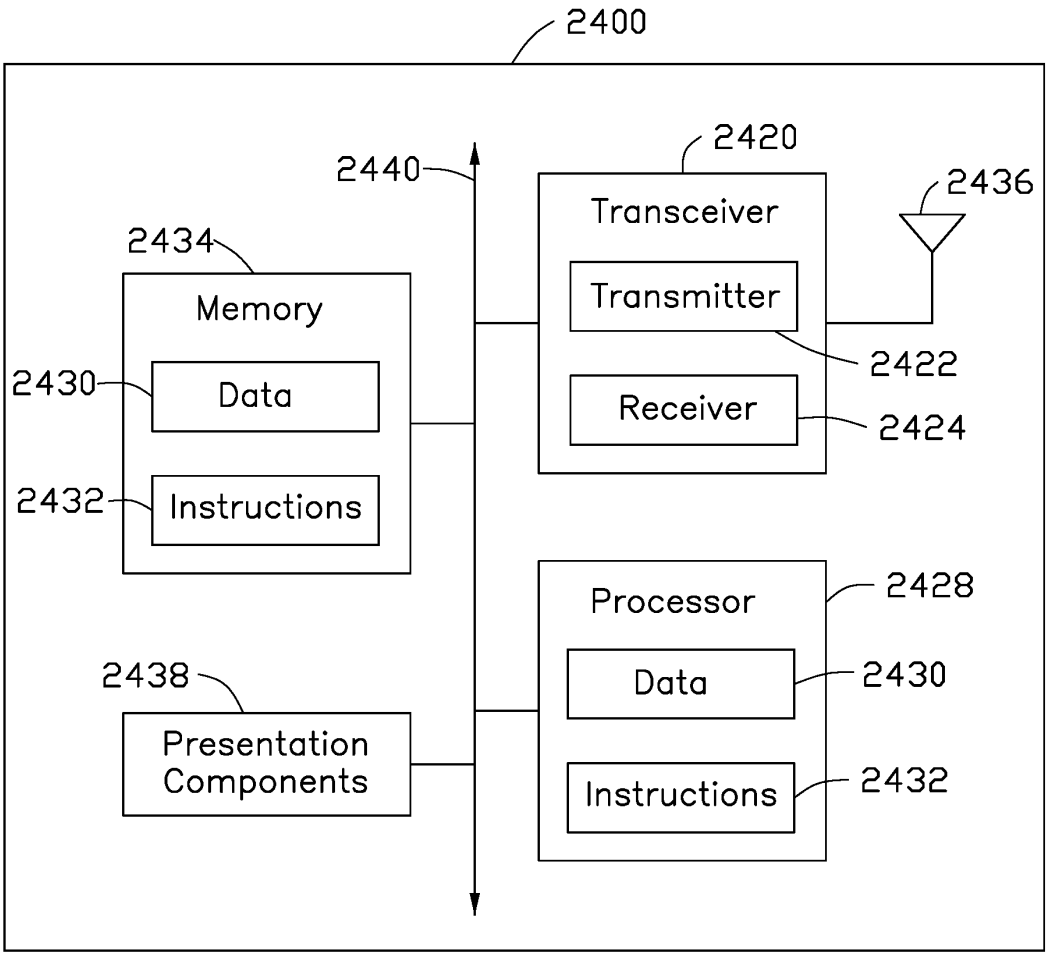
2400
2440
2420
Transceiver
2436
2434
Memory
Transmitter
2422
2430
Data
Receiver
2424
2432
Instructions
Processor
2428
2438
Data
2430
Presentation Components
Instructions
2432

FIG. 24

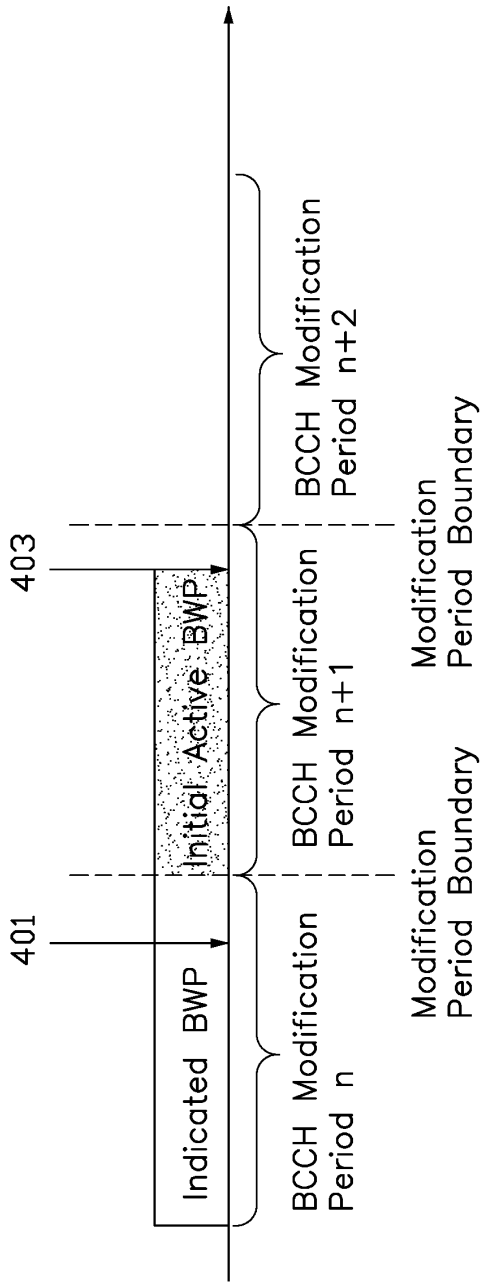
401
403
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 4

# METHODS AND APPARATUSES FOR OPERATING MULTIPLE ANTENNA PANELS

## CROSS-REFERENCE TO RELATED APPLICATION(S)

The present application claims the benefit of and priority to a provisional U.S. Patent Application Ser. No. 62/699,465 filed on Jul. 17, 2018, entitled "Method and Apparatus for leading time of beam switching for multi-panel transmission,".

## FIELD

The present disclosure generally relates to wireless communications, and more particularly, to methods and apparatuses for operating multiple antenna panels.

## BACKGROUND

Various efforts have been made to improve different aspects of wireless communications (e.g., data rate, latency, reliability, mobility, etc.) for the next generation (e.g., 5G New Radio (NR)) wireless communication systems. Multi Input Multi Output (MIMO) is one of the key features in the next generation wireless communication systems. With the MIMO technology, a number of antenna panels at the transceiver/receiver can bring extra degrees of freedom to increase the data throughput, beamforming gain and coverage.

However, due to the lack of proper signaling mechanisms, the network may not know the current antenna panel status (e.g., how many and/or which of the antenna panels of the user device is turned on/off) at the UE side, resulting in a reduced scheduling performance.

Hence, there is a need in the art for an improved signaling mechanism for operating multiple antenna panels.

## SUMMARY

The present disclosure is directed to methods and apparatuses for operating multiple antenna panels.

According to an aspect of the present disclosure, a wireless communication device is provided. The wireless communication device includes a plurality of antenna panels and a processor coupled to the antenna panels. The processor is configured to maintain a plurality of leading time values. The plurality of leading time values may indicate a plurality of leading time durations. The processor is further configured to receive an indicator for antenna panel status information from a base station (BS), and apply one of the plurality of leading time values to switch an antenna panel status of the plurality of antenna panels based on the indicator for antenna panel status information.

According to another aspect of the present disclosure, a method for operating a plurality of antenna panels is provided. The method includes maintaining, by a wireless communication device, a plurality of leading time values. The plurality of leading time values indicates a plurality of leading time durations. The method further includes receiving, by the wireless communication device, an indicator for antenna panel status information from a BS, and applying, by the wireless communication device, one of the plurality of leading time values to switch an antenna panel status of the plurality of antenna panels based on the indicator for antenna panel status information.



## BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. Various features are not drawn to scale. Dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. **1** is a schematic diagram illustrating a wireless communication device including a number of antenna panels, in accordance with example implementations of the present disclosure.

FIG. **2** is a schematic diagram illustrating a timeline of an antenna panel status of a wireless communication device, in accordance with example implementations of the present disclosure.

FIG. **3** is a schematic diagram illustrating a timeline of an antenna panel status of a wireless communication device, in accordance with example implementations of the present disclosure.

FIG. **4** is a schematic diagram illustrating a timeline of an antenna panel status of a wireless communication device, in accordance with example implementations of the present disclosure.

FIG. **5** is an example data structure indicating user equipment (UE) capability information, in accordance with example implementations of the present disclosure.

FIG. **6** is an example data structure indicating a configuration of a timer for antenna panel status, in accordance with example implementations of the present disclosure.

FIG. **7** is a flowchart for a method of selecting a scheduling offset value based on a Transmission Configuration Indicator (TCI) state indicated by a BS, in accordance with example implementations of the present disclosure.

FIG. **8** is an example data structure indicating TCI state configuration, in accordance with example implementations of the present disclosure.

FIG. **9** is an example data structure of an indicator for antenna panel status, in accordance with example implementations of the present disclosure.

FIGS. **10**A and **10**B are schematic diagrams illustrating timelines of an antenna panel status of a wireless communication device, in accordance with example implementations of the present disclosure.

FIGS. **11**A and **11**B are schematic diagrams illustrating timelines of an antenna panel status of a wireless communication device, in accordance with example implementations of the present disclosure.

FIG. **12** is a flowchart for a method of selecting an offset value for receiving an aperiodic Channel State Information Reference Signal (CSI-RS), in accordance with example implementations of the present disclosure.

FIG. **13** is an example data structure indicating an aperiodic CSI RS reception configuration, in accordance with example implementations of the present disclosure.

FIG. **14** is an example of a Media Access Control (MAC)-Control Element (CE) message, in accordance with example implementations of the present disclosure.

FIG. **15** is a schematic diagram illustrating that different triggering offset values are applied for the changes in an antenna panel status of a wireless communication device, in accordance with example implementations of the present disclosure.

FIGS. **16**A and **16**B are schematic diagrams illustrating that different triggering offset values are applied for the changes in an antenna panel status of a wireless communication device, in accordance with example implementations of the present disclosure.

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FIG. **17** is a schematic diagram illustrating a timeline of an antenna panel status of a wireless communication device, in accordance with example implementations of the present disclosure.

FIG. **18** is flowchart for a method for determining an antenna panel status of a wireless communication device based on a Discontinuous Reception (DRX) operation, in accordance with example implementations of the present disclosure.

FIG. **19** is an example data structure indicating a Radio Resource Control (RRC) configuration for a UE, in accordance with example implementations of the present disclosure.

FIG. **20** is a schematic diagram illustrating a timeline of an antenna panel status of a wireless communication device and a timing diagram of a DRX cycle, in accordance with example implementations of the present disclosure.

FIG. **21** is an example data structure indicating an RRC configuration for a UE, in accordance with example implementations of the present disclosure.

FIG. **22** is a schematic diagram illustrating a timeline of an antenna panel status of a wireless communication device and a timing diagram of a DRX cycle, in accordance with example implementations of the present disclosure.

FIG. **23** is a flowchart for a method of operating multiple antenna panels, in accordance with example implementations of the present disclosure.

FIG. **24** is a block diagram illustrating a node for wireless communication, in accordance with various aspects of the present disclosure.

## DETAILED DESCRIPTION

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.

For the purpose of consistency and ease of understanding, like features are identified (although, in some examples, not shown) by 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.

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."

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, system, architectures, and the like are omitted so as not to obscure the description with unnecessary details.

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 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.

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.

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 New Radio (NR) Radio Access Network) typically includes at least one BS, 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 radio access network (RAN) established by one or more BSs.

It should be noted that, in the present application, 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.

A BS 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 EDGE radio access Network (GERAN), General Packet Radio Service (GRPS), 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), New Radio (NR, often referred to as 5G), and/or LTE-A Pro. However, the scope of the present application should not be limited to the above-mentioned protocols.

A BS 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 BS 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 BS may connect to serve the one or more UEs through a radio interface to the network.

The BS is operable to provide radio coverage to a specific geographical area using a plurality of cells forming the radio access network. The BS 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 BS can 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) service. Each cell may have overlapped coverage areas with other cells.

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 the 3$^{rd}$ Generation Partnership Project (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.

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, SL resource may also be provided in an NR frame to support ProSe services or V2X services.

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, and B exists alone. In addition, the character "/" herein generally represents that the former and latter associated objects are in an "or" relationship.

NR power saving is an issue which have been identified in the 3GPP meetings. The objective of this issue is to minimize the power consumption with an improved wake up/go-to-sleep mechanism, and to reduce the power consumption during the network access phase when a UE operates in the RRC_CONNECTED mode. In some power saving schemes the focus is on minimizing the dominate factors of power consumption during the network access phase. Such dominate factors may include, for example, the processing of an aggregated bandwidth, the active Radio Frequency (RF) chain number, the active reception/transmission time, and the dynamic transition to a power efficient mode. In the majority cases of LTE scenarios, since little to no data may be transmitted in a Transmission Time Interval (TTI), a power saving scheme which is capable of dynamically adapting different data arrivals in the RRC_CONNECTED mode may be needed. The dynamic adaptation to the data traffic may be implemented in different dimensions, such as carriers, antennas, beamforming mechanisms, and bandwidths.

Furthermore, approaches to enhance the transition between a normal power consumption mode and a power saving mode may be needed to be considered. For example, both the network-assisted and the UE-assisted approaches may be considered for the UE's power saving mechanism.

Issues related to the leading time for beam switching may affect the power consumption. The leading time for beam switching is, or may reflect, the minimum required time for a UE to set up its antenna panel(s) for providing an indicated RX/TX beam to receive or transmit data. For example, the leading time for beam switching may be the time period between the time the UE receives a command that leads to a change(s) in the Rx beam/antenna panel status and the time that the change(s) actually occurs. In some of the present implementations, if a TCI state has not yet activated by a MAC-CE, the indicated mapping (between the TCI states and the codepoints of a Downlink Control Information (DCI) field "Transmission Configuration Indicator") should be applied starting from a specific time point (e.g., slot n+3 ms+1), when a Hybrid Automatic Repeat Request Acknowledgement (HARQ-ACK) (which is corresponding to a Physical Downlink Shared Channel (PDSCH) which carries the activation command) is transmitted in the slot n. In some of such implementations, this specific time point may be used as the starting time point of a leading time for beam switching. In some of the present implementations, if the TCI state has been activated by a MAC-CE, the leading time for beam switching may have the same starting time point as the scheduling offset. The scheduling offset, in some implementations, may be a time duration starting from the end of the last symbol of a Physical Downlink Control Channel (PDCCH) to the beginning of the first symbol of a PDSCH.

In addition, the beam switching delay may affect a UE's power consumption in the Frequency Range 2 (FR2). In order for the UE to optimize the power consumption, the UE may need to be given a sufficient leading time for beam switching. For example, the leading time for beam switching may be two milliseconds (ms) from the time a beam switch command is received (e.g., for a control-channel-based way) or acknowledged (e.g., for a MAC-CE based way) to the time the beam switch is completed.

In some implementations of the present disclosure, there may be at least three ms between two consecutive commands indicating a beam switch. Such time value may be adjusted if a longer time value is needed. In addition, from the time the UE receives the beam switch command to the time the UE switches its beam/antenna panel status, the UE may still use the active Rx beam for data reception, and there may be no interruption in the communication with the BS (e.g., a gNB).

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FIG. **1** is a schematic diagram illustrating a wireless communication device (e.g., a UE) including a number of antenna panels, in accordance with example implementations of the present disclosure. As shown in FIG. **1**, a wireless communication device **100** includes four antenna panels **102**, **104**, **106** and **108**. The antenna panels described herein may be referred to antenna arrays or antenna ports. The antenna arrays may include a number of physical antennas, while the antenna ports may not correspond to physical antennas, but rather may be logical entities distinguished by their channel models.

The ON/OFF state of each antenna panel **102**, **104**, **106** and **108** may be switched by the wireless communication device **100**. Depending on the ON/OFF state of each antenna panel **102**, **104**, **106** and **108**, the antenna panels **102**, **104**, **106** and **108** may have different antenna panel status. For example, the antenna panel status of the antenna panels **102**, **104**, **106** and **108** may be determined as a first antenna panel status if only the antenna panel **102** is turned on and the other antenna panels **104**, **106** and **108** are turned off, and determined as a second antenna panel status if all of the antenna panels **102**, **104**, **106** and **108** are turned on. It should be noted that the wireless communication device **100** including four antenna panels **102**, **104**, **106** and **108** in FIG. **1** is for illustrative purposes only, and not intended to limit the scope of the present invention. That is, a wireless communication device (e.g., the wireless communication device **100**) may include a different number of antenna panels than 4 (e.g., 6 panels, 8 panels, etc.) in some of the present implementations. Furthermore, the antenna panel status of the antenna panels of the wireless communication device may be defined arbitrarily based on the ON/OFF states and/or the number of the antenna panels.

In many cases, a BS (e.g., a gNB) may not know the current antenna panel status of the UE, which causes some issues since the BS always have to consider the worst case for the UE to perform the beam switching. For example, the BS may need to configure the UE with a leading time for beam switching which is much longer than a leading time the UE actually needs. As the leading time becomes longer, the efficiency and flexibility of the UE's operations may get lower. Hence, a signaling mechanism that helps the BS to obtain the antenna panel status of the UE may enhance the power consumption.

Another issue is related to the scheduling offset values. From Radio layer 1's (RAN1's) perspective, if a UE is configured with a "tci-PresentInDCI" Information Element (IE) set to "enabled" (for a Coreset Resource Set (CORESET) that schedules a PDSCH), the UE may assume that the TCI field is present in the DCI format 1_1 (which is transmitted over the PDCCH of the CORESET). On the other hand, if the tci-PresentInDCI IE is not configured for the CORESET (or the tci-PresentInDCI IE is set to "disabled"), or the PDSCH is scheduled by a DCI format 1_0 (e.g., for determining the PDSCH antenna port's QCL), the UE may assume that the TCI state applied for receiving the PDSCH is identical to the TCI state applied for receiving the PDCCH of the CORESET. In addition, if the tci-PresentInDCI IE is set to "enabled" and the PDSCH is scheduled by the DCI format 1_1, the UE may apply a TCI state which is indicated by the DCI to determine the QCL of the antenna port for the PDSCH. This is because the TCI state may indicate the QCL type and the QCL Reference Signal (RS) corresponding to the RX beam for receiving the PDSCH. If the time offset between the reception of the DL DCI and the corresponding PDSCH is equal to or greater than a scheduling offset value (e.g., a threshold called "Threshold-Sched-Offset"), the UE may assume that the antenna ports of one Demodulation Reference Signal (DM-RS) port group of a PDSCH of a serving cell may be QCLed with the RS(s) that is associated with the QCL type parameter(s) given by the indicated TCI state. For DL transmissions, the scheduling offset may be referred as a time period starting from the end of a PDCCH to the beginning of a PDSCH. For example, the scheduling offset may be a time period that starts from the first symbol after the end of the PDCCH to the first symbol of the PDSCH scheduled by the PDCCH. In some implementations of the present disclosure, the scheduling offset value may be determined based on the UE's capability.

However, for a scheduling offset value configured for a UE that includes only one antenna panel (or a single-antenna-panel UE), such value may not fulfill the leading time for beam switching required by another UE that includes multiple antenna panels (or a multiple-antenna-panel UE). Thus, a mechanism that is able to deal with how the UE determines which scheduling offset value (e.g., Threshold-Sched-Offset) to be applied may be needed.

Another issue is related to Sounding Reference Signal (SRS) transmission. Specifically, for aperiodic SRS transmissions and aperiodic CSI-RS receptions, the UE may need to follow the aperiodic slot triggering offset configured in the SRS resource set configuration and the CSI-RS resource set configuration, respectively. Considering that a longer leading time may be applied to the power saving operation in the multiple-antenna-panel cases, the required triggering offset configured for the single-antenna-panel cases and the multiple-antenna-panel cases may be different. Although a BS can solve this issue by configuring multiple triggering offset values for one resource set, it might cause overhead that occupies some bitfields of a DCI trigger state for an SRS request and/or a CSI request. Hence, a mechanism for determining the triggering offset of the aperiodic SRS/CSI-RS transmissions may be needed.

In addition, for SRS transmissions, a UE may be configured to switch its antenna panel status for a sounding procedure for a DL CSI acquisition. If the UE is configured with a higher layer parameter such as "SRS-SetUseusage (or SRS-usage)" in an SRS resource set (e.g., SRS-ResourceSet), and the SRS-SetUseusage (or SRS-usage) is set as "antennaSwitching," the UE may be configured with one of the following configurations depending on the UE's capability: 1TX2RX, 2TX4RX, 1TX4RX, 1TX4RX/2TX4RX, and TX=RX. The BS may configure the UEs having different capabilities with different number of SRS resource sets which contain different SRS resources. For example, for a UE configured with the 1TX2RX configuration, the BS may configure one SRS resource set which may contain two SRS resources. Since the UE needs to select and switch to the TX for transmission, there may be a guard period between each SRS transmission. The guard period may be one or two symbols, depending on the numerology of the SRS resource. However, if the UE has multiple antenna panels and at least parts of the antenna panels are turned off for power saving, the guard period for one or two symbols may not fulfill the leading time of at least 2 ms for turning on the antenna panel(s). Hence, a mechanism for the UE to perform antenna switching may be needed.

In accordance with some implementations of the present disclosure, methods and apparatuses provide techniques for addressing the above-noted issues.

For example, techniques are described for determining the scheduling offset value(s). As described above, the leading time for beam switching may be the minimum required time

for a UE to set up the antenna panels for providing an indicated RX/TX beam to receive/transmit the data. If the scheduling offset of a DL/UL RSs/channel reception/transmission cannot fulfill the leading time requirement, the UE may not be able to transmit/receive the RSs/channel successfully. In some implementations of the present disclosure, the leading time may be related to the antenna panel status. In addition, different values of the leading time may be predefined in the 3GPP technical specification(s) for each or all of the antenna panel statuses. For example, each antenna panel status may have its own leading time value. In another example, all antenna panel statuses may have the same leading time value. In some implementations of the present disclosure, the UE may report the required leading time for each or all of the antenna panel statuses. In some implementations of the present disclosure, the UE may be configured with the required leading time by the BS for each or all of the antenna panel statuses.

In some implementations of the present disclosure, the antenna panel status may contain information about how many antenna panels at the UE are used for performing the data reception/transmission of the channel/RSs, or how many antenna panels at the UE are used/active/turned on in a particular time period.

In some implementations of the present disclosure, an indicator for antenna panel status may be transmitted by the BS to indicate to a UE whether to enable/disable a power saving mode or a normal power consumption mode. In the power saving mode, the UE may turn on a smaller number of antenna panels than that in the normal power consumption mode. For example, the UE may turn on only one antenna panel when operating in the power saving mode and turn on all of its antenna panels when operating in the normal power consumption mode.

It should be noted that the two operation modes (e.g., the power saving mode and the normal power consumption mode) described herein is for illustrative purposes and not intended to limit the present invention. For example, the UE may be operable in a number of operation modes different than two. In addition, if only the power saving mode and the normal power consumption mode are involved in the power control scheme of the UE, the UE may enter the normal power consumption mode when the power saving mode is disabled. In contrast, the UE may enter the power saving mode when the normal power consumption mode is disabled.

In some implementations of the present disclosure, the indicator for antenna panel status information may include a single-bit IE. The UE may enable the power saving mode when the single-bit IE is set to a first value, and disable the power saving mode when the single-bit IE is set to a second value. The total number of turn-on/active antenna panels when the power saving mode is enabled may be less than that when the power saving mode is disabled.

In some implementations of the present disclosure, the indicator for antenna panel status information may include a multiple-bit IE. The UE may be configured to turn on a particular number of the antenna panels when the multiple-bit IE is set to a particular value.

In some implementations of the present disclosure, the indicator for antenna panel status transmitted by the BS may be used for indicating which antenna panel status the UE is to apply.

In some implementations of the present disclosure, if the UE is instructed by the BS to perform data reception using multiple antenna panels when the UE is in the power saving mode, the UE may need to apply a longer leading time than a normal leading time. Hence, in accordance with the present disclosure, some techniques are provided for ensuring that the BS and the UE have the same understanding on the antenna panel status of the UE. In some implementations of the present disclosure, the antenna panel status may be used for indicating, explicitly or implicitly, how many, or which, of the antenna panels of the UE are turned on (or active, or able to transmit and receive data), and/or how many, or which, of the antenna panels of the UE are turned off (or inactive, or not able to transmit and receive data).

In some implementations of the present disclosure, the antenna panel status of a UE may be affected by Bandwidth Part (BWP) related operations. The UE may enable the power saving mode or the normal power consumption mode based on whether the UE operates in a particular BWP. For example, when the UE operates on a default, an initial, or a first active DL/UL BWP, the UE may always enable the normal power consumption mode or the power saving mode.

In some implementations of the present disclosure, before the UE receives an RRC configuration/a MAC-CE message/a DCI message for setting the UE's antenna panels status, the UE may operate in the power saving mode or the normal power consumption mode. In some implementations of the present disclosure, the UE may apply the power saving mode or the normal power consumption mode for the antenna panels before the UE reports the UE's capability about the antenna panels.

As described above, in some implementations of the present disclosure, the indicator for antenna panel status may be a single bit IE used for indicating whether the UE is in the power saving mode or not. For example, the UE may be configured with an available number of antenna panels for each BWP configuration. Once the UE receives the indicator for antenna panel status (e.g., in the form of a single bit IE) being set to a first value (e.g., the bit value "0"), the UE may turn on only part of the antenna panels to operate in the power saving mode. In contrast, if the indicator for antenna panel status is set to a second value (e.g., the bit value "1"), the UE may turn on all of the antenna panels to enable the normal power consumption mode (or disable the power saving mode).

In some implementations of the present disclosure, the indicator for antenna panel status may be a multiple-bit IE used for indicating the antenna panels status to the UE. For example, if the UE includes four antenna panels (e.g., the antenna panels **102**, **104**, **106** and **108** shown in FIG. **1**), the bit field of the indicator for antenna panel status may be set as "00" to indicate that all of the antenna panels are turned off/inactive, or set as "01" to indicate that only one antenna panel is active, or set as "10" to indicate that only two antenna panels are active, or set as "11" to indicate that all antenna panels are active. While the indicator for antenna panel status described herein is used to indicate to the UE to turn on a particular number of antenna panels, there are other ways to use the indicator for antenna panel status in some implementations of the present disclosure. For example, the indicator for antenna panel status may be used to indicate to the UE to turn on/off which one or ones of the antenna panels. In addition, it should be noted the examples described herein are not intended for limiting the present invention. For example, the indicator for antenna panel status may have a number of bits, with each bit corresponding to a particular antenna panel status.

The indicator for antenna panel status may be transmitted from the BS to the UE via a DCI message, a MAC-CE massage, or through RRC signaling. For example, the indicator for antenna panel status information may be contained

in a TCI state ID indicated by the BS. In some implementations of the present disclosure, the value of the indicator for antenna panel status may be updated and transmitted by the UE to the BS via an Uplink Control Information (UCI) message, a MAC-CE massage, or through RRC signaling.

In some implementations of the present disclosure, the RRC configuration that contains the indicator for antenna panel status may be an independent IE configured per UE-basis. For example, the RRC configuration may be the same for one cell or one cell group. In such cases, the RRC configuration may be a cell level or cell group level configuration. In another example, the RRC configuration may be configured in a specific frequency range. For example, the RRC configuration may only exist in the FR2.

In some implementations of the present disclosure, the UE may choose a leading time for beam switching based on the antenna panel status. For example, during an RRC reconfiguration period, or before the UE receives the first RRC configuration (e.g., while the UE attempts to establish an RRC connection after a successful initial access, or while the UE performs an initial access procedure), the UE may apply a default value of the leading time. Such default value may be predefined in the 3GPP technical specification (e.g., "3 ms" defined in NR Release-15) and determined as the UE's capability for beam switching in the power saving mode. In another example, the UE may apply the longest leading time configured in a UE capability list during this period. In another example, the BS may send an indicator to the UE through an RRC configuration (e.g., powerPrefIndicationConfig), and the UE may transmit or report the current antenna panel status to the BS via another indicator (e.g., powerPrefIndication). For example, the UE may transmit an antenna panel status report to inform the BS of a change in the antenna panel status. For example, the antenna panel status report may be contained in a beam report or a Channel State Information (CSI) report. In some implementations of the present disclosure, the antenna panel status report may include a single-bit IE. The UE may set the single-bit IE to a first value to indicate that a power saving mode is enabled and set the single-bit IE to a second value to indicate that the power saving mode is disabled. In some implementations of the present disclosure, the antenna panel status report may include a multiple-bit IE. The UE may set the multiple-bit IE to a particular value when a particular number of the plurality of antenna panels are turned on.

In some implementations of the present disclosure, the BS may keep the antenna panel status report from the UE and adjust the scheduling offset based on the antenna panel status report. In some implementations of the present disclosure, the BS may configure the UE with a prohibit timer to prevent the UE from reporting the antenna panel status too frequently. The prohibit timer may be used when the UE reports the antenna panel status to the BS through the RRC message (s), MAC-CE massage(s) or DCI message(s). In some implementations of the present disclosure, the prohibit timer may start at the first subframe/slot/OFDM symbol after the UE reports the antenna panel status. For example, the prohibit timer may start at the first subframe/slot/OFDM symbol after a physical resource (e.g., a Physical Uplink Control Channel (PUCCH) or a Physical Uplink Share Channel (PUSCH)) that contains of the antenna panel status report of the UE. In addition, in some implementations of the present disclosure, the UE may not report another antenna panel status when the prohibit timer is running.

In some implementations of the present disclosure, the prohibit timer may be bidirectional. For example, the prohibit timer may start when the antenna panel status transition from the normal power consumption mode to the power saving mode, and vice versa. In some implementations of the present disclosure, the prohibit timer may be unidirectional. For example, the prohibit timer may only start when a specific power preference transition occurs (e.g., transitioning from the power saving mode to the normal power consumption mode). In some implementations of the present disclosure, the prohibit timer may be configured separately for different kinds of power preference transitions.

In some implementations of the present disclosure, the BS may configure multiple antenna panel status to a UE via an RRC configuration, and the BS may indicate one of the multiple antenna panel status through a MAC-CE message (e.g., which is called a "MAC-CE approach"). For example, if the UE is configured with four antenna panel statuses by the RRC configuration, the BS may send a MAC-CE message to indicate to the UE to use one of these four antenna panel statuses. In addition, the BS may assume that the UE may follow the leading time for the indicated antenna panel status during the time period between the reception of the MAC-CE message and the reception of another MAC-CE message that contains an indicator for antenna panel status for switching the antenna panel status.

In some implementations of the present disclosure, the UE may maintain multiple leading time values configured by the BS or predefined in the 3GPP technical specification. These leading time values may be cell-specific values or cell group-specific values.

In some implementations of the present disclosure, after the UE receives the RRC configuration, but before receiving a MAC-CE massage for activation, the UE may apply one of the leading time values configured in an RRC configuration (if the leading time values are configured in the RRC configuration by the BS) as a default value of the leading time.

In some implementations of the present disclosure, more than one antenna panel status may be collected in a list of entries. For example, each of the entries may refer to a particular antenna panel status, and each antenna panel status may be associated with a particular leading time value.

In some implementations of the present disclosure, the default value of the leading time may refer to the first entry (e.g., the entry indexed by "0") in the list of entries in the RRC configuration. In some implementations of the present disclosure, the default value of the leading time may refer to an entry for the longest leading time in the RRC configuration (if the leading time value is RRC-configured).

In some implementations of the present disclosure, a MAC-CE massage containing a number of zero bits may be used. This MAC-CE massage may be used for turning on (or "enabling") or turning off (or "disabling") the power saving mode. The UE may distinguish this MAC-CE massage based on, for example, a Logical Channel Identity (LCID).

In some implementations of the present disclosure, at least one of the following items may be included in a MAC-CE massage: a cell Identity (ID), a BWP ID, and an indicator for antenna panel status. The UE may apply an antenna panel status indicated by the MAC-CE message after the UE transmits an HARQ-ACK to the BS.

In some implementations of the present disclosure, the BS may configure multiple antenna panel statuses to a UE via an RRC configuration, and the BS may indicate one of the multiple antenna panel statuses through a DCI message (e.g., which is called a "DCI approach"). For example, if the UE is configured with eight different antenna panel statuses in the RRC configuration, the BS may transmit a DCI

message which may contain an indicator for antenna panel status to the UE to indicate to the UE to use one of the eight antenna panel statuses in the RRC configuration.

In some implementations of the present disclosure, if a UE is configured with multiple leading time values by the BS, the UE may apply one of the leading time values contained in an RRC configuration as a default leading time value after the UE receives the RRC configuration (but before receiving the DCI message). Similar to the MAC CE approach, the default leading time value may refer to the first entry of the multiple antenna panel statuses in the RRC configuration (e.g., the entry with an index value of "0"), or an entry with the longest leading time in the RRC configuration.

In some implementations of the present disclosure, the BS may use a MAC-CE message to select a subset of the leading time values from the RRC configuration and indicate one of the selected leading time value(s) by a DCI message. For example, the BS may configure 16 antenna panel statuses in an RRC configuration, and the BS may transmit a MAC-CE massage to select four of these 16 antenna panel statuses in the RRC configuration. The BS may further transmit a DCI message to indicate to the UE to use one of the four selected antenna panel statuses.

In some implementations of the present disclosure, irrespective of where the leading time values are configured, the BS may need to ensure that the triggering/scheduling offset for the DL/UL channels/signals can fulfill the requirement of leading time for switching the antenna panel status. From UE's perspective, the UE may not be expected to receive data from the BS during the scheduling offset period.

In some implementations of the present disclosure, the antenna panel status may be associated with the TCI states. For example, in addition to the QCL information, some TCI states may further contain the antenna panel status (e.g., which is indicated by an explicit bit). In addition, the maximum number of the TCI states in an RRC configuration, or a DCI message, may be expanded since the BS may need more TCI state(s) to indicate different antenna panel statuses for the same QCL information. For example, if the maximum number of TCI states is expanded from 64 to 96, the TCI state #63 may be used to represent a signal-antenna-panel status which is QCLed with the CSI-RS resource #1, and the TCI state #64 may be used to represent a multi-antenna-panel status which is QCLed with the same CSI-RS resource #1. In some implementations of the present disclosure, once the QCL information of a DL/UL RS/channel is configured with a TCI state (e.g., the TCI state #64) for multiple antenna panels, the UE may attempt to receive/transmit the DL/UL RS/channel based on a leading time for beam switching for the multiple antenna panels.

In some implementations of the present disclosure, a TCI state table may be used when the UE performs data reception/transmission by multiple antenna panels. For example, the BS may configure the UE with multiple TCI state tables. The number of entries in each TCI state table may be the same or different. The UE may select a specific TCI state table from these TCI state tables based on a MAC-CE massage (e.g., used in the MAC-CE approach) or a DCI message (e.g., used in the DCI approach). For example, if the UE receives a DCI message which contains an explicit bit (e.g., used as an indicator for antenna panel status) for indicating the UE to enable the power saving mode, the UE may attempt to receive the PDSCH using a single antenna panel, instead of using multiple antenna panels. In addition, the UE may further apply a leading time corresponding to using the single antenna panel.

In some implementations of the present disclosure, a timer may be used to determine the switch of the antenna panel status. For example, the UE may receive a timer from the BS and switch the antenna panel status from a first antenna panel status to a second antenna panel status after the timer expires. For example, when the timer expires, the UE may transition from the normal power consumption mode (e.g., in which the UE turns on N2 antenna panels) to the power saving mode (e.g., in which the UE turns on N1 antenna panel(s), where N1 is less than N2). In another example, the UE may transition from the power saving mode to the normal power consumption mode when the timer expires.

In some implementations of the present disclosure, the timer may expire when a DRX inactivity timer expires or the UE enters a DRX off-period/sleep mode.

FIG. **2** is a schematic diagram illustrating a timeline of the antenna panel status of a wireless communication device (e.g., a UE), in accordance with example implementations of the present disclosure.

In the present implementation, a timer for antenna panel status may (re)start at the first symbol after the end of the PDCCH. As shown in FIG. **2**, in the slot # n, the UE receives an indicator for antenna panel status via a DCI message which is transmitted over a PDCCH **202**. The indicator for antenna panel status may indicate to the UE to switch from a power saving mode (in which there are only N1 antenna panel(s) is active/turned on) to a normal power consumption mode (in which there are N2 antenna panels are active/turned on), where N2 is greater than N1.

As shown in FIG. **2**, there is a time gap **21** between the time the UE receives the indicator for antenna panel status from the PDCCH **202** and the time the UE actually turns on the N2 antenna panels. The time gap **21** may reflect the time required for the UE to turn on the antenna panel(s). In some implementations of the present disclosure, the time gap **21** may be deemed as the leading time for beam switching of the UE.

In some implementations of the present disclosure, the UE may start the timer for antenna panel status at the first symbol after the last symbol of the PDCCH **202** monitor occasion. Also, the UE may further receive a PDSCH **204** scheduled by the PDCCH **202** in the same slot # n.

Before the timer expires, the BS may assume that the UE may keep the antenna panel status indicated by the PDCCH **202**, or applied for the PDSCH **204**. Once the timer expires, the BS may assume that the UE may return to the power saving mode. As shown in FIG. **2**, in the slot # n+2, after the timer expires, the UE may transmit a PUCCH **206** indicated by the PDCCH **202** in the power saving mode.

In some implementations of the present disclosure, if the UE is instructed by the BS to operate in the power saving mode, the timer may not start. In addition, the indicator for antenna panel status may be implemented as any implicit/explicit data structure. For example, the indicator for antenna panel status may include a single-bit IE or a multiple-bit IE or may be contained in a beam report or a CSI report.

In some other implementations of the present disclosure, the timer for antenna panel status may start at different time points, as shown in FIGS. **3** and **4**.

FIG. **3** is a schematic diagram illustrating a timeline of the antenna panel status of a wireless communication device (e.g., a UE), in accordance with example implementations of the present disclosure. In the present implementation, the timer for antenna panel status may start at the first symbol after the end of a PUCCH. As shown in FIG. **3**, in the slot

# n, the UE receives an indicator for antenna panel status via a DCI message which is transmitted over a PDCCH **302**. The UE may further receive a PDSCH **304** which is scheduled by the PDCCH **302** in the same slot # n.

The indicator for antenna panel status may indicate to the UE to switch from a power saving mode (in which there are only N1 antenna panel(s) is turned on) to a normal power consumption mode (in which there are N2 antenna panels are turned on, where N2 is greater than N1). As shown in FIG. **3**, there is a time gap **31** between the time the UE receives the indicator for antenna panel status from the PDCCH **302** and the time the UE actually turns on the N2 antenna panels. As described above, the time gap **31** may reflect the time required for the UE to turn on the antenna panel(s). In addition, the time gap **31** may be deemed as the leading time for beam switching of the UE.

In the present implementation, the UE may start the timer at the first symbol after the last symbol of a PUCCH **306** monitor occasion. Similar to the implementations provided with reference to FIG. **2**, before the timer expires, the BS may assume that the UE may keep the antenna panel status indicated by the PDCCH **302**, or applied for the PDSCH **304**. Once the timer expires, the BS may assume that the UE may return to the power saving mode. As shown in FIG. **3**, in the slot # n+4, after the timer expires, the UE may turn off (N2−N1) antenna panels to go back to the power saving mode.

FIG. **4** is a schematic diagram illustrating a timeline of the antenna panel status of a wireless communication device (e.g., a UE), in accordance with example implementations of the present disclosure. In the present implementation, the timer for antenna panel status may start at the first symbol after the end of a PDSCH. As shown in FIG. **4**, in the slot # n, the UE may receive an indicator for antenna panel status via a DCI message which is transmitted over a PDCCH **402**. The UE may further receive a PDSCH **404**, which is scheduled by the PDCCH **402** in the same slot # n. Then, the UE may transmit a PUCCH **406**, which is indicated by the PDCCH **402**, in the slot # n+2.

The indicator for antenna panel status may indicate to the UE to switch from a power saving mode (in which there are only N1 antenna panel(s) is turned on) to a normal power consumption mode (in which there are N2 antenna panels are turned on, where N2 is greater than N1). As shown in FIG. **4**, there is a time gap **41** between the time the UE receives the indicator for antenna panel status from the PDCCH **402** and the time the UE actually turns on the N2 antenna panels. As noted above, the time gap **41** may reflect the time required for the UE to turn on the antenna panel(s). In addition, the time gap **41** may be deemed as the leading time for beam switching of the UE.

As described above, the UE may start the timer at the first symbol after the last symbol of the PDSCH **404**. Before the timer expires, the BS may assume that the UE may keep the antenna panel status indicated by the PDCCH **402** or applied for the PDSCH **404**. Once the timer expires, the BS may assume that the UE may return to the power saving mode. As shown in FIG. **4**, in the slot # n+4, after the timer expires, the UE may turn off certain antenna panel(s) to transition to the power saving mode.

The timer for antenna panel status may count based on an absolute time unit (e.g., ms), a time slot, a subframe, or an OFDM symbol. In some implementations of the present disclosure, if the timer counts based on a time slot or an OFDM symbol, the numerology of the time unit may be determined based on the PDCCH which carries the scheduling information, or based on the PDSCH/RSs/PUSCH/PUCCH which is scheduled by the PDCCH.

In some implementations of the present disclosure, the timer for antenna panel status may be an optional feature for the UE. For example, the BS may decide whether to configure the timer to the UE based on the UE's capability. In addition, if the UE is not configured with the timer for antenna panel status, the UE may not automatically switch the antenna panel status (e.g., return to the power saving mode automatically). In such a case, the UE may follow the most recently received indicator for antenna panels status (e.g., contained in a DCI message, a MAC-CE massage, or an RRC configuration) from the BS to determine the antenna panels status, until the UE sends a request to the BS and/or receives another indicator for antenna panels status from the BS. In some implementations of the present disclosure, the BS may not configure the UE with the timer for antenna panel status. In such a case, if the BS does not receive a response to the indicator for antenna panel status from the UE, the BS may assume that the UE is in the power saving mode. Hence, the BS may assume that a longer leading time may be adopted by the UE, and the BS may determine a scheduling offset value for the UE based on this assumption.

Some implementations of the present disclosure are described herein for determining the scheduling offset values and the leading time values for different antenna panel statuses.

In some implementations, there is only one leading time value for each DL/UL channel/RSs reception/transmission. Such a leading time value may be defined by the UE's capability for example. However, the above-mentioned mechanism may not be suitable for a situation where the UE needs a longer leading time for beam switching. Although the BS may configure the UE with a scheduling offset that is long enough to fulfill various leading times of different antenna panel statuses, such a configuration may cause some scheduling restrictions (e.g., because the UE may not always need to use a long leading time). Hence, in accordance with some implementations of the present disclosure, some techniques are provided to improve scheduling flexibility and performance of beam switching. For example, all DL/UL channel/RSs may be configured with one or more additional scheduling/triggering offset values for the situations where the UE may need to apply a long leading time value for beam switching, such as a PDSCH scheduling offset, a CSI-RS resource reception, a PUSCH transmission, and an SRS antenna switch.

In some implementations of the present disclosure, multiple scheduling offset values may be predefined for the UE (e.g., based on the 3GPP technical specification) or contained in the RRC configuration. The UE may apply one of the scheduling offset values based on the indicator for antenna panels status received from the BS. For example, the UE may apply a first scheduling offset value for a normal leading time case (e.g., in which the UE may not require to turn on an antenna panel, or only need to turn N1 antenna panel(s)), and apply a second scheduling offset value for a long leading time case (e.g., in which UE may need to turn on all of the antenna panels, or need to turn N2 antenna panels, where N2 is greater than N1).

In some implementations of the present disclosure, the UE may receive a plurality of scheduling offset values (e.g., including the first scheduling offset value and the second scheduling offset value) from the BS. Each of the scheduling offset values may be used for indicating a time duration counting from an end of a PDCCH to a beginning of a PDSCH. The UE may receive a first DCI message for setting

the antenna panel status to a first antenna panel status. In response to receiving the first DCI message, the UE may apply the first scheduling offset value to receive first information on a DL channel (e.g., a PDSCH) scheduled by the first DCI message. The UE may further receive a second DCI message for switching the antenna panel status from the first antenna panel status to a second antenna panel status. For example, the second DCI message may include an indicator for antenna panel status information. In response to receiving the second DCI message, the UE may apply the second scheduling offset value to receive second information on a second DL channel (e.g., another PDSCH) scheduled by the second DCI message.

In some implementations of the present disclosure, each DL/UL channel/RS may have its corresponding scheduling offset value. For example, in order to receive an aperiodic CSI-RS resource, the RRC configuration may include two scheduling offset values: one leading time value may be indicated as X1 slot(s) (e.g., one slot) used for a normal leading time case, and another leading time value may be indicated as X2 slots (e.g., three slots) used for a long leading time case, where X2 is greater than X1. The UE may select one of these scheduling offset values based on the indicator for antenna panel status received from the BS. In another example, in order to receive the PDSCH, the RRC configuration may include two scheduling offset values (e.g., the K0 parameters/values in the pdsch-TimeDomain-ResourceAllocationList IE). For example, one scheduling offset value (K0) may be indicated as X1 slot(s) for the normal leading time case, and another scheduling offset value (K0) may be indicated as X2 slots for the long leading time case. The UE may select one of the scheduling offset values based on the indicator for antenna panel status.

In some implementations of the present disclosure, the UE may receive a scheduling offset value from the BS. The scheduling offset value may include at least one of a K0 parameter/value for a DL channel (e.g., a PDSCH) and a K2 parameter/value for a UL channel (e.g., a PUSCH). If the time duration indicated by the scheduling offset value is less than the leading time duration indicated by a selected leading time value, the UE may further determine that the scheduling offset value is invalid.

In some implementations of the present disclosure, all of the DL/UL channel/RSs may apply the same leading time value for beam switching. For example, when the UE operates in the normal power consumption mode, the PUSCH transmission may be associated with a specific scheduling offset value that is used for the normal leading time case (e.g., a K2 value for determining a PUSCH transmission offset). On the other hand, the PDSCH transmission may be associated with another scheduling offset also for the normal leading time case (e.g., a K0 value for determining a PDSCH reception offset).

In contrast, when the UE operates in the power saving mode, both the PUSCH transmission and the PDSCH reception may apply the same scheduling offset value. This scheduling offset value may be predefined by the 3GPP technical specifications, or configured in the RRC configuration, or determined based on the UE's capability. In some other implementations of the present disclosure, all DL channels/RSs may apply a first scheduling offset value suitable for the long leading time case, while all UL channels/RSs may apply a second scheduling offset value also suitable for the long leading time case, where the first scheduling offset value and the second scheduling offset value may be different. In some of the present implementations, all of the DL/UL channels/RSs may be configured with an additional leading time value for a beam switch case (e.g., a PDSCH scheduling offset, a CSI-RS resource reception, a PUSCH transmission or an SRS antenna switch).

Some implementations of the present disclosure are described herein for providing techniques for helping the BS to acquire information about the antenna panel status of the UE.

In some implementations of the present disclosure, the CSI measurement/report obtained under different antenna panel statuses may be transmitted from the UE to the BS via UCI/MAC-CE messages. In the UCI case, there may be at least two ways for the UE to inform the BS of the antenna panels status. One way is to introduce a particular IE contained in the CSI report, and the other way is to reuse the reserved bit field of an IE contained in the CSI report. In addition, the UE may transmit a CSI parameter to the BS for reporting the antenna panel status. The CSI parameter may include at least one of a Precoding Matrix Indicator (PMI), a Channel Quality Indicator (CQI), a Rank Indication (RI), a Layer Indication (LI), and a Layer 1 Reference Signals Received Power (L1-RSRP).

The information used to help the BS to acquire the antenna panel status of the UE may be referred to as the UE assistance information. In some implementations of the present disclosure, the UE may transmit the UE assistance information to the BS if the UE is not configured with the timer for antenna panel status, or does not have the ability to use the timer. In some implementations of the present disclosure, the UE may transmit the UE assistance information to the BS if the UE is configured to (or have the ability to) switch its antenna panel status only when receiving the indicator for antenna panel status via a MAC-CE massage and/or an RRC message.

An example L1-RSRP report quantized table is shown as follows:

TABLE 1

| Bits | RSRP range |
|---|---|
| 0000000 | RSRP ≥ −44 dBm |
| 0000001 | −44 dBm > RSRP ≥ −45 dBm |
| 0000010 | −45 dBm > RSRP ≥ −46 dBm |
| . . . | . . . |
| 1100000 | −139 dBm > RSRP ≥ −140 dBm |
| 1100001 | −140 dBm> RSRP |
| 1100011 | Antenna panel status #0 |
| 1100100 | Antenna panel status #1 |
| . . . | . . . |
| 1111111 | Reserved |

As shown in Table 1, a number of the reserved bit fields (e.g., bit fields "1100011" and "1100100") in the L1-RSRP report quantized table are reused for indicating the antenna panel status. For example, if the UE reports a value of "1100011" as the largest L1 RSRP value in the L1-RSRP report, the BS may assume that the UE is in the power saving mode.

In some implementations of the present disclosure, if the UE is configured to perform a group-based beam reporting procedure (e.g., in which the UE may receive signals simultaneously via a group of RX beams), the antenna panel status of the UE may be indicated by an L1-RSRP related value (e.g., a reserved L1-RSRP value and/or a specific differential L1-RSRP value). For example, if the bit field for the largest L1-RSRP value is a reserved value (e.g., "1100011") and the differential L1-RSRP value is a special value (e.g., "0000"), the BS may assume that the UE is in the power saving mode or in a specific antenna panel status, as shown in Table 1.

In some implementations of the present disclosure, the BS may assume that the indicated antenna panel status will be applied by the UE from the first symbol after the end of the slot at which the UCI or the PUSCH of the MAC-CE massage is transmitted through. For example, if the UE is configured with a timer for antenna panel status (e.g., the timer described with reference to FIGS. **2**, **3** and **4**), this timer may start at the first symbol after the end of the slot at which the UCI or the PUSCH of the MAC-CE massage is transmitted through.

In some implementations of the present disclosure, the mechanisms described above can be applied for the cases that the BS configures the UE to measure the CSI-RS resource/SSB by a single antenna panel, whereas the UE is actually able to (or has to) apply multiple antenna panels in the time resource for receiving the CSI-RS resource/SSB. In some implementations of the present disclosure, the UE may indicate the antenna panel status to the BS via the CSI parameter of the CSI report.

In some implementations of the present disclosure, the UE may report multiple sets of CSI parameters to the BS. For example, among the multiple sets of CSI parameters, one set of the CSI parameters may include CSI parameter(s) received and obtained through a single antenna panel, while another set of the CSI parameters may include CSI parameter(s) received and obtained through multiple antenna panels.

In some implementations of the present disclosure, techniques are described herein for determining the antenna panel status of a UE based on a DRX operation.

The DRX operation is a mechanism that makes a UE discontinuously monitor/receive the PDCCH to reduce the power consumption of the UE. However, when performing the DRX operation, the UE may still need to monitor a number of RSs in a DRX off-duration or a DRX inactive period. Hence, in some implementations of the present disclosure, whether to enable the power saving mode at a UE may be determined based on the DRX operation.

In some implementations of the present disclosure, a UE may decide to operate in the power saving mode when the UE is in a DRX off-duration or a DRX inactive period. For example, a UE may enable the power saving mode when the UE operates in a DRX active time (or a DRX on-duration) and disable the power saving mode when the UE operates in a DRX inactive time (or a DRX off-duration).

In some implementations of the present disclosure, whether to operate in the power saving mode is independent of the DRX operation. For example, a UE may only follow the indicator for antenna panel status received from the BS, without considering whether the UE is currently in a DRX on-duration or the DRX off-duration.

In some implementations of the present disclosure, whether to operate in the power saving mode may be determined based on the length of a DRX cycle (e.g., a time gap between two UE-wake-up instances). For example, the UE may be configured with a particular threshold and determine whether to enable the power saving mode according to a comparison between the threshold and the length of the DRX period. For example, if the threshold is 50 ms and the UE is configured with a DRX period of 40 ms, then the UE may not enable the power saving mode because the length of the DRX period (40 ms) is less than the threshold (50 ms). In the same way, if the UE is configured with a DRX period of 60 ms, the UE may enable the power saving antenna status because the length of the DRX period (60 ms) is greater than the threshold (50 ms). This threshold may be predefined in the 3GPP technical specifications or configured by the BS via an RRC signaling.

In some implementations of the present disclosure, the UE may assume that it will not operate in the power saving mode if the UE is in the active time. For example, the active time may include the time while: 1) a specific timer (e.g., drx-onDurationTimer or drx-InactivityTimer or drx-RetransmissionTimerDL or drx-RetransmissionTimerUL or ra-ContentionResolutionTime) is running; or 2) a scheduling request is sent on a PUCCH and is pending; or 3) a PDCCH indicating a new transmission addressed to the Cell Radio Network Temporary Identifier (C-RNTI) of the MAC entity has not been received after successful reception of a random access response for the random access preamble not selected by the MAC entity among the contention-based random access preamble.

In some implementations of the present disclosure, the UE may automatically enter/stay the normal power consumption mode regardless of the BS's indication. For example, the UE may automatically switch the antenna panel status without further reception of a new indicator for antenna panel status information from the BS.

In some implementations of the present disclosure, if the UE is configured with a timer for antenna panel status, this timer may be affected by the DRX inactivity timer, because from the UE's perspective, whether to operate in the power saving mode may be related to the DRX operations. For example, when the DRX inactivity timer expires while the timer for antenna panel status is still running, the UE may switch to the DRX off duration and enable the power saving mode. In addition, the timer for antenna panel status may then stop. In another example, the operation of the DRX inactivity timer and the timer for antenna panel status are independent.

An illustrative example (denoted as Example 0) will now be provided, where the UE may inform the BS of the UE's capability.

FIG. **5** is an example of a data structure indicating UE capability information, in accordance with example implementations of the present disclosure. As shown in FIG. **5**, UE capability information **502** includes a number of parameters related to the antenna panel status of the UE. The parameters may include at least one of a power saving indicator (which may be used as the indicator for antenna panel status described herein), a timer for antenna panel status (for which the value may be set as "true/support" or "false/not support"), a maximum number of support antenna panels (e.g., one, two, four or eight), a support indication method (e.g., which may indicate whether an RRC, MAC-CE, or DCI approach is supported), a required time for antenna panel status switch (e.g., 1 ms, 2 ms, 3 ms, or 4 ms), and a UE assistance indication (for which the value may be set as "true/support" or "false/not support"). The UE may transmit the UE capability information **502** to the BS after establishing an RRC connection to the BS. If the UE supports the timer for antenna panel status, the BS may configure the length of the timer for antenna panel status to the UE, as shown in FIG. **6**.

FIG. **6** is an example data structure indicating the configuration of the timer for antenna panel status, in accordance with example implementations of the present disclosure. As shown in FIG. **6**, a configuration **602** may indicate that the length/duration of the timer for antenna panel status is four slots.

An illustrative example (Example 1-1) will now be provided, where the scheduling offset value (e.g., K0 value) for

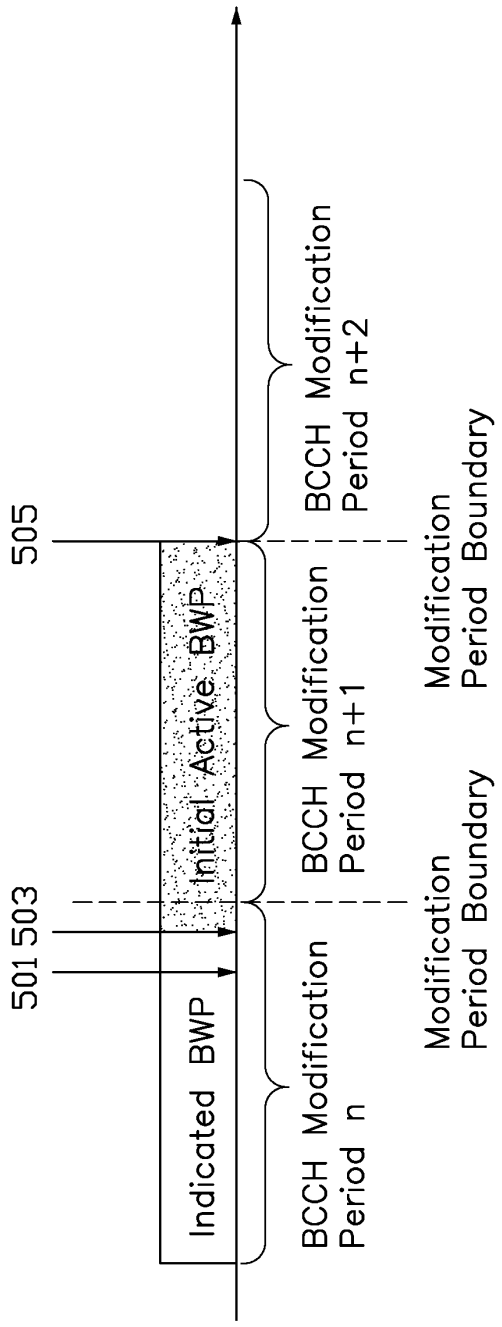
505
501
503
Initial Active BWP
Indicated BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 5

PDSCH reception may be selected based on an indicator for antenna panel status (e.g., contained in a TCI state) from the BS.

FIG. **7** is a flowchart for a method of selecting a scheduling offset value based on a TCI state indicated by the BS, in accordance with example implementations of the present disclosure.

In action **702**, a UE may be configured with multiple sets of parameters corresponding to different operation modes (e.g., the power saving mode and the normal power consumption mode). For example, the UE may be configured with two different leading time values. One leading time value may be 10 μs, and the other one may be 3 ms. As noted above, the UE may apply a first leading time when the UE needs to turn on a first number of antenna panel(s), and apply a second leading time when the UE needs to turn on a second number of antenna panel(s), where the first leading time is longer than the second leading time if the first number is greater than the second number. Hence, in this example, the shorter leading time, 10 μs, may be applied in the case that the UE does not need to further turn on an antenna panel in response to the indicator for antenna panel status, and the longer leading time, 3 ms, may be applied in the case that the UE needs to turn on one or more antenna panels to change the operation mode (e.g., to switch from the power saving mode to the normal power consumption mode).

The leading time values may be predefined in the 3GPP technical specifications or configured by the BS via an RRC signaling. In addition, the UE may be configured with a set of K0 values in the pdsch-TimeDomainResourceAllocation-List IE of an RRC configuration. An example of the K0 configuration is as follows.

TABLE 2

| Row index | K0 (normal, long) |
|---|---|
| 0 | (0 slot, 3 slots) |
| 1 | (0 slot, 3 slots) |
| . | . |
| . | . |
| . | . |
| 15 | (1 slot, 4 slots) |

For each indexed row of the K0 configuration, the UE may determine which of the normal K0 value and the long K0 value should be applied. In addition, the UE may be configured with a certain number of TCI state(s) in the RRC configuration, and each of the TCI state(s) may be associated with a particular antenna panel status.

FIG. **8** is an example data structure indicating TCI state configuration, in accordance with example implementations of the present disclosure. As shown in FIG. **8**, a TCI state configuration **802** includes 64 TCI states, and each TCI state may include a power saving mode IE for indicating whether to enable the power saving mode when the corresponding TCI state is applied.

In addition, the UE may be configured by the BS to enable the power saving mode via an indicator for antenna panel status. FIG. **9** is an example data structure for an indicator for antenna panel status, in accordance with example implementations of the present disclosure. As shown in FIG. **9**, an indicator for antenna panel status **902** includes a power saving mode IE which is set as "true" to indicate to the UE to enable the power saving mode.

It should be noted that the parameter values, data formats, and configurations provided herein are for illustrative purposes only, and not intended to limit the scope of the present invention. For example, the number of slots for each K0 value (e.g., the normal K0 value or the long K0 value) may be different for different numerologies.

Referring back to FIG. **7**. In action **704**, the UE may receive a DCI message from the BS. In action **706**, the UE may apply a TCI state indicated by the DCI message. In action **708**, the UE may apply a K0 value corresponding to the antenna panel status associated with the TCI state.

FIGS. **10**A and **10**B are schematic diagrams illustrating timelines of the antenna panel status of a wireless communication device (e.g., a UE), in accordance with example implementations of the present disclosure. It should be noted that the timeline of FIG. **10**B is continued from that of FIG. **10**A. In this example, the total number of turned-on/active antenna panels at the UE is N1 when the power saving mode is enabled and is N2 when the power saving mode is disabled, where N1 is less than N2. For example, N1 may be "1" and N2 may be the number of the antenna panels the UE has.

As shown in FIG. **10**A, the UE may receive and decode a first DCI message DCI_1 which is transmitted over a PDCCH **1002** in the slot # n. The first DCI message DCI_1 may indicate to the UE to apply a particular TCI state (e.g., the TCI state #1 contained in the TCI state configuration **802** in FIG. **8**) for a scheduling PDSCH **1004**. According to FIG. **8**, because the TCI state #1 includes a power saving mode IE which is configured with a "true" value, the UE may follow the TCI state #1 to monitor the scheduling PDSCH **1004** in the power saving mode. In some implementations of the present disclosure, the UE may apply a normal K0 value when the UE does not need to further turn on an antenna panel in response to the indicator for antenna panel status from the BS, and may apply a long K0 value when the UE needs to turn on at least one antenna panel in response to the indicator for antenna panel status. In this example, because the UE has already in the power saving mode before receiving the first DCI message DCI_1, the UE may refer to the K0 configuration in Table 2 to apply a normal K0 value (e.g., 0 slot) contained in the row entry which is indexed by "1" and associated with the TCI state #1. Once the normal K0 value (e.g., 0 slot) is applied, the UE is expected to receive the PDSCH **1004** in the same slot as the PDCCH **1002**, as shown in FIG. **10**A.

After successfully receiving and decoding the PDSCH **1004**, the UE may transmit a HARQ-ACK over a PUCCH **1006** in the slot # n+1 based on the HARQ resource indicator (ARI) contained in the first DCI message DCI_1. Then, the UE may further receive and decode a second DCI message DCI_2 which is transmitted over a PDCCH **1008** in the slot # m. In this example, the second DCI message DCI_2 may indicate to the UE to apply the TCI state #64 for a scheduling PDSCH **1010**. According to FIG. **8**, because the TCI state #64 includes a power saving mode IE which is configured with a "false" value, the TCI state #64 may indicate to the UE to receive the scheduling PDSCH **1010** in the normal power consumption mode, in which there are N2 antenna panels turned on by the UE. As noted above, because the UE needs to turn on a number of antenna panels to enter the normal power consumption mode, the UE may apply a long K0 value for receiving the PDSCH **1010**. For example, the UE may refer to the K0 configuration in Table 2 to apply a long K0 value (e.g., 4 slots) contained in the row entry which is indexed by "15" and associated with the TCI state #64. Once the long K0 value (e.g., 4 slots) is applied, the UE will expect to receive the PDSCH **1010** in the slot m+4, which is the fourth slot after the slot # m, as shown in FIG. **10**A.

After successfully receiving and decoding the PDSCH **1010**, the UE may transmit a HARQ-ACK over a PUCCH **1012** in the slot # m+6 based on the ARI contain in the second DCI message DCI_2, as shown in FIG. **10**B.

Then, the UE may receive and decode a third DCI message DCI_3 which is transmitted over a PDCCH **1014** in the slot # m+7. In this example the third DCI message DCI_3 may indicate to the UE to apply the same TCI state #64 as indicated in second DCI message DCI_2 for a scheduling PDSCH **1016**. Although the TCI state #64 may indicate to the UE to receive the scheduling PDSCH **1016** in the normal power consumption mode, the UE has already operated in the normal power consumption mode before receiving the third DCI message DCI_3. Thus, the UE does not need to further turn on an antenna panel at this moment, and the UE may apply the normal K0 value (e.g., 0 slot) to determine when to receive the PDSCH **1016** (e.g., in the same slot # m+7 as the PDCCH **1014**). After successfully receiving and decoding the PDSCH **1016**, the UE may transmit a HARQ-ACK over a PUCCH **1018** in the slot # k based on the ARI contained in the third DCI message DCI_3, as shown in FIG. **10**B.

An illustrative example (denoted as Example 1-2) will now be provided, where the scheduling offset value (e.g., K0 value) for PDSCH reception may be selected based on the TCI state and the timer for antenna panel status.

In Example 1-2, the UE may be further configured with a timer for antenna panel status in addition to the multiple sets of parameters configured in action **702** of FIG. **7**. For example, the configuration of the timer for antenna panel status may be, but not limited to, the configuration **602** in FIG. **6**. In some implementations of the present disclosure, the numerology of the timer for antenna panel status may be determined based on the scheduling PDSCH of the active DL BWP.

FIGS. **11**A and **11**B are schematic diagrams illustrating timelines of the antenna panel status of a wireless communication device (e.g., a UE), in accordance with example implementations of the present disclosure. It should be noted that the timeline of FIG. **11**B is continued from that of FIG. **11**A. In this example, the total number of turned-on/active antenna panels at the UE is N1 when the power saving mode is enabled and is N2 when the power saving mode is disabled, where N1 is less than N2. For example, N1 may be "1" and N2 may be the number of the antenna panels the UE has.

As shown in FIG. **11**A, the UE may receive and decode a first DCI message DCI_1 which is transmitted over a PDCCH **1102** in the slot # n. The first DCI message DCI_1 may indicate to the UE to apply a particular TCI state (e.g., the TCI state #1 contained in the TCI state configuration **802** in FIG. **8**) for a scheduling PDSCH **1104**. According to FIG. **8**, because the TCI state #1 includes a power saving mode IE which is configured with a "true" value, the UE may follow the TCI state #1 to monitor the scheduling PDSCH **1004** in the power saving mode. As noted above, because the UE has already in the power saving mode before receiving the first DCI message DCI_1, the UE may refer to the K0 configuration in Table 2 to apply a normal K0 value (e.g., 0 slot) contained in the row entry which is indexed by "1" and associated with the TCI state #1. Once the normal K0 value (e.g., 0 slot) is applied, the UE is expected to receive the PDSCH **1104** in the same slot as the PDCCH **1002**, as shown in FIG. **11**A.

After successfully receiving and decoding the PDSCH **1104**, the UE may transmit an HARQ-ACK over a PUCCH **1106** in the slot # n+1 based on the ARI contained in the first DCI message DCI_1. Then, the UE may further receive and decode a second DCI message DCI_2 which is transmitted over a PDCCH **1108** in the slot # m. In this example, the second DCI message DCI_2 may indicate to the UE to apply the TCI state #64 for a scheduling PDSCH **1110**. According to FIG. **8**, because the TCI state #64 includes a power saving mode IE which is configured with a "false" value, the TCI state #64 may indicate to the UE to receive the scheduling PDSCH **1110** in the normal power consumption mode, in which there are N2 antenna panels turned on by the UE. As noted above, because the UE needs to turn on a number of antenna panels to enter the normal power consumption mode, the UE may apply a long K0 value for receiving the PDSCH **1110**. For example, the UE may refer to the K0 configuration in Table 2 to apply a long K0 value (e.g., 4 slots) contained in the row entry which is indexed by "15" and associated with the TCI state #64. Once the long K0 value (e.g., 4 slots) is applied, the UE will expect to receive the PDSCH **1110** in the slot m+4, which is the fourth slot after the slot # m, as shown in FIG. **11**A. In addition, the timer for antenna panel status may start at the end of the slot # m+4.

After successfully receiving and decoding the PDSCH **1110**, the UE may transmit an HARQ-ACK over a PUCCH **1112** in the slot # m+6 based on the ARI contain in the second DCI message DCI_2, as shown in FIG. **11**B.

Then, UE may successfully receive and decode a third DCI message DCI_3 which is transmitted over a PDCCH **1114** in the slot # m+9. The third DCI message DCI_3 may indicate to the UE to apply the TCI state #64 for a scheduling PDSCH **1116**. Because the timer for antenna panel status expires in the end of the slot # m+8, the UE has already switched to the power saving mode when receiving the third DCI message DCI_3. In addition, according to FIG. **8**, the TCI state #64 may indicate to the UE to receive the PDSCH **1116** in the normal power consumption mode. Because the UE needs to turn on at least N2-N1 antenna panels to switch from the power saving mode to the normal power consumption mode, the UE may apply a long K0 value (e.g., 4 slots) based on the K0 configuration (e.g., the K0 configuration shown in Table 2), and receive the PDSCH **1116** in the slot m+13 which is the fourth slot after the slot # m+9. After successfully receiving and decoding the PDSCH **1116**, the UE may transmit an HARQ-ACK in the slot # k based on the ARI in the scheduling DCI (e.g., the third DCI message DCI_3), as shown in FIG. **11**B.

An illustrative example (denoted as Example 2-1) will now be provided, where an RRC-configured offset value for receiving an aperiodic CSI RS may be selected based on a CSI request from the BS.

FIG. **12** is a flowchart for a method of selecting an offset value (e.g. a K0 value) for receiving an aperiodic CSI-RS, in accordance with example implementations of the present disclosure.

In action **1202**, the UE may be configured with multiple sets of parameters corresponding to different operation modes (e.g., the power saving mode and the normal power consumption mode). For example, two different leading times may be predefined in the 3GPP technical specifications for the UE. One may be a shorter leading (e.g., 10 microseconds) to be used in the case that the UE does not need to further turn on an antenna panel, and the other one may be a longer leading time (e.g., 3 ms) to be used in the case that the UE needs to turn on one or more antenna panels to change the operation mode. In addition, the UE may be configured with a set of offset values (e.g., aperiodicTrig-

geringOffset) in an RRC configuration for receiving an aperiodic CSI-RS, as shown in FIG. **13**.

FIG. **13** is an example data structure indicating an aperiodic CSI RS reception configuration, in accordance with example implementations of the present disclosure. As shown in FIG. **13**, in the aperiodic CSI RS reception configuration (e.g., NZP-CSI-ResourceSet) **1302**, the aperiodicTriggeringOffset may refer to a specific row entry (e.g., indexed by "10") in the K0 configuration **1304**, which is associated with a normal K0 value of 2 slots and a long K0 value of 6 slots. The UE may be further configured in the power saving mode based on an initial indicator for antenna panel status (e.g., the indicator for antenna panel status **902** in FIG. **9**). In addition, the numerology applied in this example may be, but not limited to, 15 KHz.

Referring back to FIG. **12**. In action **1204**, the UE may receive a DCI message containing a CSI request from BS. In action **1206**, the UE may apply a K0 value corresponding to the antenna panel status indicated by the CSI request.

FIG. **14** is an example of a MAC-CE message, in accordance with example implementations of the present disclosure. As shown in FIG. **14**, a MAC-CE message **1402** includes several reserved bits (which are denoted as "R" in FIG. **14**), a cell ID, and a control bit (which is denoted as "C" in FIG. **14**). The cell ID may contain the serving cell ID (e.g., "00000" in this example). The control bit "C" may be used for indicating to the UE to enable/disable the power saving mode. For example, the UE may be indicated to enable the power saving mode when the control bit is set to a first value (e.g., "1"), or indicated to disable the power saving mode when the control bit is set to a second value (e.g., "0"). As shown in FIG. **14**, the MAC-CE message **1402** of which the control bit is set to "0" may be used for indicating to the UE to disable the power saving mode (or to operate in the normal power consumption mode).

FIG. **15** is a schematic diagram illustrating that different triggering offset values (e.g., K0 values) are applied for the changes in the antenna panel status of a wireless communication device (e.g., a UE), in accordance with example implementations of the present disclosure. In this example, the total number of turned-on/active antenna panels at the UE is N1 when the UE is in the power saving mode and is N2 when the UE is the normal power consumption mode, where N1 is less than N2. For example, N1 may be "1" and N2 may be the number of the antenna panels the UE has.

As shown in FIG. **15**, in the slot # n, the UE may receive a first DCI message DCI_1 which is transmitted over a PDCCH **1502**, and obtain a MAC-CE message (e.g., the MAC-CE message **1402** in FIG. **14**) based on the first DCI message DCI_1. The MAC-CE message may include an indicator for antenna panel status (e.g., the control bit of the MAC-CE message **1402** in FIG. **14**) used for indicating the UE to operate in the normal power consumption mode (or disable the power saving mode). Then, the UE may monitor a scheduling PDSCH **1504** based on the first DCI message DCI_1 and transmit a HARQ-ACK over a PUCCH **1508** for the MAC-CE message in the slot # n+5.

In this example, the UE may receive a second DCI message DCI_2 which is transmitted over a PDCCH **1506** in the slot # n+1. The second DCI message DCI_2 may contain a CSI request for triggering an aperiodic CSI report. For example, the CSI request for triggering the CSI-RS resource may be indicated by the BS, through the QCL information associated with the CSI-RS resource, to be received by the multiple antenna panels at the UE. In some implementations of the present disclosure, the UE may apply a normal triggering offset value when the UE does not need to further turn on an antenna panel in response to the indicator for antenna panel status obtained from the BS, and apply a long triggering offset value when the UE needs to turn on at least one antenna panel in response to the indicator for antenna panel status received from the BS. Thus, in this example, the UE may apply a long triggering offset value (e.g., aperiodicTriggeringOffset) for the CSI request to switch from the power saving mode to the normal power consumption mode. As shown in FIG. **15**, the BS may transmit the CSI-RS resource in the slot #n+7, which is the sixth time slot after the slot #n+1.

In addition, the UE may further receive a third DCI message DCI_3 which is transmitted over a PDCCH **1510** in the slot # m. The third DCI message DCI_3 may contain a CSI request for triggering an aperiodic CSI report, and the CSI request may indicate the same aperiodic CSI-RS trigger state as indicated by the CSI request contained in the second DCI message DCI_2. Since the CSI-RS resource (which is triggered by the CSI request contained in the third DCI message DCI_3) is indicated to be received by the multiple antenna panels of the UE by the BS (e.g., through the QCL information which is associated with the CSI-RS resource), the UE may decide to apply a normal triggering offset value (e.g., aperiodicTriggeringOffset) of two slots for this CSI request based on the current antenna panel status (e.g., with N2 antenna panels being turned-on). Thus, as shown in FIG. **15**, the UE may receive the corresponding aperiodic CSI-RS resource from the BS in the slot # m+2, which is the first time slot after the slot # m+1.

An illustrative example (denoted as Example 2-2) will now be provided, where an RRC-configured offset value for an aperiodic CSI RS reception may be selected based on a CSI request from the BS and a timer for antenna panel status.

In Example 2-2, the UE may be further configured with a timer for antenna panel status in addition to the multiple sets of parameters configured in action **1202** of FIG. **12**. For example, the configuration of the timer for antenna panel status may be, but not limited to, the configuration **602** in FIG. **6**. In some implementations of the present disclosure, the numerology of the timer for antenna panel status may be determined based on the scheduling PDSCH of the active DL BWP.

FIGS. **16**A and **16**B are schematic diagrams illustrating that different triggering offset values (e.g., K0 values) are applied for the changes in the antenna panel status of a wireless communication device (e.g., a UE), in accordance with example implementations of the present disclosure. It should be noted that FIG. **16**B is continued from the FIG. **16**A. In this example, the total number of turned-on/active antenna panels at the UE is N1 when the UE is in the power saving mode and is N2 when the UE is the normal power consumption mode, where N1 is less than N2. For example, N1 may be "1" and N2 may be the number of the antenna panels the UE has.

As shown in FIG. **16**A, in the slot # n, the UE may receive a first DCI message DCI_1 which is transmitted over a PDCCH **1602**, and obtain a MAC-CE message (e.g., the MAC-CE message **1402** in FIG. **14**) based on the first DCI message DCI_1. The MAC-CE message may include an indicator for antenna panel status (e.g., the control bit of the MAC-CE message **1402** in FIG. **14**) that may indicate to the UE to operate in the normal power consumption mode. The UE may monitor a scheduling PDSCH **1604** based on the first DCI message DCI_1 and transmit an HARQ-ACK over a PUCCH **1608** for the MAC-CE message in the slot # n+5.

In addition, the UE may receive a second DCI message DCI_2 which is transmitted over a PDCCH **1606** in the slot

# n+1. The second DCI message DCI_2 may contain a CSI request for triggering an aperiodic CSI report. For example, the CSI request for triggering the CSI-RS resource may be indicated by the BS, through the QCL information associated with the CSI-RS resource, to be received by the multiple antenna panels at the UE. As described above, the UE may apply a long triggering offset value (e.g., aperiodicTriggeringOffset) for the CSI request because the UE may need to turn on at least one antenna panel in response to the indicator for antenna panel status obtained from the BS. As shown in FIG. **16**A, the BS may transmit the CSI-RS resource in the slot #n+7, which is the sixth time slot after the slot #n+1. In this example, the timer for antenna panel status may also start at the beginning of the slot #n+7.

Referring to FIG. **16**B. The timer may then expire at the end of the slot n+10, and the UE may switch from the normal power consumption mode to the power saving mode. In addition, the UE may then receive a third DCI message DCI_3 which is transmitted over a PDCCH **1610** in the slot # m, where m>n+10. The third DCI message DCI_3 may contain a CSI request for triggering an aperiodic CSI report, and the CSI request may indicate the same aperiodic CSI-RS trigger state as indicated by the second DCI message DCI_2. Since the CSI-RS resource triggered by the CSI request is indicated by the BS, through the QCL information associated to the CSI-RS resource, to be received by multiple antenna panels of the UE, the UE may decide to apply a long triggering offset value (e.g., aperiodicTriggeringOffset) for this CSI request based on current antenna panels status (e.g., with N1 antenna panels being turned-on). Thus, as shown in FIG. **16**B, the BS may transmit the aperiodic CSI-RS resource in the slot # m+5, which is the fifth time slot after the slot # m.

An illustrative example (denoted as Example 3-1) will now be provided, where a UE may indicate its antenna panel status through at least one explicit bit in a CSI report.

FIG. **17** is a schematic diagram illustrating a timeline of the antenna panel status of a wireless communication device (e.g., a UE), in accordance with example implementations of the present disclosure. In this example, the total number of turned-on/active antenna panels at the UE is N1 when the UE is in the power saving mode and is N2 when the UE is the normal power consumption mode, where N1 is less than N2.

In this example, the UE may be configured with a periodic CSI report and the periodicity for the CSI report may be 20 slots. In addition, the UE may be configured with a timer for antenna panel status. The configuration of the timer for antenna panel status may be, but not limited to, the configuration **602** shown in FIG. **6**. In some implementations of the present disclosure, the numerology of the timer for antenna panel status may be determined based on the scheduling PDSCH of active DL BWP.

Referring back to FIG. **17**, the UE may use N1 antenna panel(s) to receive a CSI-RS #1 for calculating a CSI report which is to be transmitted over a PUCCH **1702** in the slot # n. Hence, the bit field in the CSI report may be set to a first value (e.g., "1") to indicate that the UE is in the power saving mode.

On the other hand, if the UE changes to use multiple antenna panels to receive the CSI-RS #2 for calculating a CSI report which is to be transmitted over a PUCCH **1704** in the slot # n+20, the bit field in this CSI report may be set to a second value (e.g., "0") to indicate that the UE is in normal power consumption mode (e.g., by disabling the power saving mode).

An illustrative example (denoted as Example 4-1) will now be provided, where the antenna panel status may be switched based on a DRX operation.

FIG. **18** is a flowchart for a method for determining the antenna panel status of a wireless communication device (e.g., a UE) based on a DRX operation, in accordance with example implementations of the present disclosure. As shown in FIG. **18**, in action **1802**, the UE may be configured with a DRX inactivity timer by the BS. In action **1804**, the UE may switch the antenna panel status based on the DRX inactivity timer.

In some implementations of the present disclosure, the DRX inactivity timer may be used to define how long a UE should remain in the ON state after the reception of a PDCCH. For example, while the DRX inactivity timer is running, the UE may remain in the ON state.

In Example 4-1, the UE may be configured with a DRX period and a timer for antenna panel status. In addition, the BS may indicate to the UE to operate in the normal power consumption mode, as shown in FIG. **19**.

FIG. **19** is an example data structure indicating an RRC configuration for the UE, in accordance with example implementations of the present disclosure. As shown in FIG. **19**, an RRC configuration **1902** may include a DRX configuration and an antenna panel status configuration. The DRX configuration may be configured with a DRX inactivity timer for 2 ms and a DRX cycle of 50 ms. The antenna panel status configuration may indicate that the power saving mode is to be disabled (e.g., with a "false" value) and the length of the timer for the antenna panel status is four slots.

FIG. **20** is a schematic diagram illustrating a timeline of the antenna panel status of a wireless communication device (e.g., a UE) and a timing diagram of a DRX cycle, in accordance with example implementations of the present disclosure. In the present implementation, the timer for antenna panel status may have the same operation as the DRX inactivity timer. In addition, the total number of turned-on/active antenna panels at the UE is N1 when the UE is in the power saving mode and is N2 when the UE is the normal power consumption mode, where N1 is less than N2.

As shown in FIG. **20**, the UE may receive a DCI message in the slot # n at which the UE is in a DRX on-duration. In response to receiving the DCI message, the UE may start both the DRX inactivity timer and the timer for antenna panel status, if the DCI message is used for indicating to the UE to operate in the normal power consumption mode. Then, if the timer for antenna panel status is going to stop/expire at the beginning of the slot # n+4 (e.g., according to the RRC configuration **1902** in FIG. **19**), the DRX inactivity timer may follow the timer for antenna panel status to stop/expire at the same timing (e.g., at the beginning of the slot # n+4). Thus, the UE may enter a DRX off-duration and operate in the power saving mode at the same time.

An illustrative example (denoted as Example 4-2) will now be provided, where the antenna panel status may be switched based on a DRX operation.

In Example 4-2, the UE may be configured with a DRX inactivity timer by the BS. In addition, the UE may be indicated by the BS to operate in the normal power consumption mode based on an RRC configuration, as shown in FIG. **21**.

FIG. **21** is an example data structure indicating an RRC configuration for the UE, in accordance with example implementations of the present disclosure. As shown in FIG. **21** an RRC configuration **2102** may include a DRX configuration

and an antenna panel status configuration. The DRX configuration may be configured with a DRX inactivity timer for 2 ms and a DRX cycle of 50 ms. Furthermore, the antenna panel status configuration may indicate that the power saving mode is to be disabled (e.g., with a "False" value).

FIG. **22** is a schematic diagram illustrating a timeline of the antenna panel status of a wireless communication device (e.g., a UE) and a timing diagram of a DRX cycle, in accordance with example implementations of the present disclosure. In the present implementation, the antenna panel status of a UE may follow the DRX cycles. In addition, the total number of turned-on/active antenna panels at the UE is N1 when the UE is in the power saving mode, and is N2 when the UE is the normal power consumption mode, where N1 is less than N2.

As shown in FIG. **22**, the UE may at first operate in the normal power consumption mode based on the most recently received BS instruction (e.g., received through an RRC configuration, a MAC-CE message or a DCI message). If the UE does not receive a PDCCH in the DRX on-duration (at which the UE is in an active state), the UE may then switch to the power saving mode after the UE enters the DRX off-duration (at which the UE is in an inactive/sleep state).

FIG. **23** is a flowchart for a method of operating multiple antenna panels, in accordance with example implementations of the present disclosure.

In action **2302**, a wireless communication device (e.g., a UE) may maintain a plurality of leading time values, wherein the plurality of leading time values may indicate a plurality of leading time durations.

In action **2304**, the wireless communication device may receive an indicator for antenna panel status information from a BS.

In action **2306**, the wireless communication device may apply one of the plurality of leading time values to switch an antenna panel status of the plurality of antenna panels based on the received indicator for antenna panel status information.

FIG. **24** is a block diagram illustrating a node for wireless communication, in accordance with various aspects of the present application. As shown in FIG. **24**, a node **2400** may include a transceiver **2420**, a processor **2428**, a memory **2434**, one or more presentation components **2438**, and at least one antenna **2436**. The node **2400** may also include an RF spectrum band module, a BS 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 FIG. **24**). Each of these components may be in communication with each other, directly or indirectly, over one or more buses **2440**. In one implementation, the node **2400** may be a UE or a BS that performs various functions described herein, for example, with reference to FIGS. **1** through **23**.

The transceiver **2420** having a transmitter **2422** (e.g., transmitting/transmission circuitry) and a receiver **2424** (e.g., receiving/reception circuitry) may be configured to transmit and/or receive time and/or frequency resource partitioning information. In some implementations, the transceiver **2420** 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. The transceiver **2420** may be configured to receive data and control channels.

The node **2400** may include a variety of computer-readable media. Computer-readable media may be any available media that may be accessed by the node **2400** 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.

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.

The memory **2434** may include computer-storage media in the form of volatile and/or non-volatile memory. The memory **2434** may be removable, non-removable, or a combination thereof. Example memory includes solid-state memory, hard drives, optical-disc drives, and etc. As illustrated in FIG. **24**, The memory **2434** may store computer-readable, computer-executable instructions **2432** (e.g., software codes) that are configured to, when executed, cause the processor **2428** to perform various functions described herein, for example, with reference to FIGS. **1** through **23**. Alternatively, the instructions **2432** may not be directly executable by the processor **2428** but be configured to cause the node **2400** (e.g., when compiled and executed) to perform various functions described herein.

The processor **2428** (e.g., having processing circuitry) may include an intelligent hardware device, e.g., a Central Processing Unit (CPU), a microcontroller, an ASIC, and etc. The processor **2428** may include memory. The processor **2428** may process the data **2430** and the instructions **2432** received from the memory **2434**, and information through the transceiver **2420**, the base band communications module, and/or the network communications module. The processor **2428** may also process information to be sent to the transceiver **2420** for transmission through the antenna **2436**, to the network communications module for transmission to a core network.

One or more presentation components **2438** presents data indications to a person or other device. Examples of presentation components **2438** may include a display device, speaker, printing component, vibrating component, etc.

From the above description, it is manifested that various techniques may be used for implementing the concepts described in the present application 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 may 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 application 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.

What is claimed is:

**1**. A wireless communication device comprising:

a plurality of antenna panels;

a processor coupled to the plurality of antenna panels and configured to:

maintain a plurality of leading time values, the plurality of leading time values indicating a plurality of leading time durations;

receive an indicator for antenna panel status information from a base station (BS);

apply one of the plurality of leading time values to switch an antenna panel status of the plurality of antenna panels based on the indicator for antenna panel status information;

receive a scheduling offset value from the BS, the scheduling offset value comprising at least one of a K0 parameter for a Downlink (DL) channel and a K2 parameter for an Uplink (UL) channel; and

determine that the scheduling offset value is invalid, when a time duration indicated by the scheduling offset value is less than a leading time duration indicated by the applied leading time value.

**2**. The wireless communication device of claim **1**, wherein the processor is further configured to:

receive a timer from the BS; and

switch the antenna panel status from a first antenna panel status to a second antenna panel status after the timer expires.

**3**. The wireless communication device of claim **2**, wherein the timer expires when one of a Discontinuous Reception (DRX) inactivity timer expires and the wireless communication device enters one of a DRX off-period and a sleep mode.

**4**. The wireless communication device of claim **1**, wherein the processor is further configured to:

transmit an antenna panel status report to inform the BS of the switch of the antenna panel status.

**5**. The wireless communication device of claim **4**, wherein the antenna panel status report is contained in one of a beam report and a Channel State Information (CSI) report.

**6**. The wireless communication device of claim **4**, wherein the antenna panel status report comprises a single-bit Information Element (IE), and the processor is further configured to:

set the single-bit IE to a first value to indicate that a power saving mode is enabled; and

set the single-bit IE to a second value to indicate that the power saving mode is disabled,

wherein a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is enabled is less than a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is disabled.

**7**. The wireless communication device of claim **4**, wherein the antenna panel status report comprises a multiple-bit Information Element (IE), and the processor is further configured to:

set the multiple-bit IE to a particular value associated with a particular number of the plurality of antenna panels being turned on.

**8**. The wireless communication device of claim **1**, wherein the indicator for antenna panel status information comprises a single-bit Information Element (IE), and the processor is further configured to:

enable a power saving mode when the single-bit IE is set to a first value; and

disable the power saving mode when the single-bit IE is set to a second value,

wherein a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is enabled is less than a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is disabled.

**9**. The wireless communication device of claim **1**, wherein the indicator for antenna panel status information comprises a multiple-bit Information Element (IE), and the processor is further configured to:

turn on a particular number of the plurality of antenna panels when the multiple-bit IE is set to a particular value.

**10**. The wireless communication device of claim **1**, wherein the indicator for antenna panel status information is contained in a Transmission Configuration Indicator (TCI) state Identity (ID) indicated by the BS.

**11**. The wireless communication device of claim **1**, wherein the plurality of leading time values is one of cell-specific values and cell group-specific values.

**12**. The wireless communication device of claim **1**, wherein the processor is further configured to:

switch the antenna panel status from a first antenna panel status to a second antenna panel status in response to receiving the indicator for antenna panel status information; and

automatically switch the antenna panel status from the second antenna panel status to a third antenna panel status without further reception of an indicator for antenna panel status information from the BS.

**13**. The wireless communication device of claim **1**, wherein the processor is further configured to:

enable a power saving mode when the wireless communication device operates in a Discontinuous Reception (DRX) active time; and

disable the power saving mode when the wireless communication device operates in a DRX inactive time,

wherein a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is enabled is less than a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is disabled.

**14**. The wireless communication device of claim **1**, wherein the processor is further configured to:

enable a power saving mode based on whether the wireless communication device operates in a particular Bandwidth Part (BWP),

wherein:

a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is enabled is less than a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is disabled; and

the particular BWP is one of a default BWP, an initial BWP, and a first active BWP.

**15**. A method performed by a wireless communication device for operating a plurality of antenna panels, the method comprising:

maintaining a plurality of leading time values, the plurality of leading time values indicating a plurality of leading time durations;

receiving an indicator for antenna panel status information from a base station (BS);

applying one of the plurality of leading time values to switch an antenna panel status of the plurality of antenna panels based on the indicator for antenna panel status information;

receiving a scheduling offset value from the BS, the scheduling offset value comprising at least one of a K0 parameter for a Downlink (DL) channel and a K2 parameter for an Uplink (UL) channel; and

determining that the scheduling offset value is invalid, when a time duration indicated by the scheduling offset value is less than a leading time duration indicated by the applied leading time value.

**16**. The method of claim **15**, further comprising:

receiving a timer from the BS; and

switching the antenna panel status from a first antenna panel status to a second antenna panel status after the timer expires.

**17**. The method of claim **16**, wherein the timer expires when one of a Discontinuous Reception (DRX) inactivity timer expires and the wireless communication device enters one of a DRX off-period and a sleep mode.

**18**. The method of claim **15**, further comprising:

transmitting an antenna panel status report to inform the BS of the switch of the antenna panel status.

**19**. The method of claim **18**, wherein the antenna panel status report is contained in one of a beam report and a Channel State Information (CSI) report.

**20**. The method of claim **18**, wherein the antenna panel status report comprises a single-bit Information Element (IE), and the method further comprises:

setting the single-bit IE to a first value to indicate that a power saving mode is enabled; and

setting the single-bit IE to a second value to indicate that the power saving mode is disabled;

wherein a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is enabled is less than a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is disabled.

**21**. The method of claim **18**, wherein the antenna panel status report comprises a multiple-bit Information Element (IE), and the method further comprises:

setting the multiple-bit IE to a particular value associated with a particular number of the plurality of antenna panels being turned on.

**22**. The method of claim **15**, wherein the indicator for antenna panel status information comprises a single-bit Information Element (IE), and the method further comprises:

enabling a power saving mode when the single-bit IE is set to a first value; and

disabling the power saving mode when the single-bit IE is set to a second value,

wherein a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is enabled is less than a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is disabled.

**23**. The method of claim **15**, wherein the indicator for antenna panel status information comprises a multiple-bit Information Element (IE), and the method further comprises:

turning on a particular number of the plurality of antenna panels when the multiple-bit IE is set to a particular value.

**24**. The method of claim **15**, wherein the indicator for antenna panel status information is contained in a Transmission Configuration Indicator (TCI) state Identity (ID) indicated by the BS.

**25**. The method of claim **15**, wherein the plurality of leading time values is one of cell-specific values and cell group-specific values.

**26**. The method of claim **15**, further comprising:

switching the antenna panel status from a first antenna panel status to a second antenna panel status in response to receiving the indicator for antenna panel status information; and

automatically switch the antenna panel status from the second antenna panel status to a third antenna panel status without further reception of an indicator for antenna panel status information from the BS.

**27**. The method of claim **15**, further comprising:

enabling a power saving mode when the wireless communication device operates in a Discontinuous Reception (DRX) active time; and

disabling the power saving mode when the wireless communication device operates in a DRX inactive time,

wherein a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is enabled is less than a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is disabled.

**28**. The method of claim **15**, further comprising:

enabling a power saving mode based on whether the wireless communication device operates in a particular Bandwidth Part (BWP),

wherein:

a total number of turned-on antenna panels in the plurality of antenna panels when the power saving mode is enabled is less than a total number of turned-on antenna panels when the power saving mode is disabled; and

the particular BWP is one of a default BWP, an initial BWP, and a first active BWP.

* * * * *

# Exhibit 4

US011115165B2

(12) **United States Patent**
**Tsai et al.**

(10) **Patent No.: US 11,115,165 B2**
(45) **Date of Patent: Sep. 7, 2021**

(54) **METHOD AND APPARATUS FOR MULTIPLE TRANSMIT/RECEIVE POINT (TRP) OPERATIONS**

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(72) Inventors: **Tsung-Hua Tsai**, Hsinchu (TW); **Chie-Ming Chou**, Hsinchu (TW)

(73) Assignee: **FG Innovation Company Limited**, Tuen Mun (HK)

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(21) Appl. No.: **16/673,151**

(22) Filed: **Nov. 4, 2019**

(65) **Prior Publication Data**

US 2020/0145159 A1 May 7, 2020

**Related U.S. Application Data**

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(51) **Int. Cl.**
***H04L 1/00*** (2006.01)
***H04W 72/04*** (2009.01)
***H04L 5/00*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***H04L 5/0048*** (2013.01); ***H04L 5/0023*** (2013.01); ***H04L 5/0035*** (2013.01); ***H04L 5/0053*** (2013.01); ***H04W 72/042*** (2013.01)

(58) **Field of Classification Search**
CPC ... H04L 5/0048; H04L 5/0023; H04L 5/0035; H04L 5/0053; H04W 72/042
See application file for complete search history.

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| 2020/0045700 | A1* | 2/2020 | Sun | H04W 72/04 |
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| WO | 2018128376 | A1 | 7/2018 |

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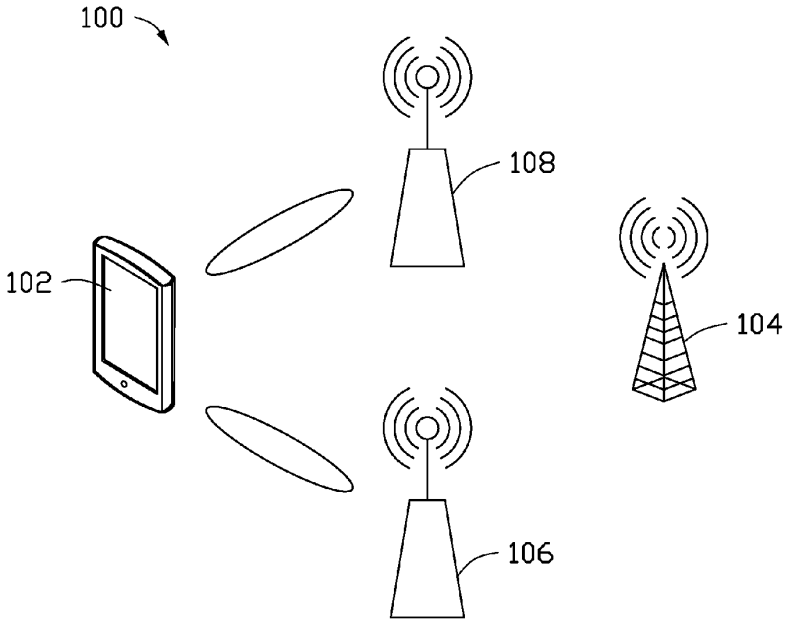
*Primary Examiner* — Ronald B Abelson
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

A method includes receiving, by a User Equipment (UE), Transmission Configuration Indicator (TCI) state data in a Physical Download Control Channel (PDCCH) determining multiple Physical Downlink Shared Channels (PDSCHs), where the TCI state data is associated with multiple Demodulation Reference Signal (DMRS) port groups, and obtaining, by the UE, multiple Quasi Co-Location (QCL) assumptions for receiving the PDSCHs based on the DMRS port groups associated with the TCI state data.

**12 Claims, 6 Drawing Sheets**



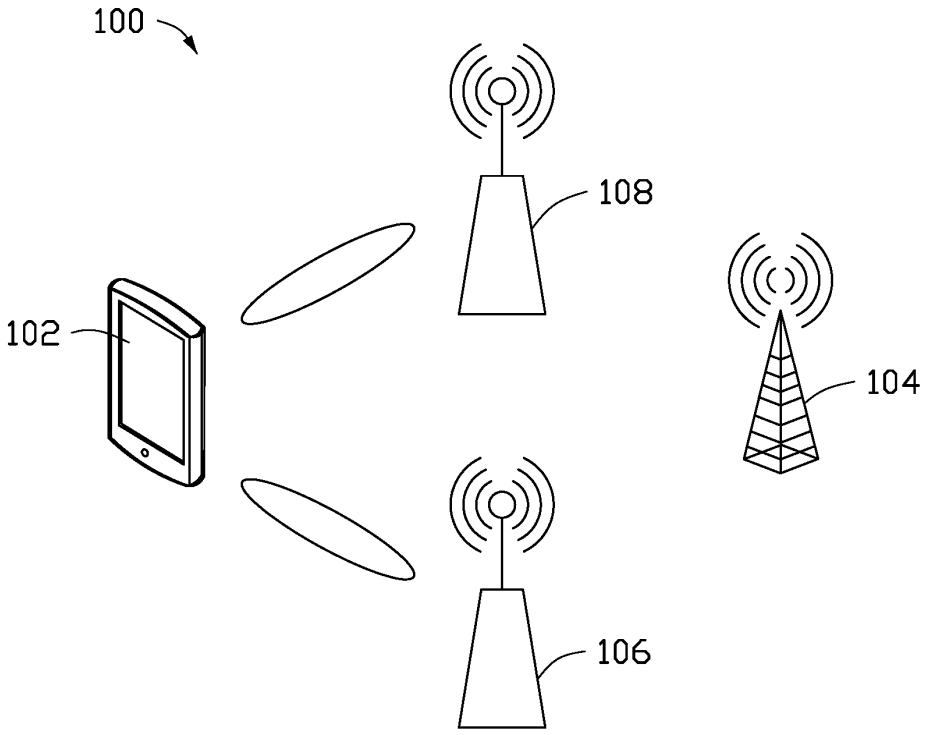



FIG. 1

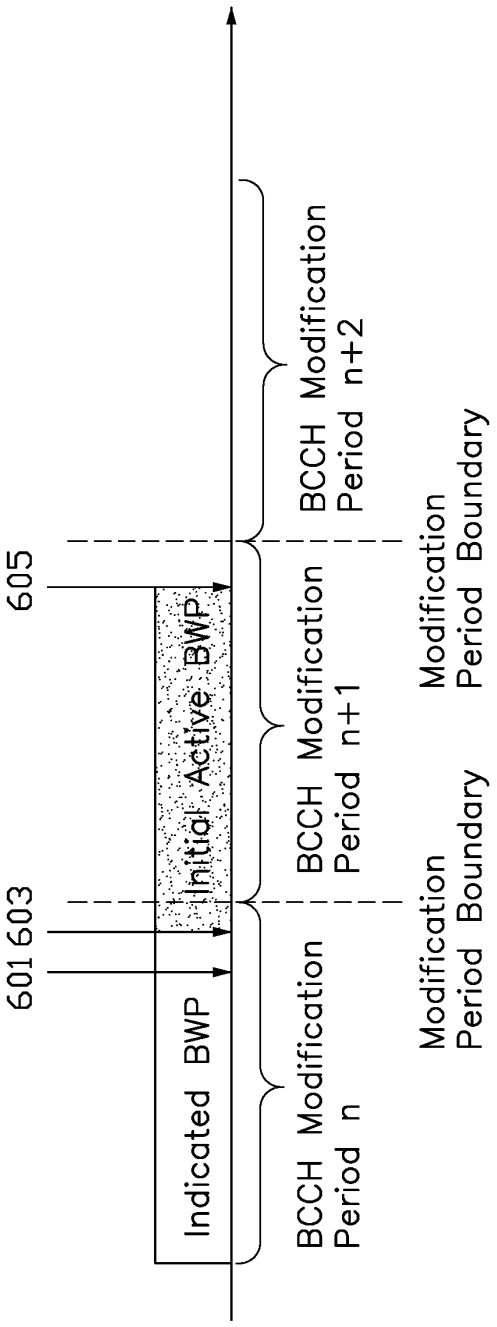

601
603
605
Indicated BWP
Initial Active BWP
BCCH Modification Period n
BCCH Modification Period n+1
BCCH Modification Period n+2
Modification Period Boundary
Modification Period Boundary

FIG. 6

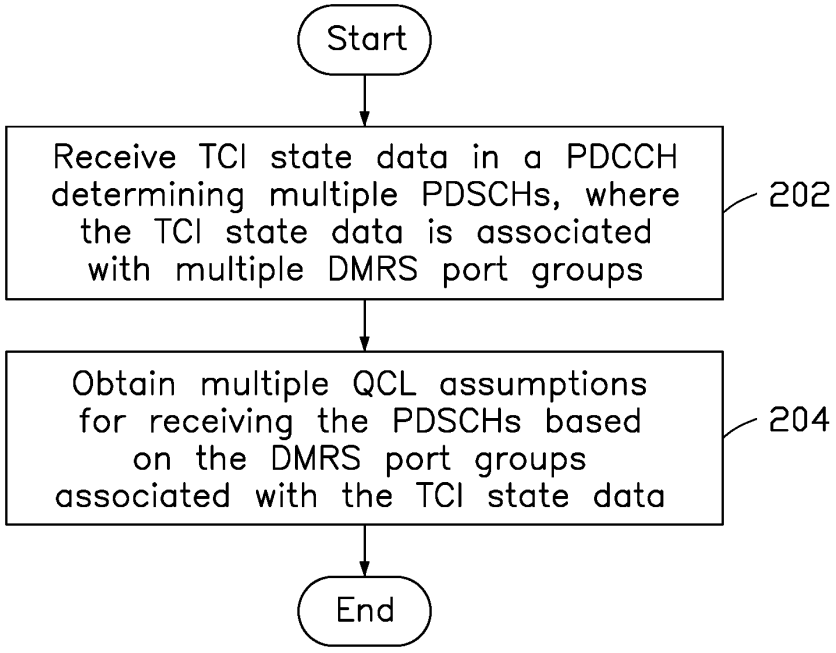

Start
Receive TCI state data in a PDCCH determining multiple PDSCHs, where the TCI state data is associated with multiple DMRS port groups
202
Obtain multiple QCL assumptions for receiving the PDSCHs based on the DMRS port groups associated with the TCI state data
204
End

FIG. 2

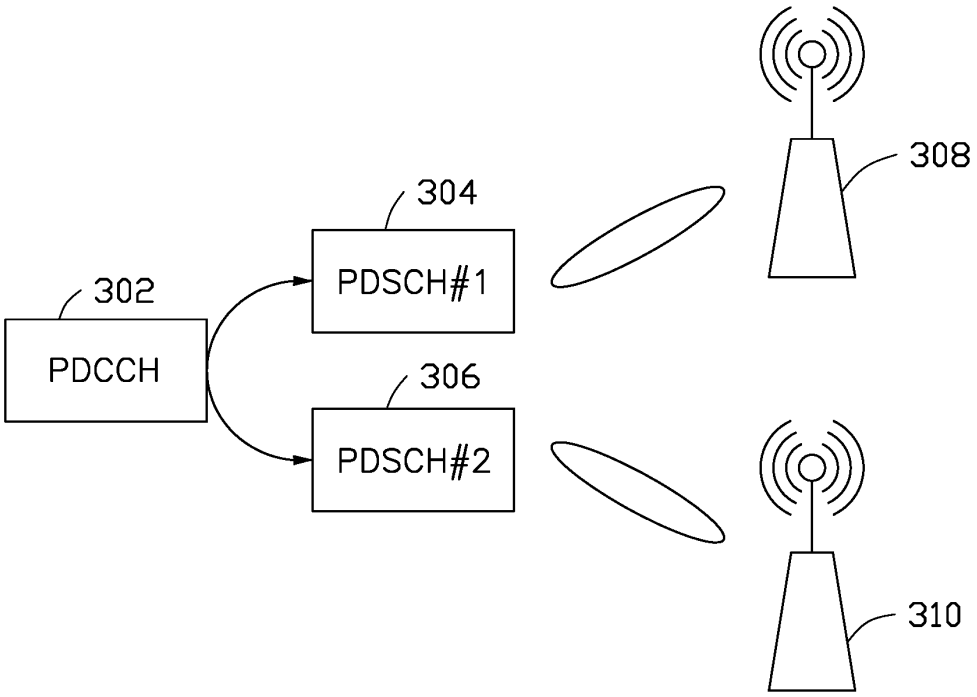



FIG. 3

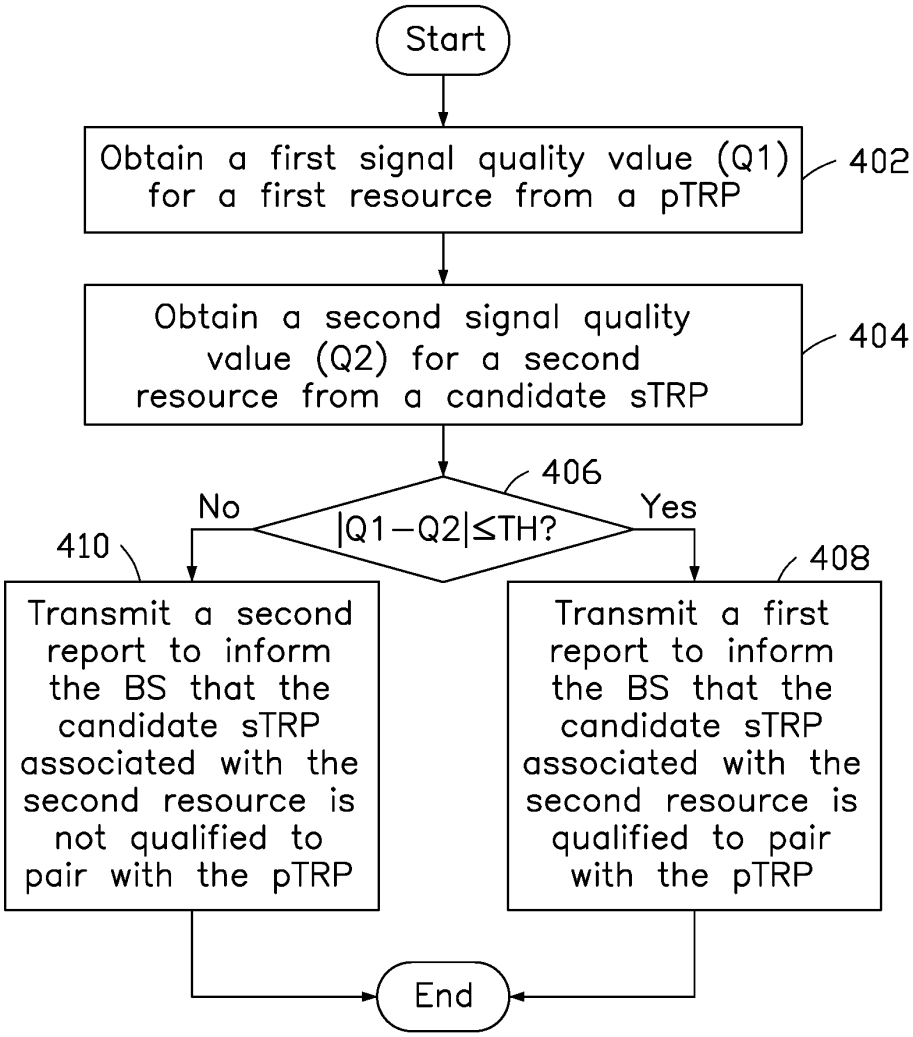

Start
Obtain a first signal quality value (Q1) for a first resource from a pTRP
402
Obtain a second signal quality value (Q2) for a second resource from a candidate sTRP
404
406
|Q1−Q2|≤TH?
No
Yes
410
Transmit a second report to inform the BS that the candidate sTRP associated with the second resource is not qualified to pair with the pTRP
408
Transmit a first report to inform the BS that the candidate sTRP associated with the second resource is qualified to pair with the pTRP
End

FIG. 4

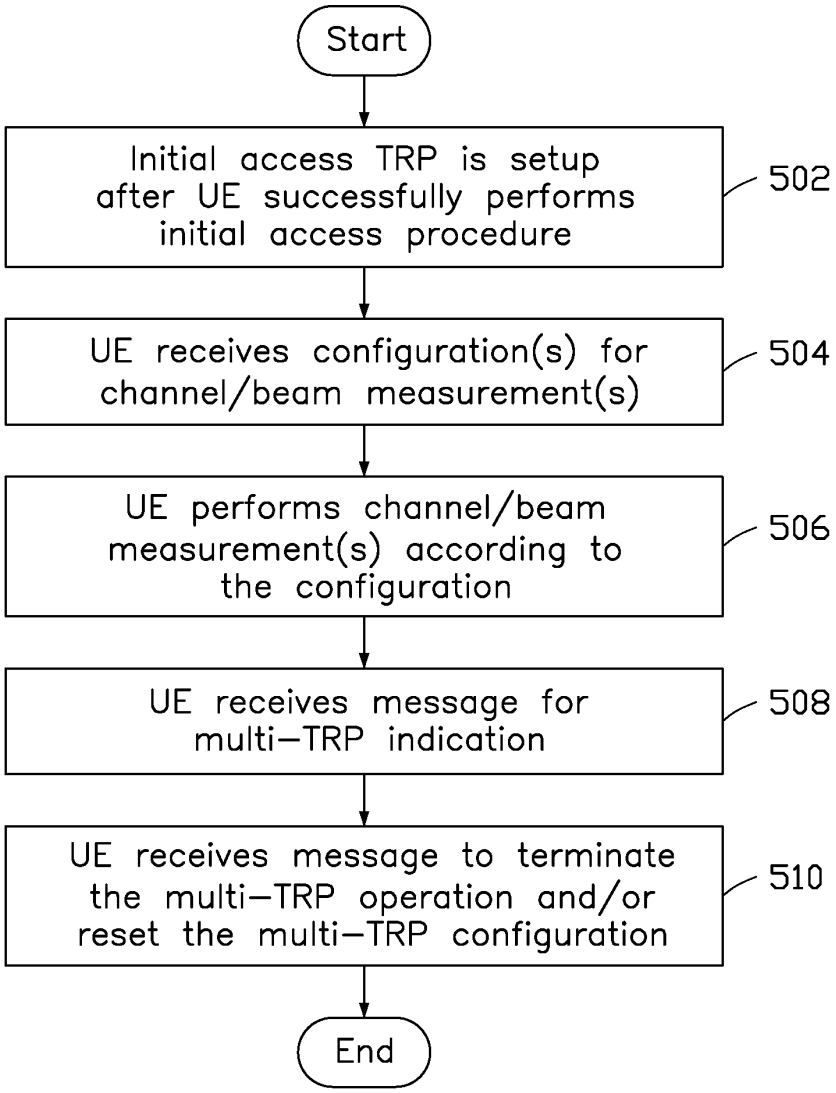

Start
Initial access TRP is setup after UE successfully performs initial access procedure
502
UE receives configuration(s) for channel/beam measurement(s)
504
UE performs channel/beam measurement(s) according to the configuration
506
UE receives message for multi-TRP indication
508
UE receives message to terminate the multi-TRP operation and/or reset the multi-TRP configuration
510
End

FIG. 5

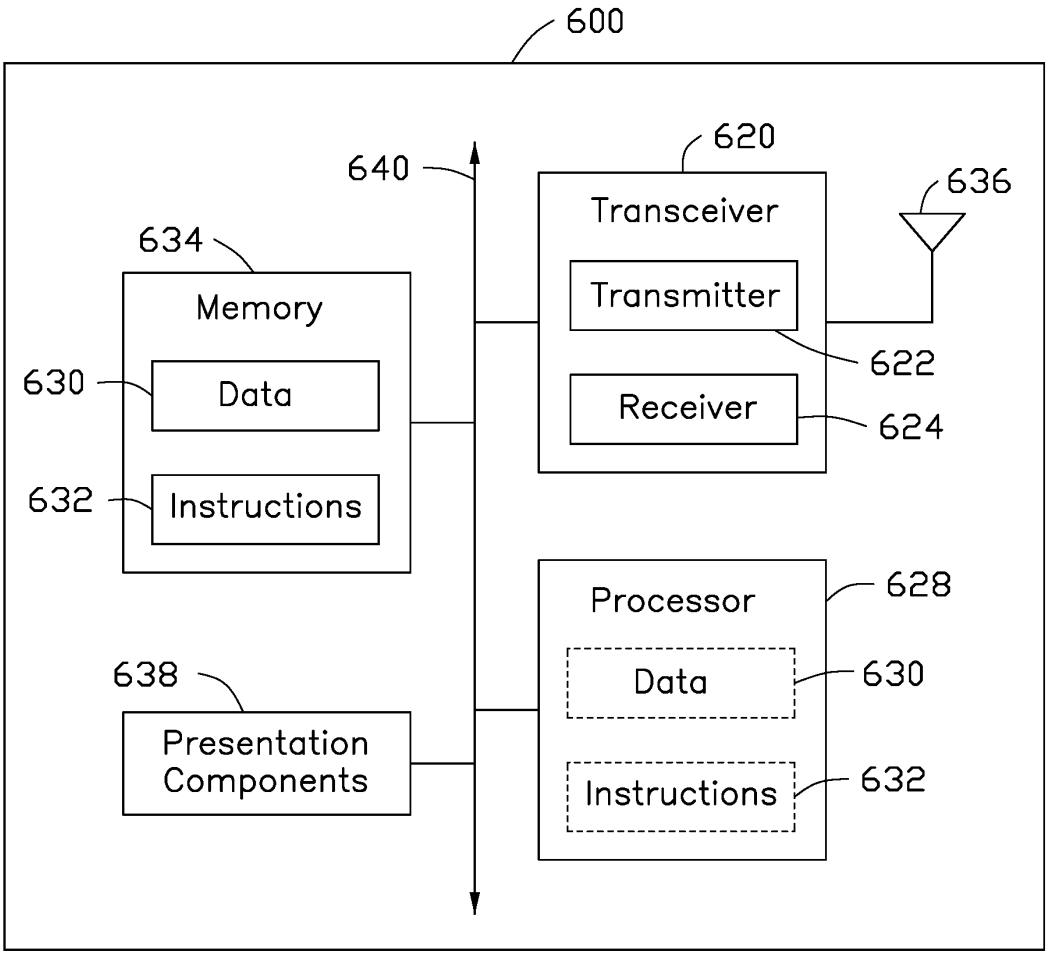

600
640
620
Transceiver
636
634
Memory
Transmitter
630
Data
622
Receiver
624
632
Instructions
Processor
628
638
Data
630
Presentation Components
Instructions
632

FIG. 6

# METHOD AND APPARATUS FOR MULTIPLE TRANSMIT/RECEIVE POINT (TRP) OPERATIONS

## CROSS-REFERENCE TO RELATED APPLICATION(S)

The present application claims the benefit of and priority to a provisional U.S. Patent Application Ser. No. 62/754,706 filed on Nov. 2, 2018, entitled "Procedure for Multiple Transmit/Receive Point," (hereinafter referred to as "US75391 application"). The disclosure of the US75391 application is hereby incorporated fully by reference into the present application.

## FIELD

The present disclosure generally relates to wireless communications, and more particularly, to methods and apparatuses for multiple Transmit/Receive Point (TRP) operations.

## BACKGROUND

Various efforts have been made to improve different aspects of wireless communications (e.g., data rate, latency, reliability, mobility, etc.) for the next generation (e.g., Fifth Generation (5G) New Radio (NR)) wireless communication systems. Among the new concepts in the next generation wireless communication systems, leveraging multiple TRPs may be vital to improve coverage, reliability, and capacity performance of the system. For example, in order to support the growth in data traffic in 5G and to enhance the coverage, the wireless devices may be expected to access networks composed of multiple TRPs.

However, in the current multi-TRP environment, all TRPs in a cell may have the same cell Identity (ID), which means a User Equipment (UE) may not be able to distinguish these TRPs from each other if there is no further identification or information for each TRP.

Therefore, there is a need in the art for an improved communication mechanism for multiple TRP operations.

## SUMMARY

The present disclosure is directed to methods and apparatuses for multi-TRP operations.

According to an aspect of the present disclosure, a UE is provided. The UE includes one or more non-transitory computer-readable media having computer-executable instructions embodied thereon and at least one processor coupled to the one or more non-transitory computer-readable media. The at least one processor is configured to execute the computer-executable instructions to receive Transmission Configuration Indicator (TCI) state data in a Physical Download Control Channel (PDCCH) determining multiple Physical Downlink Shared Channels (PDSCHs), where the TCI state data is associated with multiple Demodulation Reference Signal (DMRS) port groups. The processor is further configured to obtain multiple Quasi Co-Location (QCL) assumptions for receiving the PDSCHs based on the DMRS port groups associated with the TCI state data.

According to another aspect of the present disclosure, a method of wireless communications is provided. The method includes receiving, by a UE, TCI state data in a PDCCH determining multiple PDSCHs, where the TCI state data is associated with a multiple DMRS port groups. The method further includes obtaining, by the UE, multiple QCL assumptions for receiving the PDSCHs based on the DMRS port groups associated with the TCI state data.



## BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. Various features are not drawn to scale. Dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. **1** is a schematic diagram illustrating a multi-TRP system, in accordance with example implementations of the present application.

FIG. **2** is a flowchart for a process of multi-TRP operations, in accordance with example implementations of the present application.

FIG. **3** is a schematic diagram illustrating multiple PDSCHs determined from a single PDCCH, in accordance with example implementations of the present application.

FIG. **4** is a flowchart for a process of identifying a secondary TRP (sTRP), in accordance with example implementations of the present application.

FIG. **5** is a flowchart for a process of multi-TRP operations, in accordance with example implementations of the present application.

FIG. **6** is a block diagram illustrating a node for wireless communication, in accordance with example implementations of the present application.

## DETAILED DESCRIPTION

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.

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.

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."

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.

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.

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.

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 New Radio (NR) Radio Access Network (RAN)) typically includes at least one Base Station (BS), at least one User Equipment (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 BSs.

It should be noted that, in the present application, 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.

A BS 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 application should not be limited to the above-mentioned protocols.

A BS 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 Evolved Universal Terrestrial Radio Access (E-UTRA) BS 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 BS may serve one or more UEs through a radio interface.

The BS is operable to provide radio coverage to a specific geographical area using a plurality of cells forming the radio access network. The BS 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 BS can 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) service. Each cell may have overlapped coverage areas with other cells.

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 the 3$^{rd}$ Generation Partnership Project (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 adaptation may be configured based on the channel conditions and/or the service applications.

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, SL resources may also be provided in an NR frame to support ProSe services or V2X services.

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.

FIG. **1** is a schematic diagram illustrating a multi-TRP system **100**, in accordance with example implementations of the present application. As shown in FIG. **1**, the multi-TRP

system **100** includes a UE **102**, a BS **104**, and TRPs **106** and **108**. It should be noted that even though two TRPs are included in the example implementation illustrated in FIG. **1**, any number of TRPs may communicate with the UE in some other implementations. In addition, each TRP may communicate with the BS **104** through a wired or wireless connection.

The TRPs **106** and **108** may be macro-cells, small-cells, pico-cells, femto-cells, Remote Radio Heads (RRHs), relay nodes or antenna panels, which may be deployed anywhere such as in the interior of a room, in/on a building, on top of a house or streetlamps. The UE **102** may connect to the BS **104** through the TRPs **106** and **108**.

Each of the TRPs **106** and **108** may have one or more antenna panels to provide directional beams towards the UE **102**. The antenna panels distributed on the TRPs may be jointly used in the data transmissions to the UE, thereby forming a Multi-Input Multi-Output (MIMO) system.

FIG. **2** is a flowchart for a process of multi-TRP operations, in accordance with example implementations of the present application.

In action **202**, the UE may receive TCI state data in a PDCCH determining multiple PDSCHs. The TCI state data may be associated with multiple DMRS port groups. In action **204**, the UE may obtain multiple QCL assumptions for receiving the PDSCHs based on the DMRS port groups associated with the TCI state data.

The QCL assumptions may include different parameters, such as the spatial-domain QCL parameters (e.g., QCL TypeD parameter), or other QCL parameters such as, at least one of the average delay, the delay spread, the Doppler shift, and the Doppler spread. For example, each QCL assumption may include at least one of a time-domain QCL parameter, a frequency-domain QCL parameter, and a spatial-domain QCL parameter.

In some of the present implementations, the UE may identify different TRPs (e.g., the TRPs **106** and **108** in FIG. **1**) based on the QCL assumptions.

In some of the present implementations, each QCL assumption may correspond to one of the DMRS port groups associated with the TCI state data. For example, the QCL assumptions and the DMRS port groups may have a one-to-one mapping relationship. In some of the present implementations, the UE may receive the DMRS port groups corresponding to the PDSCHs via a Radio Resource Control (RRC) signaling.

In some of the present implementations, the mapping relationship between the QCL assumptions and the DMRS port groups may be modified. For example, the UE may receive an instruction for indicating a relationship (e.g., a mapping relationship) between the QCL assumptions and the DMRS port groups via a Medium Access Control (MAC) Control Element (CE), Downlink Control Information (DCI), or an RRC signaling. In some of the present implementations, indicating the relationship between the QCL assumptions and the DMRS port groups may include at least one of modifying, adding, deleting, and selecting the relationship between the QCL assumptions and the DMRS port groups. In some other implementations, the UE may be configured with a timer, and the mapping relationship between the QCL assumptions and the DMRS port groups may be modified when the timer expires.

In some of the present implementations, the TCI state of a DL channel (e.g., a PDCCH or a PDSCH) may include multiple QCL Reference Signal (RS) sets, and each QCL RS set may correspond to one DMRS port group. For example, the TCI state data may correspond to a TCI state configuration that includes multiple QCL RS sets, and each of the QCL RS sets may correspond to one of the DMRS port groups associated with the TCI state data.

FIG. **3** is a schematic diagram illustrating multiple PDSCHs determined from a single PDCCH, in accordance with example implementations of the present application. As shown in FIG. **3**, the UE may receive DCI that contains a TCI state data (e.g., a TCI code point) from the PDCCH **302**. After successfully decoding the TCI code point, the UE may obtain multiple TCI states each being associated with one DMRS port group. For example, each TCI state may contain parameters for configuring the QCL relationship between the DL/UL RS(s) and the DM-RS port(s) of a corresponding PDSCH. The QCL relationship may be configured by higher layer parameters, such as qcl-Type1 and qcl-Type2. In addition, the QCL type (e.g., QCL-TypeA, QCL-TypeB, QCL-TypeC and QCL-TypeD) corresponding to each DL RS may be given by a higher layer parameter (e.g., qcl-Type) in the QCL assumption/information. In some other implementations, the TCI state data may be a TRP index that is configured per a cell/Component Carrier (CC), or Bandwidth Part (BWP) basis.

In the example implementation, the UE may derive multiple PDSCHs based on the DMRS port groups associated with the TCI state data in the DCI, because each DMRS port group may correspond to one PDSCH. As shown in FIG. **3**, if the TCI state data is associated with DMRS port group #1 and DMRS port group #2, which are configured by the BS via an RRC signaling, the UE may then determine the QCL assumptions for PDSCH #1 **304** and PDSCH #2 **306** based on the DMRS port group #1 and DMRS port group #2, respectively. Each of the PDSCHs (e.g., PDSCH #1 **304** and PDSCH #2 **306**) derived from the PDCCH **302** may correspond to a TRP. As shown in FIG. **3**, the PDSCH #1 **304** and PDSCH #2 **306** may be associated with TRPs **308** and **310**, respectively. In some of the present implementations, after determining the QCL assumptions for the PDSCH #1 **304** and the PDSCH #2 **306**, the UE may use them to identify the TRPs **308** and **310**.

In some other implementations, the DCI in the PDCCH **302** may schedule a single PDSCH (not illustrated in FIG. **3**), and the TRPs **308** and **310** may correspond to different transmission layers of this PDSCH. Each transmission layer may correspond to a data stream from a TRP.

In some of the present implementations, when a UE performs an initial access procedure successfully, the UE may obtain the resource(s) of a Downlink (DL)/Uplink (UL) channel/beam for communicating with the BS through a certain TRP. This TRP may be referred to as an initial access TRP. In some of the present implementations, the resource of a DL channel/beam may be a Synchronization Signal (SS)/Physical Broadcast Channel (PBCH) Block (SSB), and the UL channel/beam may be a Physical Random Access Channel (PRACH). The UE may select the SSB through a random access procedure, and use the corresponding resources (e.g., which are configured with the same spatial QCL (sQCL) assumption as the selected SSB) to perform channel/beam measurements.

In some of the present implementations, the UE may be configured with resources that are orthonormal to the SSB to perform the channel/beam measurements.

In some of the present implementations, a TRP may be classified as a primary TRP (pTRP) or a secondary TRP (sTRP) for further operations. For example, the UE may adopt different time-domain behaviors (e.g., the aperiodic/semi-persistent/periodic reporting behavior) to report Channel State Information (CSI)/beam measurement results to the

pTRP(s) and sTRP(s). For example, the UE may adopt a periodic or semi-persistent reporting process with respect to the RS resource(s) coming from the pTRP, and apply an aperiodic reporting process with respect to the RS resource(s) coming from the sTRP.

In some of the present implementations, the UE may perform Beam Management (BM) procedures based on the network-configured resources. The UE may report the measurement results to the BS to help the BS to determine the primary communication link (e.g., including the pTRP) to the UE. For example, the BS may schedule a qualified resource (e.g., a beam/channel with a quality value exceeding a predetermined threshold) as the primary communication link to the UE. In this case, the TRP transmitting the qualified resource may be deemed as the pTRP.

In some of the present implementations, the UE may be notified to change its pTRP if the quality of the resource from the original pTRP changes. It should be noted that the number of the qualified resources and the pTRPs may be arbitrary.

In some of the present implementations, one or more antenna panels may be embedded in a single TRP. Each antenna panel may transmit at least one resource (beam/channel) in a time unit.

In some of the present implementations, the pTRP may be determined in an implicit way. For example, a TRP at which a specific resource is transmitted may be determined as a pTRP. The specific resource may include at least one of an SSB, a Channel State Information Reference Signal (CSI-RS), a Sounding Reference Signal (SRS), a PDCCH, a PDCCH that Control Resource Set (CORESET) #0 or search space #0 is located, a broadcast signal (e.g., a PBCH), a PDSCH of Remaining Minimum System Information (RMSI), and a beam/channel having a quality that exceeds a predetermined threshold. In some other implementations, the pTRP for the UE may be determined in an explicit way. For example, the BS may indicate one or more pTRPs to the UE via an RRC signaling, a MAC-CE or DCI.

In some of the present implementations, for those TRPs that are not selected as the pTRP(s), they may be determined as sTRPs for the UE if these TRPs satisfy certain condition(s), as shown in FIG. **4**.

FIG. **4** is a flowchart for a process of identifying an sTRP, in accordance with example implementations of the present application. In action **402**, the UE may obtain a first signal quality value (Q1) for a first resource from a pTRP. In action **404**, the UE may obtain a second signal quality value (Q2) for a second resource from a candidate sTRP. The values, Q1 and Q2, may be (but not limited to) Layer 1 (L1)-Reference Signals Received Power (RSRP) values, L1-Reference Signals Received Quality (RSRQ) values, L1-Signal to Interference plus Noise Ratio (SINR) values, RSRP values, RSRQ values, SINR values, or any combination thereof.

In action **406**, the UE may determine whether the difference between Q1 and Q2 is less than, or equal to, a predetermined threshold (TH). In some of the present implementations, the predetermined threshold TH may be configured by the BS.

If the outcome of action **406** is "yes", the UE, in action **408**, may transmit a first report to inform the BS that the candidate sTRP associated with the second resource is qualified to pair with the pTRP. In response to the first report, the BS may add this candidate sTRP as an sTRP for the UE, and inform the UE of the information of the pTRP(s) and/or sTRP(s). Conversely, if the outcome of action **406** is "no", the UE, in action **410**, may transmit a second report to inform the BS that the candidate sTRP associated with the second resource is not qualified to pair with the pTRP. In this case, the BS may decide not to add this candidate sTRP as an sTRP for the UE.

In some of the present implementations, the first and second resources described in actions **402** and **404** may be composite resources. A composite resource may be the first one (or a predetermined one) of the resources in a resource set that is configured for the TRP, or a union resource among all the resource(s) in the resource set, or a resource corresponding to a statistical average beam direction of the TRP. The UE may receive the composite resource of a composite beam/channel from each TRP based on a corresponding QCL assumption. In some of the present implementations, the composite resource may be a TRP-specific resource or a cell-specific resource if the composite resource is composited by at least one SSB resource. Conversely, if the composite resource is not composited by any SSB resource, the composite resource may be a UE-specific resource. In some of the present implementations, the composite resource may be transmitted in a broadcast manner, and compared to a resource that is used in a single-TRP BM procedure, the composite resource may correspond to a wider beam.

Using the composite resources may help the UE perform multi-TRP measurements more efficiently, because the UE may only need to measure one resource (composite resource) for each TRP at the beginning of the measurement.

In some of the present implementations, when several TRPs are distributed around the UE, the UE may be configured with a composite resource set. Each composite resource in the composite resource set may represent an average beam direction of an individual TRP. In this manner, the UE may report suitable TRP pairs to the BS quickly.

In some of the present implementations, once the pTRP(s) and sTRP(s) are determined, the BS may collect these pTRP(s) and sTRP(s) in a serving TRP set, and inform the UE of this serving TRP set via RRC signaling, a MAC CE, DCI, or any combination thereof.

In some of the present implementations, a variation in beam/channel quality may lead to a change in the configuration of the pTRP(s) and/or sTRP(s). For example, when the BS detects that the TRP with the best/qualified beam quality has changed, the BS may instruct the UE to modify/select the related configurations of the pTRP(s) and/or sTRP(s) to change the pTRP(s) and/or sTRP(s).

In some of the present implementations, the UE may receive a trigger event with a predetermined offset from the BS. The UE may determine whether the difference between the beam/channel quality of the pTRP and that of the sTRP exceeds this predetermined offset. If the determination's result is positive, the UE may transmit a report to request the BS to modify/select the related configurations of the pTRP(s) and/or sTRP(s).

In some of the present implementations, the UE may monitor the CORESET of a TRP based on a QCL assumption that is made for monitoring a PDCCH that schedules multiple PDSCHs. In this case, each PDSCH may be transmitted from a separate TRP. In some other implementations, the UE may monitor the CORESET of a TRP based on a QCL assumption that is made for monitoring a PDCCH that schedules a single PDSCH. In this case, different transmission layers of this PDSCH may be transmitted by the respective TRPs. In some other implementations, the UE may monitor the CORESET of a TRP based on multiple QCL assumptions that are made for monitoring multiple PDCCHs, each scheduling a PDSCH, and each NR-PDSCH may be transmitted from a separate TRP. In some other implementations, the UE may monitor the CORESET of a

TRP based on multiple QCL assumptions that are made for monitoring multiple PDCCHs, each scheduling a PDSCH, and each NR-PDSCH may be transmitted from a separate TRP.

FIG. **5** is a flowchart for a process of multi-TRP operations, in accordance with example implementations of the present disclosure.

In action **502**, an initial access TRP is setup after the UE successfully performs an initial access procedure. For example, after successfully performing the initial access procedure, the UE may get a DL/UL resource (e.g., channel/beam) to communicate with the BS through a TRP. This TRP may be set as the initial access TRP for the UE. The initial access TRP may be used as a pTRP from the UE's perspective.

In action **504**, the UE may receive configuration(s) for channel/beam measurement(s). For example, the UE may receive the configurations of K (e.g., K=0, 1, 2, . . . ) resource(s) and/or L (e.g., L=0, 1, 2, . . . ) resource for channel/beam measurements. The UE may apply the same QCL assumption as the SSB on which the UE camps during the random access procedure to receive the K resource(s). In addition, the L resource(s) may be orthonormal to the SSB on which the UE camps during the random access procedure. In some of the present implementations, the resources in the same resource set may have the same time-domain behavior, and each RS may correspond to a channel/beam of a TRP.

In action **506**, the UE may perform channel/beam measurement(s) according to the configuration. For example, the UE may perform the channel/beam measurement(s) according to the configuration(s) of the K and/or L resource(s). The UE may obtain the channel/beam statues/quality information (e.g. L1-RSRP, L1-RSRQ, L1-SINR, RSRP, RSRQ, SINR, or any combination thereof) from the channel/beam measurement. In some of the present implementations, the spatial domain filter information for receiving each DL resource may be obtained from the measurement. The spatial domain information may include at least one Receive (RX) radiation pattern and/or RX panel.

In some of the present implementations, the UE may report at least one of the resource indicator (or beam index), the measurement metric information, and the correlation information according to the configuration(s) obtained in action **504**. The resource indicator may be, but not limited to, an SSB resource indicator (if the resource is an SSB), a CSI-RS resource indicator (if the resource is a CSI-RS), a DMRS resource indicator (if the resource is a DMRS), or an SRS resource indicator. The measurement metric information may be, but not limited to, an L1-RSRP, an L1-RSRQ, an L1-SINR, a RSRP, a RSRQ, an SINR, or any combination thereof. In some of the present implementations, the measurement metric information that is related to a resource may be differentially encoded with respective to another resource. For example, a differential L1-RSRP offset level for the $2^{nd}$ measured resource may be obtained by subtracting L1-RSRP #1 from L1-RSRP #2, where L1-RSRP #1 is an L1-RSRP obtained from the $1^{st}$ resource measurement, and L1-RSRP #2 is an L1-RSRP obtained from the $2^{nd}$ resource measurement. The correlation information may include a correlation factor/indicator that indicates the spatial correlation between two or more observed resources. In some of the present implementations, the UE may compare the spatial correlation factor/indicator with a correlation threshold to determine whether the spatial correlation between the observed resources is high or not. The correlation threshold may be configured by the BS or determined based on the UE's implementations. The UE may be instructed to report the highest and/or lowest spatial correlation factor/indicator. In some of the present implementations, the correlation information may include at least one of a high/low correlation indicator and the indicators of the observed resources. The high/low correlation indicator may be used for indicating that the spatial correlation between the observed resources is high/low.

In some of the present implementations, the BS may determine compatible resources for serving the TRPs, based on the correlation information received from the UE, to improve the spatial diversity/multiplexing performance. In some of the present implementations, the correlation factor/indicator may be obtained by calculating the Angle-of-Arrival (AoA) related parameters for the channel/beams of the RS resources from the TRPs.

In action **508**, the UE may receive a message of a multi-TRP indication (e.g., indicating the information of pTRP(s) and/or sTRP(s)). For example, the message for indicating the information of pTRP(s) may contain at least one TCI-state indication that indicates a reference RS resource for a DL control channel and/or an SSB selected through the random access procedure. In this case, CORESET #0 or search space #0 may be located in the reference RS resource. In addition, the message for indicating the information of sTRP(s) may include at least one TCI-state indication that indicates at least one reference resource(s) for the DL shared channel(s). In this case, the UE may know that the TRP transmitting the indicated reference resource is an sTRP. In some of the present implementations, the TCI-state indication may correspond to one or more DMRS port groups, and each DMRS port group ID may correspond to a TRP ID.

In some of the present implementations, the target RS port/resource group (e.g., the DMRS port group of a PDSCH/PDCCH) may have the same QCL assumption as that of the source TRP-RS resource, which means the UE may assume that all ports/resources in the same target RS port/resource group may be from the same TRP, while the ports/resources in different target RS port/resource groups may be from different TRPs.

In action **510**, the UE may receive a message to terminate the multi-TRP operation and/or reset the multi-TRP configuration. For example, after receiving the message, the UE may terminate, cancel, or reset at least one of the correlation information of the reference RS resources among the TRPs, the TRP setting (e.g., including the resource setting and/or reporting setting), and the correspondence among the DMRS ports, DMRS port groups, TCI states, and QCL assumptions. In some of the present implementations, if there is no UE-specific scheduling for a while (e.g., before a timer expires), or a BWP switching happens, the UE may release the previous setting/configuration.

In some of the present implementations, the configuration that the UE receives in action **504** may be the composite resource configuration for the composite beam/channel from each TRP. The UE may perform channel/beam measurements on the composite resources of the respective TRPs. In this manner, the channel/beam measurements may be performed more efficiently, because the UE may only need to measure one resource (composite resource) for each TRP.

In some of the present implementations, the BS may indicate at least one pTRP resource set to the UE through at least one of the configuration of the pTRP, the predetermined resource(s) associated with the pTRP ID, and the best channel quality determined by the BS or UE.

AO 120 (Rev. 08/10)

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| 1 | 10,743,238 | 8/11/2020 | TOGAIL TECHNOLOGIES LTD. |
| 2 | 10,791,502 | 9/29/2020 | TOGAIL TECHNOLOGIES LTD. |
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|---|---|---|---|---|
| 16/372,389 | 09/29/2020 | 10791502 | US76468 | 2472 |

54000 7590 09/09/2020

ScienBiziP, PC
550 South Hope Street
Suite 2825
Los Angeles, CA 90071

# ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

HUNG-CHEN CHEN, Hsinchu, TAIWAN;
FG Innovation Company Limited, Tuen Mun, HONG KONG;
CHIE-MING CHOU, Hsinchu, TAIWAN;
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 16372389 |
| Filing Date | 2019-04-01 |
| First Named Inventor | HUNG-CHEN CHEN |
| Art Unit | 2642 |
| Examiner Name | Marcos Batista |
| Attorney Docket Number | US76468 |

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|---|---|---|---|---|---|---|
| Change(s) applied to document, /J.T./ 8/18/2020 | 1 | 20150140999 | A1 | 2015-05-21 | ~~HUAWEI TECHNOLOGY CO., LTD.~~ Zhang et al. | description, paragraphs [0154]-[0170] |

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|---|---|---|---|---|---|---|---|---|
| | 1 | 107690200 | CN | A | 2018-02-13 | CHINA ACADEMY TELECOMMUNICATIONS TECHNOLOGY | the whole document | ☓ |
| | 2 | 107809753 | CN | A | 2018-03-16 | ZTE CORPORATION | the whole document | ☒ |
| | 3 | 107223353 | CN | A | 2017-09-29 | BEIJING XIAOMI MOBILE SOFTWARE CO., LTD. | the whole document | ☒ |

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|---|---|---|---|---|
| 16/372389 | 04/01/2019 | HUNG-CHEN CHEN | US76468 | 2472 |

TITLE OF INVENTION:

| APPLN: TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | Undiscounted | 1000 | | | 1000 | 10/07/2020 |

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1a. NAME OF ASSIGNEE: FG Innovation Company Limited

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Tuen Mun, HONG KONG

Please check the appropriate assignee categories (will not be printed on the patent): ☐ Individual ☑ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☑ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies

4b. Payment of Fees(s): **(Please first reapply and previously paid fee shown above)**
☐ A check is enclosed
☐ Payment be credit card. Form PTO-2038 is attached
☑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 602615 (enclose an extra copy of this form)

5. Change of Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

☐ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

☐ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Alvin Koan/ Date 08/21/2020

Typed or printed name Alvin Koan Registration No. 68468



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## OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

## Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.