

METHODS AND APPARATUSES FOR HARQ-ACK FEEDBACK SKIPPING

TECHNICAL FIELD

[0001] Embodiments of the present disclosure generally relate to wireless communication technology, and more particularly to hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback determination.

BACKGROUND

[0002] A wireless communication system may include one or multiple network communication devices, such as base stations (BS), which may support wireless communication for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communication system may support wireless communication with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like)) or frequency resources (e.g., subcarriers, carriers, or the like). Additionally, the wireless communication system may support wireless communication across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) (which is also known as new radio (NR)) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

SUMMARY

[0003] An article “a” before an element is unrestricted and understood to refer to “at least one” of those elements or “one or more” of those elements. The terms “a,” “at least one,” “one or more,” and “at least one of one or more” may be interchangeable. As used herein, including in the claims, “or” as used in a list of items (e.g., a list of items prefaced by a phrase such as “at least one of” or “one or more of” or “one or both

of”) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” shall be construed in the same manner as the phrase “based at least in part on.” Further, as used herein, including in the claims, a “set” may include one or more elements.

[0004] Some embodiments of the present disclosure provide a UE. The UE may include at least one memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive signaling for configuring a first set of serving cells for multi-cell scheduling; receive, from a physical downlink control channel (PDCCH) monitoring occasion, a downlink control information (DCI) format scheduling a second set of serving cells in the first set of serving cells and indicating a physical uplink control channel (PUCCH) transmission occasion for the UE to transmit hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback for the DCI format; and determine whether to generate the HARQ-ACK feedback for the DCI format in response to determining that an active downlink (DL) bandwidth part (BWP) on a first serving cell of the second set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the first serving cell.

[0005] Some embodiments of the present disclosure provide a BS. The BS may include at least one memory; and at least one processor coupled with the at least one memory and configured to cause the BS to: transmit, to a UE, signaling for configuring a first set of serving cells for multi-cell scheduling; transmit, to the UE in a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for the UE to transmit HARQ-ACK feedback for the DCI format; determine whether or not the HARQ-ACK feedback for the DCI format is generated by the UE in the case that an active DL BWP change happens on a fifth serving cell of the first set of serving cells after the PDCCH monitoring occasion and before the PUCCH transmission occasion; and in response to determining that the HARQ-ACK feedback for the DCI format is

generated by the UE, receive the HARQ-ACK feedback for the DCI format from the UE in the PUCCH transmission occasion.

[0006] Some embodiments of the present disclosure provide a processor. The processor may include at least one controller coupled with at least one memory and configured to cause the processor to: receive signaling for configuring a first set of serving cells for multi-cell scheduling; receive, from a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for the UE to transmit HARQ-ACK feedback for the DCI format; and determine whether to generate the HARQ-ACK feedback for the DCI format in response to determining that an active DL BWP on a first serving cell of the second set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the first serving cell.

[0007] Some embodiments of the present disclosure provide a processor. The processor may include at least one controller coupled with at least one memory and configured to cause the processor to: transmit, to a UE, signaling for configuring a first set of serving cells for multi-cell scheduling; transmit, to the UE in a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for the UE to transmit HARQ-ACK feedback for the DCI format; determine whether or not the HARQ-ACK feedback for the DCI format is generated by the UE in the case that an active DL BWP change happens on a fifth serving cell of the first set of serving cells after the PDCCH monitoring occasion and before the PUCCH transmission occasion; and in response to determining that the HARQ-ACK feedback for the DCI format is generated by the UE, receive the HARQ-ACK feedback for the DCI format from the UE in the PUCCH transmission.

[0008] Some embodiments of the present disclosure provide a method for wireless communication. The method may include: receiving signaling for configuring a first set of serving cells for multi-cell scheduling; receiving, from a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for a UE to transmit HARQ-ACK

feedback for the DCI format; and determining whether to generate the HARQ-ACK feedback for the DCI format in response to determining that an active DL BWP on a first serving cell of the second set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the first serving cell.

[0009] Some embodiments of the present disclosure provide a method for wireless communication. The method may include: transmitting, to a UE, signaling for configuring a first set of serving cells for multi-cell scheduling; transmitting, to the UE in a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for the UE to transmit HARQ-ACK feedback for the DCI format; determining whether or not the HARQ-ACK feedback for the DCI format is generated by the UE in the case that an active DL BWP change happens on a fifth serving cell of the first set of serving cells after the PDCCH monitoring occasion and before the PUCCH transmission occasion; and in response to determining that the HARQ-ACK feedback for the DCI format is generated by the UE, receiving the HARQ-ACK feedback for the DCI format from the UE in the PUCCH transmission.

[0010] Some embodiments of the present disclosure provide an apparatus. According to some embodiments of the present disclosure, the apparatus may include: at least one non-transitory computer-readable medium having stored thereon computer-executable instructions; at least one receiving circuitry; at least one transmitting circuitry; and at least one processor coupled to the at least one non-transitory computer-readable medium, the at least one receiving circuitry and the at least one transmitting circuitry, wherein the at least one non-transitory computer-readable medium and the computer executable instructions may be configured to, with the at least one processor, cause the apparatus to perform a method according to some embodiments of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] In order to describe the manner in which the advantages and features of the disclosure can be obtained, a description of the disclosure is rendered by reference to

specific embodiments thereof, which are illustrated in the appended drawings. These drawings depict only exemplary embodiments of the disclosure and are not therefore to be considered limiting of its scope.

[0012] FIG. 1 illustrates a schematic diagram of a wireless communication system in accordance with some embodiments of the present disclosure;

[0013] FIGs. 2A and 2B illustrate schematic diagrams of HARQ-ACK feedback skipping due to BWP change in accordance with some embodiments of the present disclosure;

[0014] FIGs. 3A-3C illustrate schematic diagrams of HARQ-ACK codebook determination in accordance with some embodiments of the present disclosure;

[0015] FIGs. 4 and 5 illustrate flowcharts of wireless communication methods in accordance with some embodiments of the present disclosure;

[0016] FIG. 6 illustrates an example of a UE in accordance with some embodiments of the present disclosure;

[0017] FIG. 7 illustrates an example of a processor in accordance with some embodiments of the present disclosure; and

[0018] FIG. 8 illustrates an example of a network equipment (NE) in accordance with some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0019] The detailed description of the appended drawings is intended as a description of the preferred embodiments of the present disclosure and is not intended to represent the only form in which the present disclosure may be practiced. It should be understood that the same or equivalent functions may be accomplished by different embodiments that are intended to be encompassed within the spirit and scope of the present disclosure.

[0020] Reference will now be made in detail to some embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings. To facilitate understanding, embodiments are provided under a specific network architecture(s) and new service scenarios, such as the 3rd generation partnership project (3GPP) 5G NR or 6G, 3GPP LTE, and so on. It is contemplated that along with the developments of network architectures and new service scenarios, all embodiments in the present disclosure are also applicable to similar technical problems; and moreover, the terminologies recited in the present disclosure may change, which should not affect the principles of the present disclosure.

[0021] HARQ-ACK feedback skipping may be adopted for a single-cell scheduling DCI format when an active DL BWP change on a scheduled cell or an active UL BWP change on the PUCCH cell happens after the monitoring occasion that provides the DCI format and before the PUCCH transmission occasion that is scheduled by the DCI format. Existing technologies do not provide any solutions regarding HARQ-ACK feedback skipping for multi-cell scheduling DCI format.

[0022] The present disclosure provides various methods and apparatuses for HARQ-ACK feedback skipping for multi-cell scheduling DCI format and for HARQ-ACK codebook determination.

[0023] FIG. 1 illustrates a schematic diagram of wireless communication system 100 in accordance with some embodiments of the present disclosure.

[0024] The wireless communication system 100 may include one or more NEs 102 (e.g., one or more BSs), one or more UEs 104, and a core network (CN) 106. The wireless communication system 100 may support various radio access technologies. In some implementations, the wireless communication system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communication system 100 may be a NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultra-wideband (5G-UWB) network. In other implementations, the wireless communication system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), and IEEE 802.20. The wireless communication

system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communication system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0025] The one or more NEs 102 may be dispersed throughout a geographic region to form the wireless communication system 100. One or more of the NEs 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0026] An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with a different NE 102.

[0027] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communication system 100. A UE 104 may include or may be referred to as a remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

[0028] A UE 104 may be able to support wireless communication directly with other

UEs 104 over a communication link. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0029] An NE 102 may support communication with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with another NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N3 or another network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more NEs 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as radio heads, smart radio heads, or transmission-reception points (TRPs).

[0030] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management (AMF)) functions and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more NEs 102 associated with the CN 106.

[0031] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N3, or another network interface). The packet data network may include an application server. In some implementations, one or more

UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0032] In the wireless communication system 100, the NEs 102 and the UEs 104 may use resources of the wireless communication system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communication). In some implementations, the NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0033] In some embodiments, the NEs 102 may include one or more relay nodes, integrated access and backhaul (IAB) nodes or wireless access backhaul (WAB) nodes which can provide wireless access services for UEs 104. A relay node (or an IAB node or a WAB node) can directly connect to a BS or hop through one or more relay nodes (or one or more IAB or WAB nodes) before reaching the BS.

[0034] One or more numerologies may be supported in the wireless communication system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal

cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix. A sixth numerology (e.g., $\mu=5$) may be associated with a sixth subcarrier spacing (e.g., 480 kHz) and a normal cyclic prefix. A seventh numerology (e.g., $\mu=6$) may be associated with a seventh subcarrier spacing (e.g., 960 kHz) and a normal cyclic prefix. For ambient IoT communication, additional numerologies (e.g., $\mu=-1$ or $\mu=-2$) may be introduced corresponding to 7.5 kHz or 3.75 kHz respectively.

[0035] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0036] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communication system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., orthogonal frequency-division multiplexing (OFDM) symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology.

It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0037] In the wireless communication system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communication system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 102 and the UEs 104 may perform wireless communication over one or more of the operating frequency bands. In some implementations, FR1 may be used by the NEs 102 and the UEs 104, among other equipment or devices for cellular communication traffic (e.g., control information, data). In some implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0038] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0039] A UE 104 may include computing devices, such as desktop computers, laptop computers, personal digital assistants (PDAs), tablet computers, smart televisions (e.g., televisions connected to the Internet), set-top boxes, game consoles, security systems (including security cameras), vehicle on-board computers, network devices (e.g., routers, switches, and modems), or the like. According to some embodiments of the present disclosure, a UE 104 may include a portable wireless communication device, a smart phone, a cellular telephone, a flip phone, a device having a subscriber identity

module, a personal computer, a selective call receiver, or any other device that is capable of sending and receiving communication signals on a wireless network. In some embodiments of the present disclosure, a UE 104 includes wearable devices, such as smart watches, fitness bands, optical head-mounted displays, or the like. Moreover, a UE 104 may be referred to as a subscriber unit, a mobile, a mobile station, a user, a terminal, a mobile terminal, a wireless terminal, a fixed terminal, a subscriber station, a user terminal, or a device, or described using other terminology used in the art. A UE 104 may communicate with an NE 102 (e.g., a BS) via uplink (UL) communication signals. An NE 102 may communicate with a UE 104 via downlink (DL) communication signals.

[0040] In some embodiments of the present disclosure, an NE 102 and a UE 104 may communicate over licensed spectrums, whereas in some other embodiments, an NE 102 and a UE 104 may communicate over unlicensed spectrums. The present disclosure is not intended to be limited to the implementation of any particular wireless communication system architecture or protocol. Persons skilled in the art should understand that as technology develops and advances, the terminologies described in the present disclosure may change, but should not affect or limit the principles and spirit of the present disclosure.

[0041] In a wireless communication system, such as the wireless communication system 100, a UE may monitor a PDCCH in one or more search spaces. The PDCCH may carry a DCI format, which may schedule an uplink channel, such as a physical uplink shared channel (PUSCH), or a downlink channel, such as a PDSCH, on a cell. In the case that a DCI format schedules a PDSCH, the UE may transmit HARQ-ACK feedback (e.g., HARQ-ACK information bit(s)) for the PDSCH through a PUSCH or a PUCCH. For example, the PUCCH may carry a HARQ-ACK codebook including the HARQ-ACK information bit(s) for the PDSCH.

[0042] In some embodiments of present disclosure, a DCI format may not necessarily schedule an uplink or downlink channel, but may indicate certain information to the UE and may require a corresponding HARQ-ACK feedback to indicate the reception of the DCI format. In the context of the present disclosure, HARQ-ACK feedback for the scheduled channel(s) (e.g., PDSCH(s)) and HARQ-ACK feedback indicating the

reception of the DCI format can be referred to as HARQ-ACK feedback for the DCI format.

[0043] In some embodiments of the present disclosure, HARQ-ACK feedback skipping may be adopted for a single-cell scheduling DCI format under certain scenarios, for example, when an active DL BWP change on a scheduled cell or an active UL BWP change on the PUCCH cell happens after the monitoring occasion that provides the DCI format and before the PUCCH transmission occasion that is scheduled by the DCI format. The single-cell scheduling DCI format in the present disclosure refers to the DCI format that can schedule a maximum of one cell, including for example, DCI format 1_0, DCI format 1_1 or DCI format 1_2 as specified in 3GPP specifications. The PUCCH cell in the present disclosure refers to the cell where the PUCCH is to be transmitted, e.g., UL primary cell (PCell) or primary secondary cell (PSCell).

[0044] For example, when a PDCCH monitoring occasion that provides a DCI format (i.e., a single-cell scheduling DCI format such as DCI format 1_0, DCI format 1_1 or DCI format 1_2) is before an active DL BWP change on a cell, the DCI format does not trigger the active DL BWP change for the cell, and the PUCCH indicated by the DCI format is to be transmitted after the active DL BWP change on the cell, then the corresponding HARQ-ACK information for the DCI format is skipped. For example, as shown in FIG. 2A, DCI 211 schedules a PDSCH on a cell and indicates corresponding HARQ-ACK feedback to be transmitted in PUCCH 215. DCI 213 indicates that the active DL BWP of the cell is switched from BWP1 to BWP2. Since the PUCCH is to be transmitted after the active DL BWP change on the cell, the HARQ-ACK information bit for DCI 211 is skipped, i.e., not generated.

[0045] For example, when a PDCCH monitoring occasion that provides a DCI format (i.e., a single-cell scheduling DCI format such as DCI format 1_0, DCI format 1_1 or DCI format 1_2) is before an active UL BWP change on the PUCCH cell, and the PUCCH indicated by the DCI format is to be transmitted after the active UL BWP change on the PUCCH cell, the corresponding HARQ-ACK information for the DCI format is skipped. For example, as shown in FIG. 2B, DCI 231 schedules a PDSCH and indicates corresponding HARQ-ACK feedback to be transmitted in PUCCH 235

on the PUCCH cell. DCI 233 indicates that the active UL BWP of the PUCCH cell is switched from BWP1 to BWP2. Since the PUCCH is to be transmitted after the active UL BWP change on the PUCCH cell, the HARQ-ACK information bit for DCI 231 is skipped, i.e., not generated.

[0046] In some embodiments of the present disclosure, the wireless communication system 100 may be designed to support carrier aggregation (CA). For example, the wireless communication system 100 may support a maximum of 16 component carriers (CCs) in the case of carrier aggregation (CA) or a maximum of 32 CCs in the case of dual connectivity (DC). In some embodiments of the present disclosure, to reduce signaling overhead, it would be beneficial to use a single DCI format to schedule multiple PDSCHs or PUSCHs on multiple cells (or carriers). In the context of the present disclosure, the term "cell" may be used interchangeably with the term "carrier." In the present disclosure, the DCI format that can schedule one or more cells is referred to as the multi-cell scheduling DCI format.

[0047] For example, a set of cells which can include up to M cells (e.g., M=4) can be configured for a UE by a BS via, for example, radio resource control (RRC) signaling. The value of M may be predefined (e.g., in a standard(s)). One DCI format can schedule one or more cells within the set of cells for DL transmission with one PDSCH per scheduled cell. In some examples, a DCI format may not schedule any cells in the set of cells but indicate certain information (e.g., indicating secondary cell (SCell) dormancy or the like) with respect to at least one cell in the set of cells. In some examples, a DCI format may schedule one or more cells in the set of cells and indicate certain information with respect to at least one cell in the set of cells. All these DCI format can be referred to as a multi-cell scheduling DCI format, that is, a DCI format associated with the configured set of cells for multi-cell scheduling. For convenience, DCI format 1_3 is used in this disclosure as an example of such a DCI format.

[0048] Embodiments of the present disclosure provide various methods for determining HARQ-ACK feedback for a multi-cell scheduling DCI format (e.g., DCI format 1_3). For example, solutions for performing HARQ-ACK feedback skipping for a multi-cell scheduling DCI format are provided.

[0049] In some embodiments of the present disclosure, HARQ-ACK feedback for a

multi-cell scheduling DCI format may be skipped when an active UL BWP change on the PUCCH cell happens after the PDCCH monitoring occasion that provides the DCI format and before the PUCCH transmission occasion that is scheduled by the DCI format. That is, HARQ-ACK information for all cells co-scheduled by the DCI format is not generated.

[0050] In some embodiments of the present disclosure, HARQ-ACK feedback for a multi-cell scheduling DCI format may be skipped when an active DL BWP change on a scheduled cell happens after the PDCCH monitoring occasion that provides the DCI format and before the PUCCH transmission occasion that is scheduled by the DCI format. That is, HARQ-ACK information for all cells co-scheduled by the DCI format is not generated.

[0051] For example, referring to FIG. 3A, DCI 351 may schedule 4 PDSCHs (i.e., PDSCH 371, PDSCH 372, PDSCH 373 and PDSCH 374) on 4 respective cells (i.e., cell 361, cell 362, cell 363 and cell 364) and indicate corresponding HARQ-ACK feedback for the 4 co-scheduled cells to be transmitted in PUCCH 353. Another DCI (not shown in FIG. 3A) indicates that the active DL BWP of cell 364 is switched from BWP 1 to BWP 2. In some embodiments, HARQ-ACK information for all cells (i.e., cell 361, cell 362, cell 363 and cell 364) or for all PDSCHs (i.e., PDSCH 371, PDSCH 372, PDSCH 373 and PDSCH 374) co-scheduled by DCI 351 is not generated.

[0052] The above solution may be straightforward, but is somewhat arbitrary. A subtle solution may be desired. For example, one solution may be only skipping the HARQ-ACK information bit for the cell (e.g., cell 364) with the active DL BWP change. However, if only the HARQ-ACK information bit for the cell with active DL BWP change is skipped, another problem that needs to be addressed is how to generate the HARQ-ACK codebook for the DCI format. For example, it needs to be resolved how to arrange the remaining HARQ-ACK information bits that are not skipped for the DCI format in the HARQ-ACK codebook. In addition, since the DCI format may also indicate certain information to a UE (e.g., SCell dormancy indication), it needs to be resolved whether the HARQ-ACK information bit for such indication should be skipped.

[0053] Embodiments of the present disclosure provide various methods for HARQ-

ACK feedback determination. For example, solutions are proposed for generating HARQ-ACK feedback for a DCI format when an active DL BWP change happens. For example, solutions are proposed for generating a Type-2 (or dynamic) HARQ-ACK codebook when an active DL BWP change happens. More details on the embodiments of the present disclosure will be illustrated in the following text in combination with the appended drawings.

[0054] In some embodiments of the present disclosure, a Type-2 HARQ-ACK codebook may include two HARQ-ACK sub-codebooks (denoted as "sub-codebook #1" and "sub-codebook #2").

[0055] In some embodiments, sub-codebook #1 may include HARQ-ACK information bits for PDSCH receptions scheduled by respective DCI formats with each DCI format scheduling one PDSCH or HARQ-ACK information bits for DCI formats without scheduling any PDSCH with required HARQ-ACK feedback. For example, sub-codebook #1 may include HARQ-ACK feedback for DCI format(s) having a single HARQ-ACK information bit. That is, a single HARQ-ACK information bit may be generated in sub-codebook #1 for each DCI format associated with this sub-codebook.

[0056] For example, sub-codebook #1 may include HARQ-ACK information bits for PDSCHs respectively scheduled by DCI format 1_0, DCI format 1_1, DCI format 1_2 and DCI format 1_3 scheduling one PDSCH, and HARQ-ACK information bits for DCI format(s) which does not schedule any PDSCH and is transmitted for a DL semi-persistent scheduling (SPS) PDSCH release, transmission configuration indication (TCI) update, SCell dormancy indication or other purposes.

[0057] In some embodiments, sub-codebook #2 may include HARQ-ACK information bits corresponding to the remaining DCI formats that are not associated with sub-codebook #1 in DCI formats with corresponding HARQ-ACK information bits to be transmitted in the same HARQ-ACK codebook (i.e., in the same PUCCH). For example, sub-codebook #2 may include HARQ-ACK feedback for DCI format(s) having more than one HARQ-ACK information bit. That is, more than one HARQ-ACK information bit may be generated in sub-codebook #2 for each DCI format associated with this sub-codebook.

[0058] For example, sub-codebook #2 may include (1) HARQ-ACK information bits for PDSCHs scheduled by respective DCI formats (e.g., DCI formats 1_3), with each DCI format 1_3 scheduling more than one PDSCH, (2) HARQ-ACK information bits for one or more PDSCHs scheduled by a DCI format 1_3 (denoted as DCI #J), and (3) a HARQ-ACK information bit for SCell dormancy indication, where DCI #J schedules the one or more PDSCHs and indicates SCell dormancy. For example, a DCI format associated with sub-codebook #2 may be a DCI format (e.g., DCI format 1_3) scheduling more than one PDSCH, or a DCI format (e.g., DCI format 1_3) scheduling one or more PDSCHs and indicating SCell dormancy.

[0059] In some embodiments, the number of HARQ-ACK information bits (denoted as M') for each DCI format associated with sub-codebook #2 may be based on a maximum number of HARQ-ACK information bits per DCI format (e.g., DCI format 1_3) among all the DCI formats in the same PUCCH group. For example, the value of M' may be based on (e.g., equal to) the maximum number of cells co-scheduled by one multi-cell scheduling DCI format (e.g., DCI format 1_3). For example, the value of M' may be based on the predefined value of M (e.g., M'=M=4).

[0060] In some embodiments, sub-codebook #1 may be placed in front of sub-codebook #2. In some embodiments, sub-codebook #2 may be placed in front of sub-codebook #1.

[0061] In the context of the present application, for a set of serving cells (denoted as cell set #Z1) configured for multi-cell scheduling, it is assuming that a maximum of M cells can be co-scheduled by a multi-cell scheduling DCI format in the same PUCCH group.

[0062] In some embodiments of the present disclosure, a DCI format (denoted as DCI #A) may indicate SCell dormancy and does not schedule a PDSCH on any cell within cell set #Z1.

[0063] In some embodiments, DCI #A may indicate SCell dormancy by reinterpreting (or repurposing) a predefined set of DCI fields corresponding to a certain serving cell (denoted as cell #A) in cell set #Z1. Cell #A may be a serving cell having a corresponding invalid frequency domain resource assignment (FDRA) value in DCI #A.

For example, cell #A may be a serving cell with a predefined cell index (e.g., smallest cell index) among cells having corresponding invalid FDRA values in DCI #A. The predefined set of DCI fields may include one or more of the following fields corresponding to cell #A: modulation coding scheme (MCS) of transport block (TB) 1, new data indicator (NDI) of TB1, redundancy version (RV) of TB1, and HARQ process number. Cell #A can be referred to as a serving cell "virtually" scheduled by DCI #A. In other words, a "virtual" PDSCH is assumed to be scheduled on cell #A by DCI #A. The invalid FDRA value in the present disclosure may refer to all bits of frequency domain resource assignment in the DCI format are set to 0 for resource allocation type 0, or set to 1 for resource allocation type 1, or set to 0 or 1 for dynamic switch resource allocation type. The valid FDRA value in the present disclosure may refer to at least one bit of frequency domain resource assignment in the DCI format is not set to 0 for resource allocation type 0, or not set to 1 for resource allocation type 1, or not set to 0 or 1 for dynamic switch resource allocation type.

[0064] In some embodiments, when an active DL BWP on any cell within cell set #Z1 is changed after the PDCCH monitoring occasion that provides DCI #A (e.g., DCI #A is transmitted by a BS or received by a UE in the PDCCH monitoring occasion) and before the PUCCH transmission occasion that is scheduled by DCI #A (e.g., DCI #A indicates that HARQ-ACK feedback for the DCI is transmitted in this PUCCH transmission occasion), and DCI #A does not trigger the active DL BWP change on the single cell, the HARQ-ACK information bit for DCI #A is skipped, i.e., not generated. The HARQ-ACK information bit for the virtual cell (i.e., cell #A) is skipped, i.e., not generated. That is, the UE does not generate HARQ-ACK feedback for DCI #A.

[0065] Alternatively, an acknowledgement (ACK) may be generated for DCI #A. That is, an ACK may be generated for SCell dormancy or for the virtual cell (i.e., cell #A). For example, a single bit indicating ACK is generated as the corresponding HARQ-ACK information bit for DCI #A for SCell dormancy indication. The single bit can be included in sub-codebook #1.

[0066] In some embodiments of the present disclosure, a DCI format (denoted as DCI #B1) may schedule at least one (actual) PDSCH on a set of serving cells (denoted as cell set #Z2) within cell set #Z1. When an active DL BWP on a cell (denoted as cell

#B1) of cell set #Z2 is changed after the PDCCH monitoring occasion that provides DCI #B1 (e.g., DCI #B1 is transmitted by a BS or received by a UE in the PDCCH monitoring occasion) and before the PUCCH transmission occasion that is scheduled by DCI #B1 (e.g., DCI #B1 indicates that HARQ-ACK feedback for the DCI is transmitted in this PUCCH transmission occasion), and DCI #B1 does not trigger the active DL BWP change on cell #B1, the HARQ-ACK information bit for cell #B1 is skipped. That is, the UE does not generate HARQ-ACK information bit for cell #B1.

[0067] In some embodiments, cell set #Z2 may include a serving cell (denoted as cell #B2) where an active DL BWP on cell #B2 maintains the same (e.g., the active DL BWP on cell #B2 maintains the same after the PDCCH monitoring occasion that provides DCI #B1 and before the PUCCH transmission occasion that is scheduled by DCI #B1), the HARQ-ACK information bit for cell #B2 may be generated, for example, based on the decoding outcome of the corresponding PDSCH scheduled on cell #B2.

[0068] In some embodiments, DCI #B1 may further indicate SCell dormancy. For example, DCI #B1 may indicate SCell dormancy by reinterpreting a set of fields associated with a serving cell (denoted as cell #B3) of a set of serving cells (denoted as cell set #Z3) within cell set #Z1. For example, cell set #Z3 may include the serving cell(s) having an invalid FDRA value(s) indicated in DCI #B1 and cell #B3 may be a serving cell with a predefined cell index (e.g., smallest cell index) in cell set #Z3.

[0069] In some embodiments, an ACK may be generated for cell #B3. That is, an ACK may be generated for SCell dormancy indication. For example, a single bit indicating ACK is generated as the corresponding HARQ-ACK information bit for cell #B3. In some embodiments, the HARQ-ACK information bit for cell #B3 may be skipped. That is, HARQ-ACK information for SCell dormancy indication may be skipped. The above embodiments can be applied regardless of whether there is an active DL BWP change on a cell within cell set #Z3.

[0070] In some embodiments, a negative ACK (NACK) may be generated for each of the remaining cells in cell set #Z3. For example, a single bit indicating NACK is generated as the corresponding HARQ-ACK information bit for a cell other than cell #B3 in cell set #Z3. In some embodiments, the HARQ-ACK information bits for the remaining cells in cell set #Z3 may be skipped. The above embodiments can be

applied regardless of whether there is an active DL BWP change on a cell within cell set #Z3.

[0071] In some embodiments, an active DL BWP on at least one cell of cell set #Z3 is changed after the PDCCH monitoring occasion that provides DCI #B1 and before the PUCCH transmission occasion that is scheduled by DCI #B1, and DCI #B1 does not trigger the active DL BWP change on the at least one cell. In these embodiments, in some examples, an ACK may be generated for cell #B3 and the HARQ-ACK information bits for the remaining cells in cell set #Z3 may be skipped. In these embodiments, in some examples, an ACK may be generated for cell #B3 and a NACK may be generated for each of the remaining cells in cell set #Z3. In these embodiments, in some examples, the HARQ-ACK information bits for all cells in cell set #Z3 may be skipped.

[0072] In some embodiments, if HARQ-ACK feedback is generated for DCI #B1, the HARQ-ACK feedback for DCI #B1 may be included in sub-codebook #1 or sub-codebook #2, depending on the total HARQ-ACK information bits generated for DCI #B1. For example, if the number of the HARQ-ACK information bits for DCI #B1 is greater than 1, the HARQ-ACK information bits for DCI #B1 is included in sub-codebook #2; otherwise, if the bit number is equal to 1, the single HARQ-ACK information bit for DCI #B1 can be included in either sub-codebook #1 or sub-codebook #2. If the bit number of the HARQ-ACK information bits for DCI #B1 is greater than 1, the HARQ-ACK information bits for DCI #B1 may be first ordered according to a predefined rule and then included in sub-codebook #2 with possible padding bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format. If the number of the HARQ-ACK information bits for DCI #B1 is equal to 1 and the single HARQ-ACK information bit for DCI #B1 is included sub-codebook #2, padding bits are appended to the single HARQ-ACK information bit to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[0073] For example, DCI #B1 may schedule a single PDSCH on a single serving cell (e.g., cell #B1) within cell set #Z1. When an active DL BWP change on the single cell happens after the PDCCH monitoring occasion that provides DCI #B1 and before the PUCCH transmission occasion that is scheduled by DCI #B1 and DCI #B1 does not

trigger the active DL BWP change on the cell, the corresponding HARQ-ACK information bit for the single PDSCH (or for the single serving cell) is skipped, i.e., not generated. That is, no HARQ-ACK feedback is generated for DCI #B1.

[0074] For example, DCI #B1 may schedule a plurality of PDSCHs (e.g., N PDSCHs), with valid FDRA values on the respective N serving cells within cell set #Z1. In some examples, an active DL BWP change may occur on K cells of the N cells after the PDCCH monitoring occasion that provides DCI #B1 and before the PUCCH transmission occasion that is scheduled by DCI #B1 and DCI #B1 does not trigger the active DL BWP change on the K cells.

[0075] In some embodiments, if $K=N$, then the HARQ-ACK information for the N PDSCHs on the N cells is not generated. That is, the HARQ-ACK information for the N cells or for DCI #B1 is skipped, or no HARQ-ACK feedback is generated for the N cells or for DCI #B1.

[0076] In some embodiments, if $K=N-1$, then the corresponding HARQ-ACK information for the K PDSCHs on the respective K cells with active DL BWP change is not generated while the corresponding HARQ-ACK information for the remaining single PDSCH on the single cell without active DL BWP change is generated. That is, a single HARQ-ACK information bit may be generated for DCI #B1.

[0077] The HARQ-ACK information bit for the remaining single PDSCH (or the single cell without active DL BWP change) may be generated based on the decoding result of the remaining single PDSCH at the UE. In some examples, the generated HARQ-ACK information bit for the remaining single PDSCH (or the single cell without active DL BWP change) may be included in sub-codebook #1. In some examples, the generated HARQ-ACK information bit may be included in sub-codebook #2. Padding bits (e.g., $M'-1$ NACK bits) may be appended to the generated single HARQ-ACK information bit to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[0078] In some embodiments, if $K=1, 2, \dots, \text{or } N-2$, then the corresponding HARQ-ACK information for the K PDSCHs on the respective K cells with active DL BWP change is not generated while the corresponding HARQ-ACK information for the

remaining N-K PDSCHs on the respective N-K cells without active DL BWP change is generated. That is, N-K HARQ-ACK information bits may be generated for DCI #B1. The HARQ-ACK information bits for the remaining N-K PDSCHs (or for the N-K cells without active DL BWP change) may be generated based on the respective decoding results and included in sub-codebook #2. The generated HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the N-K cells). Padding bits (e.g., $M'+K-N$ NACK bits) may be appended to the ordered HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[0079] In some embodiments, if $K=0$, no HARQ-ACK skipping is needed. The corresponding HARQ-ACK information for the N PDSCHs are generated based on the respective decoding results and included in sub-codebook #2. That is, N HARQ-ACK information bits may be generated for DCI #B1. The generated HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the N cells). Padding bits (e.g., $M'-N$ NACK bits) may be appended to the ordered HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[0080] For example, referring to FIG. 3B, a UE may be configured with 4 cells (i.e., cell 361, cell 362, cell 363 and cell 364) for multi-cell scheduling. It is assumed that the ascending order of the serving cell indexes of the 4 cells is cell 361 < cell 362 < cell 363 < cell 364. DCI 311 may schedule 3 PDSCHs (i.e., PDSCH 321, PDSCH 322 and PDSCH 323) on 3 respective cells (i.e., cell 361, cell 362 and cell 363) with respective valid FDRA values and indicate corresponding HARQ-ACK feedback for the 3 co-scheduled to be transmitted in PUCCH 313. When cell 361 and cell 363 have an active DL BWP change while cell 362 does not have an active DL BWP change (i.e., $M'=4$, $N=3$ and $K=2$), then a single HARQ-ACK information bit (denoted as "a2") for PDSCH 322 on cell 362 is generated. Then, 3 NACK bits as padding bits are appended to the generated HARQ-ACK information bit to match the maximum 4 HARQ-ACK information bits per a DCI format. That is, sub-codebook #2 may include HARQ-ACK feedback {a2, NACK, NACK, NACK} for DCI 311.

[0081] For example, DCI #B1 may schedule at least one PDSCH (e.g., X PDSCHs where $X \geq 1$) with valid FDRA values on the respective X serving cells within cell set #Z1 and indicate SCell dormancy. DCI #B1 may indicate SCell dormancy by reinterpreting a set of fields associated with a serving cell with the smallest serving cell index among Y serving cells ($Y \geq 1$ and $X+Y \leq M$) within cell set #Z1, wherein the Y serving cells are indicated by corresponding invalid FDRA values in DCI #B1.

[0082] In some embodiments, as stated above, the serving cell with the smallest serving cell index among Y serving cells is regarded as a virtually scheduled cell and it is assumed that a virtual PDSCH is scheduled on this virtually scheduled cell. The virtual PDSCH is assumed to provide one TB which has been correctly decoded by the UE. Therefore, an ACK (e.g., a single bit indicating ACK) may be generated for this cell (or the virtual PDSCH). In other words, an ACK may be generated for SCell dormancy indication. In some embodiments, the HARQ-ACK information bit for this virtually scheduled cell (or the virtual PDSCH) may be skipped. In other words, the HARQ-ACK information for SCell dormancy indication is not generated.

[0083] In some examples, an active DL BWP change may occur on K' cells of the X cells after the PDCCH monitoring occasion that provides DCI #B1 and before the PUCCH transmission occasion that is scheduled by DCI #B1 and DCI #B1 does not trigger the active DL BWP change on the K' cells.

[0084] In some embodiments, if $K'=X$, then the corresponding HARQ-ACK information for the X PDSCHs on the X cells is not generated. Only HARQ-ACK information for SCell dormancy indication is generated. That is, a single HARQ-ACK information bit may be generated for DCI #B1. In some examples, the generated single HARQ-ACK information bit may be included in sub-codebook #1. In some examples, the generated single HARQ-ACK information bit may be included in sub-codebook #2 with padding bits (e.g., $M'-1$ NACK bits) appended thereto to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[0085] In some embodiments, if $K'=1, 2, \dots, \text{or } X-1$, then the corresponding HARQ-ACK information for the K' PDSCHs on the respective K' cells with active DL BWP change is not generated while the corresponding HARQ-ACK information for the remaining $X-K'$ PDSCHs on the respective $X-K'$ cells without active DL BWP change

is generated based on respective decoding outcomes. The HARQ-ACK information bits for the remaining $X-K'$ PDSCHs (or for the $X-K'$ cells without active DL BWP change) and the single HARQ-ACK bit (e.g., an ACK bit) for SCell dormancy indication (e.g., a total of $X-K'+1$ bits for DCI #B1) are included in sub-codebook #2. The $X-K'+1$ HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the $X-K'$ cells and the virtually scheduled cell). Padding bits (e.g., $M'-X+K'-1$ NACK bits) may be appended to the ordered $X-K'+1$ HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[0086] In some embodiments, if $K'=0$, no HARQ-ACK skipping is needed. The corresponding HARQ-ACK information for the X PDSCHs are generated based on the respective decoding results and included in sub-codebook #2 with the single HARQ-ACK bit (e.g., an ACK bit) for SCell dormancy indication. That is, a total of $X+1$ bits are included in sub-codebook #2. The generated $X+1$ HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the X cells and the virtually scheduled cell). Padding bits (e.g., $M'-X-1$ NACK bits) may be appended to the ordered $X+1$ HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[0087] For example, referring to FIG. 3C, a UE may be configured with 4 cells (i.e., cell 361, cell 362, cell 363 and cell 364) for multi-cell scheduling. It is assumed that the ascending order of the serving cell indexes of the 4 cells is cell 361 < cell 362 < cell 363 < cell 364. DCI 331 may schedule 2 PDSCHs (i.e., PDSCH 341 and PDSCH 342) on 2 respective cells (i.e., cell 361 and cell 362). That is, the corresponding FDRA values for cell 361 and cell 362 in DCI 331 are valid. DCI 331 may schedule 2 cells (i.e., cell 363 and cell 364) with invalid FDRA values and one or more fields corresponding to cell 363 in DCI 331 is repurposed for SCell dormancy indication. DCI 331 may indicate corresponding HARQ-ACK feedback for DCI 331 to be transmitted in PUCCH 333.

[0088] When cell 361 has an active DL BWP change (i.e., $M'=4$, $X=2$, $K'=1$ and $Y=2$),

then a single HARQ-ACK information bit (denoted as "b2") for PDSCH 342 on cell 362 is generated and an ACK bit is generated for cell 363. The 2 HARQ-ACK information bits may be ordered based on an ascending order of associated serving cell indexes, i.e., {b2, ACK}. Then, 2 NACK bits as padding bits are appended to the ordered HARQ-ACK information bits to match the maximum 4 HARQ-ACK information bits per a DCI format. That is, sub-codebook #2 may include HARQ-ACK feedback {b2, ACK, NACK, NACK} for DCI 331.

[0089] In some examples, an active DL BWP change may occur on at least one cell of the Y cells after the PDCCH monitoring occasion that provides DCI #B1 and before the PUCCH transmission occasion that is scheduled by DCI #B1 and DCI #B1 does not trigger the active DL BWP change on the at least one cell.

[0090] In some embodiments, the HARQ-ACK information for each of the X PDSCHs on the respective X cells is generated based on respective decoding results. The HARQ-ACK information bit (e.g., an ACK bit) for SCell dormancy indication and the corresponding HARQ-ACK information bits for the X PDSCHs (e.g., a total of X+1 bits for DCI #B1) are ordered according to the associated serving cell indexes (i.e., serving cell indexes of the X cells and the virtually scheduled cell). The X+1 bits are included in sub-codebook #2 and may be appended with padding bits (e.g., M'-X-1 NACK bits) to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[0091] In some embodiments, in addition to the HARQ-ACK information bits generated for the X PDSCHs and the HARQ-ACK information bit (e.g., an ACK bit) generated for SCell dormancy indication, a NACK bit may be generated for each of the remaining cells within the Y cells (i.e., Y-1 cells excluding the cell with the smallest serving cell index within the Y cells). That is, a total of X+Y HARQ-ACK information bits may be generated for DCI #B1. The X+Y (i.e., X + 1(ACK) + Y-1(NACK)) bits are ordered according to the associated serving cell indexes (i.e., serving cell indexes of the X+Y cells). The X+Y bits are included in sub-codebook #2 and may be appended with padding bits (e.g., M'-X-Y NACK bits) to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[0092] In some embodiments, the HARQ-ACK information for the X PDSCHs on the

respective X cells is skipped, i.e., not generated. The HARQ-ACK information bit (e.g., an ACK bit) for SCell dormancy indication is included in sub-codebook #1. That is, a single ACK bit is generated for DCI #B1.

[0093] In some embodiments, the HARQ-ACK information for DCI #B1 is skipped, i.e., not generated. That is, no HARQ-ACK feedback is generated for DCI #B1.

[0094] In some embodiments of the present disclosure, a DCI format (denoted as DCI #B2) may schedule at least one (actual) PDSCH on a set of serving cells (denoted as cell set #Z2') within cell set #Z1. When an active DL BWP on a cell (denoted as cell #B1') of cell set #Z2' is changed after the PDCCH monitoring occasion that provides DCI #B2 (e.g., DCI #B2 is transmitted by a BS or received by a UE in the PDCCH monitoring occasion) and before the PUCCH transmission occasion that is scheduled by DCI #B2 (e.g., DCI #B2 indicates that HARQ-ACK feedback for the DCI is transmitted in this PUCCH transmission occasion), and DCI #B2 does not trigger the active DL BWP change on cell #B1', a NACK may be generated for cell #B1'. For example, a single bit indicating NACK is generated as the corresponding HARQ-ACK information bit for cell #B1'. Alternatively, the HARQ-ACK information bit for cell #B1' is skipped. That is, the UE does not generate HARQ-ACK information bit for cell #B1'.

[0095] In some embodiments, cell set #Z2' may include a serving cell (denoted as cell #B2') where an active DL BWP on cell #B2' maintains the same (e.g., the active DL BWP on cell #B2' maintains the same after the PDCCH monitoring occasion that provides DCI #B2 and before the PUCCH transmission occasion that is scheduled by DCI #B2), the HARQ-ACK information bit for cell #B2' may be generated, for example, based on the decoding outcome of the corresponding PDSCH scheduled on cell #B2'.

[0096] In some embodiments, DCI #B2 may further indicate SCell dormancy. For example, DCI #B2 may indicate SCell dormancy by reinterpreting a set of fields associated with a serving cell (denoted as cell #B3') of a set of serving cells (denoted as cell set #Z3') within cell set #Z1. For example, cell set #Z3' may include the serving cell(s) having an invalid FDRA value(s) indicated in DCI #B2 and cell #B3' may be a serving cell with a predefined cell index (e.g., smallest cell index) in cell set #Z3'.

[0097] In some embodiments, an ACK may be generated for cell #B3'. That is, an ACK may be generated for SCell dormancy indication. For example, a single bit indicating ACK is generated as the corresponding HARQ-ACK information bit for cell #B3'. In some embodiments, the HARQ-ACK information bit for cell #B3' may be skipped. That is, HARQ-ACK information for SCell dormancy indication may be skipped. The above embodiments can be applied regardless of whether there is an active DL BWP change on a cell within cell set #Z3'.

[0098] In some embodiments, a NACK may be generated for each of the remaining cells in cell set #Z3'. For example, a single bit indicating NACK is generated as the corresponding HARQ-ACK information bit for a cell other than cell #B3' in cell set #Z3'. In some embodiments, the HARQ-ACK information bits for the remaining cells in cell set #Z3' may be skipped. The above embodiments can be applied regardless of whether there is an active DL BWP change on a cell within cell set #Z3'.

[0099] In some embodiments, an active DL BWP on at least one cell of cell set #Z3' is changed after the PDCCH monitoring occasion that provides DCI #B2 and before the PUCCH transmission occasion that is scheduled by DCI #B2, and DCI #B2 does not trigger the active DL BWP change on the at least one cell. In these embodiments, in some examples, an ACK may be generated for cell #B3' and the HARQ-ACK information bits for the remaining cells in cell set #Z3' may be skipped. In these embodiments, in some examples, an ACK may be generated for cell #B3' and a NACK may be generated for each of the remaining cells in cell set #Z3'. In these embodiments, in some examples, the HARQ-ACK information bits for all cells in cell set #Z3' may be skipped.

[00100] In some embodiments, if HARQ-ACK feedback is generated for DCI #B2, the HARQ-ACK feedback for DCI #B2 may be included in sub-codebook #1 or sub-codebook #2, depending on the total HARQ-ACK information bits generated for DCI #B2. For example, if the bit number of the HARQ-ACK information bits for DCI #B2 is greater than 1, the HARQ-ACK information bits for DCI #B2 is included in sub-codebook #2; otherwise, if the bit number is equal to 1, the single HARQ-ACK information bit for DCI #B2 can be included in either sub-codebook #1 or sub-codebook #2. If the bit number of the HARQ-ACK information bits for DCI #B2 is

greater than 1, the HARQ-ACK information bits for DCI #B2 may be first ordered according to a predefined rule and then included in sub-codebook #2 with possible padding bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format. If the bit number of the HARQ-ACK information bits for DCI #B2 is equal to 1 and the single HARQ-ACK information bit for DCI #B2 is included sub-codebook #2, padding bits are appended to the single HARQ-ACK information bit to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00101] For example, DCI #B2 may schedule a single PDSCH on a single serving cell (e.g., cell #B1') within cell set #Z1. When an active DL BWP change on the single cell happens after the PDCCH monitoring occasion that provides DCI #B2 and before the PUCCH transmission occasion that is scheduled by DCI #B2 and DCI #B2 does not trigger the active DL BWP change on the cell, a NACK bit may be generated for the single PDSCH (or for the single serving cell). That is, a NACK bit is generated as the HARQ-ACK feedback for DCI #B2. The generated NACK bit may be included in sub-codebook #1.

[00102] For example, DCI #B2 may schedule a plurality of PDSCHs (e.g., N PDSCHs), with valid FDRA values on the respective N serving cells within cell set #Z1. In some examples, an active DL BWP change may occur on K cells of the N cells after the PDCCH monitoring occasion that provides DCI #B2 and before the PUCCH transmission occasion that is scheduled by DCI #B2 and DCI #B2 does not trigger the active DL BWP change on the K cells.

[00103] In some embodiments, if $K=N$, then the corresponding HARQ-ACK information for the N PDSCHs on the N cells is not generated. That is, the corresponding HARQ-ACK information for the N cells or for DCI #B2 is skipped, or no HARQ-ACK feedback is generated for the N cells or for DCI #B2. Alternatively, N NACK bits may be generated for the N PDSCHs (or for the N cells, or for DCI #B2). The generated HARQ-ACK information bits may be included in sub-codebook #2. Padding bits (e.g., $M'-N$ NACK bits) may be appended to the generated HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00104] In some embodiments, if $K=N-1$, then the corresponding HARQ-ACK

information for the K PDSCHs on the respective K cells with active DL BWP change is generated as "NACK" while the corresponding HARQ-ACK information for the remaining single PDSCH on the single cell without active DL BWP change is generated based on the decoding result of the single PDSCH at the UE. The generated HARQ-ACK information bits for the N cells (e.g., K (or N-1) NACK bits and 1 bit for the single cell without active DL BWP change) may be included in sub-codebook #2. That is, N HARQ-ACK information bits may be generated for DCI #B2. The generated HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the N cells). Padding bits (e.g., M'-N NACK bits) may be appended to the ordered N HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00105] In some embodiments, if $K=1, 2, \dots, \text{or } N-2$, then the corresponding HARQ-ACK information for the K PDSCHs on the respective K cells with active DL BWP change is generated as "NACK" while the corresponding HARQ-ACK information for the remaining N-K PDSCHs on the respective N-K cells without active DL BWP change is generated based on the respective decoding results of the N-K PDSCHs at the UE. The generated HARQ-ACK information bits for the N cells (e.g., K NACK bits and N-K bits for the cells without active DL BWP change) may be included in sub-codebook #2. That is, N HARQ-ACK information bits may be generated for DCI #B2. The generated HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the N cells). Padding bits (e.g., M'-N NACK bits) may be appended to the ordered N HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00106] In some embodiments, if $K=0$, no HARQ-ACK skipping is needed. The corresponding HARQ-ACK information for the N PDSCHs are generated based on the respective decoding results and included in sub-codebook #2. The generated HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the N cells). Padding bits (e.g., M'-N NACK bits) may be appended to the ordered HARQ-ACK information bits to match the maximum HARQ-ACK

information bits (e.g., M' bits) per a DCI format.

[00107] For example, referring to FIG. 3B, a UE may be configured with 4 cells (i.e., cell 361, cell 362, cell 363 and cell 364) for multi-cell scheduling. It is assumed that the ascending order of the serving cell indexes of the 4 cells is cell 361 < cell 362 < cell 363 < cell 364. DCI 311 may schedule 3 PDSCHs (i.e., PDSCH 321, PDSCH 322 and PDSCH 323) on 3 respective cells (i.e., cell 361, cell 362 and cell 363) with respective valid FDRA values and indicate corresponding HARQ-ACK feedback for the 3 co-scheduled cells to be transmitted in PUCCH 313. When cell 361 and cell 363 have an active DL BWP change while cell 362 does not have an active DL BWP change (i.e., $M'=4$, $N=3$ and $K=2$), then a single HARQ-ACK information bit (e.g., "a2") for PDSCH 322 on cell 362 is generated. In addition, a NACK bit may be generated for each of PDSCH 321 and PDSCH 323 on cell 361 and cell 363. The single HARQ-ACK information bit (e.g., "a2") for PDSCH 322 on cell 362 and the two NACK bits for PDSCH 321 and PDSCH 323 on cell 361 and cell 363 are ordered according to the serving cell indexes as {NACK, a2, NACK}. Then, 1 NACK bit as a padding bit is appended to the ordered HARQ-ACK information bit to match the maximum 4 HARQ-ACK information bits per a DCI format. That is, sub-codebook #2 may include HARQ-ACK feedback {NACK, a2, NACK, NACK} for DCI 311.

[00108] For example, DCI #B2 may schedule at least one PDSCH (e.g., X PDSCHs where $X \geq 1$) with valid FDRA values on the respective X serving cells within cell set #Z1 and indicate SCell dormancy. DCI #B2 may indicate SCell dormancy by reinterpreting a set of fields associated with a serving cell with the smallest serving cell index among Y serving cells ($Y \geq 1$ and $X+Y \leq M$) within cell set #Z1, wherein the Y serving cells are indicated by corresponding invalid FDRA values in DCI #B2.

[00109] In some embodiments, as stated above, the serving cell with the smallest serving cell index among Y serving cells is regarded as a virtually scheduled cell and it is assumed that a virtual PDSCH is scheduled on this virtually scheduled cell. The virtual PDSCH is assumed to provide one TB which has been correctly decoded by the UE. Therefore, an ACK (e.g., a single bit indicating ACK) may be generated for this cell (or the virtual PDSCH). In other words, an ACK may be generated for SCell dormancy indication. In some embodiments, the HARQ-ACK information bit for this

virtually scheduled cell (or the virtual PDSCH) may be skipped. In other words, the HARQ-ACK information for SCell dormancy indication is not generated.

[00110] In some examples, an active DL BWP change may occur on K' cells of the X cells after the PDCCH monitoring occasion that provides DCI #B2 and before the PUCCH transmission occasion that is scheduled by DCI #B2 and DCI #B2 does not trigger the active DL BWP change on the K' cells.

[00111] In some embodiments, if $K'=X$, then the corresponding HARQ-ACK information for the X PDSCHs on the X cells with active DL BWP change may be generated as "NACK". A single HARQ-ACK bit (e.g., an ACK bit) may be generated for SCell dormancy indication. That is, an ACK bit may be generated for the virtually scheduled cell. The NACK bits for the X cells and the single HARQ-ACK bit (e.g., an ACK bit) for SCell dormancy indication (e.g., a total of $X+1$ bits for DCI #B2) are included in sub-codebook #2. The $X+1$ HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the X cells and the virtually scheduled cell). Padding bits (e.g., $M'-X-1$ NACK bits) may be appended to the ordered $X+1$ HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00112] In some embodiments, if $K'=X$, in addition to the NACK bits generated for the X cells with active DL BWP change and the HARQ-ACK information bit (e.g., an ACK bit) generated for SCell dormancy indication, a NACK bit may be generated for each of the remaining cells within the Y cells (i.e., $Y-1$ cells excluding the cell with the smallest serving cell index (i.e., the virtually scheduled cell) within the Y cells). That is, $X+Y$ HARQ-ACK information bits may be generated for DCI #B2. The $X+Y$ (i.e., $X(\text{NACK}) + 1(\text{ACK}) + Y-1(\text{NACK})$) bits are ordered according to the associated serving cell indexes (i.e., serving cell indexes of the $X+Y$ cells). The $X+Y$ bits are included in sub-codebook #2 and may be appended with padding bits (e.g., $M'-X-Y$ NACK bits) to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00113] In some embodiments, if $K'=X$, only the HARQ-ACK information (e.g., an ACK bit) for SCell dormancy indication is generated and is included in sub-codebook

#1. The HARQ-ACK information for the X PDSCHs on the X cells is skipped, i.e., not generated. That is, a single ACK bit is generated for DCI #B2.

[00114] In some embodiments, if $K'=1, 2, \dots, \text{or } X-1$, then the corresponding HARQ-ACK information for the K' PDSCHs on the respective K' cells with active DL BWP change is generated as "NACK" while the corresponding HARQ-ACK information for the remaining $X-K'$ PDSCHs on the respective $X-K'$ cells without active DL BWP change is generated based on respective decoding outcomes. The HARQ-ACK feedback for DCI #B2 is included in sub-codebook #2.

[00115] In some examples, the HARQ-ACK information bits for the remaining $X-K'$ PDSCHs (or for the $X-K'$ cells without active DL BWP change), the HARQ-ACK information bits for the K' PDSCHs (or for the K' cells with active DL BWP change) and the single HARQ-ACK bit (e.g., an ACK bit) for SCell dormancy indication (e.g., a total of $X+1$ bits for DCI #B2) are included in sub-codebook #2. The $X+1$ HARQ-ACK information bits (i.e., $X-K' + K'(\text{NACK}) + 1(\text{ACK})$) may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the X cells and the virtually scheduled cell). Padding bits (e.g., $M'-X-1$ NACK bits) may be appended to the ordered $X+1$ HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00116] In some embodiments, in addition to the HARQ-ACK information bits generated for the $X-K'$ cells without active DL BWP change, the HARQ-ACK information bits (e.g., NACK bits) for the K' cells with active DL BWP change and the single HARQ-ACK bit (e.g., an ACK bit) for SCell dormancy indication, a NACK bit may be generated for each of the remaining cells within the Y cells (i.e., $Y-1$ cells excluding the cell with the smallest serving cell index within the Y cells). That is, $X+Y$ (i.e., $X-K' + K'(\text{NACK}) + 1(\text{ACK}) + Y-1(\text{NACK})$) HARQ-ACK information bits may be generated for DCI #B2. The $X+Y$ bits are ordered according to the associated serving cell indexes (i.e., serving cell indexes of the $X+Y$ cells). The $X+Y$ bits are included in sub-codebook #2 and may be appended with padding bits (e.g., $M'-X-Y$ NACK bits) to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00117] In some embodiments, if $K'=0$, no HARQ-ACK skipping is needed. The corresponding HARQ-ACK information for the X PDSCHs are generated based on the respective decoding results and included in sub-codebook #2 with the single HARQ-ACK bit (e.g., an ACK bit) for SCell dormancy indication. That is, a total of $X+1$ bits are included in sub-codebook #2. The generated $X+1$ HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the X cells and the virtually scheduled cell). Padding bits (e.g., $M'-X-1$ NACK bits) may be appended to the ordered $X+1$ HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00118] For example, referring to FIG. 3C, a UE may be configured with 4 cells (i.e., cell 361, cell 362, cell 363 and cell 364) for multi-cell scheduling. It is assumed that the ascending order of the serving cell indexes of the 4 cells is cell 361 < cell 362 < cell 363 < cell 364. DCI 331 may schedule 2 PDSCHs (i.e., PDSCH 341 and PDSCH 342) on 2 respective cells (i.e., cell 361 and cell 362). That is, the corresponding FDRA values for cell 361 and cell 362 in DCI 331 are valid. DCI 331 may schedule 2 cells (i.e., cell 363 and cell 364) with invalid FDRA values and one or more fields corresponding to cell 363 in DCI 331 is repurposed for SCell dormancy indication. DCI 331 may indicate corresponding HARQ-ACK feedback for DCI 331 to be transmitted in PUCCH 333.

[00119] In some embodiments, when cell 361 has an active DL BWP change (i.e., $M'=4$, $X=2$, $K'=1$ and $Y=2$), then a single HARQ-ACK information bit (e.g., b_2) for PDSCH 342 on cell 362 is generated, a NACK bit is generated for cell 361 and an ACK bit is generated for cell 363. The 3 HARQ-ACK information bits may be ordered based on an ascending order of associated serving cell indexes, i.e., {NACK, b_2 , ACK}. Then, 1 NACK bit as a padding bit are appended to the ordered HARQ-ACK information bits to match the maximum 4 HARQ-ACK information bits per a DCI format. That is, sub-codebook #2 may include HARQ-ACK feedback {NACK, b_2 , ACK, NACK} for DCI 331.

[00120] In some embodiments, when cell 361 has an active DL BWP change (i.e., $M'=4$, $X=2$, $K'=1$ and $Y=2$), then a single HARQ-ACK information bit (e.g., b_2) for PDSCH

342 on cell 362 is generated, a NACK bit is generated for cell 361, an ACK bit is generated for cell 363 and a NACK bit is generated for cell 364. The 4 HARQ-ACK information bits may be ordered based on an ascending order of associated serving cell indexes, i.e., {NACK, b2, ACK, NACK}. No padding bit is needed since there are already 4 HARQ-ACK information bits which matches the maximum 4 HARQ-ACK information bits per a DCI format. That is, sub-codebook #2 may include HARQ-ACK feedback {NACK, b2, ACK, NACK} for DCI 331.

[00121] In some examples, an active DL BWP change may occur on at least one cell of the Y cells after the PDCCH monitoring occasion that provides DCI #B2 and before the PUCCH transmission occasion that is scheduled by DCI #B2 and DCI #B2 does not trigger the active DL BWP change on the at least one cell.

[00122] In some embodiments, the HARQ-ACK information for each of the X PDSCHs on the respective X cells is generated based on respective decoding results. The HARQ-ACK information bit (e.g., an ACK bit) for SCell dormancy indication and the corresponding HARQ-ACK information bits for the X PDSCHs are ordered according to the associated serving cell indexes (i.e., serving cell indexes of the X cells and the virtually scheduled cell). That is, X+1 HARQ-ACK information bits may be generated for DCI #B2. The X+1 bits are included in sub-codebook #2 and may be appended with padding bits (e.g., M'-X-1 NACK bits) to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00123] In some embodiments, in addition to the HARQ-ACK information bits generated for the X PDSCHs and the HARQ-ACK information bit (e.g., an ACK bit) generated for SCell dormancy indication, a NACK bit may be generated for each of the remaining cells within the Y cells (i.e., Y-1 cells excluding the cell with the smallest serving cell index within the Y cells). That is, X+Y (i.e., X + 1(ACK) + Y-1(NACK)) HARQ-ACK information bits may be generated for DCI #B2. The X+Y bits are ordered according to the associated serving cell indexes (i.e., serving cell indexes of the X+Y cells). The X+Y bits are included in sub-codebook #2 and may be appended with padding bits (e.g., M'-X-Y NACK bits) to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00124] In some embodiments, the HARQ-ACK information for the X PDSCHs on the

respective X cells is skipped, i.e., not generated. The HARQ-ACK information bit (e.g., an ACK bit) for SCell dormancy indication is included in sub-codebook #1. That is, a single ACK bit is generated for DCI #B2.

[00125] In some embodiments, the HARQ-ACK information for DCI #B2 is skipped, i.e., not generated. That is, no HARQ-ACK feedback is generated for DCI #B2.

[00126] In some embodiments of the present disclosure, a DCI format (denoted as DCI #B3) may schedule at least one (actual) PDSCH on a set of serving cells (denoted as cell set #Z2") within cell set #Z1. When an active DL BWP on a cell (denoted as cell #B1") of cell set #Z2" is changed after the PDCCH monitoring occasion that provides DCI #B3 (e.g., DCI #B3 is transmitted by a BS or received by a UE in the PDCCH monitoring occasion) and before the PUCCH transmission occasion that is scheduled by DCI #B3 (e.g., DCI #B3 indicates that HARQ-ACK feedback for the DCI is transmitted in this PUCCH transmission occasion), and DCI #B3 does not trigger the active DL BWP change on cell #B1", the HARQ-ACK information bit for each cell in cell set #Z2" is skipped. That is, the UE does not generate HARQ-ACK information bits for cells in cell set #Z2". Alternatively, a NACK may be generated for each cell in cell set #Z2". For example, a single bit indicating NACK is generated as the corresponding HARQ-ACK information bit for each cell in cell set #Z2".

[00127] In some embodiments, DCI #B3 may further indicate SCell dormancy. For example, DCI #B3 may indicate SCell dormancy by reinterpreting a set of fields associated with a serving cell (denoted as cell #B3") of a set of serving cells (denoted as cell set #Z3") within cell set #Z1. For example, cell set #Z3" may include the serving cell(s) having an invalid FDRA value(s) indicated in DCI #B3 and cell #B3" may be a serving cell with a predefined cell index (e.g., smallest cell index) in cell set #Z3".

[00128] In some embodiments, an ACK may be generated for cell #B3". That is, an ACK may be generated for SCell dormancy indication. For example, a single bit indicating ACK is generated as the corresponding HARQ-ACK information bit for cell #B3". In some embodiments, the HARQ-ACK information bit for cell #B3" may be skipped. That is, HARQ-ACK information for SCell dormancy indication may be skipped. The above embodiments can be applied regardless of whether there is an

active DL BWP change on a cell within cell set #Z3".

[00129] In some embodiments, a NACK may be generated for each of the remaining cells in cell set #Z3". For example, a single bit indicating NACK is generated as the corresponding HARQ-ACK information bit for a cell other than cell #B3" in cell set #Z3". In some embodiments, the HARQ-ACK information bits for the remaining cells in cell set #Z3" may be skipped. The above embodiments can be applied regardless of whether there is an active DL BWP change on a cell within cell set #Z3".

[00130] In some embodiments, an active DL BWP on at least one cell of cell set #Z3" is changed after the PDCCH monitoring occasion that provides DCI #B3 and before the PUCCH transmission occasion that is scheduled by DCI #B3, and DCI #B3 does not trigger the active DL BWP change on the at least one cell. In these embodiments, in some examples, an ACK may be generated for cell #B3" and the HARQ-ACK information bits for the remaining cells in cell set #Z3" may be skipped. In these embodiments, in some examples, an ACK may be generated for cell #B3" and a NACK may be generated for each of the remaining cells in cell set #Z3". In these embodiments, in some examples, the HARQ-ACK information bits for all cells in cell set #Z3" may be skipped.

[00131] In some embodiments, if HARQ-ACK feedback is generated for DCI #B3, the HARQ-ACK feedback for DCI #B3 may be included in sub-codebook #1 or sub-codebook #2, depending on the total HARQ-ACK information bits generated for DCI #B3. For example, if the bit number of the HARQ-ACK information bits for DCI #B3 is greater than 1, the HARQ-ACK information bits for DCI #B3 is included in sub-codebook #2; otherwise, if the bit number is equal to 1, the single HARQ-ACK information bit for DCI #B3 can be included in either sub-codebook #1 or sub-codebook #2. If the bit number of the HARQ-ACK information bits for DCI #B3 is greater than 1, the HARQ-ACK information bits for DCI #B3 may be first ordered according to a predefined rule and then included in sub-codebook #2 with possible padding bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format. If the bit number of the HARQ-ACK information bits for DCI #B3 is equal to 1 and the single HARQ-ACK information bit for DCI #B3 is included sub-codebook #2, padding bits are appended to the single HARQ-ACK information bit to

match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00132] For example, DCI #B3 may schedule a single PDSCH on a single serving cell (e.g., cell #B1") within cell set #Z1. When an active DL BWP change on the single cell happens after the PDCCH monitoring occasion that provides DCI #B3 and before the PUCCH transmission occasion that is scheduled by DCI #B3 and DCI #B3 does not trigger the active DL BWP change on the cell, the corresponding HARQ-ACK information bit for the single PDSCH (or for the single serving cell) is skipped, i.e., not generated. That is, no HARQ-ACK feedback is generated for DCI #B3.

[00133] For example, DCI #B3 may schedule a plurality of PDSCHs (e.g., N PDSCHs), with valid FDRA values on the respective N serving cells within cell set #Z1. In some examples, an active DL BWP change may occur on at least one cell of the N cells after the PDCCH monitoring occasion that provides DCI #B3 and before the PUCCH transmission occasion that is scheduled by DCI #B3 and DCI #B3 does not trigger the active DL BWP change on the at least one cell.

[00134] In some embodiments, a NACK may be generated for each of the N PDSCHs on the respective N cells. For example, a single bit indicating NACK is generated as the corresponding HARQ-ACK information bit for each of the N PDSCHs (or for each of the N cells). The generated N HARQ-ACK information bits (i.e., N NACK bits for DCI #B3) may be included in sub-codebook #2. Padding bits (e.g., $M'-N$ NACK bits) may be appended to the generated HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00135] In some embodiments, the corresponding HARQ-ACK information for the N cells or for DCI #B3 is skipped. That is, no HARQ-ACK feedback is generated for the N cells or for DCI #B3.

[00136] For example, DCI #B3 may schedule at least one PDSCH (e.g., X PDSCHs where $X \geq 1$) with valid FDRA values on the respective X serving cells within cell set #Z1 and indicate SCell dormancy. DCI #B3 may indicate SCell dormancy by reinterpreting a set of fields associated with a serving cell with the smallest serving cell index among Y serving cells ($Y \geq 1$ and $X+Y \leq M$) within cell set #Z1, wherein the Y serving cells are indicated by corresponding invalid FDRA values in DCI #B3.

[00137] In some embodiments, as stated above, the serving cell with the smallest serving cell index among Y serving cells is regarded as a virtually scheduled cell and it is assumed that a virtual PDSCH is scheduled on this virtually scheduled cell. The virtual PDSCH is assumed to provide one TB which has been correctly decoded by the UE. Therefore, an ACK (e.g., a single bit indicating ACK) may be generated for this cell (or the virtual PDSCH). In other words, an ACK may be generated for SCell dormancy indication. In some embodiments, the HARQ-ACK information bit for this virtually scheduled cell (or the virtual PDSCH) may be skipped. In other words, the HARQ-ACK information for SCell dormancy indication is not generated.

[00138] In some examples, an active DL BWP change may occur on at least one cell of the X cells after the PDCCH monitoring occasion that provides DCI #B3 and before the PUCCH transmission occasion that is scheduled by DCI #B3 and DCI #B3 does not trigger the active DL BWP change on the at least one cell.

[00139] In some embodiments, the corresponding HARQ-ACK information for each of the X PDSCHs on the respective X cells may be generated as "NACK". A single HARQ-ACK bit (e.g., an ACK bit) may be generated for SCell dormancy indication. That is, an ACK bit may be generated for the virtually scheduled cell. The NACK bits for the X cells and the single HARQ-ACK bit (e.g., an ACK bit) for SCell dormancy indication (e.g., a total of X+1 bits for DCI #B3) are included in sub-codebook #2. The X+1 HARQ-ACK information bits may be ordered based on, for example, a predefined order (e.g., ascending or descending order) of the corresponding serving cell indexes (i.e., serving cell indexes of the X cells and the virtually scheduled cell). Padding bits (e.g., M'-X-1 NACK bits) may be appended to the ordered X+1 HARQ-ACK information bits to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00140] In some embodiments, in addition to the NACK bits generated for the X cells and the HARQ-ACK information bit (e.g., an ACK bit) generated for SCell dormancy indication, a NACK bit may be generated for each of the remaining cells within the Y cells (i.e., Y-1 cells excluding the cell with the smallest serving cell index (i.e., the virtually scheduled cell) within the Y cells). That is, X+Y (i.e., X(NACK) + 1(ACK) + Y-1(NACK)) HARQ-ACK information bits may be generated for DCI #B3. The

X+Y bits are ordered according to the associated serving cell indexes (i.e., serving cell indexes of the X+Y cells). The X+Y bits are included in sub-codebook #2 and may be appended with padding bits (e.g., $M'-X-Y$ NACK bits) to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00141] In some embodiments, only the HARQ-ACK information (e.g., an ACK bit) for SCell dormancy indication is generated and is included in sub-codebook #1. The HARQ-ACK information for the X PDSCHs on the respective X cells is skipped, i.e., not generated. That is, a single ACK bit is generated for DCI #B3.

[00142] In some embodiments, the HARQ-ACK information for DCI #B3 is skipped, i.e., not generated. That is, the HARQ-ACK information for the X PDSCHs on the respective X cells is skipped, i.e., not generated. The HARQ-ACK information for SCell dormancy indication is also skipped, i.e., not generated. That is, no HARQ-ACK feedback is generated for DCI #B3.

[00143] In some examples, an active DL BWP change may occur on at least one cell of the Y cells after the PDCCH monitoring occasion that provides DCI #B3 and before the PUCCH transmission occasion that is scheduled by DCI #B3 and DCI #B3 does not trigger the active DL BWP change on the at least one cell.

[00144] In some embodiments, the HARQ-ACK information for each of the X PDSCHs on the respective X cells is generated based on respective decoding results. The HARQ-ACK information bit (e.g., an ACK bit) for SCell dormancy indication and the corresponding HARQ-ACK information bits for the X PDSCHs are ordered according to the associated serving cell indexes (i.e., serving cell indexes of the X cells and the virtually scheduled cell). That is, X+1 HARQ-ACK information bits may be generated for DCI #B3. The X+1 bits are included in sub-codebook #2 and may be appended with padding bits (e.g., $M'-X-1$ NACK bits) to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00145] In some embodiments, in addition to the HARQ-ACK information bits generated for the X PDSCHs and the HARQ-ACK information bit (e.g., an ACK bit) generated for SCell dormancy indication, a NACK bit may be generated for each of the remaining cells within the Y cells (i.e., Y-1 cells excluding the cell with the smallest

serving cell index within the Y cells). That is, $X+Y$ (i.e., $X + 1(\text{ACK}) + Y-1(\text{NACK})$) HARQ-ACK information bits may be generated for DCI #B3. The $X+Y$ bits are ordered according to the associated serving cell indexes (i.e., serving cell indexes of the $X+Y$ cells). The $X+Y$ bits are included in sub-codebook #2 and may be appended with padding bits (e.g., $M'-X-Y$ NACK bits) to match the maximum HARQ-ACK information bits (e.g., M' bits) per a DCI format.

[00146] In some embodiments, the HARQ-ACK information for the X PDSCHs on the respective X cells is skipped, i.e., not generated. The HARQ-ACK information bit (e.g., an ACK bit) for SCell dormancy indication is included in sub-codebook #1. That is, a single ACK bit is generated for DCI #B3.

[00147] In some embodiments, the HARQ-ACK information for DCI #B3 is skipped, i.e., not generated. That is, no HARQ-ACK feedback is generated for DCI #B3.

[00148] FIG. 4 illustrates a flowchart of method 400 for wireless communication in accordance with some embodiments of the present disclosure. Details described in all of the foregoing embodiments of the present disclosure are applicable for the embodiments shown in FIG. 4. In some examples, method 400 may be performed by a UE, for example, UE 104 as described with reference to FIG. 1. In some embodiments, the UE may execute a set of instructions to control the functional elements of the UE to perform the described functions or operations. In some examples, a processor of a UE may cause the UE to perform method 400.

[00149] At 411, a UE may receive signaling for configuring a first set of serving cells for multi-cell scheduling. At 413, the UE may receive, from a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for the UE to transmit HARQ-ACK feedback for the DCI format. At 415, the UE may determine whether to generate the HARQ-ACK feedback for the DCI format in response to determining that an active DL BWP on a first serving cell of the second set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the first serving cell.

[00150] In some embodiments, determining whether to generate the HARQ-ACK

feedback for the DCI format may include: determining not to generate a HARQ-ACK information bit for the first serving cell; or determining to generate a negative acknowledgement (NACK) for the first serving cell.

[00151] In some embodiments, the second set of serving cells may include a second serving cell and an active DL BWP on the second serving cell maintains the same. Determining whether to generate the HARQ-ACK feedback for the DCI format may include determining to generate a HARQ-ACK information bit for the second serving cell. For example, the HARQ-ACK information bit for the second serving cell may be generated based on decoding outcome.

[00152] In some embodiments, determining whether to generate the HARQ-ACK feedback for the DCI format may include: determining not to generate a HARQ-ACK information bit for each cell in the second set of serving cells; or determining to generate a NACK for each cell in the second set of serving cells.

[00153] In some embodiments, the DCI format further indicates SCell dormancy by reinterpreting a set of fields associated with a third serving cell of a third set of serving cells in the first set of serving cells.

[00154] In some embodiments, determining whether to generate the HARQ-ACK feedback for the DCI format may include: determining to generate an ACK for the third serving cell; or determining not to generate a HARQ-ACK information bit for the third serving cell.

[00155] In some embodiments, the UE may perform one of the following in response to determining that an active DL BWP on a fourth serving cell of the third set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the fourth serving cell: generating an ACK for the third serving cell and not generating a HARQ-ACK information bit for each of the remaining cell(s) in the third set of serving cells; generating an ACK for the third serving cell and generating a NACK for each of the remaining cell(s) in the third set of serving cells; and not generating a HARQ-ACK information bit for each cell in the third set of serving cells.

[00156] In some embodiments, the UE may perform one or more of: generate a first HARQ-ACK sub-codebook comprising HARQ-ACK feedback for a first type of DCI format; and generate a second HARQ-ACK sub-codebook comprising HARQ-ACK feedback for a second type of DCI format. The first type of DCI format corresponds to a single HARQ-ACK information bit and the second type of DCI format corresponds to a predefined number of HARQ-ACK information bits, the predefined number being greater than one.

[00157] In some embodiments, the HARQ-ACK feedback for the DCI format is included in the first HARQ-ACK sub-codebook.

[00158] In some embodiments, the HARQ-ACK feedback for the DCI format is included in the second HARQ-ACK sub-codebook. The UE may: order HARQ-ACK information bits generated for the DCI format; and in response to a number of bits of the generated HARQ-ACK information bits being less than the predefined number, add at least one padding bit to the generated HARQ-ACK information bits to match the predefined number.

[00159] It should be appreciated by persons skilled in the art that the sequence of the operations in exemplary method 400 may be changed and some of the operations in exemplary method 400 may be eliminated or modified, without departing from the spirit and scope of the disclosure.

[00160] FIG. 5 illustrates a flowchart of method 500 for wireless communication in accordance with some embodiments of the present disclosure. Details described in all of the foregoing embodiments of the present disclosure are applicable for the embodiments shown in FIG. 5. In some examples, method 500 may be performed by a BS or an NE (for example, NE 102 as described with reference to FIG. 1). In some embodiments, the BS or the NE may execute a set of instructions to control the functional elements of the BS or the NE to perform the described functions or operations. In some examples, a processor of an NE may cause the NE to perform method 500.

[00161] At 511, a BS may transmit, to a UE, signaling for configuring a first set of serving cells for multi-cell scheduling. At 513, the BS may transmit, to the UE in a

PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for the UE to transmit HARQ-ACK feedback for the DCI format.

[00162] At 515, the BS may determine whether or not the HARQ-ACK feedback for the DCI format is generated by the UE in the case that an active DL BWP change happens on a fifth serving cell of the first set of serving cells after the PDCCH monitoring occasion and before the PUCCH transmission occasion. At 517, the BS may receive the HARQ-ACK feedback for the DCI format from the UE in the PUCCH transmission occasion in response to determining that the HARQ-ACK feedback for the DCI format is generated by the UE.

[00163] In some embodiments, the fifth serving cell is a cell in the second set of serving cells. Determining whether or not the HARQ-ACK feedback for the DCI format is generated may include: determining that a HARQ-ACK information bit is not generated for the fifth serving cell; or determining that a NACK is generated for the fifth serving cell.

[00164] In some embodiments, the second set of serving cells may include a second serving cell. An active DL BWP on the second serving cell may maintain the same. Determining whether or not the HARQ-ACK feedback for the DCI format is generated further may include determining that a HARQ-ACK information bit is generated for the second serving cell.

[00165] In some embodiments, the fifth serving cell is a cell in the second set of serving cells. Determining whether or not the HARQ-ACK feedback for the DCI format is generated may include: determining that a HARQ-ACK information bit is not generated for each cell in the second set of serving cells; or determining that a NACK is generated for each cell in the second set of serving cells.

[00166] In some embodiments, the DCI format further indicates SCell dormancy by reinterpreting a set of fields associated with a third serving cell of a third set of serving cells in the first set of serving cells.

[00167] In some embodiments, the fifth serving cell is a cell in the second set of serving

cells. Determining whether or not the HARQ-ACK feedback for the DCI format is generated may include: determining that a HARQ-ACK information bit is generated for the third serving cell; or determining that a HARQ-ACK information bit is not generated for the third serving cell.

[00168] In some embodiments, the fifth serving cell is a cell in the third set of serving cells. Determining whether or not the HARQ-ACK feedback for the DCI format is generated may include: determining that a HARQ-ACK information bit is generated for the third serving cell and a HARQ-ACK information bit is not generated for each of the remaining cell(s) in the third set of serving cells; determining that a HARQ-ACK information bit is generated for the third serving cell and a negative ACK (NACK) is generated for each of the remaining cell(s) in the third set of serving cells; or determining that a HARQ-ACK information bit is not generated for each cell in the third set of serving cells.

[00169] In some embodiments, the HARQ-ACK feedback for the DCI format is included in a first HARQ-ACK sub-codebook including HARQ-ACK feedback for a first type of DCI format or a second HARQ-ACK sub-codebook including HARQ-ACK feedback for a second type of DCI format. The first type of DCI format corresponds to a single HARQ-ACK information bit and the second type of DCI format corresponds to a predefined number of HARQ-ACK information bits. The predefined number is greater than one.

[00170] It should be appreciated by persons skilled in the art that the sequence of the operations in exemplary method 500 may be changed and some of the operations in exemplary method 500 may be eliminated or modified, without departing from the spirit and scope of the disclosure.

[00171] FIG. 6 illustrates an example of a UE 600 in accordance with aspects of the present disclosure. The UE 600 may include a processor 602, a memory 604, a controller 606, and a transceiver 608. The processor 602, the memory 604, the controller 606, or the transceiver 608, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more

interfaces.

[00172] The processor 602, the memory 604, the controller 606, or the transceiver 608, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[00173] The processor 602 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 602 may be configured to operate the memory 604. In some other implementations, the memory 604 may be integrated into the processor 602. The processor 602 may be configured to execute computer-readable instructions stored in the memory 604 to cause the UE 600 to perform various functions of the present disclosure.

[00174] The memory 604 may include volatile or non-volatile memory. The memory 604 may store computer-readable, computer-executable code including instructions when executed by the processor 602 cause the UE 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as the memory 604 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[00175] In some implementations, the processor 602 and the memory 604 coupled with the processor 602 may be configured to cause the UE 600 to perform one or more of the functions described herein (e.g., executing, by the processor 602, instructions stored in the memory 604). For example, the processor 602 may support wireless communication at the UE 600 in accordance with examples as disclosed herein. For example, the UE 600 may be configured to support means for performing the operations as described with respect to FIG. 4.

[00176] For example, the UE 600 may be configured to support: a means for receiving signaling for configuring a first set of serving cells for multi-cell scheduling; a means for receiving, from a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for a UE to transmit HARQ-ACK feedback for the DCI format; and a means for determining whether to generate the HARQ-ACK feedback for the DCI format in response to determining that an active DL BWP on a first serving cell of the second set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the first serving cell.

[00177] The controller 606 may manage input and output signals for the UE 600. The controller 606 may also manage peripherals not integrated into the UE 600. In some implementations, the controller 606 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 606 may be implemented as part of the processor 602.

[00178] In some implementations, the UE 600 may include at least one transceiver 608. In some other implementations, the UE 600 may have more than one transceiver 608. The transceiver 608 may represent a wireless transceiver. The transceiver 608 may include one or more receiver chains 610, one or more transmitter chains 612, or a combination thereof.

[00179] A receiver chain 610 may be configured to receive signals (e.g., control information, data, or packets) over a wireless medium. For example, the receiver chain 610 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 610 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 610 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 610 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[00180] A transmitter chain 612 may be configured to generate and transmit signals

(e.g., control information, data, or packets). The transmitter chain 612 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 612 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 612 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[00181] It should be appreciated by persons skilled in the art that the components in exemplary UE 600 may be changed, for example, some of the components in exemplary UE 600 may be omitted or modified or a new component(s) may be added to exemplary UE 600, without departing from the spirit and scope of the disclosure. For example, in some embodiments, the UE 600 may not include the controller 606.

[00182] FIG. 7 illustrates an example of a processor 700 in accordance with aspects of the present disclosure. The processor 700 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 700 may include a controller 702 configured to perform various operations in accordance with examples as described herein. The processor 700 may optionally include at least one memory 704, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 700 may optionally include one or more arithmetic-logic units (ALUs) 706. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00183] The processor 700 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor

700) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[00184] The controller 702 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 700 to cause the processor 700 to support various operations in accordance with examples as described herein. For example, the controller 702 may operate as a control unit of the processor 700, generating control signals that manage the operation of various components of the processor 700. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[00185] The controller 702 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 704 and determine a subsequent instruction(s) to be executed to cause the processor 700 to support various operations in accordance with examples as described herein. The controller 702 may be configured to track memory address of instructions associated with the memory 704. The controller 702 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 702 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 700 to cause the processor 700 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 702 may be configured to manage flow of data within the processor 700. The controller 702 may be configured to control transfer of data between registers, ALUs, and other functional units of the processor 700.

[00186] The memory 704 may include one or more caches (e.g., memory local to or included in the processor 700 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 704 may reside within or on a processor chipset (e.g., local to the processor 700). In some other implementations, the memory 704 may reside external to the processor chipset (e.g.,

remote to the processor 700).

[00187] The memory 704 may store computer-readable, computer-executable code including instructions that, when executed by the processor 700, cause the processor 700 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 702 and/or the processor 700 may be configured to execute computer-readable instructions stored in the memory 704 to cause the processor 700 to perform various functions. For example, the processor 700 and/or the controller 702 may be coupled with or to the memory 704, the processor 700, the controller 702, and the memory 704 may be configured to perform various functions described herein. In some examples, the processor 700 may include multiple processors and the memory 704 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[00188] The one or more ALUs 706 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 706 may reside within or on a processor chipset (e.g., the processor 700). In some other implementations, the one or more ALUs 706 may reside external to the processor chipset (e.g., the processor 700). One or more ALUs 706 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 706 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 706 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 706 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 706 to handle conditional operations, comparisons, and bitwise operations.

[00189] The processor 700 may support wireless communication in accordance with examples as disclosed herein.

[00190] For example, the processor 700 may be configured to support means for

performing the operations as described with respect to FIG. 4. For example, the processor 700 may be configured to or operable to support: a means for receiving signaling for configuring a first set of serving cells for multi-cell scheduling; a means for receiving, from a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for a UE to transmit HARQ-ACK feedback for the DCI format; and a means for determining whether to generate the HARQ-ACK feedback for the DCI format in response to determining that an active DL BWP on a first serving cell of the second set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the first serving cell.

[00191] For example, the processor 700 may be configured to support means for performing the operations as described with respect to FIG. 5. For example, the processor 700 may be configured to or operable to support: a means for transmitting, to a UE, signaling for configuring a first set of serving cells for multi-cell scheduling; a means for transmitting, to the UE in a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for the UE to transmit HARQ-ACK feedback for the DCI format; a means for determining whether or not the HARQ-ACK feedback for the DCI format is generated by the UE in the case that an active DL BWP change happens on a fifth serving cell of the first set of serving cells after the PDCCH monitoring occasion and before the PUCCH transmission occasion; and a means for receiving the HARQ-ACK feedback for the DCI format from the UE in the PUCCH transmission in response to determining that the HARQ-ACK feedback for the DCI format is generated by the UE.

[00192] It should be appreciated by persons skilled in the art that the components in exemplary processor 700 may be changed, for example, some of the components in exemplary processor 700 may be omitted or modified or a new component(s) may be added to exemplary processor 700, without departing from the spirit and scope of the disclosure. For example, in some embodiments, the processor 700 may not include the ALUs 706.

[00193] FIG. 8 illustrates an example of an NE 800 in accordance with aspects of the present disclosure. The NE 800 may include a processor 802, a memory 804, a controller 806, and a transceiver 808. The processor 802, the memory 804, the controller 806, or the transceiver 808, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[00194] The processor 802, the memory 804, the controller 806, or the transceiver 808, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a DSP, an ASIC, or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[00195] The processor 802 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 802 may be configured to operate the memory 804. In some other implementations, the memory 804 may be integrated into the processor 802. The processor 802 may be configured to execute computer-readable instructions stored in the memory 804 to cause the NE 800 to perform various functions of the present disclosure.

[00196] The memory 804 may include volatile or non-volatile memory. The memory 804 may store computer-readable, computer-executable code including instructions when executed by the processor 802 cause the NE 800 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as the memory 804 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[00197] In some implementations, the processor 802 and the memory 804 coupled with the processor 802 may be configured to cause the NE 800 to perform one or more of

the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804). For example, the processor 802 may support wireless communication at the NE 800 in accordance with examples as disclosed herein. For example, the NE 800 may be configured to support means for performing the operations as described with respect to FIG. 5.

[00198] For example, the NE 800 may be configured to support: a means for transmitting, to a UE, signaling for configuring a first set of serving cells for multi-cell scheduling; a means for transmitting, to the UE in a PDCCH monitoring occasion, a DCI format scheduling a second set of serving cells in the first set of serving cells and indicating a PUCCH transmission occasion for the UE to transmit HARQ-ACK feedback for the DCI format; a means for determining whether or not the HARQ-ACK feedback for the DCI format is generated by the UE in the case that an active DL BWP change happens on a fifth serving cell of the first set of serving cells after the PDCCH monitoring occasion and before the PUCCH transmission occasion; and a means for receiving the HARQ-ACK feedback for the DCI format from the UE in the PUCCH transmission in response to determining that the HARQ-ACK feedback for the DCI format is generated by the UE.

[00199] The controller 806 may manage input and output signals for the NE 800. The controller 806 may also manage peripherals not integrated into the NE 800. In some implementations, the controller 806 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 806 may be implemented as part of the processor 802.

[00200] In some implementations, the NE 800 may include at least one transceiver 808. In some other implementations, the NE 800 may have more than one transceiver 808. The transceiver 808 may represent a wireless transceiver. The transceiver 808 may include one or more receiver chains 810, one or more transmitter chains 812, or a combination thereof.

[00201] A receiver chain 810 may be configured to receive signals (e.g., control information, data, or packets) over a wireless medium. For example, the receiver chain 810 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 810 may include at least one amplifier (e.g., an

LNA) configured to amplify the received signal. The receiver chain 810 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 810 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[00202] A transmitter chain 812 may be configured to generate and transmit signals (e.g., control information, data, or packets). The transmitter chain 812 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as AM, FM, or digital modulation schemes like PSK or QAM. The transmitter chain 812 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 812 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[00203] It should be appreciated by persons skilled in the art that the components in exemplary NE 800 may be changed, for example, some of the components in exemplary NE 800 may be omitted or modified or a new component(s) may be added to exemplary NE 800, without departing from the spirit and scope of the disclosure. For example, in some embodiments, the NE 800 may not include the controller 806.

[00204] Those having ordinary skill in the art would understand that the operations or steps of the methods described in connection with the aspects disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. Additionally, in some aspects, the operations or steps of the methods may reside as one or any combination or set of codes and/or instructions on a non-transitory computer-readable medium, which may be incorporated into a computer program product.

[00205] While this disclosure has been described with specific embodiments thereof, it is evident that many alternatives, modifications, and variations may be apparent to

those skilled in the art. The disclosure is not limited to the examples and designs described herein but is to be accorded with the broadest scope consistent with the principles and novel features disclosed herein. For example, various components of the embodiments may be interchanged, added, or substituted in other embodiments. Also, all of the elements of each figure are not necessary for the operation of the disclosed embodiments. For example, one of ordinary skill in the art of the disclosed embodiments would be enabled to make and use the teachings of the disclosure by simply employing the elements of the independent claims. Accordingly, embodiments of the disclosure as set forth herein are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the disclosure.

[00206] In this document, the terms "includes," "including," or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that includes a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element preceded by "a," "an," or the like does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that includes the element. Also, the term "another" is defined as at least a second or more. The term "having" or the like, as used herein, is defined as "including." Expressions such as "A and/or B" or "at least one of A and B" may include any and all combinations of words enumerated along with the expression. For instance, the expression "A and/or B" or "at least one of A and B" may include A, B, or both A and B. The wording "the first," "the second" or the like is only used to clearly illustrate the embodiments of the present disclosure, but is not used to limit the substance of the present disclosure.

WHAT IS CLAIMED:

1. A user equipment (UE), comprising:
 - at least one memory; and
 - at least one processor coupled with the at least one memory and configured to cause the UE to:
 - receive signaling for configuring a first set of serving cells for multi-cell scheduling;
 - receive, from a physical downlink control channel (PDCCH) monitoring occasion, a downlink control information (DCI) format scheduling a second set of serving cells in the first set of serving cells and indicating a physical uplink control channel (PUCCH) transmission occasion for the UE to transmit hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback for the DCI format; and
 - determine whether to generate the HARQ-ACK feedback for the DCI format in response to determining that an active downlink (DL) bandwidth part (BWP) on a first serving cell of the second set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the first serving cell.
2. The UE of claim 1, wherein determining whether to generate the HARQ-ACK feedback for the DCI format comprises:
 - determining not to generate a HARQ-ACK information bit for the first serving cell; or
 - determining to generate a negative acknowledgement (NACK) for the first serving cell.
3. The UE of claim 1, wherein the second set of serving cells comprises a second serving cell and an active DL BWP on the second serving cell maintains the same, and wherein determining whether to generate the HARQ-ACK feedback for the DCI format

further comprises determining to generate a HARQ-ACK information bit for the second serving cell.

4. The UE of claim 1, wherein determining whether to generate the HARQ-ACK feedback for the DCI format comprises:

determining not to generate a HARQ-ACK information bit for each cell in the second set of serving cells; or

determining to generate a negative acknowledgement (NACK) for each cell in the second set of serving cells.

5. The UE of claim 1, wherein the DCI format further indicates secondary cell (SCell) dormancy by reinterpreting a set of fields associated with a third serving cell of a third set of serving cells in the first set of serving cells.

6. The UE of claim 5, wherein determining whether to generate the HARQ-ACK feedback for the DCI format comprises:

determining to generate an acknowledgement (ACK) for the third serving cell;

or

determining not to generate a HARQ-ACK information bit for the third serving cell.

7. The UE of claim 5, wherein the at least one processor is further configured to cause the UE to perform one of the following in response to determining that an active DL BWP on a fourth serving cell of the third set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the fourth serving cell:

generating an acknowledgement (ACK) for the third serving cell and not generating a HARQ-ACK information bit for each of the remaining cell(s) in the third set of serving cells;

generating an ACK for the third serving cell and generating a negative ACK (NACK) for each of the remaining cell(s) in the third set of serving cells; and
not generating a HARQ-ACK information bit for each cell in the third set of serving cells.

8. The UE of claim 1, wherein the at least one processor is further configured to cause the UE to perform one or more of:

generate a first HARQ-ACK sub-codebook comprising HARQ-ACK feedback for a first type of DCI format, and

generate a second HARQ-ACK sub-codebook comprising HARQ-ACK feedback for a second type of DCI format; and

wherein the first type of DCI format corresponds to a single HARQ-ACK information bit and the second type of DCI format corresponds to a predefined number of HARQ-ACK information bits, the predefined number being greater than one.

9. The UE of claim 8, wherein the HARQ-ACK feedback for the DCI format is included in the first HARQ-ACK sub-codebook.

10. The UE of claim 8, wherein the HARQ-ACK feedback for the DCI format is included in the second HARQ-ACK sub-codebook and the at least one processor is further configured to cause the UE to:

order HARQ-ACK information bits generated for the DCI format; and

in response to a number of bits of the generated HARQ-ACK information bits being less than the predefined number, add at least one padding bit to the generated HARQ-ACK information bits to match the predefined number.

11. A base station (BS), comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the BS to:

transmit, to a user equipment (UE), signaling for configuring a first set of serving cells for multi-cell scheduling;

transmit, to the UE in a physical downlink control channel (PDCCH) monitoring occasion, a downlink control information (DCI) format scheduling a second set of serving cells in the first set of serving cells and indicating a physical uplink control channel (PUCCH) transmission occasion for the UE to transmit hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback for the DCI format;

determine whether or not the HARQ-ACK feedback for the DCI format is generated by the UE in the case that an active downlink (DL) bandwidth part (BWP) change happens on a fifth serving cell of the first set of serving cells after the PDCCH monitoring occasion and before the PUCCH transmission occasion; and

in response to determining that the HARQ-ACK feedback for the DCI format is generated by the UE, receive the HARQ-ACK feedback for the DCI format from the UE in the PUCCH transmission occasion.

12. The BS of claim 11, wherein the fifth serving cell is a cell in the second set of serving cells, and determining whether or not the HARQ-ACK feedback for the DCI format is generated comprises:

determining that a HARQ-ACK information bit is not generated for the fifth serving cell; or

determining that a negative acknowledgement (NACK) is generated for the fifth serving cell.

13. The BS of claim 11, wherein the second set of serving cells comprises a second serving cell and an active DL BWP on the second serving cell maintains the same, and wherein determining whether or not the HARQ-ACK feedback for the DCI format is

generated further comprises determining that a HARQ-ACK information bit is generated for the second serving cell.

14. The BS of claim 11, wherein the fifth serving cell is a cell in the second set of serving cells, and determining whether or not the HARQ-ACK feedback for the DCI format is generated comprises:

determining that a HARQ-ACK information bit is not generated for each cell in the second set of serving cells; or

determining that a negative acknowledgement (NACK) is generated for each cell in the second set of serving cells.

15. The BS of claim 11, wherein the DCI format further indicates secondary cell (SCell) dormancy by reinterpreting a set of fields associated with a third serving cell of a third set of serving cells in the first set of serving cells.

16. The BS of claim 15, wherein the fifth serving cell is a cell in the second set of serving cells, and determining whether or not the HARQ-ACK feedback for the DCI format is generated comprises:

determining that a HARQ-ACK information bit is generated for the third serving cell; or

determining that a HARQ-ACK information bit is not generated for the third serving cell.

17. The BS of claim 15, wherein the fifth serving cell is a cell in the third set of serving cells and determining whether or not the HARQ-ACK feedback for the DCI format is generated comprises:

determining that a HARQ-ACK information bit is generated for the third serving cell and a HARQ-ACK information bit is not generated for each of the remaining cell(s) in the third set of serving cells;

determining that a HARQ-ACK information bit is generated for the third serving cell and a negative ACK (NACK) is generated for each of the remaining cell(s) in the third set of serving cells; or

determining that a HARQ-ACK information bit is not generated for each cell in the third set of serving cells.

18. The BS of claim 11, wherein the HARQ-ACK feedback for the DCI format is included in a first HARQ-ACK sub-codebook comprising HARQ-ACK feedback for a first type of DCI format or a second HARQ-ACK sub-codebook comprising HARQ-ACK feedback for a second type of DCI format, and

wherein the first type of DCI format corresponds to a single HARQ-ACK information bit and the second type of DCI format corresponds to a predefined number of HARQ-ACK information bits, the predefined number being greater than one.

19. A processor, comprising:

at least one controller coupled with at least one memory and configured to cause the processor to:

receive signaling for configuring a first set of serving cells for multi-cell scheduling;

receive, from a physical downlink control channel (PDCCH) monitoring occasion, a downlink control information (DCI) format scheduling a second set of serving cells in the first set of serving cells and indicating a physical uplink control channel (PUCCH) transmission occasion for a user equipment (UE) to transmit hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback for the DCI format; and

determine whether to generate the HARQ-ACK feedback for the DCI format in response to determining that an active downlink (DL) bandwidth part (BWP) on a first serving cell of the second set of serving cells is changed after the PDCCH

monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the first serving cell.

20. A method for wireless communication, comprising:

receiving signaling for configuring a first set of serving cells for multi-cell scheduling;

receiving, from a physical downlink control channel (PDCCH) monitoring occasion, a downlink control information (DCI) format scheduling a second set of serving cells in the first set of serving cells and indicating a physical uplink control channel (PUCCH) transmission occasion for a user equipment (UE) to transmit hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback for the DCI format; and

determining whether to generate the HARQ-ACK feedback for the DCI format in response to determining that an active downlink (DL) bandwidth part (BWP) on a first serving cell of the second set of serving cells is changed after the PDCCH monitoring occasion and before the PUCCH transmission occasion and the DCI format does not trigger the active DL BWP change on the first serving cell.