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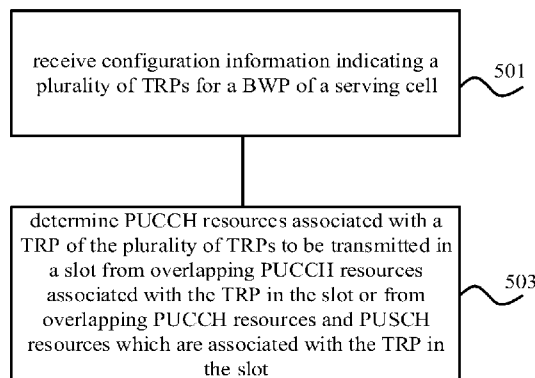


Figure 5

(57) Abstract: Various aspects of the present disclosure relate to a method and apparatus of supporting uplink control information multiplexing. An exemplary method performed by a UE includes: receiving configuration information indicating a plurality of TRPs for a BWP of a serving cell; and determining PUCCH resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and PUSCH resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.



METHOD AND APPARATUS OF SUPPORTING UPLINK CONTROL INFORMATION MULTIPLEXING

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a method and apparatus of supporting uplink control information (UCI) multiplexing.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications 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 communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) 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 implementations of the methods and apparatuses described herein may further include a UE for wireless communication, which includes: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive configuration information indicating a plurality of transmit-receive points (TRPs) for a bandwidth part (BWP) of a serving cell; and determine physical uplink control channel (PUCCH) resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and physical uplink shared channel (PUSCH) resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

[0005] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to not be scheduled to transmit a PUCCH resource or a PUSCH resource associated with the TRP of a smaller priority index that will overlap in time with a PUCCH resource associated with the TRP with a larger priority index with (HARQ)-acknowledge (ACK) information only in response to a physical downlink shared channel (PDSCH) reception without a corresponding physical downlink control channel (PDCCH) unless the UE is provided a parameter as uci-MuxWithDiffPrio.

[0006] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to not be scheduled to transmit a PUCCH resource associated with the TRP of a smaller priority index that will overlap in time with a PUSCH resource associated with the TRP of a larger priority index with semi-persistent (SP)-

channel state information (CSI) reports without a corresponding PDCCH unless the UE is provided a parameter as uci-MuxWithDiffPrio.

[0007] In some implementations of the methods and apparatuses described herein, a parameter as ackNackFeedbackMode configured to be separate is provided for the UE, and the at least one processor is configured to cause the UE to be scheduled to transmit a PUCCH resource or PUSCH resource by the TRP which overlaps with another PUCCH resource or PUSCH resource scheduled by another TRP of the plurality of TRPs.

[0008] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine up to two PUCCH resources associated with the TRP to be transmitted in the slot, wherein, in the case of lacking a parameter as ackNackFeedbackMode configured to be separate and a number of the up to two PUCCH resources is 2, one PUCCH resource of the up to two PUCCH resources is PUCCH format 0 or format 2.

[0009] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to transmit at most two PUCCH resources per TRP per slot depending on capability of the UE.

[0010] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine up to two PUCCH resources associated with the TRP to be transmitted in the slot, wherein, in the case that there are more than two PUCCH resources associated with the plurality of TRPs in the slot after the UCI multiplexing, a first PUCCH resource of up to two determined PUCCH resources associated with the plurality of TRPs to be transmitted in the slot is a PUCCH resource which has a highest priority of the more than two PUCCH resources according to a priority index of the PUCCH resource and priority of UCI in the PUCCH resource.

[0011] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to determine a second PUCCH resource of the two determined PUCCH resources to be: a PUCCH resource which has a highest priority of PUCCH resources with format 0 or format 2 of the more than two PUCCH resources excluding the first PUCCH resource according to a priority index of the PUCCH resource

and priority of UCI in the PUCCH resource, in the case that a parameter as `ackNackFeedbackMode` configured to be separate is not provided for the UE and the first PUCCH resource is format 1, format 3 or format 4; otherwise, a PUCCH resource which has a highest priority of remaining PUCCH resources of the more than two PUCCH resources according to a priority index of the PUCCH resource and priority of UCI in the PUCCH resource.

[0012] In some implementations of the methods and apparatuses described herein, in the case that a determined PUCCH resource associated with the TRP carries scheduling request (SR) and is overlapped with a PUSCH associated with another TRP of the plurality of TRPs in the slot, the at least one processor is configured to cause the UE to transmit the determined PUCCH resource with the SR and the PUSCH.

[0013] In some implementations of the methods and apparatuses described herein, in the case that a determined PUCCH resource associated with the TRP carries SR and is overlapped with a PUSCH associated with another TRP of the plurality of TRPs, the at least one processor is configured to cause the UE to: in the case that the SR is a positive SR with a priority higher than that of the PUSCH or the PUSCH is without uplink (UL)-shared channel (SCH), transmit the determined PUCCH resource with the SR and drop the PUSCH; otherwise transmit the PUSCH and drop the determined PUCCH resource in the case that there is only SR in the PDCCH resource, otherwise, transmit the PUSCH and the determined PUCCH resource without the SR.

[0014] In some implementations of the methods and apparatuses described herein, in the case that a determined PUCCH resource associated with the TRP carries SR and is overlapped with a PUSCH associated with another TRP of the plurality of TRPs, the at least one processor is configured to cause the UE to: in the case that the SR is a positive SR with a priority higher than that of the PUSCH or the PUSCH is without UL-SCH, transmit the determined PUCCH resource with the SR and the PUSCH; otherwise, transmit the PUSCH and drop the determined PUCCH resource in the case that there is only SR in the PDCCH resource, otherwise, transmit the PUSCH and the determined PUCCH resource without the SR.

[0015] In some implementations of the methods and apparatuses described herein, the predefined timing condition is identical with a timing condition specified in TS38.213 for UCI multiplexing of overlapping PUCCHs and/or PUSCHs.

[0016] In some implementations of the methods and apparatuses described herein, a mechanism of UCI multiplexing based on each TRP in the UE is configured by radio resource control (RRC) signaling or in accordance with a predefined rule.

[0017] In some implementations of the methods and apparatuses described herein, the configuration information indicates the plurality of TRPs by indicating a plurality of control resource set (CORESET) pool index values, wherein, each CORESET pool index value represents a TRP.

[0018] Some implementations of the methods and apparatuses described herein may further include a processor for wireless communication, which includes: at least one controller coupled with at least one memory and configured to cause the processor to: receive configuration information indicating a plurality of TRPs for a BWP of a serving cell; and determine PUCCH resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and PUSCH resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

[0019] Some implementations of the methods and apparatuses described herein may further include a network equipment (NE) for wireless communication, which includes: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the NE to: transmit configuration information indicating a plurality of TRPs for a BWP of a serving cell; and receive PUCCH resources associated with a TRP of the plurality of TRPs in a slot from a UE, wherein, the received PUCCH resource associated with the TRP is determined by the UE from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and PUSCH resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the

overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

[0020] Some implementations of the methods and apparatuses described herein may further include a method performed by a UE, which include: receiving configuration information indicating a plurality of TRPs for a BWP of a serving cell; and determining PUCCH resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and PUSCH resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0022] Figure 2 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0023] Figure 3 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0024] Figure 4 illustrates an example of a NE in accordance with aspects of the present disclosure.

[0025] Figure 5 illustrates a flowchart of method performed by a UE in accordance with aspects of the present disclosure.

[0026] Figure 6 illustrates a flowchart of method performed by a NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0027] Although simultaneous uplink (UL) transmission with multiple panels (or associated with multiple TRPs) is studied in 3rd generation partnership project (3GPP) release (R)18, only PUSCH (also referred to as a PUSCH resource) per panel (e.g., simultaneous transmission of PUSCH with a panel and PUSCH with another panel) is supported. Regarding a TRP or panel, it can be represented by various manners. For example, in multi-downlink control information (M-DCI) based M-TRP operations etc., there are multiple CORESET pool index values, e.g., two different CORESETPoolIndex values configured by RRC in an activated BWP of the serving cell, and each CORESET pool index value represents a TRP.

[0028] In accordance with some aspects of the present disclosure, in order to further enhance uplink transmission, simultaneous PUCCH plus PUCCH/PUSCH transmission (also referred to as simultaneous transmission of PUCCH plus PUCCH/PUSCH or the like) associated with multiple TRPs (or with multiple panels) is proposed, which may be supported in 3GPP R19. Taking two TRPs (or two panels) as an example of multi-TRP (M-TRP) scenarios (or operations or the like), simultaneous PUCCH plus PUCCH/PUSCH transmission means PUCCH(s) associated with a TRP (or a panel) and PUCCH(s) or PUSCH(s) associated with the other TRP (or the other panel) can be simultaneously transmitted in the UE. That is, in the case of simultaneous PUCCH plus PUCCH/PUSCH transmission associated with two or more TRPs (part or all of configured TRPs in the M-TRP scenarios), uplink transmission(s) associated with at least one TRP of the two or more TRPs is PUCCH.

[0029] In the case of supporting simultaneous PUCCH plus PUCCH/PUSCH transmission, some aspects associated with uplink transmission may be further enhanced. For example, UCI (e.g., CSI or HARK information or SR etc.) multiplexing on overlapping PUCCH(s) and/or PUSCH(s) is considered, and aspects of the present disclosure propose UCI multiplexing per TRP. Then, issues, e.g., whether the timing condition for UCI multiplexing should be enhanced accordingly, and whether SR in a PUCCH resource towards a TRP and a PUSCH towards another TRP can be transmitted simultaneously etc., should be discussed and determined. Besides, whether the maximum number of PUCCH resources per slot is maintained or changed should also be studied accordingly.

[0030] At least considering the above technical problems, aspects of the present disclosure disclose a technical solution of supporting UCI multiplexing, e.g., a method and apparatus of supporting UCI multiplexing, which involves enhancements on uplink transmission where a mechanism (or scheme or the like) of UCI multiplexing per TRP (or panel) is supported in scenarios of multi-TRP in the case of simultaneous transmission of PUCCH plus PUCCH/PUSCH.

[0031] For example, in some implementations of the present disclosure, in the case that UCI multiplexing per TRP (or a mechanism of UCI multiplexing per TRP or the like) is supported, the timing condition specified in TS38.213 for UCI multiplexing of overlapping PUCCHs and/or PUSCHs is applied for overlapping PUCCH(s) and/or PUSCH(s) associated with the same TRP.

[0032] In some implementations of the present disclosure, in the case that UCI multiplexing per TRP is supported, restrictions for a PUCCH with HARQ-ACK information only in response to a PDSCH reception without a corresponding PDCCH or a PUSCH with SP-CSI report(s) without a corresponding PDCCH is applied per TRP.

[0033] In some implementations of the present disclosure, in the case that UCI multiplexing per TRP is supported, restrictions for PUCCH and PUSCH if UE is provided `ackNackFeedbackMode` being separate in M-DCI based M-TRP operations that a PUCCH or PUSCH scheduled by a TRP cannot overlap with another PUCCH or PUSCH scheduled by another TRP, is only applied in the case that UCI multiplexing (or a procedure of UCI multiplexing) is not performed per TRP.

[0034] In some implementations of the present disclosure, in the case that UCI multiplexing per TRP is supported, technical solutions are proposed to determine the PUCCH(s) to be transmitted after UCI multiplexing per TRP is performed. In addition, technical solutions related to how to transmit SR is proposed, which is applied in the case that a PUCCH resource with SR associated with a TRP determined to be transmitted is overlapped with a PUSCH associated with another TRP.

[0035] In short, aspects of the present disclosure propose simultaneous PUCCH plus PUCCH/PUSCH transmission and UCI multiplexing per TRP, which will enhance uplink transmission and UCI multiplexing.

[0036] Aspects of the present disclosure are described in the context of a wireless communications system.

[0037] Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications 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 communications system 100 may be a NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other implementations, the wireless communications 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), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0038] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 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.

[0039] 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 different NE 102.

[0040] The one or more UE 104 may be dispersed throughout a geographic region of the wireless communications 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.

[0041] 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.

[0042] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N2, or 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 NE 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 a radio heads, smart radio heads, or TRPs.

[0043] 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 functions (AMF)) 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 NE 102 associated with the CN 106.

[0044] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N2, 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).

[0045] In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications 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 communications). 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.

[0046] One or more numerologies may be supported in the wireless communications 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.

[0047] 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.

[0048] 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 communications 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., 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.

[0049] In the wireless communications 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 communications 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 communications 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 communications 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.

[0050] 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.

[0051] In order to further enhance uplink transmission, simultaneous transmission of PUCCH plus PUCCH/PUSCH is supported in M-TRP operations, and UCI multiplexing on overlapping PUCCH(s) and/or PUSCH(s) can be performed per TRP (or per panel) to at least

simplify the enhancements on uplink transmission. Whether a mechanism or scheme of simultaneous transmission of PUCCH plus PUSCH/PUCCH is supported (or implemented or applied etc.) is configured by RRC or according to predefined rule(s) in specification, which is also dependent on the capability of a specific UE. Similarly, whether UCI multiplexing per TRP is supported is also configured by RRC or according to predefined rule(s), which is also dependent on the capability of a specific UE. For simplification and clearness, herein, it is always assumed that simultaneous transmission of PUCCH plus PUSCH and UCI multiplexing per TRP is supported unless otherwise specified.

[0052] In M-TRP scenarios, based on each configured TRP TRPs (e.g., per TRP), when there are overlapping PUCCH resources associated with the TRP in a slot and overlapping PUSCH resources satisfy a predefined timing condition, UCI multiplexing per TRP can be performed on the overlapping PUCCH resources. Then, UE will determine PUCCH resource(s) associated with the TRP to be transmitted in the slot. Similarly, when there are overlapping PUCCH resource(s) and PUSCH resource(s) associated with a TRP in a slot in M-TRP scenarios, which satisfy a predefined timing condition, UCI multiplexing per TRP can be performed on the overlapping PUCCH resource(s) and PUSCH resource(s). UE will determine PUCCH resources associated with the TRP to be transmitted in the slot from the overlapping PUCCH resource(s) and PUSCH resource(s) after the UCI multiplexing per TRP is performed.

[0053] In some implementations of the present disclosure, the predefined timing condition is identical with the timing condition specified in 3GPP TS38.213 for UCI multiplexing on overlapping PUCCHs and/or PUSCHs, e.g., as described in clauses 9.2.5.1, 9.2.5.2 and 9.2.5.3 in TS38.213.

[0054] Taking M-DCI based M-TRP operations as an example, where a TRP is represented by a CORESETPoolIndex value, according to R18, a PUCCH resource or a configured grant (CG) Type 1 PUSCH is associated with a CORESETPoolIndex value by RRC configuration, and a dynamic grant (DG) PUSCH or a CG Type 2 PUSCH is associated with a CORESETPoolIndex value by its corresponding DCI. Accordingly, the recitation related to timing condition specified in 3GPP TS38.213 for UCI multiplexing on overlapping

PUCCHs and/or PUSCHs may be updated as follows in view of UCI multiplexing per CORESETPoolIndex value.

"If a UE would transmit multiple overlapping PUCCHs associated with a same CORESETPoolIndex value in a slot or overlapping PUCCH(s) and PUSCH(s) which are associated with a same CORESETPoolIndex value in a slot and, when applicable as described in clauses 9.2.5.1, 9.2.5.2 and 9.2.5.3, the UE is configured to multiplex different UCI types or UCI of different priority indexes in one PUCCH, and at least one of the multiple overlapping PUCCHs or PUSCHs is in response to a DCI format detection by the UE, the UE multiplexes all corresponding UCI types or UCI of different priority indexes if the following conditions are met. If one of the PUCCH transmissions or PUSCH transmissions is in response to a DCI format detection by the UE, the UE expects that the first symbol S_0 of the earliest PUCCH or PUSCH, among a group overlapping PUCCHs and PUSCHs in the slot, satisfies the following timeline conditions

- S_0 is not before a symbol with CP starting after $T_{proc,1}^{mux}$ after a last symbol of any corresponding PDSCH, $T_{proc,1}^{mux}$ is given by maximum of $\{T_{proc,1}^{mux,1}, \dots, T_{proc,1}^{mux,i}, \dots\}$ where for the i -th PDSCH with corresponding HARQ-ACK transmission on a PUCCH which is in the group of overlapping PUCCHs and PUSCHs, $T_{proc,1}^{mux,i} = (N_1 + d_{1,1} + 1) \cdot (2048 + 144) \cdot \kappa \cdot 2^{-\mu} \cdot T_C$, $d_{1,1}$ is selected for the i -th PDSCH following [6, TS 38.214], N_1 is selected based on the UE PDSCH processing capability of the i -th PDSCH and SCS configuration μ , where μ corresponds to the smallest SCS configuration among the SCS configurations used for the PDCCH scheduling the i -th PDSCH, the i -th PDSCH, the PUCCH with corresponding HARQ-ACK transmission for the i -th PDSCH, and all PUSCHs in the group of overlapping PUCCHs and PUSCHs.
- S_0 is not before a symbol with CP starting after $T_{proc,release}^{mux}$ after a last symbol of a PDCCH reception providing a DCI format having associated HARQ-ACK information without scheduling a PDSCH reception. $T_{proc,release}^{mux}$ is given by maximum of $\{T_{proc,release}^{mux,1}, \dots, T_{proc,release}^{mux,i}, \dots\}$ where for the i -th PDCCH providing the DCI format with corresponding HARQ-ACK transmission on a PUCCH which is in the group of overlapping PUCCHs and PUSCHs, $T_{proc,release}^{mux,i} = (N + 1) \cdot (2048 + 144) \cdot \kappa \cdot 2^{-\mu} \cdot T_C$, N as described in clause 10.2, where μ corresponds to the smallest SCS configuration among the SCS configurations used for the PDCCH, the PUCCH with corresponding HARQ-ACK information, and all PUSCHs in the group of overlapping PUCCHs and PUSCHs.
- if there is no aperiodic CSI report multiplexed in a PUSCH in the group of overlapping PUCCHs and PUSCHs, S_0 is not before a symbol with CP starting after $T_{proc,2}^{mux}$ after a last symbol of
 - any PDCCH with the DCI format scheduling an overlapping PUSCH, and

- any PDCCH providing a DCI format with corresponding HARQ-ACK information in an overlapping PUCCH in the slot

If there is at least one PUSCH in the group of overlapping PUCCHs and PUSCHs, $T_{proc,2}^{mux}$ is given by maximum of $\{T_{proc,2}^{mux,1}, \dots, T_{proc,2}^{mux,i}, \dots\}$ where for the i -th PUSCH which is in the group of overlapping PUCCHs and PUSCHs, $T_{proc,2}^{mux,i} = \max\left((N_2 + d_{2,1} + 1) \cdot (2048 + 144) \cdot \kappa \cdot 2^{-\mu} \cdot T_C + T_{switch}, d_{2,2}\right)$, $d_{2,1}$, $d_{2,2}$ and T_{switch} are selected for the i -th PUSCH following [6, TS 38.214], N_2 is selected based on the UE PUSCH processing capability of the i -th PUSCH and SCS configuration μ , where μ corresponds to the smallest SCS configuration among the SCS configurations used for the PDCCH scheduling the i -th PUSCH, the PDCCHs scheduling the PDSCHs, or providing the DCI formats without scheduling PDSCHs, with corresponding HARQ-ACK information on a PUCCH which is in the group of overlapping PUCCHs/PUSCHs, and all PUSCHs in the group of overlapping PUCCHs and PUSCHs.

If there is no PUSCH in the group of overlapping PUCCHs and PUSCHs, $T_{proc,2}^{mux}$ is given by maximum of $\{T_{proc,2}^{mux,1}, \dots, T_{proc,2}^{mux,i}, \dots\}$ where for the i -th PDSCH, or the i -th PDCCH providing a DCI format without scheduling PDSCH, with corresponding HARQ-ACK information on a PUCCH which is in the group of overlapping PUCCHs, $T_{proc,2}^{mux,i} = (N_2 + 1) \cdot (2048 + 144) \cdot \kappa \cdot 2^{-\mu} \cdot T_C$, N_2 is selected based on the UE PUSCH processing capability of the PUCCH serving cell if configured. N_2 is selected based on the UE PUSCH processing capability 1, if PUSCH processing capability is not configured for the PUCCH serving cell. μ is selected based on the smallest SCS configuration between the SCS configuration used for the PDCCH scheduling the i -th PDSCH, or providing the i -th DCI format without scheduling PDSCH, with corresponding HARQ-ACK information on a PUCCH which is in the group of overlapping PUCCHs, and the SCS configuration for the PUCCH serving cell.

- if there is an aperiodic CSI report multiplexed in a PUSCH in the group of overlapping PUCCHs and PUSCHs, S_0 is not before a symbol with CP starting after $T_{proc,CSI}^{mux} = \max\left((Z + d) \cdot (2048 + 144) \cdot \kappa \cdot 2^{-\mu} \cdot T_C + T_{switch}, d_{2,2}\right)$ after a last symbol of
- any PDCCH with the DCI format scheduling an overlapping PUSCH, and
- any PDCCH scheduling a PDSCH, or providing a DCI format, with corresponding HARQ-ACK information in an overlapping PUCCH in the slot

where μ corresponds to the smallest SCS configuration among the SCS configuration of the PDCCHs, the smallest SCS configuration for the group of the overlapping PUSCHs, and the smallest SCS configuration of CSI-RS associated with the DCI format scheduling the PUSCH with the multiplexed aperiodic CSI report, and $d = 2$ for $\mu = 0, 1$, $d = 3$ for $\mu = 2$, and $d = 4$ for $\mu = 3$. T_{switch} is

defined in [6, TS 38.214] and it is applied only if Z_1 of Table 5.4-1 in [6, TS 38.214] is applied to the determination of Z .

- N_1 , N_2 , $d_{1,1}$, $d_{2,1}$, $d_{2,2}$, and Z are defined in [6, TS 38.214] and κ and T_C are defined in [4, TS 38.211].

If a UE would transmit multiple overlapping PUCCHs associated with a same CORESETPoolIndex value in a slot or overlapping PUCCH(s) and PUSCH(s) which are associated with a same CORESETPoolIndex value in a slot, one of the PUCCHs includes HARQ-ACK information in response to an SPS PDSCH reception, and any PUSCH is not in response to a DCI format detection, the UE expects that the first symbol S_0 of the earliest PUCCH or PUSCH satisfies the first of the previous timeline conditions with the exception that components associated to a SCS configuration for a PDCCH scheduling a PDSCH or a PUSCH are absent from the timeline conditions.

A UE does not expect a PUCCH or a PUSCH which is associated with a CORESETPoolIndex value that is in response to a DCI format detection to overlap with any other PUCCH or PUSCH which is associated with the same CORESETPoolIndex value that does not satisfy the above timing conditions."

[0055] Besides the timing condition, there are some further restrictions on the overlapping PUCCH resource or overlapping PUCCH resource(s) and PUSCH resource(s) associated with the same TRP in the case of supporting UCI multiplexing per TRP.

[0056] For example, in some implementations of the present disclosure, the TRP will not schedule the UE to transmit a PUCCH resource or a PUSCH resource associated with a TRP of a smaller priority index that will overlap in time with a PUCCH resource associated with the same TRP with a larger priority index with HARQ-ACK information only in response to a PDSCH reception without a corresponding PDCCH unless the UE is provided a parameter as uci-MuxWithDiffPrio. In some other implementations of the present disclosure, the TRP will not schedule the UE to transmit a PUCCH resource associated with the TRP of a smaller priority index that will overlap in time with a PUSCH resource associated with the TRP of a larger priority index with SP-CSI reports without a corresponding PDCCH unless the UE is provided a parameter as uci-MuxWithDiffPrio.

[0057] Still taking M-DCI based M-TRP operations as an example, where a TRP is represented by a CORESETPoolIndex value, the corresponding restrictions on overlapping PUCCH resources and/or PUSCH resources in TS38.213 will be updated as follows in view of UCI multiplexing per CORESETPoolIndex value.

"A UE does not expect to be scheduled to transmit a PUCCH or a PUSCH associated with a CORESETPoolIndex value with smaller priority index that would overlap in time with a PUCCH associated with the same CORESETPoolIndex value of larger priority index with HARQ-ACK information only in response to a PDSCH reception without a corresponding PDCCH unless the UE is provided uci-MuxWithDiffPrio. A UE does not expect to be scheduled to transmit a PUCCH associated with a CORESETPoolIndex value of smaller priority index that would overlap in time with a PUSCH associated with the same CORESETPoolIndex value of larger priority index with SP-CSF report(s) without a corresponding PDCCH unless the UE is provided uci-MuxWithDiffPrio."

[0058] In accordance with legacy specification, if UE is provided `ackNackFeedbackMode` being separate in M-DCI based M-TRP scenarios, there is a restriction for PUCCH and PUSCH that a PUCCH or PUSCH scheduled by a CORESETPoolIndex value cannot overlap with another PUCCH or PUSCH scheduled by another CORESETPoolIndex value. However, this restriction is not needed if UCI multiplexing per TRP is applied because simultaneous transmission of PUCCH plus PUSCH is supported, that is, a PUCCH associated with a TRP can be transmitted with another PUSCH or PUCCH associated with another TRP. Thus, even in the case that a parameter as `ackNackFeedbackMode` configured to be separate is provided for the UE, the TRP may schedule the UE to transmit a PUCCH resource or PUSCH resource by a TRP which overlaps with another PUCCH resource or PUSCH resource scheduled by another TRP.

[0059] Taking M-DCI based M-TRP operations as an example, where a TRP is represented by a CORESETPoolIndex value, the corresponding restrictions on overlapping PUCCH resources and/or PUSCH resources in TS38.213 will be updated as follows in view of UCI multiplexing per CORESETPoolIndex value. The parameter "*UCI multiplexing per CORESETPoolIndex value*" may also be replaced with "*enableSTx2PofmDCIForPUCCHandPUSCHPUCCH*" or the like.

"A UE that

- is not provided `coresetPoolIndex` or is provided `coresetPoolIndex` with a value of 0 for first CORESETs on active DL BWPs of serving cells, and*
- is provided `coresetPoolIndex` with a value of 1 for second CORESETs on active DL BWPs of the serving cells, and*
- is provided `ackNackFeedbackMode` = separate*
- is not provided UCI multiplexing per CORESETPoolIndex value*

does not expect a PUCCH or a PUSCH transmission triggered by a detection of a DCI format in a PDCCH received in a CORESET from the first CORESETs to overlap in time with a PUCCH or a PUSCH transmission triggered by a detection of a DCI format in a PDCCH received in a CORESET from the second CORESETs."

[0060] Aspects of the present disclosure also propose enhancements on the maximum number of PUCCH resources per slot and the determination of the PUCCH resources per slot.

[0061] According to legacy specification, UE can transmit up to 2 PUCCH resources per slot which is shown in the following.

"A UE may transmit one or two PUCCHs on a serving cell in different symbols within a slot. When the UE transmits two PUCCHs in a slot and the UE is not provided `ackNackFeedbackMode = separate`, at least one of the two PUCCHs uses PUCCH format 0 or PUCCH format 2.

If a UE is provided `ackNackFeedbackMode = separate`, the UE may transmit up to two PUCCHs with HARQ-ACK information in different symbols within a slot."

[0062] In some implementations of the present disclosure (scheme 1), UE will determine up to two PUCCH resources per TRP to be transmitted in a slot. That is, after UCI multiplexing (including PUCCH and/or PUSCH multiplexing) per TRP, at most two PUCCH resources are determined per TRP. In the case that a parameter as `ackNackFeedbackMode` configured to be `separate` is not provided for UE and up to two PUCCH resources are determined per TRP, at least one PUCCH resource of two PUCCH resources is PUCCH format 0 or format 2 if two PUCCH resources are determined. Taking two configured TRPs as an example of M-DCI M-TRP scenarios, all the PUCCH resources determined to be transmitted in a slot are up to four after UCI multiplexing per TRP is performed.

[0063] Accordingly, the aforementioned restriction on the maximum number of PUCCH resources per slot in TS38.213 can be updated as follows to be used as the restriction on the maximum number of PUCCH resources per `CORESETPoolIndex` value per slot in view of UCI multiplexing per `CORESETPoolIndex` value. The parameter "`enableSTx2PofmDCIForPUCCHandPUSCHPUCCH`" may also be replaced with "UCI multiplexing per `CORESETPoolIndex`" or the like.

"A UE may transmit one or two PUCCHs associated with a same `CORESETPoolIndex` value on a serving cell in different symbols within a slot. When the UE transmits two

PUCCHs associated with a same CORESETPoolIndex value in a slot and the UE is not provided ackNackFeedbackMode = separate, at least one of the two PUCCHs uses PUCCH format 0 or PUCCH format 2.

If a UE is provided ackNackFeedbackMode = separate, the UE may transmit up to two PUCCHs with HARQ-ACK information within a slot if enableSTx2PofinDCIForPUCCHandPUSCHPUCCH is configured."

[0064] In some other implementations of the present disclosure (scheme 2), the aforementioned legacy restriction is maintained in the case of supporting simultaneous transmission of PUCCH plus PUSCH/PUCCH. After UCI multiplexing (including PUCCH and PUSCH multiplexing) per TRP is performed, at most two PUCCH resources in a slot will be determined per TRP, and then at most two PUCCH resources considering all the configured TRPs are determined finally to be transmitted in a slot. In the case that there are more than two PUCCH resources in a slot considering all the configured TRPs after the UCI multiplexing is performed per TRP per slot, at most two PUCCH resources will be determined or selected from the more than two PUCCH resources.

[0065] For example, the first PUCCH resource of at most two determined PUCCH resources considering all the configured TRPs to be transmitted in a slot is a PUCCH resource which has a highest priority of the more than two PUCCH resources according to a priority index of the PUCCH resource and priority of UCI in the PUCCH resource.

[0066] When determining the second PUCCH resource of two determined PUCCH resources, whether a parameter as ackNackFeedbackMode = separate is provided for UE is considered. In the case that the parameter as ackNackFeedbackMode = separate is provided for UE, the second PUCCH resource is a PUCCH resource which has the highest priority of remaining PUCCH resources of the more than two PUCCH resources in addition to the first PUCCH resource according to a priority index of the PUCCH resource and priority of UCI in the PUCCH resource. In the case that the parameter as ackNackFeedbackMode = separate is not provided for UE, the format of the first PUCCH resource is considered. In the case that the first PUCCH resource is not a short PUCCH, e.g., being format 1, format 3 or format 4 (not format 0 or format 2), the second PUCCH resource is a PUCCH resource which has the highest priority of PUCCH resources with format 0 or format 2 of the more than two PUCCH

resources according to a priority index of the PUCCH resource and priority of UCI in the PUCCH resource, if any. In the case that the first PUCCH resource is a short PUCCH, e.g., not being format 1, format 3 or format 4 (is format 0 or format 2), the second PUCCH resource is a PUCCH resource which has the highest priority of the remaining PUCCH resources of the more than two PUCCH resources in addition to the first PUCCH resource according to a priority index of the PUCCH resource and priority of UCI of the PUCCH resource.

[0067] Taking M-DCI based M-TRP operations as an example, where a TRP is represented by a CORESETPoolIndex value, an exemplary PUCCH resource determination procedure is illustrated as follows in the case that the number of the whole determined PUCCH resources exceeds 2 after UCI multiplexing per slot per CORESETPoolIndex value:

- the first PUCCH resource of the whole determined PUCCH resources is determined as a PUCCH resource which has the highest priority index of the whole determined PUCCH resources and has the highest UCI priority if more than one PUCCH resource of the whole determined PUCCH resources has the same highest priority
 - if the UE is not provided *ackNackFeedbackMode = separate*,
 - ◆ if the first PUCCH is a short PUCCH resource which is PUCCH format 0 or format 2, then the second PUCCH resource is determined as a PUCCH resource with the highest priority of the remaining PUCCH resources according to the priority index of the PUCCH resource and the priority of CSI in the PUCCH resource
 - ◆ if the first PUCCH is not a short PUCCH resource with PUCCH format 0 or PUCCH format 2, then the second PUCCH resource is determined as a PUCCH resource with the highest priority of the remaining PUCCH resources with format 0 or format 2 according to the priority index of the PUCCH resource and the priority of CSI in the PUCCH resource, if any.
 - otherwise,
 - ◆ the second PUCCH resource is determined as a PUCCH resource with the highest priority of the remaining PUCCH resources according to the priority index of a PUCCH resource and the priority of CSI in the PUCCH resource.

[0068] Scheme 1 and scheme 2 can be configured or predefined. For a specific UE supporting UCI multiplexing per TRP, whether to apply scheme 1 or scheme 2 can also be dependent on the capability of the UE.

[0069] For PUCCH resources determination after UCI multiplexing per TRP, a determined PUCCH resource associated with a TRP may carry SR and is overlapped with a PUSCH associated with another TRP. Then, how to transmit the PUCCH, SR and/or PUSCH should be settled.

[0070] In some implementations of the present disclosure, the legacy rule of SR multiplexing PUSCH is not maintained any more, and UE will transmit the determined PUCCH resource with the SR and the PUSCH simultaneously.

[0071] In some other implementations of the present disclosure, SR cannot be transmitted with a PUSCH simultaneously where the legacy principle is maintained. In the case that the overlapped PUSCH is a PUSCH without UL-SCH or the SR is a positive state with a priority higher than the overlapped PUSCH is lower priority, then UE will transmit the PUCCH resource with the SR and drop the overlapped PUSCH. Otherwise, UE will transmit the overlapped PUSCH; and, regarding the PUCCH resource, UE will transmit the PUCCH resource without the SR, or drop the PUCCH resource if only SR is carried in the PUCCH resource.

[0072] In some yet implementations of the present disclosure, SR cannot be transmitted with a PUSCH simultaneously where the legacy principle is maintained. In the case that the SR is a positive SR with a priority higher than that of the overlapped PUSCH or the overlapped PUSCH is without UL-SCH, UE will transmit the determined PUCCH resource with the SR and the overlapped PUSCH. Otherwise, UE will transmit the overlapped PUSCH; and, regarding the PUCCH resource, UE will transmit the PUCCH resource without the SR, or drop the PUCCH resource if only SR is carried in the PUCCH resource.

[0073] For persons skilled in the art, although the technical solutions are illustrated mainly considering the UE side, the operations in the network side can be consistently determined and thus will not repeat.

[0074] Figure 2 illustrates an example of a UE 200 in accordance with aspects of the present disclosure. The UE 200 may include a processor 202, a memory 204, a controller 206, and a transceiver 208. The processor 202, the memory 204, the controller 206, or the transceiver 208, 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.

[0075] The processor 202, the memory 204, the controller 206, or the transceiver 208, 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.

[0076] The processor 202 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 202 may be configured to operate the memory 204. In some other implementations, the memory 204 may be integrated into the processor 202. The processor 202 may be configured to execute computer-readable instructions stored in the memory 204 to cause the UE 200 to perform various functions of the present disclosure.

[0077] The memory 204 may include volatile or non-volatile memory. The memory 204 may store computer-readable, computer-executable code including instructions when executed by the processor 202 cause the UE 200 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 204 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.

[0078] In some implementations, the processor 202 and the memory 204 coupled with the processor 202 may be configured to cause the UE 200 to perform one or more of the

functions described herein (e.g., executing, by the processor 202, instructions stored in the memory 204). For example, the processor 202 may support wireless communication at the UE 200 in accordance with examples as disclosed herein. The UE 200 may be configured to support a means for receiving configuration information indicating a plurality of TRPs for a BWP of a serving cell, and a means for determining PUCCH resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and PUSCH resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

[0079] The controller 206 may manage input and output signals for the UE 200. The controller 206 may also manage peripherals not integrated into the UE 200. In some implementations, the controller 206 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 206 may be implemented as part of the processor 202.

[0080] In some implementations, the UE 200 may include at least one transceiver 208. In some other implementations, the UE 200 may have more than one transceiver 208. The transceiver 208 may represent a wireless transceiver. The transceiver 208 may include one or more receiver chains 210, one or more transmitter chains 212, or a combination thereof.

[0081] A receiver chain 210 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 210 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 210 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 210 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 210 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0082] A transmitter chain 212 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 212 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 212 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 212 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0083] Figure 3 illustrates an example of a processor 300 in accordance with aspects of the present disclosure. The processor 300 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 300 may include a controller 302 configured to perform various operations in accordance with examples as described herein. The processor 300 may optionally include at least one memory 304, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 300 may optionally include one or more arithmetic-logic units (ALUs) 306. 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).

[0084] The processor 300 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 300) 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).

[0085] The controller 302 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 300 to cause the processor 300 to support various operations in accordance with examples as described herein. For example, the controller 302 may operate as a control unit of the processor 300, generating control signals that manage the operation of various components of the processor 300. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0086] The controller 302 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 304 and determine subsequent instruction(s) to be executed to cause the processor 300 to support various operations in accordance with examples as described herein. The controller 302 may be configured to track memory address of instructions associated with the memory 304. The controller 302 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 302 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 300 to cause the processor 300 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 302 may be configured to manage flow of data within the processor 300. The controller 302 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 300.

[0087] The memory 304 may include one or more caches (e.g., memory local to or included in the processor 300 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 304 may reside within or on a processor chipset (e.g., local to the processor 300). In some other implementations, the memory 304 may reside external to the processor chipset (e.g., remote to the processor 300).

[0088] The memory 304 may store computer-readable, computer-executable code including instructions that, when executed by the processor 300, cause the processor 300 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 302 and/or the processor 300 may be configured to execute computer-readable instructions stored in the memory 304 to cause the processor 300 to perform various functions. For example, the processor 300 and/or the controller 302 may be coupled with or to the memory 304, the processor 300, the controller 302, and the memory 304 may be configured to perform various functions described herein. In some examples, the processor 300 may include multiple processors and the memory 304 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.

[0089] The one or more ALUs 306 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 306 may reside within or on a processor chipset (e.g., the processor 300). In some other implementations, the one or more ALUs 306 may reside external to the processor chipset (e.g., the processor 300). One or more ALUs 306 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 306 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 306 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 306 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 306 to handle conditional operations, comparisons, and bitwise operations.

[0090] The processor 300 may support wireless communication in accordance with examples as disclosed herein. The processor 300 may be configured to or operable to support a means for receiving configuration information indicating a plurality of TRPs for a BWP of a serving cell, and a means for determining PUCCH resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and PUSCH resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition

and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

[0091] Figure 4 illustrates an example of a NE 400 in accordance with aspects of the present disclosure. The NE 400 may include a processor 402, a memory 404, a controller 406, and a transceiver 408. The processor 402, the memory 404, the controller 406, or the transceiver 408, 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.

[0092] The processor 402, the memory 404, the controller 406, or the transceiver 408, 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.

[0093] The processor 402 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 402 may be configured to operate the memory 404. In some other implementations, the memory 404 may be integrated into the processor 402. The processor 402 may be configured to execute computer-readable instructions stored in the memory 404 to cause the NE 400 to perform various functions of the present disclosure.

[0094] The memory 404 may include volatile or non-volatile memory. The memory 404 may store computer-readable, computer-executable code including instructions when executed by the processor 402 cause the NE 400 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 404 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.

[0095] In some implementations, the processor 402 and the memory 404 coupled with the processor 402 may be configured to cause the NE 400 to perform one or more of the functions described herein (e.g., executing, by the processor 402, instructions stored in the memory 404). For example, the processor 402 may support wireless communication at the NE 400 in accordance with examples as disclosed herein. The NE 400 may be configured to support a means for transmitting configuration information indicating a plurality of TRPs for a BWP of a serving cell; and a means for receiving PUCCH resources associated with a TRP of the plurality of TRPs in a slot from a UE, wherein, the received PUCCH resource associated with the TRP is determined by the UE from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and PUSCH resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

[0096] The controller 406 may manage input and output signals for the NE 400. The controller 406 may also manage peripherals not integrated into the NE 400. In some implementations, the controller 406 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 406 may be implemented as part of the processor 402.

[0097] In some implementations, the NE 400 may include at least one transceiver 408. In some other implementations, the NE 400 may have more than one transceiver 408. The transceiver 408 may represent a wireless transceiver. The transceiver 408 may include one or more receiver chains 410, one or more transmitter chains 412, or a combination thereof.

[0098] A receiver chain 410 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 410 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 410 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 410 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 410 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0099] A transmitter chain 412 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 412 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 412 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 412 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0100] Figure 5 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein. In some implementations, the UE may execute a set of instructions to control the function elements of the UE to perform the described functions.

[0101] At 501, the method may include receiving configuration information indicating a plurality of TRPs for a BWP of a serving cell. The operations of 501 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 501 may be performed by a UE as described with reference to Figure 2.

[0102] At 503, the method may include determining PUCCH resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and PUSCH resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources. The operations of 503 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 503 may be performed by a UE as described with reference to Figure 2.

[0103] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0104] Figure 6 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a NE as described herein. In some implementations, the NE may execute a set of instructions to control the function elements of the NE to perform the described functions.

[0105] At 601, the method may include transmitting configuration information indicating a plurality of TRPs for a BWP of a serving cell. The operations of 601 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 601 may be performed by a NE as described with reference to Figure 4.

[0106] At 603, the method may include receiving PUCCH resources associated with a TRP of the plurality of TRPs in a slot from a UE, wherein, the received PUCCH resource associated with the TRP is determined by the UE from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and PUSCH resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and UCI multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources. The operations of 603 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 603 may be performed by a NE as described with reference to Figure 4.

[0107] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0108] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the

disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment (UE) for wireless communication, 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 configuration information indicating a plurality of transmit-receive points (TRPs) for a bandwidth part (BWP) of a serving cell; and
 - determine physical uplink control channel (PUCCH) resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and physical uplink shared channel (PUSCH) resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and uplink control information (UCI) multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.
2. The UE of claim 1, wherein, the at least one processor is configured to cause the UE to not be scheduled to transmit a PUCCH resource or a PUSCH resource associated with the TRP of a smaller priority index that will overlap in time with a PUCCH resource associated with the TRP with a larger priority index with (HARQ)-acknowledge (ACK) information only in response to a physical downlink shared channel (PDSCH) reception without a corresponding physical downlink control channel (PDCCH) unless the UE is provided a parameter as *uci-MuxWithDiffPrio*.
3. The UE of claim 1, wherein, the at least one processor is configured to cause the UE to not be scheduled to transmit a PUCCH resource associated with the TRP of a smaller priority index that will overlap in time with a PUSCH resource associated with the TRP of a

larger priority index with semi-persistent (SP)-channel state information (CSI) reports without a corresponding physical downlink control channel (PDCCH) unless the UE is provided a parameter as *uci-MuxWithDiffPrio*.

4. The UE of claim 1, wherein, a parameter as *ackNackFeedbackMode* configured to be separate is provided for the UE, and the at least one processor is configured to cause the UE to be scheduled to transmit a PUCCH resource or PUSCH resource by the TRP which overlaps with another PUCCH resource or PUSCH resource scheduled by another TRP of the plurality of TRPs.

5. The UE of claim 1, wherein, the at least one processor is configured to cause the UE to:

determine up to two PUCCH resources associated with the TRP to be transmitted in the slot, wherein, in the case of lacking a parameter as *ackNackFeedbackMode* configured to be separate and a number of the up to two PUCCH resources is 2, one PUCCH resource of the up to two PUCCH resources is PUCCH format 0 or format 2.

6. The UE of claim 1, wherein, the at least one processor is configured to cause the UE to transmit at most two PUCCH resources per TRP per slot depending on capability of the UE.

7. The UE of claim 1, wherein, the at least one processor is configured to cause the UE to:

determine up to two PUCCH resources associated with the TRP to be transmitted in the slot,

wherein, in the case that there are more than two PUCCH resources associated with the plurality of TRPs in the slot after the UCI multiplexing, a first PUCCH resource of up to two determined PUCCH resources associated with the plurality of TRPs to be transmitted in the slot is a PUCCH resource which has a highest priority of the more than two PUCCH resources according to a priority index of the PUCCH resource and priority of UCI in the PUCCH resource.

8. The UE of claim 7, wherein, the at least one processor is configured to cause the UE to determine a second PUCCH resource of the two determined PUCCH resources to be:

a PUCCH resource which has a highest priority of PUCCH resources with format 0 or format 2 of the more than two PUCCH resources excluding the first PUCCH resource according to a priority index of the PUCCH resource and priority of UCI in the PUCCH resource, in the case that a parameter as *ackNackFeedbackMode* configured to be separate is not provided for the UE and the first PUCCH resource is format 1, format 3 or format 4; otherwise,

a PUCCH resource which has a highest priority of remaining PUCCH resources of the more than two PUCCH resources according to a priority index of the PUCCH resource and priority of UCI in the PUCCH resource.

9. The UE of claim 1, wherein, in the case that a determined PUCCH resource associated with the TRP carries scheduling request (SR) and is overlapped with a PUSCH associated with another TRP of the plurality of TRPs in the slot, the at least one processor is configured to cause the UE to transmit the determined PUCCH resource with the SR and the PUSCH.

10. The UE of claim 1, wherein, in the case that a determined PUCCH resource associated with the TRP carries scheduling request (SR) and is overlapped with a PUSCH associated with another TRP of the plurality of TRPs, the at least one processor is configured to cause the UE to:

in the case that the SR is a positive SR with a priority higher than that of the PUSCH or the PUSCH is without uplink (UL)-shared channel (SCH), transmit the determined PUCCH resource with the SR and drop the PUSCH; otherwise

transmit the PUSCH and drop the determined PUCCH resource in the case that there is only SR in the PDCCH resource, otherwise, transmit the PUSCH and the determined PUCCH resource without the SR.

11. The UE of claim 1, wherein, in the case that a determined PUCCH resource associated with the TRP carries scheduling request (SR) and is overlapped with a PUSCH associated with another TRP of the plurality of TRPs, the at least one processor is configured

to cause the UE to:

in the case that the SR is a positive SR with a priority higher than that of the PUSCH or the PUSCH is without uplink (UL)-shared channel (SCH), transmit the determined PUCCH resource with the SR and the PUSCH; otherwise,

transmit the PUSCH and drop the determined PUCCH resource in the case that there is only SR in the PDCCH resource, otherwise, transmit the PUSCH and the determined PUCCH resource without the SR.

12. The UE of claim 1, wherein, the predefined timing condition is identical with a timing condition specified in TS38.213 for UCI multiplexing of overlapping PUCCHs and/or PUSCHs.

13. The UE of claim 1, wherein, a mechanism of UCI multiplexing based on each TRP in the UE is configured by radio resource control (RRC) signaling or in accordance with a predefined rule.

14. The UE of claim 1, wherein, the configuration information indicates the plurality of TRPs by indicating a plurality of control resource set (CORESET) pool index values, wherein, each CORESET pool index value represents a TRP.

15. A processor for wireless communication, comprising:
at least one controller coupled with at least one memory and configured to cause the processor to:

receive configuration information indicating a plurality of transmit-receive points (TRPs) for a bandwidth part (BWP) of a serving cell; and

determine physical uplink control channel (PUCCH) resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and physical uplink shared channel (PUSCH) resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined

timing condition and uplink control information (UCI) multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

16. A network equipment (NE) for wireless communication, comprising:
at least one memory; and
at least one processor coupled with the at least one memory and configured to cause the NE to:

transmit configuration information indicating a plurality of transmit-receive points (TRPs) for a bandwidth part (BWP) of a serving cell; and

receive physical uplink control channel (PUCCH) resources associated with a TRP of the plurality of TRPs in a slot from a user equipment (UE), wherein, the received PUCCH resource associated with the TRP is determined by the UE from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and physical uplink shared channel (PUSCH) resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and uplink control information (UCI) multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

17. A method performed by a user equipment (UE), comprising:
receiving configuration information indicating a plurality of transmit-receive points (TRPs) for a bandwidth part (BWP) of a serving cell; and
determining physical uplink control channel (PUCCH) resources associated with a TRP of the plurality of TRPs to be transmitted in a slot from overlapping PUCCH resources associated with the TRP in the slot or from overlapping PUCCH resources and physical uplink shared channel (PUSCH) resources which are associated with the TRP in the slot, wherein, the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources satisfy a predefined timing condition and uplink control information (UCI)

multiplexing is performed on the overlapping PUCCH resources or the overlapping PUCCH resources and PUSCH resources.

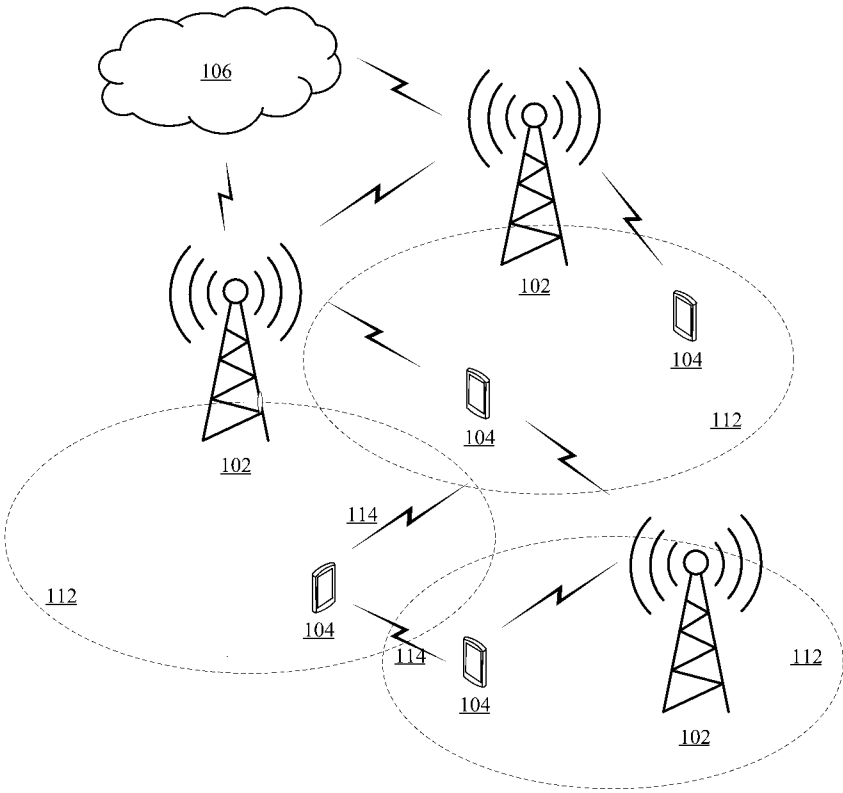


Figure 1

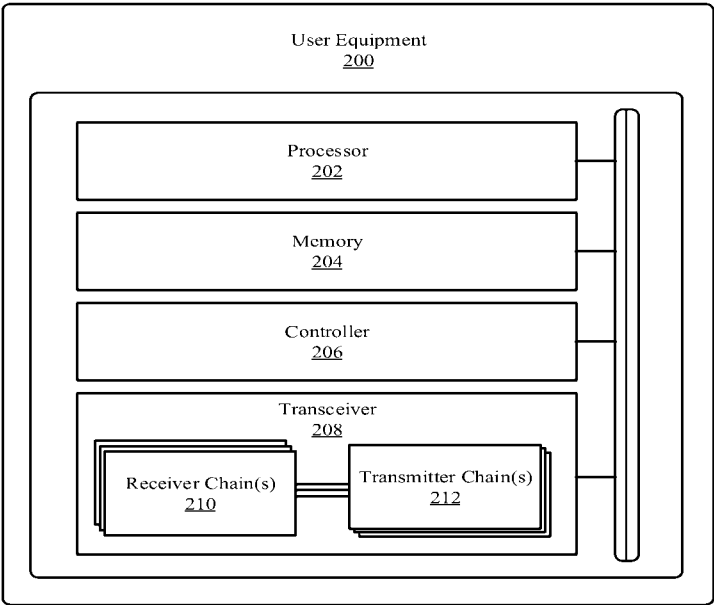


Figure 2

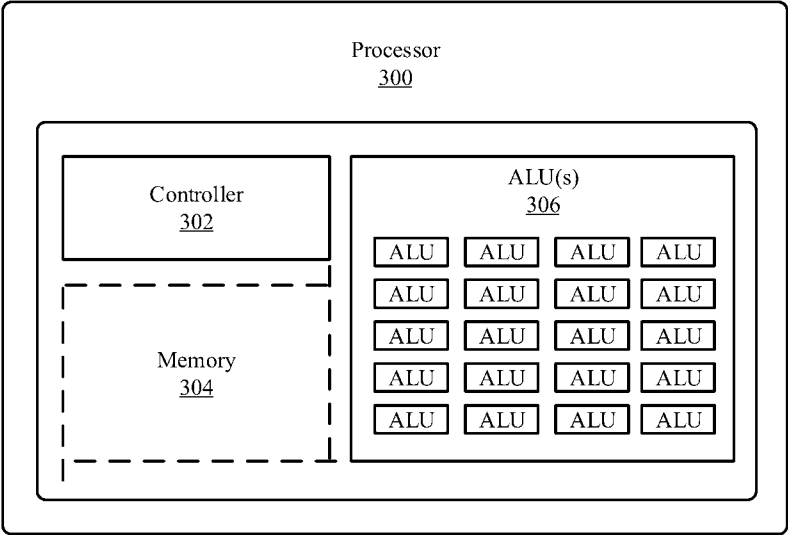


Figure 3

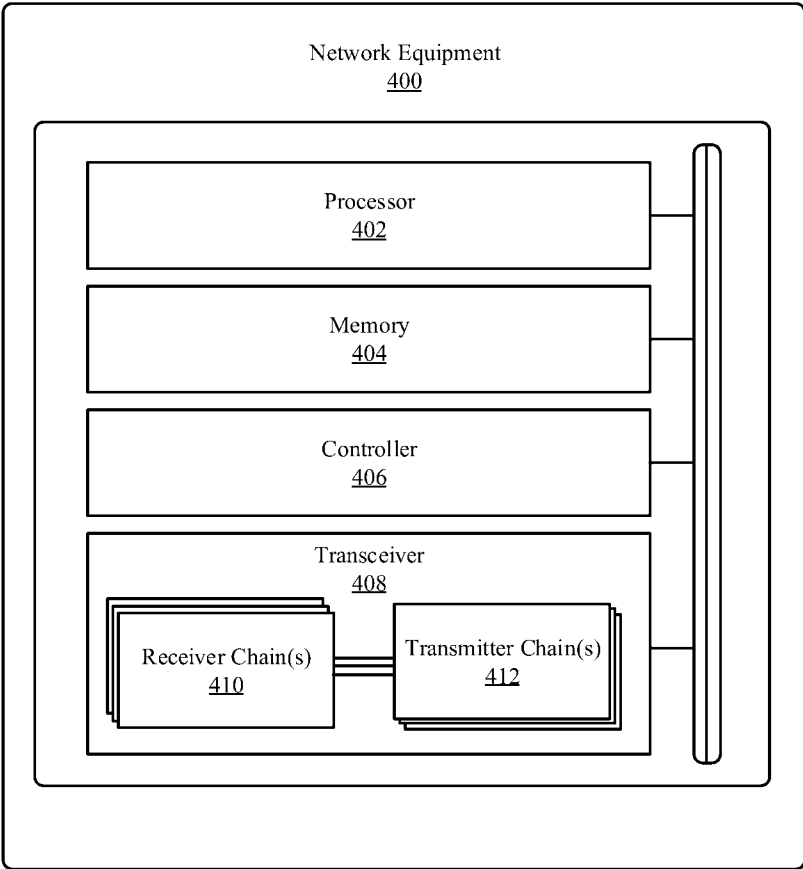


Figure 4

3 / 3

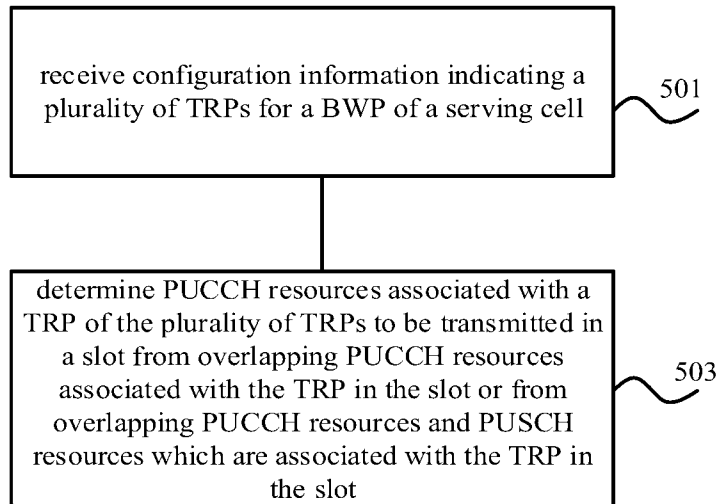


Figure 5

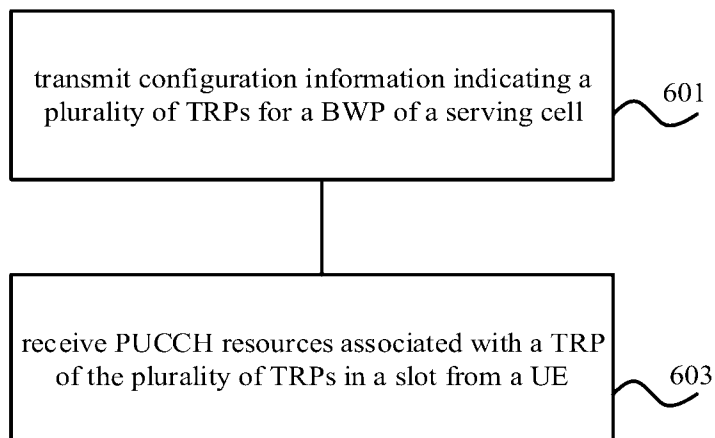


Figure 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/121978

A. CLASSIFICATION OF SUBJECT MATTER H04W72/0446(2023.01)i According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC:H04W Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNTXT, ENTXT, DWPI, CNKI, IEEE, 3GPP: MTRP, M-TRP, multi+, PUCCH, UCI, PUSCH, timeline, condition, multiplex+, overlap+, configur+		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2022206899 A1 (FG INNOVATION COMPANY LIMITED) 06 October 2022 (2022-10-06) description, paragraphs [0082]-[00127]	1-17
A	CN 115462144 A (QUALCOMM INCORPORATED) 09 December 2022 (2022-12-09) the whole document	1-17
A	US 2021105766 A1 (FG INNOVATION COMPANY LIMITED) 08 April 2021 (2021-04-08) the whole document	1-17
A	US 202225380 A1 (SAMSUNG ELECTRONICS CO., LTD.) 14 July 2022 (2022-07-14) the whole document	1-17
A	US 2023087223 A1 (SAMSUNG ELECTRONICS CO., LTD.) 23 March 2023 (2023-03-23) the whole document	1-17
A	WO 202153258 A1 (LENOVO (SINGAPORE) PTE. LTD.) 21 July 2022 (2022-07-21) the whole document	1-17
A	WO 2023049096 A1 (INTEL CORPORATION) 30 March 2023 (2023-03-30) the whole document	1-17
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “D” document cited by the applicant in the international application “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family		
Date of the actual completion of the international search 06 June 2024		Date of mailing of the international search report 12 June 2024
Name and mailing address of the ISA/CN CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China		Authorized officer LI,WenJuan Telephone No. (+86) 010-53961585

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/121978

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NOKIA et al. "Summary #1 of Multi-TRP PUCCH and PUSCH Enhancements" 3GPP TSG RAN WG1 #107-e R1-2112583, 16 August 2021 (2021-08-16), 全文	1-17

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2023/121978

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2022206899	A1	06 October 2022	EP	4302541	A1	10 January 2024
				US	2024089062	A1	14 March 2024
				CN	117063578	A	14 November 2023
CN	115462144	A	09 December 2022	WO	2021226740	A1	18 November 2021
				IN	202247054066	A	30 September 2022
				EP	4147512	A1	15 March 2023
				US	2023138449	A1	04 May 2023
US	2021105766	A1	08 April 2021	EP	4026385	A1	13 July 2022
				WO	2021068865	A1	15 April 2021
				KR	20220063224	A	17 May 2022
				US	2022322340	A1	06 October 2022
				JP	2022549660	A	28 November 2022
				CN	114503761	A	13 May 2022
				IN	202247023297	A	27 May 2022
US	2022225380	A1	14 July 2022	WO	2022154528	A1	21 July 2022
				KR	20230130624	A	12 September 2023
				EP	4252475	A1	04 October 2023
				CN	114765885	A	19 July 2022
US	2023087223	A1	23 March 2023	WO	2021162510	A1	19 August 2021
				EP	4093130	A1	23 November 2022
				KR	20210103293	A	23 August 2021
WO	2022153258	A1	21 July 2022	US	2024089970	A1	14 March 2024
				EP	4252377	A1	04 October 2023
				BR	112023014130	A2	22 August 2023
				CN	116711248	A	05 September 2023
WO	2023049096	A1	30 March 2023	CN	117480845	A	30 January 2024