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(71) Applicant: **GOOGLE LLC** [US/US]; 1600 Amphitheatre Parkway, Mountain View, California 94043 (US).

(72) Inventor; and

(71) Applicant (for BZ only): **ZHANG, Yushu** [CN/CN]; 4th, 5th, 6th, 7th Floor And 8th Floor 801-806, 808-814, Building 1 No. 2 Kexueyuan South Road, Haidian District, Beijing 100190 (CN).

(72) Inventor: **HUANG, Chi-Lin**; 15F. No.168, Dunhua N. Rd., Songshan District, Taipei City, Taiwan 10548 (CN).

(74) Agent: **CHINA SINDA INTELLECTUAL PROPERTY LIMITED**; 11/F, Tower B, Focus Place, 19 Financial Street, Xicheng District, Beijing 100033 (CN).

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(54) Title: METHOD FOR POWER ALLOCATION TO UPLINK SIMULTANEOUS TRANSMISSION WITH MULTI-PANEL

(57) Abstract: The present disclosure provides methods, systems, and techniques for determining uplink transmission power for simultaneous transmission with multi-panel (STxMP). The methods and techniques herein facilitate STxMP for high uplink throughput and/or reliability, for two or more transmit-receive-points (TRPs) and two or more antenna panels. An example method by a user equipment (UE) includes receiving (206), from a network entity, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels. The power allocation is based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels. The UE then transmits (210), to the network entity, the uplink signal from the multiple antenna panels based on the power allocation.

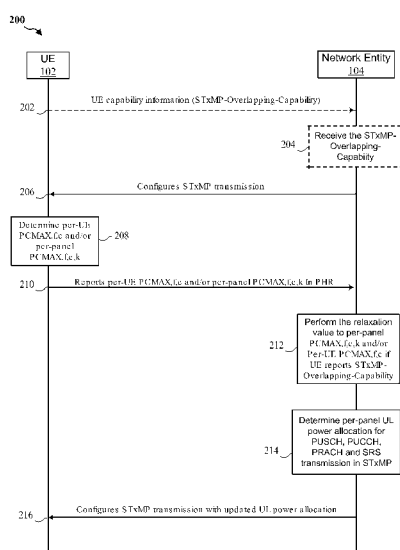


FIG. 2



METHOD FOR POWER ALLOCATION TO UPLINK SIMULTANEOUS TRANSMISSION WITH MULTI-PANEL

FIELD

[0001] The present disclosure relates generally to wireless communications, and more particularly, to transmission power control.

BACKGROUND

[0002] The Third Generation Partnership Project (3GPP) specifies a radio interface referred to as fifth generation (5G) new radio (NR) (5G NR). An architecture for a 5G NR wireless communication system includes a 5G core (5GC) network, a 5G radio access network (5G-RAN), a user equipment (UE), etc. The 5G NR architecture seeks to provide increased data rates, decreased latency, and/or increased capacity compared to prior generation cellular communication systems.

[0003] A base station (BS, such as a gNB) may configure a UE to transmit an uplink signal/channel (e.g., sounding reference signal (SRS), physical uplink control channel (PUCCH), or physical uplink shared channel (PUSCH), physical random access channel (PRACH)) based on one spatial domain filter (e.g., one beam, from one panel). The network entity may provide beam indication (e.g., transmission configuration indication (TCI) indication or spatial relation information indication) for an uplink signal/channel by RRC signaling, media access control (MAC) control element (CE), or downlink control information (DCI). The UE may derive the uplink beam and the uplink power control parameters (e.g., P_0 , alpha, pathloss reference signal, and closed-loop power control index) based on the indicated TCI or spatial relation information. The TCI for transmitting an uplink signal/channel may include a joint TCI or uplink (UL) TCI. The current technical specifications provide the uplink power control for PUSCH, PUCCH, PRACH, and SRS.

SUMMARY

[0004] The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects. This summary neither identifies key or critical elements of all aspects nor delineates the scope of any or all aspects. Its sole purpose

is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

[0005] The present disclosure provides methods, systems, and techniques for determining uplink transmission power for simultaneous transmission with multi-panel (STxMP). The methods and techniques herein facilitate STxMP for high uplink throughput and/or reliability, for two or more transmit-receive-points (TRPs) and two or more antenna panels. An antenna panel or a panel includes a group of antenna elements that is configurable to form various beams (e.g., spatial filters). Across different panels, multiple beams may be used for downlink reception or uplink transmission. The transmission power by each panel is subject to various adjustments or limitations, such as the maximum transmission power for various signals (e.g., sounding reference signal (SRS), physical random access channel (PRACH), physical uplink shared channel (PUSCH), physical uplink control channel (PUCCH), etc.), the maximum power reduction (MPR), the additional maximum power reduction (A-MPR), the power management maximum output power reduction (P-MPR), and others.

[0006] According to general aspects of this disclosure, a method for wireless communications by a user equipment (UE) includes receiving, from a network entity, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels. The UE transmits, to the network entity, the uplink signal from the multiple antenna panels based on the power allocation.

[0007] According to general aspects of this disclosure, a method for wireless communications by a network entity includes transmitting, to the UE, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels.

[0008] According to general aspects of this disclosure, an apparatus includes one or more radio frequency (RF) modems; a processor coupled to the one or more RF modems; and at least one memory storing executable instructions. The executable instructions manipulate at least one of the processor or the one or more RF modems to perform the above methods, which are discussed in details herein.

[0009] Detailed examples of various specific aspects are provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0010] FIG. 1 illustrates a diagram of a wireless communications system that includes multiple user equipments (UEs) and network entities in communication over one or more cells.
- [0011] FIG. 2 illustrates an example of a procedure for uplink power determination and allocation in simultaneous transmission with multi-panel (STxMP) between a UE and a network entity, in accordance with aspects of this disclosure.
- [0012] FIG. 3 illustrates an example of a procedure for uplink power determination and allocation in STxMP between a UE and a network entity, in accordance with aspects of this disclosure.
- [0013] FIG. 4 is a flowchart of a method of wireless communication at a UE, in accordance with aspects of this disclosure.
- [0014] FIG. 5 is a flowchart of a method of wireless communication at a network entity, in accordance with aspects of this disclosure.
- [0015] FIG. 6 is a diagram illustrating a hardware implementation for an example UE apparatus, in accordance with aspects of this disclosure.
- [0016] FIG. 7 is a diagram illustrating a hardware implementation for one or more example network entities, in accordance with aspects of this disclosure.
- [0017] Like numerals indicate like elements.

DETAILED DESCRIPTION

- [0018] The present disclosure provides methods, systems, and techniques for determining uplink transmission power for simultaneous transmission with multi-panel (STxMP). The methods and techniques herein facilitate STxMP for high uplink throughput and/or reliability, for two or more transmit-receive-points (TRPs) and two or more antenna panels. An antenna panel or a panel includes a group of antenna elements that is configurable to form various beams (e.g., spatial filters). Across different panels, multiple beams may be used for downlink reception or uplink transmission. The transmission power by each panel is subject to various adjustments or limitations, such as the maximum transmission power for various signals (e.g., sounding reference signal (SRS), physical random access channel (PRACH), physical uplink shared channel (PUSCH), physical uplink control channel (PUCCH), etc.), the maximum

power reduction (MPR), the additional maximum power reduction (A-MPR), the power management maximum output power reduction (P-MPR), and others.

[0019] When a user equipment (UE) supports STxMP, the UE may support at least two independent UL beams with at least two panels as the minimum UE capability. In one implementation, the UE may have two panels placed proximate to each other such that two independent transmission (Tx) beams may transmit signals with overlapping beam coverage. As such, the power level for each of the two panels may need adjustment or updates to conform to the limitations.

[0020] For example, the overlapping beams may violate the radio frequency (RF) emission requirements, such as, for example, power class requirement ($EIRP_{max}$ and TRP_{max}), due to the superposition of the two beams within the overlapping beam coverage. In addition, currently the standard does not specify how to determine “per-panel” RF parameters (e.g., $P_{CMAX,f,c,k}$, $MPR_{f,c,k}$, $A-MPR_{f,c,k}$, $P-MPR_{f,c,k}$ for carrier f in the primary cell c , $k=0,1,\dots$ is the index of panel) and how to determine “per-UE” RF parameters (e.g., $P_{CMAX,f,c}$, $MPR_{f,c}$, $A-MPR_{f,c}$, $P-MPR_{f,c}$) (See e.g., 3GPP TS 38.213).

[0021] In addition, the UE may have two panels placed at a sufficient distance from each other such that two independent transmission (Tx) beams may transmit signals without any overlapping beam coverage. As such, each panel may approach the maximum transmission power, causing potential difficulties in power sharing and/or power scaling between panels and to conform to RF emission requirements.

[0022] In an aspect, this disclosure provides methods for uplink power allocation in STxMP. From the network entity’s perspective, the network entity may receive UE capability signaling for overlapping beam information in STxMP, and transmit control signaling for per-panel power allocation, e.g., per-panel $P_{CMAX,f,c,k}$, $MPR_{f,c,k}$, $A-MPR_{f,c,k}$, and/or $P-MPR_{f,c,k}$. Correspondingly, the UE may transmit the UE capability or status signaling regarding overlapping beam information in STxMP to the network entity. The UE may receive control signaling for per-panel power allocation, e.g., per-panel $P_{CMAX,f,c,k}$, $MPR_{f,c,k}$, $A-MPR_{f,c,k}$, and/or $P-MPR_{f,c,k}$, per-panel $P_{CMAX,f,c,k}$ determination in STxMP, per-panel $MPR_{f,c,k}$ determination in STxMP, per-panel $A-MPR_{f,c,k}$ determination in STxMP, or per-panel $P-MPR_{f,c,k}$ determination in STxMP.

[0023] Currently, to facilitate simultaneous multi-panel uplink (UL) transmission for higher UL throughput/reliability, focusing on multi-TRP, the following have not yet been fully specified. First, UL precoding indication for PUSCH, where no new

codebook is introduced for multi-panel simultaneous transmission. Second, the total number of layers is up to four across all panels and total number of codewords is up to two across all panels, considering single DCI and multi-DCI based multi-TRP operation. Third, UL beam indication for PUCCH/PUSCH, where unified TCI framework extension in objective 2 is assumed, considering single DCI and multi-DCI based multi-TRP operation. For the case of multi-DCI based multi-TRP operation, only PUSCH+PUSCH, or PUCCH+PUCCH is transmitted across two panels in a same CC.

[0024] In some aspects, PUSCH power allocation equation can be determined using the equation(s) in the 3GPP technical specifications. It is observed that $P_{\text{CMAX},f,c}$ is the key term in PUSCH power allocation. In some aspects, PUCCH power allocation equation can be shown using the equation(s) in the 3GPP technical specifications. It is observed that $P_{\text{CMAX},f,c}$ is the key term in PUCCH power allocation. In some aspects, SRS power allocation equation can be shown using the equation(s) in the 3GPP technical specifications. It is observed that $P_{\text{CMAX},f,c}$ is the key term in SRS power allocation. In some aspects, physical random access channel (PRACH) power allocation equation can be shown using the equation(s) in the 3GPP technical specifications. It is observed that $P_{\text{CMAX},f,c(i)}$ is the key term in PRACH power allocation.

[0025] In addition, it is also observed that $P_{\text{CMAX},f,c}$ is the key term in power head room report (PHR) (e.g., defined in TS 38.213). PHR is the value for the residual power allocation reported to the network to assist the network scheduling. $P_{\text{CMAX},f,c}$ can be reported in the PHR to be used by the gNB for scheduling decision.

[0026] $P_{\text{CMAX},f,c}$ is UE configured maximum output power for carrier f of serving cell c in PUSCH/PUCCH/SRS/PRACH transmission occasion (e.g., defined in RAN4 specification TS 38.101-1). In some aspects, the carrier frequency range 2 (FR2) $P_{\text{CMAX},f,c}$ shall be determined by the corresponding measured peak Effective Isotropic Radiated Power (EIRP) $P_{\text{UMAX},f,c}$ to be upper bounded by EIRP_{max} and to be lower bounded by the combination of parameters such as $P_{\text{powerclass}}$, $\text{MPR}_{f,c}$, $\text{A-MPR}_{f,c}$, $\text{P-MPR}_{f,c}$, DP_{IBE} , $\text{DMB}_{\text{P,n}}$, and $\text{T}(\text{DP})$, and by the corresponding measured total radiated power (TRP) $P_{\text{TMAX},f,c}$ is upper bounded by TRP_{max} .

[0027] $P_{\text{powerclass}}$ is the UE minimum peak EIRP for the UE power class (e.g., defined in TS 38.101-2).

[0028] EIRP_{max} is the applicable maximum EIRP by regulatory requirement for the UE power class (e.g., specified in TS 38.101-2).

[0029] TRP_{max} is the maximum TRP for the UE power class (e.g., specified in TS 38.101-2).

[0030] $DMB_{P,n}$ the peak EIRP relaxation in band n with UE supported multi-band for the UE power class (e.g., specified in TS 38.101-2).

[0031] DP_{IBE} is 1.0 dB if UE declares support for *mpr-PowerBoost-FR2-r16*, UL transmission is QPSK, $MPR_{f,c} = 0$ and when NS_200 applies and the network configures the UE to operate with *mpr-PowerBoost-FR2-r16*, otherwise DP_{IBE} is 0.0 dB.

[0032] The tolerance $T(DP)$ for applicable values of ΔP (values in dB) (e.g., specified in TS 38.101-2).

[0033] $MPR_{f,c}$ is the maximum power reduction (MPR) due to modulation orders, transmit bandwidth configurations, waveform types and narrow allocations (e.g., specified in TS 38.101-2).

[0034] Take Power Class 1 as an example, the UE can determine MPR by

$$MPR = \text{Max}(MPR_{WT}, MPR_{narrow}).$$

where MPR_{narrow} is determined by the following condition:

(1) $MPR_{narrow} = 14.4$ dB, when $BW_{alloc,RB} \leq 1.44$ MHz,

(2) $MPR_{narrow} = 10$ dB, when $1.44 \text{ MHz} < BW_{alloc,RB} \leq 10.8$ MHz,

where $BW_{alloc,RB}$ is the bandwidth of the RB allocation size.

[0035] MPR_{WT} is determined by the upper bound in the following Table according to what modulation order (e.g., QPSK, 16QAM, 64QAM, etc.), what transmission waveform type (e.g., discrete Fourier transform spread orthogonal frequency division multiplexing (DFT-s-OFDM) or cyclic prefix OFDM (CP-OFDM)), and how RB is allocated (e.g., Outer RB allocations, Inner RB allocations,...). The more detailed definition of RB allocations can be referred to in 3GPP TS 38.101-2. In one example, if the UE is configured by DFT-s-OFDM waveform type and Outer RB allocation with QPSK modulation, the UE is allowed to reduce maximum UL power no more than 6.5 dB as specified in Table 1. In other words, the UE still can determine MPR below 6.5 if the UE has a good quality for RF front end implementation.

Modulation		MPR _{WT} (dB), BW _{channel} ≤ 200 MHz		
		Outer RB allocations	Inner RB allocations	
			Region 1	Region 2
DFT-s-OFDM	Pi/2 BPSK	≤ 5.5	0.0	≤ 3.0
	QPSK	≤ 6.5	0.0	≤ 3.0
	16 QAM	≤ 6.5	≤ 4.0	≤ 4.0
	64 QAM	≤ 6.5	≤ 5.0	≤ 5.0
CP-OFDM	QPSK	≤ 7.0	≤ 4.5	≤ 4.5
	16 QAM	≤ 7.0	≤ 5.5	≤ 5.5
	64 QAM	≤ 7.5	≤ 7.5	≤ 7.5

Table 1: MPRWT for power class 1, BW_{channel} ≤ 200 MHz

[0036] A-MPR_{f,c} is the additional maximum power reduction (A-MPR) used to accommodate the additional emission requirement in different countries (e.g., specified in TS 38.101-2). Each additional emission requirement is associated with a unique network signalling (NS) value which is indicated in IE *additionalSpectrumEmission* for the corresponding applicable operating band in IE *freqBandIndicatorNR* in RRC signaling. For example, if the Power Class 1 UE received network signaling with NS_202, the UE is allowed to reduce maximum UL power no more than 11 dB (e.g., specified in TS38.101-2).

[0037] P-MPR_{f,c} is the power management maximum output power reduction (P-MPR) which is used to ensure compliance with applicable electromagnetic power density exposure requirements. There are two possible use cases for P-MPR. The one is that if the field of UE capability *maxUplinkDutyCycle-FR2* is present and the network configures the UE with the percentage of uplink symbols transmitted within any 1 second evaluation period larger than *maxUplinkDutyCycle-FR2*, the UE can apply P-MPR_{f,c} to follows the uplink scheduling without violating the emission requirements.

[0038] The other one is that the UE shall apply P-MPR_{f,c} to ensure compliance with applicable electromagnetic power density exposure requirements and addressing unwanted emissions / self defense requirements in case of simultaneous transmissions on multiple radio access technology (RAT(s)) for scenarios not in the scope of 3GPP specifications; ensuring compliance with applicable electromagnetic power density exposure requirements in case of proximity detection is used to address such requirements that require a lower maximum output power.

[0039] In addition, Maximum Permissible Exposure (MPE) P-MPR Reporting capability *tdd-MPE-P-MPR-Reporting-r16* is used to report $P\text{-MPR}_{f_c}$ when the reporting conditions configured by gNB are met. This UE capability is applicable to all FR2 power classes. As described herein, panel or antenna panel may include a group of antenna element that controls beam independently and has the following attributes. First, within a panel, one beam can be selected and used for DL reception or UL transmission. Second, across different panels, multiple beams (each selected per panel) may be used for DL reception or UL transmission. Third, a beam means a spatial filter associated with transmission or reception.

[0040] FIG. 1 illustrates a diagram 100 of a wireless communications system associated with a plurality of cells 190. The wireless communications system includes user equipments (UEs) 102 and base stations/network entities 104. Some base stations may include an aggregated base station architecture and other base stations may include a disaggregated base station architecture. The aggregated base station architecture utilizes a radio protocol stack that is physically or logically integrated within a single radio access network (RAN) node. A disaggregated base station architecture utilizes a protocol stack that is physically or logically distributed among two or more units (e.g., radio unit (RU) 106, distributed unit (DU) 108, central unit (CU) 110). For example, a CU 110 is implemented within a RAN node, and one or more DUs 108 may be co-located with the CU 110, or alternatively, may be geographically or virtually distributed throughout one or multiple other RAN nodes. The DUs 108 may be implemented to communicate with one or more RUs 106. Any of the RU 106, the DU 108 and the CU 110 can be implemented as virtual units, such as a virtual radio unit (VRU), a virtual distributed unit (VDU), or a virtual central unit (VCU). The base station/network entity 104 (e.g., an aggregated base station or disaggregated units of the base station, such as the RU 106 or the DU 108), may be referred to as a transmission reception point (TRP).

[0041] Operations of the base station 104 and/or network designs may be based on aggregation characteristics of base station functionality. For example, disaggregated base station architectures are utilized in an integrated access backhaul (IAB) network, an open-radio access network (O-RAN) network, or a virtualized radio access network (vRAN), which may also be referred to a cloud radio access network (C-RAN). Disaggregation may include distributing functionality across the two or more units at various physical locations, as well as distributing functionality for at least one

unit virtually, which can enable flexibility in network designs. The various units of the disaggregated base station architecture, or the disaggregated RAN architecture, can be configured for wired or wireless communication with at least one other unit. For example, the base stations 104d, 104e and/or the RUs 106a, 106b, 106c, 106d may communicate with the UEs 102a, 102b, 102c, 102d, and/or 102s via one or more radio frequency (RF) access links based on a Uu interface. In examples, multiple RUs 106 and/or base stations 104 may simultaneously serve the UEs 102, such as by intra-cell and/or inter-cell access links between the UEs 102 and the RUs 106/base stations 104.

[0042] The RU 106, the DU 108, and the CU 110 may include (or may be coupled to) one or more interfaces configured to transmit or receive information/signals via a wired or wireless transmission medium. For example, a wired interface can be configured to transmit or receive the information/signals over a wired transmission medium, such as via the fronthaul link 160 between the RU 106d and the baseband unit (BBU) 112 of the base station 104d associated with the cell 190d. The BBU 112 includes a DU 108 and a CU 110, which may also have a wired interface (e.g., midhaul link) configured between the DU 108 and the CU 110 to transmit or receive the information/signals between the DU 108 and the CU 110. In further examples, a wireless interface, which may include a receiver, a transmitter, or a transceiver, such as an RF transceiver, configured to transmit and/or receive the information/signals via the wireless transmission medium, such as for information communicated between the RU 106a of the cell 190a and the base station 104e of the cell 190e via cross-cell communication beams 136-138 of the RU 106a and the base station 104e.

[0043] The RUs 106 may be configured to implement lower layer functionality. For example, the RU 106 is controlled by the DU 108 and may correspond to a logical node that hosts RF processing functions, or lower layer PHY functionality, such as execution of fast Fourier transform (FFT), inverse FFT (iFFT), digital beamforming, physical random access channel (PRACH) extraction and filtering, etc. The functionality of the RU 106 may be based on the functional split, such as a functional split of lower layers.

[0044] The RUs 106 may transmit or receive over-the-air (OTA) communication with one or more UEs 102. For example, the RU 106b of the cell 190b communicates with the UE 102b of the cell 190b via a first set of communication beams 132 of the RU 106b and a second set of communication beams 134b of the UE 102b, which may

correspond to inter-cell communication beams or, in some examples, cross-cell communication beams. For instance, the UE 102b of the cell 190b may communicate with the RU 106a of the cell 190a via a third set of communication beams 134a of the UE 102b and a fourth set of communication beams 136 of the RU 106a. DUs 108 can control both real-time and non-real-time features of control plane and user plane communications of the RUs 106.

[0045] Any combination of the RU 106, the DU 108, and the CU 110, or reference thereto individually, may correspond to a base station 104. Thus, the base station 104 may include at least one of the RU 106, the DU 108, or the CU 110. The base stations 104 provide the UEs 102 with access to a core network. The base stations 104 may relay communications between the UEs 102 and the core network (not shown). The base stations 104 may be associated with macrocells for higher-power cellular base stations and/or small cells for lower-power cellular base stations. For example, the cell 190e may correspond to a macrocell, whereas the cells 190a-190d may correspond to small cells. Small cells include femtocells, picocells, microcells, etc. A network that includes at least one macrocell and at least one small cell may be referred to as a “heterogeneous network.”

[0046] Transmissions from a UE 102 to a base station 104/RU 106 are referred to as uplink (UL) transmissions, whereas transmissions from the base station 104/RU 106 to the UE 102 are referred to as downlink (DL) transmissions. Uplink transmissions may also be referred to as reverse link transmissions and downlink transmissions may also be referred to as forward link transmissions. For example, the RU 106d utilizes antennas of the base station 104d of cell 190d to transmit a downlink/forward link communication to the UE 102d or receive an uplink/reverse link communication from the UE 102d based on the Uu interface associated with the access link between the UE 102d and the base station 104d/RU 106d.

[0047] Communication links between the UEs 102 and the base stations 104/RUs 106 may be based on multiple-input and multiple-output (MIMO) antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity. The communication links may be associated with one or more carriers. The UEs 102 and the base stations 104/RUs 106 may utilize a spectrum bandwidth of Y MHz (e.g., 5, 10, 15, 20, 100, 400, 800, 1600, 2000, etc. MHz) per carrier allocated in a carrier aggregation of up to a total of Yx MHz, where x component carriers (CCs) are used for communication in each of the uplink and downlink directions. The carriers may

or may not be adjacent to each other along a frequency spectrum. In examples, uplink and downlink carriers may be allocated in an asymmetric manner, with more or fewer carriers allocated to either the uplink or the downlink. A primary component carrier and one or more secondary component carriers may be included in the component carriers. The primary component carrier may be associated with a primary cell (PCell) and a secondary component carrier may be associated with a secondary cell (SCell).

[0048] Some UEs 102, such as the UEs 102a and 102s, may perform device-to-device (D2D) communications over sidelink. For example, a sidelink communication/D2D link utilizes a spectrum for a wireless wide area network (WWAN) associated with uplink and downlink communications. Such sidelink/D2D communication may be performed through various wireless communications systems, such as wireless fidelity (Wi-Fi) systems, Bluetooth systems, Long Term Evolution (LTE) systems, New Radio (NR) systems, etc.

[0049] The UEs 102 and the base stations 104/RUs 106 may each include a plurality of antennas. The plurality of antennas may correspond to antenna elements, antenna panels, and/or antenna arrays that may facilitate beamforming operations. For example, the RU 106b transmits a downlink beamformed signal based on a first set of communication beams 132 to the UE 102b in one or more transmit directions of the RU 106b. The UE 102b may receive the downlink beamformed signal based on a second set of communication beams 134b from the RU 106b in one or more receive directions of the UE 102b. In a further example, the UE 102b may also transmit an uplink beamformed signal (e.g., sounding reference signal (SRS)) to the RU 106b based on the second set of communication beams 134b in one or more transmit directions of the UE 102b. The RU 106b may receive the uplink beamformed signal from the UE 102b in one or more receive directions of the RU 106b. The UE 102b may perform beam training to determine the best receive and transmit directions for the beamformed signals. The transmit and receive directions for the UEs 102 and the base stations 104/RUs 106 may or may not be the same.

[0050] In further examples, beamformed signals may be communicated between a first base station/RU 106a and a second base station 104e. For instance, the base station 104e of the cell 190e may transmit a beamformed signal to the RU 106a based on the communication beams 138 in one or more transmit directions of the base station 104e. The RU 106a may receive the beamformed signal from the base station 104e of the cell 190e based on the RU communication beams 136 in one or more receive

directions of the RU 106a. In further examples, the base station 104e transmits a downlink beamformed signal to the UE 102e based on the communication beams 138 in one or more transmit directions of the base station 104e. The UE 102e receives the downlink beamformed signal from the base station 104e based on UE communication beams 130 in one or more receive directions of the UE 102e. The UE 102e may also transmit an uplink beamformed signal to the base station 104e based on the UE communication beams 130 in one or more transmit directions of the UE 102e, such that the base station 104e may receive the uplink beamformed signal from the UE 102e in one or more receive directions of the base station 104e.

[0051] The base station 104 may include and/or be referred to as a network entity. That is, “network entity” may refer to the base station 104 or at least one unit of the base station 104, such as the RU 106, the DU 108, and/or the CU 110. The base station 104 may also include and/or be referred to as a next generation evolved Node B (ng-eNB), a next generation NB (gNB), an evolved NB (eNB), an access point, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), a TRP, a network node, network equipment, or other related terminology. The base station 104 or an entity at the base station 104 can be implemented as an IAB node, a relay node, a sidelink node, an aggregated (monolithic) base station, or a disaggregated base station including one or more RUs 106, DUs 108, and/or CUs 110. A set of aggregated or disaggregated base stations may be referred to as a next generation-radio access network (NG-RAN). In some examples, the UE 102a operates in dual connectivity (DC) with the base station 104e and the base station/RU 106a. In such cases, the base station 104e can be a master node and the base station/RU 160a can be a secondary node.

[0052] Uplink/downlink signaling may also be communicated via a satellite positioning system (SPS) 114. In an example, the SPS 114 associated with the cell 190c may be in communication with one or more UEs 102, such as the UE 102c, and one or more base stations 104/RUs 106, such as the RU 106c. The SPS 114 may correspond to one or more of a Global Navigation Satellite System (GNSS), a global position system (GPS), a non-terrestrial network (NTN), or other satellite position/location system. The SPS 114 may be associated with LTE signals, NR signals (e.g., based on round trip time (RTT) and/or multi-RTT), wireless local area network (WLAN) signals, a terrestrial beacon system (TBS), sensor-based information, NR enhanced cell ID (NR

E-CID) techniques, downlink angle-of-departure (DL-AoD), downlink time difference of arrival (DL-TDOA), uplink time difference of arrival (UL-TDOA), uplink angle-of-arrival (UL-AoA), and/or other systems, signals, or sensors.

[0053] Still referring to FIG. 1, in certain aspects, any of the UEs 102 may include a STxMP power determination component 140 configured to receive, such as from the network entity 104, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels. The STxMP power determination component 140 then transmits, to the network entity, the uplink signal from the multiple antenna panels based on the power allocation.

[0054] In certain aspects, any of the base stations 104 or a network entity of the base stations 104 may include a STxMP power allocation component 150 configured to transmit, to the UE, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels.

[0055] Accordingly, FIG. 1 describes a wireless communication system that may be implemented in connection with aspects of one or more other figures described herein. Further, although the following description may be focused on 5G NR, the concepts described herein may be applicable to other similar areas, such as 5G-Advanced and future versions, LTE, LTE-advanced (LTE-A), and other wireless technologies, such as 6G.

[0056] FIG. 2 illustrates an example of a procedure 200 for uplink power determination and allocation in simultaneous transmission with multi-panel (STxMP) between a UE 102 and a network entity 104, in accordance with aspects of this disclosure. As shown, the UE 102 first determines whether it supports UL Tx beam overlapping transmission among multi-panels in STxMP and reports 202 STxMP-overlapping-capability in RRC UE capability signaling to the network entity. The STxMP-overlapping-capability information includes whether the UE support UL Tx beam overlapping transmission and/or the UL power relaxation value for STxMP.

[0057] The network entity 104 receives 204 the STxMP overlapping capability and configures 206 simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE 102. The UE102 determines 208 per-UE $P_{\text{CMAX},f,c}$ or at least one

per-panel $P_{\text{CMAX},f,c,k}$ for at least one panel from the PHR. The network entity 104 receives 210 per-UE $P_{\text{CMAX},f,c}$ from the PHR where per-UE $P_{\text{CMAX},f,c}$ is derived from the calculation of per-panel $P_{\text{CMAX},f,c,k}$ by the UE or receives at least one per-panel $P_{\text{CMAX},f,c,k}$ for at least one panel from the PHR. In some aspects, the parameters corresponding to per-UE may refer to parameters specified across the multiple antenna panels of the UE.

[0058] The network entity 104 applies 212 relaxation values to per-panel UE $P_{\text{CMAX},f,c}$ and/or per-panel $P_{\text{CMAX},f,c,k}$ when the UE reports the STxMP overlapping capability. The network entity 104 then utilize 214 the STxMP-overlapping-capability information and per-UE $P_{\text{CMAX},f,c}$ or at least one per-panel $P_{\text{CMAX},f,c,k}$ to determine per-panel UL power allocation for PUSCH, PUCCH, PRACH, and/or SRS transmission. In some aspects, the network entity 104 may modify or adjust the per-panel parameters based on the relaxation values. The network entity 104 transmits 216 a configuration message to the UE 102 for STxMP transmission with updated power allocation.

[0059] In some implementations, assuming that the UE equipped with two panels does not indicate STxMP-overlapping-capability, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE first determines per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ and per-UE $P_{\text{CMAX},f,c}$ derived from the calculation of per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ by following the emission requirements. If or when the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH, and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ which are acquired by equal-splitting per-UE $P_{\text{CMAX},f,c}$. If or when the UE reports per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH, and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$.

[0060] In one example, assuming the UE not indicating STxMP-overlapping-capability, the network entity may configure the UE by single-DCI (s-DCI) or multi-DCI (m-DCI) with transmission configuration indication (TCI)#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. If or when the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH by applying $P_{\text{CMAX},f,c,k=0}=P_{\text{CMAX},f,c,k=1}=P_{\text{CMAX},f,c} - 3\text{dB}$. If or when the UE reports per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ in the PHR, the network

entity may determine per-panel UL power allocation for PUSCH by applying $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$. In other example, the same procedure for per-panel power allocation can be applied to PUCCH, PRACH, and/or SRS transmission.

[0061] In some implementations, assuming that the UE 102 equipped with two panels has indicated to the network entity 104 the UE's STxMP-overlapping-capability, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE first determines per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ and per-UE $P_{\text{CMAX},f,c}$ derived from the calculation of per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ by following the emission requirements.

[0062] If or when the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity determines per-panel UL power allocation for PUSCH, PUCCH, PRACH, and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0} = P_{\text{CMAX},f,c} - X1$ (dB) and $P_{\text{CMAX},f,c,k=1} = P_{\text{CMAX},f,c} - X2$ (dB), where (X1,X2) can be the relaxation value (X1',X2') (dB) in STxMP-overlapping-capability or (X1,X2) is determined by the network entity. In one implementation, the relaxation value can be reported as one value X' (dB) in STxMP-overlapping-capability, and the network can determine X1 and X2 by following the equation $X' = X1 + X2$ (dB).

[0063] In one example, the network can determine X1 from $0 < X1 \leq X1'$ and X2 from $0 < X2 \leq X2'$. If or when the UE reports per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH, and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0} - X1$ (dB) and $P_{\text{CMAX},f,c,k=1} - X2$ (dB), where (X1,X2) can be the relaxation value (X1',X2') (dB) in STxMP-overlapping-capability or (X1,X2) is determined by the network entity. In one implementation, the relaxation value can be reported as one value X' (dB) in STxMP-overlapping-capability, and the network can determine X1 and X2 by following the equation $X' = X1 + X2$ (dB). In one example, the network can determine X1 from $0 < X1 \leq X1'$ and X2 from $0 < X2 \leq X2'$.

[0064] In one example, assuming the UE indicating STxMP-overlapping-capability, the network entity may configure the UE by single-DCI (s-DCI) or multi-DCI (m-DCI) with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. If or when the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH by applying $P_{\text{CMAX},f,c,k=0} = P_{\text{CMAX},f,c} - 1$ dB and $P_{\text{CMAX},f,c,k=1} = P_{\text{CMAX},f,c} - 2$ dB, where (X1=1,X2=2) can be the relaxation value (X1'=1,X2'=2) (dB) in STxMP-overlapping-capability or

($X_1=1, X_2=2$) is determined by the network entity. In one implementation, the relaxation value can be reported as one value $X'=1+2=3$ (dB) in STxMP-overlapping-capability, and the network can determine $X_1=1$ (dB) and $X_2=2$ (dB) by following the equation $X'=X_1+X_2$ (dB).

[0065] In one example, the network can determine X_1 from $0 < X_1 \leq 1$ and X_2 from $0 < X_2 \leq 2$. If or when the UE reports per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH by applying per-panel $P_{\text{CMAX},f,c,k=0} - 1$ (dB) and $P_{\text{CMAX},f,c,k=1} - 2$ (dB), where ($X_1=1, X_2=2$) can be the relaxation value ($X_1'=1, X_2'=2$) (dB) in STxMP-overlapping-capability or ($X_1=1, X_2=2$) is determined by the network entity. In one implementation, the relaxation value can be reported as one value $X'=1+2=3$ (dB) in STxMP-overlapping-capability, and the network can determine $X_1=1$ (dB) and $X_2=2$ (dB) by following the equation $X'=X_1+X_2$ (dB). In one example, the network can determine X_1 from $0 < X_1 \leq 1$ and X_2 from $0 < X_2 \leq 2$. In other example, the same procedure for per-panel power allocation can be applied to PUCCH, PRACH and/or SRS transmission.

[0066] In an embodiment, a UE first determines whether the UE supports UL Tx beam overlapping transmission among multi-panels in STxMP and reports STxMP-overlapping-capability for at least a group of beams (e.g., a group of SSBs or CSI-RSs) to the network entity by RRC signaling, MAC control element (CE) or uplink control information (UCI) on PUCCH or PUSCH. The STxMP-overlapping-capability information includes whether the UE support UL Tx beam overlapping transmission, Tx overlapping beam-group among panels and/or the UL power relaxation value for Tx overlapping beam-group among panels in STxMP.

[0067] In some implementations, the UE reports some information to indicate whether the uplink Tx beams for a group of SSBs/CSI-RSs are overlapping or not in a group-based beam report instance, where the UE reports the UE supports simultaneous multi-panel transmission for each reported group of SSB resource indicators (SSBRIs) or CSI-RS resource indicators (CRIs). In some other implementations, the UE reports some information to indicate whether the uplink Tx beams for the indicated TCI states for STxMP are overlapping or not. The network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. Then, the network entity receives per-UE $P_{\text{CMAX},f,c}$ from the PHR where per-UE

$P_{\text{CMAX},f,c}$ is derived from the calculation of per-panel $P_{\text{CMAX},f,c,k}$ by the UE or receives at least one per-panel $P_{\text{CMAX},f,c,k}$ from the PHR.

[0068] The network entity further checks whether the current active UE UL Tx beams among panels is in Tx overlapping beam-group among panels. If the current active Tx beams among panels is not in Tx overlapping beam-group among panels, the network entity may utilize per-UE $P_{\text{CMAX},f,c}$ or every per-panel $P_{\text{CMAX},f,c,k}$ to determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission. If the current active Tx beams among panels is in Tx overlapping beam-group among panels, the network entity applies the UL power relaxation value in STxMP-overlapping-capability to per-UE $P_{\text{CMAX},f,c}$ or every per-panel $P_{\text{CMAX},f,c,k}$ and determines per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission.

[0069] In some implementations, assuming the UE equipped with two panels without indicating STxMP-overlapping-capability, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE first determines per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ and per-UE $P_{\text{CMAX},f,c}$ derived from the calculation of per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ by following the emission requirements. If or when the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ which are acquired by equal-splitting per-UE $P_{\text{CMAX},f,c}$. If or when the UE reports per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$.

[0070] In one example, assuming the UE not indicating STxMP-overlapping-capability, the network entity may configure the UE by single-DCI (s-DCI) or multi-DCI (m-DCI) with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. If or when the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH by applying $P_{\text{CMAX},f,c,k=0}=P_{\text{CMAX},f,c,k=1}=P_{\text{CMAX},f,c} - 3\text{dB}$. If or when the UE reports per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH by applying $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$. In other example, the same procedure for per-panel power allocation can be applied to PUCCH, PRACH, and/or SRS transmission.

[0071] In some implementations, assuming the UE equipped with two panels with indicating STxMP-overlapping-capability, the UE first determines Tx overlapping beam group among panels by checking the overlapping beam coverage is larger than X-percent, and reports Tx overlapping beam group by SRS resource indicator (SRI) with associated *srs-ResourceSetId* in STxMP-overlapping-capability. The network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. Then, the UE determines per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ and per-UE $P_{\text{CMAX},f,c}$ derived from the calculation of per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ by following the emission requirements.

[0072] If the network entity checks that the current active UL Tx beams among panels is not in Tx overlapping beam-group among panels and the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH, and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ which are acquired by equal-splitting per-UE $P_{\text{CMAX},f,c}$. If the network entity checks that the current active UL Tx beams among panels is not in Tx overlapping beam-group among panels and the UE reports per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH, and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$.

[0073] On the other hand, if the network entity checks that the current active UL Tx beams among panels is in Tx overlapping beam-group among panels and the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH, and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0} = P_{\text{CMAX},f,c} - X1$ (dB) and $P_{\text{CMAX},f,c,k=1} = P_{\text{CMAX},f,c} - X2$ (dB), where (X1,X2) can be the relaxation value (X1',X2') (dB) in STxMP-overlapping-capability or (X1,X2) is determined by the network entity. In one implementation, the relaxation value can be reported as one value X' (dB) in STxMP-overlapping-capability, and the network can determine X1 and X2 by following the equation $X' = X1 + X2$ (dB). In one example, the network can determine X1 from $0 < X1 \leq X1'$ and X2 from $0 < X2 \leq X2'$.

[0074] If the network entity checks that the current active UL Tx beams among panels is in Tx overlapping beam-group among panels and the UE reports per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission by

applying $P_{\text{CMAX},f,c,k=0} - X1$ (dB) and $P_{\text{CMAX},f,c,k=1} - X2$ (dB), where (X1,X2) can be the relaxation value (X1',X2') (dB) in STxMP-overlapping-capability or (X1,X2) is determined by the network entity. In one implementation, the relaxation value can be reported as one value X' (dB) in STxMP-overlapping-capability, and the network can determine X1 and X2 by following the equation $X'=X1+X2$ (dB). In one example, the network can determine X1 from $0 < X1 \leq X1'$ and X2 from $0 < X2 \leq X2'$.

[0075] In one example, assuming the UE indicating STxMP-overlapping-capability, the UE first determines Tx overlapping beam group among panels by checking the overlapping beam coverage is larger than 85-percent, and reports Tx-overlapping-beam-group#1 = {(SRI=1, *SRS-ResourceSetId*=1), (SRI=1, *SRS-ResourceSetId*=2)}, Tx-overlapping-beam-group#2 = {(SRI=3, *SRS-ResourceSetId*=1), (SRI=, *SRS-ResourceSetId*=2)} in STxMP-overlapping-capability to the network entity, where the UE determines *SRS-ResourceSetId*=1 for Panel-1 and *SRS-ResourceSetId*=2 for Panel-2.

[0076] The network entity may configure the UE by single-DCI (s-DCI) or multi-DCI (m-DCI) with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. Then, the UE determines per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ and per-UE $P_{\text{CMAX},f,c}$ derived from $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ by following the emission requirements. If the network entity checks that {TCI#1,TCI#2} is not in Tx-overlapping-beam-group#1 or Tx-overlapping-beam-group#2 and the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity determines per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ which are acquired by equal-splitting per-UE $P_{\text{CMAX},f,c}$. If the network entity checks that {TCI#1,TCI#2} is not in Tx-overlapping-beam-group#1 or Tx-overlapping-beam-group#2 and the UE reports per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission by applying per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$.

[0077] If the network entity checks that {TCI#1,TCI#2} is in Tx-overlapping-beam-group#1 or Tx-overlapping-beam-group#2 and the UE reports per-UE $P_{\text{CMAX},f,c}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission by applying $P_{\text{CMAX},f,c,k=0} = P_{\text{CMAX},f,c} - 1$ (dB) and $P_{\text{CMAX},f,c,k=1} = P_{\text{CMAX},f,c} - 2$ (dB), where (X1=1,X2=2) can be the relaxation value (X1'=1,X2'=2) (dB) in STxMP-overlapping-capability or (X1=1,X2=2) is

determined by the network entity. In one implementation, the relaxation value can be reported as one value $X'=1+2=3$ (dB) in STxMP-overlapping-capability, and the network can determine $X1=1$ (dB) and $X2=2$ (dB) by following the equation $X'=X1+X2$ (dB).

[0078] In one example, the network can determine $X1$ from $0 < X1 \leq 1$ and $X2$ from $0 < X2 \leq 2$. If the network entity checks that $\{TCI\#1, TCI\#2\}$ is in Tx-overlapping-beam-group#1 or Tx-overlapping-beam-group#2 and the UE reports per-panel $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ in the PHR, the network entity may determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission by applying $P_{CMAX,f,c,k=0} - 1$ (dB) and $P_{CMAX,f,c,k=1} - 2$ (dB), where $(X1=1, X2=2)$ can be the relaxation value $(X1'=1, X2'=2)$ (dB) in STxMP-overlapping-capability or $(X1=1, X2=2)$ is determined by the network entity. In one implementation, the relaxation value can be reported as one value $X'=1+2=3$ (dB) in STxMP-overlapping-capability, and the network can determine $X1=1$ (dB) and $X2=2$ (dB) by following the equation $X'=X1+X2$ (dB). In one example, the network can determine $X1$ from $0 < X1 \leq 1$ and $X2$ from $0 < X2 \leq 2$.

[0079] In some implementation, the network can determine whether the UE is in STxMP overlapping transmission by sequentially measuring Tx power for UL transmission with each panel and simultaneous UL transmission with multi panels.

[0080] In one example, assuming the UE equipped with two panels, the network first measure Tx_power#1 by configured UL transmission for only Panel-1 with UL TCI#1 (with associated SRS) or SRI#1. The network second measure Tx_power#2 by configured UL transmission for only Panel-2 with UL TCI#2 (with associated SRS) or SRI#2. Then, the UE measures Tx_power#3 by configured simultaneous UL transmission for Panel-1 and Panel-2 with both TCI#1 (or SRI#1) and TCI#2 (or SRI#2). Hence, the network can check whether the condition $Tx_power\#3 > \max(Tx_power\#1, Tx_power\#2)$ is met or not. If the condition is met, the network can determine TCI#1 (or SRI#1) and TCI#2 (or SRI#2) has overlapping transmission in TxMP. In some implementations, the measured Tx_power can be UL PUSCH power and/or UL SRS power.

[0081] FIG. 3 illustrates an example of a procedure 300 for uplink power determination and allocation in STxMP between a UE and a network entity, in accordance with aspects of this disclosure. Compared to the procedure 200 of FIG. 2, the UE 102 does not, in the procedure 300, initially provide UE capability information regarding

STxMP overlapping to the network entity 104. The procedure 300 starts when the network entity transmits 206 a configuration message for STxMP transmission to the UE 102.

[0082] The UE 102 then determines 304 whether active UL beams are overlapping by overlapping beam coverage. If or when the active UL beams are overlapping, the UE 102 applies 306 relaxation values to power reduction parameters for each of the multiple antenna panels. In some aspects, the UE 102 may modify or adjust the parameters based on the relaxation values. The UE 102 further determines 308 the maximum transmission power across the multiple panels for the UE 102 (per-UE) or for each of the multiple antenna panels (per-panel).

[0083] The UE 102 reports 310 the power parameters in a power headroom report (PHR) to the network entity 104 (details below). The network entity 104 determines 312 per-panel uplink power allocation for various uplink signals, including PUSCH, PUCCH, PRACH, and SRS, for transmission in STxMP by the UE. The network entity 104 then transmits 314 another configuration message with the updated power allocation to the UE 102.

[0084] In an embodiment, in Figure 3, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE first determines whether the active UL Tx beams among panels is overlapping by checking the overlapping beam coverage is larger than X-percent. If or when the UE verifies that active UL Tx beams are overlapping, the UE first determine per-panel $MPR_{f,c,k}$, $A-MPR_{f,c,k}$ and $P-MPR_{f,c,k}$ by applying the relaxation values to single-panel $MPR_{f,c}$, $A-MPR_{f,c}$ and $P-MPR_{f,c}$. Then, the UE determines per-panel $P_{CMAX,f,c,k}$ by setting $P_{UMAX,f,c,k}$ and $P_{TMAX,f,c,k}$ to meet the following equation. The UE determines per-UE $P_{CMAX,f,c}$ by setting $S_k P_{UMAX,f,c,k} \leq EIRP_{max}$ and $S_k P_{TMAX,f,c,k} \leq TRP_{max}$. Where one possible implementation for $P_{UMAX,f,c,k}$ could be $P_{CMAX,f,c,k} + \text{UE Tx antenna beam forming gain}$.

$$\begin{aligned} & P_{Powerclass} + DP_{TBE} - \text{MAX}(\text{MAX}(MPR_{f,c,k}, A-MPR_{f,c,k}) + \Delta MB_{P,n}, P-MPR_{f,c,k}) - \\ & \text{MAX}\{\text{T}(\text{MAX}(MPR_{f,c,k}, A-MPR_{f,c,k})), \text{T}(P-MPR_{f,c,k})\} \leq P_{UMAX,f,c,k} \leq EIRP_{max} \\ & P_{TMAX,f,c,k} \leq TRP_{max} \end{aligned}$$

[0085] Then, the UE reports $P_{CMAX,f,c}$ or per-panel $P_{CMAX,f,c,k}$ in the PHR to the network entity. The network entity utilize per-UE $P_{CMAX,f,c}$ or every per-panel $P_{CMAX,f,c,k}$ to determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission.

[0086] In some implementations, assuming the UE equipped with two panels, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If the active UL Tx beams are overlapping, the UE determines $MPR_{f,c,k=0}$, $MPR_{f,c,k=1}$, $A-MPR_{f,c,k=0}$, $A-MPR_{f,c,k=1}$, $P-MPR_{f,c,k=0}$ and $P-MPR_{f,c,k=1}$ by applying the relaxation values $X=X1+X2$ (dB), $Y=Y1+Y2$ (dB), $Z=Z1+Z2$ (dB) to single-panel $MPR_{f,c}$, $A-MPR_{f,c}$ and $P-MPR_{f,c}$, where $MPR_{f,c,k=0} = MPR_{f,c} + X1$ (dB), $MPR_{f,c,k=1} = MPR_{f,c} + X2$ (dB), $A-MPR_{f,c,k=0} = A-MPR_{f,c} + X1$ (dB), $A-MPR_{f,c,k=1} = A-MPR_{f,c} + X2$ (dB), $P-MPR_{f,c,k=0} = P-MPR_{f,c} + X1$ (dB), and $P-MPR_{f,c,k=1} = P-MPR_{f,c} + X2$ (dB). Then, the UE determines $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ by setting $P_{UMAX,f,c,k=0}$, $P_{UMAX,f,c,k=1}$ and $P_{TMAX,f,c,k=0}$, $P_{TMAX,f,c,k=1}$ to meet the above equation. The UE determines per-UE $P_{CMAX,f,c}$ by setting $P_{UMAX,f,c,k=0} + P_{UMAX,f,c,k=1} \leq EIRP_{max}$ and $P_{TMAX,f,c,k=0} + P_{TMAX,f,c,k=1} \leq TRP_{max}$. Then, the UE reports $P_{CMAX,f,c}$ or per-panel $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ in the PHR to the network entity. The network entity utilize per-UE $P_{CMAX,f,c}$ or every per-panel per-panel $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ to determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission.

[0087] In one example, assuming the UE equipped with two panels, the network entity may configure the UE by single-DCI (s-DCI) or multi-DCI (m-DCI) with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than 85-percent. If the active UL Tx beams are overlapping, the UE determines $MPR_{f,c,k=0}$, $MPR_{f,c,k=1}$, $A-MPR_{f,c,k=0}$, $A-MPR_{f,c,k=1}$, $P-MPR_{f,c,k=0}$ and $P-MPR_{f,c,k=1}$ by applying the relaxation values $X=1+2$ (dB), $Y=1+2$ (dB), $Z=1+2$ (dB) to single-panel $MPR_{f,c}$, $A-MPR_{f,c}$ and $P-MPR_{f,c}$, where $MPR_{f,c,k=0} = MPR_{f,c} + 1$ (dB), $MPR_{f,c,k=1} = MPR_{f,c} + 2$ (dB), $A-MPR_{f,c,k=0} = A-MPR_{f,c} + 1$ (dB), $A-MPR_{f,c,k=1} = A-MPR_{f,c} + 2$ (dB), $P-MPR_{f,c,k=0} = P-MPR_{f,c} + 1$ (dB), and $P-MPR_{f,c,k=1} = P-MPR_{f,c} + 2$ (dB). Then, the UE determines $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ by setting $P_{UMAX,f,c,k=0}$, $P_{UMAX,f,c,k=1}$ and $P_{TMAX,f,c,k=0}$, $P_{TMAX,f,c,k=1}$ to meet the above equation. The UE determines per-UE $P_{CMAX,f,c}$ by setting $P_{UMAX,f,c,k=0} + P_{UMAX,f,c,k=1} \leq EIRP_{max}=55$ dBm (Power Class 1) and $P_{TMAX,f,c,k=0} + P_{TMAX,f,c,k=1} \leq TRP_{max} = 35$ dBm (Power Class 1). Then, the UE reports $P_{CMAX,f,c}$ or per-panel $P_{CMAX,f,c,k=0}$ and

$P_{\text{CMAX},f,c,k=1}$ in the PHR to the network entity. The network entity utilize per-UE $P_{\text{CMAX},f,c}$ or every per-panel per-panel $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ to determine per-panel UL power allocation for PUSCH transmission. In other example, the same procedure for per-panel power allocation can be applied to PUCCH, PRACH and/or SRS transmission.

[0088] In an embodiment, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE first determines whether the active UL Tx beams among panels is overlapping by checking the overlapping beam coverage is larger than X-percent. If or when the UE verifies that there is no overlapped active UL Tx beams, the UE first determine per-panel $\text{MPR}_{f,c,k}$, $\text{A-MPR}_{f,c,k}$ and $\text{P-MPR}_{f,c,k}$ by applying single-panel $\text{MPR}_{f,c}$, $\text{A-MPR}_{f,c}$ and $\text{P-MPR}_{f,c}$. Then, the UE determines per-panel $P_{\text{CMAX},f,c,k}$ by setting $P_{\text{UMAX},f,c,k}$ and $P_{\text{TMAX},f,c,k}$ to meet the following equation. The UE determines per-UE $P_{\text{CMAX},f,c}$ by setting $S_k P_{\text{UMAX},f,c,k} \in \text{EIRP}_{\text{max}}$ or $\max(P_{\text{UMAX},f,c,k=0}, P_{\text{UMAX},f,c,k=1}, \dots) \in \text{EIRP}_{\text{max}}$ and $S_k P_{\text{TMAX},f,c,k} \in \text{TRP}_{\text{max}}$. Where one possible implementation for $P_{\text{UMAX},f,c,k}$ could be $P_{\text{CMAX},f,c,k} + \text{UE Tx antenna beam forming gain}$.

$$\begin{aligned} & P_{\text{Powerclass}} + \text{DP}_{\text{IBE}} - \text{MAX}(\text{MAX}(\text{MPR}_{f,c,k} \text{ A- } \text{MPR}_{f,c,k}) + \Delta \text{MB}_{\text{P},n}, \text{P-MPR}_{f,c,k}) - \\ & \text{MAX}\{\text{T}(\text{MAX}(\text{MPR}_{f,c,k}, \text{A- } \text{MPR}_{f,c,k})), \text{T}(\text{P-MPR}_{f,c,k})\} \leq P_{\text{UMAX},f,c,k} \leq \text{EIRP}_{\text{max}} \\ & P_{\text{TMAX},f,c,k} \leq \text{TRP}_{\text{max}} \end{aligned}$$

[0089] Then, the UE reports $P_{\text{CMAX},f,c}$ or per-panel $P_{\text{CMAX},f,c,k}$ in the PHR to the network entity. The network entity utilize per-UE $P_{\text{CMAX},f,c}$ or every per-panel $P_{\text{CMAX},f,c,k}$ to determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission.

[0090] In some implementations, assuming the UE equipped with two panels, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If there is **no** overlapped active UL Tx beams, the UE determines $\text{MPR}_{f,c,k=0}$, $\text{MPR}_{f,c,k=1}$, $\text{A-MPR}_{f,c,k=0}$, $\text{A-MPR}_{f,c,k=1}$, $\text{P-MPR}_{f,c,k=0}$ and $\text{P-MPR}_{f,c,k=1}$ by applying single-panel $\text{MPR}_{f,c}$, $\text{A-MPR}_{f,c}$ and $\text{P-MPR}_{f,c}$, where $\text{MPR}_{f,c,k=0} = \text{MPR}_{f,c}$, $\text{MPR}_{f,c,k=1} = \text{MPR}_{f,c}$, $\text{A-MPR}_{f,c,k=0} = \text{A-MPR}_{f,c}$, $\text{A-MPR}_{f,c,k=1} = \text{A-MPR}_{f,c}$, $\text{P-MPR}_{f,c,k=0} = \text{P-MPR}_{f,c}$, and $\text{P-MPR}_{f,c,k=1} = \text{P-MPR}_{f,c}$. Then, the UE determines $P_{\text{CMAX},f,c,k=0}$ and $P_{\text{CMAX},f,c,k=1}$ by setting $P_{\text{UMAX},f,c,k=0}$, $P_{\text{UMAX},f,c,k=1}$ and $P_{\text{TMAX},f,c,k=0}$, $P_{\text{TMAX},f,c,k=1}$ to meet the above equation. The UE determines per-UE $P_{\text{CMAX},f,c}$ by setting $P_{\text{UMAX},f,c,k=0} +$

$P_{UMAX,f,c,k=1} \in EIRP_{max}$ and $P_{TMAX,f,c,k=0} + P_{TMAX,f,c,k=1} \in TRP_{max}$. Then, the UE reports $P_{CMAX,f,c}$ or per-panel $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ in the PHR to the network entity. The network entity utilize per-UE $P_{CMAX,f,c}$ or every per-panel per-panel $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ to determine per-panel UL power allocation for PUSCH, PUCCH, PRACH and/or SRS transmission.

[0091] In one example, assuming the UE equipped with two panels, the network entity may configure the UE by single-DCI or multi-DCI with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. The UE first determine whether TCI#1 and TCI#2 are overlapping by checking the overlapping beam coverage is larger than 85-percent. If there is **no** overlapped active UL Tx beams, the UE determines $MPR_{f,c,k=0}$, $MPR_{f,c,k=1}$, $A-MPR_{f,c,k=0}$, $A-MPR_{f,c,k=1}$, $P-MPR_{f,c,k=0}$ and $P-MPR_{f,c,k=1}$ by applying single-panel $MPR_{f,c}$, $A-MPR_{f,c}$ and $P-MPR_{f,c}$, where $MPR_{f,c,k=0} = MPR_{f,c}$, $MPR_{f,c,k=1} = MPR_{f,c}$, $A-MPR_{f,c,k=0} = A-MPR_{f,c}$, $A-MPR_{f,c,k=1} = A-MPR_{f,c}$, $P-MPR_{f,c,k=0} = P-MPR_{f,c}$, and $P-MPR_{f,c,k=1} = P-MPR_{f,c}$. Then, the UE determines $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ by setting $P_{UMAX,f,c,k=0}$, $P_{UMAX,f,c,k=1}$ and $P_{TMAX,f,c,k=0}$, $P_{TMAX,f,c,k=1}$ to meet the above equation. The UE determines per-UE $P_{CMAX,f,c}$ by setting $P_{UMAX,f,c,k=0} + P_{UMAX,f,c,k=1} \in EIRP_{max} = 55$ dBm (Power Class 1) and $P_{TMAX,f,c,k=0} + P_{TMAX,f,c,k=1} \in TRP_{max} = 35$ dBm (Power Class 1). Then, the UE reports $P_{CMAX,f,c}$ or per-panel $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ in the PHR to the network entity. The network entity may utilize per-UE $P_{CMAX,f,c}$ or every per-panel $P_{CMAX,f,c,k=0}$ and $P_{CMAX,f,c,k=1}$ to determine per-panel UL power allocation for PUSCH transmission. In other example, the same procedure for per-panel power allocation can be applied to PUCCH, PRACH and/or SRS transmission.

[0092] In an embodiment, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE determine per-panel $MPR_{f,c,k}$ by applying the relaxation value to single-panel $MPR_{f,c}$. The UE should follow emission requirement and determines the relaxation value for STxMP according to RB allocations, modulation order, waveform type.

[0093] In some implementations, assuming the UE equipped with two panels, the network entity configures simultaneous UL transmission with multi-panel by single-DCI to the UE. The UE determines $MPR_{f,c,k=0}$ and $MPR_{f,c,k=1}$ by applying the relaxation value $X = X1 + X2$ (dB) to single-panel $MPR_{f,c}$, where $MPR_{f,c,k=0} = MPR_{f,c} + X1$ (dB), $MPR_{f,c,k=1} = MPR_{f,c} + X2$ (dB). The UE determines X (dB) and $(X1, X2)$

(dB) according to at least one of the factors: RB allocations in the scheduled single-DCI; modulation order in the scheduled single-DCI; waveform type for the scheduled channels.

[0094] In one example, assuming the UE equipped with two panels, the network entity may configure the UE by single-DCI with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. The UE determines $MPR_{f,c,k=0}$ and $MPR_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2=3$ (dB) to single-panel $MPR_{f,c}$, where $MPR_{f,c,k=0} = MPR_{f,c} + 1$ (dB) and $MPR_{f,c,k=1} = MPR_{f,c} + 2$ (dB). The UE determines $X=3$ (dB) and $(X_1, X_2)=(1,2)$ (dB) according to the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping) in the scheduled single-DCI, modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) in the scheduled single-DCI and waveform type (e.g., DFT-s-OFDM) for the scheduled channels.

[0095] In some implementations, assuming the UE equipped with two panels, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI to the UE. The UE determines $MPR_{f,c,k=0}$ and $MPR_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel $MPR_{f,c}$, where $MPR_{f,c,k=0} = MPR_{f,c} + X_1$ (dB), $MPR_{f,c,k=1} = MPR_{f,c} + X_2$ (dB). The UE determines $X=3$ (dB) and $(X_1, X_2)=(1,2)$ (dB) according to at least one of the factors: allocated RB allocations for at least one of the scheduled channels, modulation order for at least one of the scheduled channels; waveform type for at least one of the scheduled channels.

[0096] In one example, assuming the UE equipped with two panels, the network entity may configure the UE by multi-DCI with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. The UE determines $MPR_{f,c,k=0}$ and $MPR_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel $MPR_{f,c}$, where $MPR_{f,c,k=0} = MPR_{f,c} + X_1$ (dB) and $MPR_{f,c,k=1} = MPR_{f,c} + X_2$ (dB). The UE determines $X=3$ (dB) and $(X_1, X_2)=(1,2)$ (dB) according to the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping) in the scheduled multi-DCI, modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) in the scheduled multi-DCI and waveform type (e.g., DFT-s-OFDM) for the scheduled channels, or $X=5$ (dB) and $(X_1, X_2)=(2,3)$ (dB) with the non-overlapping RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2 are non-overlapping) in the scheduled multi-DCI, different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) in the scheduled multi-DCI, and waveform type (e.g., DFT-s-

OFDM), or $X=7$ (dB) and $(X1,X2)=(3,4)$ (dB) with the partial-overlapping RB allocations (e.g., 75RB for Panel-1 and 100RB for Panel-2 are partial-overlapping) in the scheduled multi-DCI, different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) in the scheduled multi-DCI, and waveform type (e.g., DFT-s-OFDM) for the scheduled channels.

[0097] In some implementations, the UE can directly determine per-panel $MPR_{f,c,k}$ for overlapping transmission in STxMP by single-DCI or multi-DCI configuration with the same RB allocations, modulation order and waveform type, or by multi-DCI configuration with different RB allocations, modulation order and waveform type.

[0098] In some implementations, the UE can directly determine per-UE MPR_{STxMP} for overlapping transmission in STxMP by single-DCI or multi-DCI configuration with the same RB allocations, modulation order and waveform type, or by multi-DCI configuration with different RB allocations, modulation order and waveform type.

[0099] In an embodiment, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE determine per-panel $MPR_{f,c,k}$ by applying the rule of single-panel $MPR_{f,c}$ according to at least one of the factors: RB allocations, modulation order, and waveform type.

[00100] In some implementations, assuming the UE equipped with two panels, the network entity configures simultaneous UL transmission with multi-panel by single-DCI or multi-DCI to the UE. The UE determines $MPR_{f,c,k=0} = MPR_{f,c}$ and $MPR_{f,c,k=1} = MPR_{f,c}$ according to single-DCI or multi-DCI with the same RB allocations, modulation order and waveform type, or according to X-percent overlapping beam coverage and multi-DCI with the different RB allocations, modulation order and waveform type.

[00101] In one example, assuming the UE equipped with two panels, the network entity may configure the UE by single-DCI or multi-DCI with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. The UE determines $MPR_{f,c,k=0} = 2$ (dB) and $MPR_{f,c,k=1} = 2$ (dB) according to single-DCI or multi-DCI with the same RB allocations (e.g., 50RB for Panel-1 and 50RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) and waveform type (e.g., DFT-s-OFDM), or determines $MPR_{f,c,k=0} = 2$ (dB) and $MPR_{f,c,k=1} = 4$ (dB) according to multi-DCI with the different RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) and waveform type (e.g., DFT-s-OFDM).

[00102] In an embodiment, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE first determines whether the active UL Tx beams among panels is overlapping by checking the overlapping beam coverage is larger than X-percent. If or when the UE verifies that active UL Tx beams are overlapping, the UE determine per-panel $\text{MPR}_{f,c,k}$ by applying the relaxation value to the rule of single-panel $\text{MPR}_{f,c}$. The UE should follow emission requirement and determines the relaxation value for STxMP according to RB allocations, modulation order, waveform type, and overlapping beam coverage. If or when the UE verifies that active UL Tx beams are not overlapping, the UE determine per-panel $\text{MPR}_{f,c,k}$ by applying the rule of single-panel $\text{MPR}_{f,c}$ according to RB allocations, modulation order, waveform type, and overlapping beam coverage.

[00103] In some implementations, assuming the UE equipped with two panels, the network entity configures simultaneous UL transmission with multi-panel by single-DCI to the UE. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If the active UL Tx beams are overlapping, the UE determines $\text{MPR}_{f,c,k=0}$ and $\text{MPR}_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-panel $\text{MPR}_{f,c}$, where $\text{MPR}_{f,c,k=0} = \text{MPR}_{f,c} + X1$ (dB) and $\text{MPR}_{f,c,k=1} = \text{MPR}_{f,c} + X2$ (dB). The UE determines X (dB) and $(X1, X2)$ (dB) according to X-percent overlapping beam coverage and single-DCI with the same RB allocations, modulation order and waveform type for each panel.

[00104] In one example, assuming the UE equipped with two panels, the network entity may configure the UE by single-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. The UE first determine whether UL TCI#1 and UL TCI#2 are overlapping by checking the overlapping beam coverage is larger than 85-percent. If the active UL Tx beams are overlapping, the UE determines $\text{MPR}_{f,c,k=0}$ and $\text{MPR}_{f,c,k=1}$ by applying the relaxation value $X=X1+X2=3$ (dB) to single-panel $\text{MPR}_{f,c}$, where $\text{MPR}_{f,c,k=0} = \text{MPR}_{f,c} + 1$ (dB) and $\text{MPR}_{f,c,k=1} = \text{MPR}_{f,c} + 2$ (dB). The UE determines $X=3$ (dB) and $(X1, X2)=(1,2)$ (dB) according to X-percent overlapping beam coverage and single-DCI with the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) and waveform type (e.g., DFT-s-OFDM).

[00105] In some implementations, assuming the UE equipped with two panels, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI to the UE. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If the active UL Tx beams are overlapping, the UE determines $\text{MPR}_{f,c,k=0}$ and $\text{MPR}_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel $\text{MPR}_{f,c}$, where $\text{MPR}_{f,c,k=0} = \text{MPR}_{f,c} + X_1$ (dB) and $\text{MPR}_{f,c,k=1} = \text{MPR}_{f,c} + X_2$ (dB). The UE determines $X=3$ (dB) and $(X_1, X_2)=(1,2)$ (dB) according to X-percent overlapping beam coverage and multi-DCI with the same or different RB allocations, modulation order and waveform type for each panel.

[00106] In one example, assuming the UE equipped with two panels, the network entity may configure the UE by multi-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. The UE first determine whether UL TCI#1 and UL TCI#2 are overlapping by checking the overlapping beam coverage is larger than 85-percent. If the active UL Tx beams are overlapping, the UE determines $\text{MPR}_{f,c,k=0}$ and $\text{MPR}_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel $\text{MPR}_{f,c}$, where $\text{MPR}_{f,c,k=0} = \text{MPR}_{f,c} + X_1$ (dB) and $\text{MPR}_{f,c,k=1} = \text{MPR}_{f,c} + X_2$ (dB). The UE determines $X=3$ (dB) and $(X_1,X_2)=(1,2)$ (dB) according to X-percent overlapping beam coverage and multi-DCI with the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) and waveform type (e.g., DFT-s-OFDM), or $X=5$ (dB) and $(X_1,X_2)=(2,3)$ (dB) with the non-overlapping RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2 are non-overlapping), different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2), and waveform type (e.g., DFT-s-OFDM), or $X=7$ (dB) and $(X_1,X_2)=(3,4)$ (dB) with the partial-overlapping RB allocations (e.g., 75RB for Panel-1 and 100RB for Panel-2 are partial-overlapping), different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2), and waveform type (e.g., DFT-s-OFDM).

[00107] In some implementations, assuming the UE equipped with two panels, the network entity configures simultaneous UL transmission with multi-panel by single-DCI or multi-DCI to the UE. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If the active UL Tx beams are not overlapping, the UE determines $\text{MPR}_{f,c,k=0} = \text{MPR}_{f,c}$ and $\text{MPR}_{f,c,k=1} = \text{MPR}_{f,c}$ according to single-DCI or multi-DCI

with the same RB allocations, modulation order and waveform type, or according to X-percent overlapping beam coverage and multi-DCI with the different RB allocations, modulation order and waveform type.

[00108] In one example, assuming the UE equipped with two panels, the network entity may configure the UE by single-DCI or multi-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. The UE first determine whether UL TCI#1 and UL TCI#2 are overlapping by checking the overlapping beam coverage is larger than 85-percent. If the active UL Tx beams are not overlapping, the UE determines $\text{MPR}_{f,c,k=0} = 2$ (dB) and $\text{MPR}_{f,c,k=1} = 2$ (dB) according to X-percent overlapping beam coverage and single-DCI or multi-DCI with the same RB allocations (e.g., 50RB for Panel-1 and 50RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) and waveform type (e.g., DFT-s-OFDM), or determines $\text{MPR}_{f,c,k=0} = 2$ (dB) and $\text{MPR}_{f,c,k=1} = 4$ (dB) according to X-percent overlapping beam coverage and multi-DCI with the different RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) and waveform type (e.g., DFT-s-OFDM).

[00109] In an embodiment, the network first broadcasts a network signaling (NS) value associated with an operating band indicated in RRC signaling to the UE. Then, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE determine per-panel A-MPR_{f,c,k} by applying the relaxation value to single-panel A-MPR_{f,c}. The UE should follow the additional emission requirement for the NS value with the associated operating band and determines the relaxation value for STxMP according to at least one of the factors: RB allocations, modulation order, waveform type, and the additional emission requirement.

[00110] In some implementations, assuming the UE equipped with two panels, the network first broadcasts a NS value associated with an operating band indicated in RRC signaling to the UE. Then, the network entity configures simultaneous UL transmission with multi-panel by single-DCI to the UE. The UE determines A-MPR_{f,c,k=0} and A-MPR_{f,c,k=1} by applying the relaxation value $X=X1+X2$ (dB) to single-panel A-MPR_{f,c}, where $\text{A-MPR}_{f,c,k=0} = \text{A-MPR}_{f,c} + X1$ (dB) and $\text{A-MPR}_{f,c,k=1} = \text{A-MPR}_{f,c} + X2$ (dB). The UE determines X (dB) and (X1,X2) (dB) according to at least one of the factors: RB allocations in the scheduled single-DCI, modulation order

in the scheduled single-DCI, waveform type for the scheduled channels and the additional emission requirement.

[00111] In one example, assuming the UE equipped with two panels, the network first broadcasts NS_202 value associated with band n257 indicated in RRC signaling to the UE. Then, the network entity may configure the UE by single-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. The UE determines $A-MPR_{f,c,k=0}$ and $A-MPR_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-panel $A-MPR_{f,c}$, where $A-MPR_{f,c,k=0} = A-MPR_{f,c}$ (11 for Power Class1) + $X1$ (dB) and $A-MPR_{f,c,k=1} = A-MPR_{f,c}$ (11 for Power Class1) + $X2$ (dB). The UE determines $X=5$ (dB) and $(X1,X2)=(2,3)$ (dB) according to the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping) in the scheduled single-DCI, modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) in the scheduled single-DCI, waveform type (e.g., DFT-s-OFDM) for the scheduled channel and the additional emission requirement for NS_202 associated with n257.

[00112] In some implementations, assuming the UE equipped with two panels, the network first broadcasts a NS value associated with an operating band indicated in RRC signaling to the UE. Then, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI to the UE. The UE determines $A-MPR_{f,c,k=0}$ and $A-MPR_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-panel $A-MPR_{f,c}$, where $A-MPR_{f,c,k=0} = A-MPR_{f,c} + X1$ (dB) and $A-MPR_{f,c,k=1} = A-MPR_{f,c} + X2$ (dB). The UE determines X (dB) and $(X1,X2)$ (dB) according to at least one of the factors: allocated RB allocations for at least one of the scheduled channels, modulation order for at least one of the scheduled channels; waveform type for at least one of the scheduled channels and the additional emission requirement.

[00113] In one example, assuming the UE equipped with two panels, the network first broadcasts NS_202 value associated with band n257 indicated in RRC signaling to the UE. Then, the network entity configures the UE by multi-DCI with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. The UE determines $A-MPR_{f,c,k=0}$ and $A-MPR_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-panel $A-MPR_{f,c}$, where $A-MPR_{f,c,k=0} = A-MPR_{f,c}$ (11 for Power Class1) + $X1$ (dB) and $A-MPR_{f,c,k=1} = A-MPR_{f,c}$ (11 for Power Class1) + $X2$ (dB). The UE determines $X=3$ (dB) and $(X1,X2)=(1,2)$ (dB) according to the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping) in the scheduled

multi-DCI, modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) in the scheduled multi-DCI, waveform type (e.g., DFT-s-OFDM) for the scheduled channels and the additional emission requirement NS_202 with n257, or X=5 (dB) and (X1,X2)=(2,3) (dB) with the non-overlapping RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2 are non-overlapping) in the scheduled multi-DCI, different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) in the scheduled multi-DCI, waveform type (e.g., DFT-s-OFDM) for the scheduled channels and the additional emission requirement NS_202 with n257, or X=7 (dB) and (X1,X2)=(3,4) (dB) with the partial-overlapping RB allocations (e.g., 75RB for Panel-1 and 100RB for Panel-2 are partial-overlapping) in the scheduled multi-DCI, different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) in the scheduled multi-DCI, waveform type (e.g., DFT-s-OFDM) for the scheduled channels and the additional emission requirement NS_202 with n257.

[00114] In some implementations, the UE can directly determine per-panel A-MPR_{f,c,k} for overlapping transmission in STxMP by single-DCI or multi-DCI configuration with the same RB allocations, modulation order and waveform type, or by multi-DCI configuration with different RB allocations, modulation order and waveform type.

[00115] In some implementations, the UE can directly determine per-UE A-MPR_{STxMP} for overlapping transmission in STxMP by single-DCI or multi-DCI configuration with the same RB allocations, modulation order and waveform type, or by multi-DCI configuration with different RB allocations, modulation order and waveform type.

[00116] In an embodiment, the network first broadcasts a network signaling (NS) value associated with an operating band indicated in RRC signaling to the UE. Then, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE determine per-panel A-MPR_{f,c,k} applying the rule of single-panel A-MPR_{f,c} according to at least one of the factors: RB allocations, modulation order, waveform type, and the additional emission requirement.

[00117] In some implementations, assuming the UE equipped with two panels, the network first broadcasts a NS value associated with an operating band indicated in RRC signaling to the UE. The UE determines A-MPR_{f,c,k=0} = A-MPR_{f,c} and A-MPR_{f,c,k=1} = A-MPR_{f,c} according to at least one of the factors: single-DCI or multi-DCI with the same RB allocations, modulation order, waveform type and the additional emission requirement, or according to at least one of the factors: multi-

DCI with the different RB allocations, modulation order, waveform type and the additional emission requirement.

[00118] In one example, assuming the UE equipped with two panels, the network first broadcasts NS_202 value associated with band n257 indicated in RRC signaling to the UE. Then, the network entity configures the UE by multi-DCI with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. The UE determines $A-MPR_{f,c,k=0} = 11$ (dB) and $A-MPR_{f,c,k=l} = 11$ (dB) according to 85-percent overlapping beam coverage and single-DCI or multi-DCI with the same RB allocations (e.g., 50RB for Panel-1 and 50RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2), waveform type (e.g., DFT-s-OFDM), and the additional emission requirement NS_202 with n257 or determines $A-MPR_{f,c,k=0} = 13$ (dB) and $A-MPR_{f,c,k=l} = 15$ (dB) according to 85-percent overlapping beam coverage and multi-DCI with the different RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2), waveform type (e.g., DFT-s-OFDM), and the additional emission requirement NS_202 with n257.

[00119] In an embodiment, the network first broadcasts a network signaling (NS) value associated with an operating band indicated in RRC signaling to the UE. Then, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. The UE first determines whether the active UL Tx beams among panels is overlapping by checking the overlapping beam coverage is larger than X-percent. If or when the UE verifies that active UL Tx beams are overlapping, the UE determine per-panel $A-MPR_{f,c,k}$ by applying the relaxation value to single-panel $A-MPR_{f,c}$. The UE should follow the additional emission requirement for the NS value with the associated operating band and determines the relaxation value for STxMP according to RB allocations, modulation order, waveform type, overlapping beam coverage, and the additional emission requirement. If or when the UE verifies that active UL Tx beams are not overlapping, the UE determine per-panel $A-MPR_{f,c,k}$ applying the rule of single-panel $A-MPR_{f,c}$ according to RB allocations, modulation order, waveform type, overlapping beam coverage, and the additional emission requirement.

[00120] In some implementations, assuming the UE equipped with two panels, the network first broadcasts a NS value associated with an operating band indicated in RRC signaling to the UE. Then, the network entity configures simultaneous UL

transmission with multi-panel by single-DCI to the UE. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If the active UL Tx beams are overlapping, the UE determines $A-MPR_{f,c,k=0}$ and $A-MPR_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-panel $A-MPR_{f,c}$, where $A-MPR_{f,c,k=0} = A-MPR_{f,c} + X1$ (dB) and $A-MPR_{f,c,k=1} = A-MPR_{f,c} + X2$ (dB). The UE determines X (dB) and (X1,X2) (dB) according to X-percent overlapping beam coverage and single-DCI with the same RB allocations, modulation order, waveform type and the additional emission requirement for each panel.

[00121] In one example, assuming the UE equipped with two panels, the network first broadcasts NS_202 value associated with band n257 indicated in RRC signaling to the UE. Then, the network entity may configure the UE by single-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. The UE first determine whether UL TCI#1 and UL TCI#2 are overlapping by checking the overlapping beam coverage is larger than 85-percent. If the active UL Tx beams are overlapping, the UE determines $A-MPR_{f,c,k=0}$ and $A-MPR_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-panel $A-MPR_{f,c}$, where $A-MPR_{f,c,k=0} = A-MPR_{f,c} (11 \text{ for Power Class1}) + X1$ (dB) and $A-MPR_{f,c,k=1} = A-MPR_{f,c} (11 \text{ for Power Class1}) + X2$ (dB). The UE determines $X=5$ (dB) and $(X1,X2)=(2,3)$ (dB) according to 85-percent overlapping beam coverage and single-DCI with the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2), waveform type (e.g., DFT-s-OFDM) and the additional emission requirement for NS_202 associated with n257.

[00122] In some implementations, assuming the UE equipped with two panels, the network first broadcasts a NS value associated with an operating band indicated in RRC signaling to the UE. Then, the network entity configures simultaneous UL transmission with multi-panel by multi-DCI to the UE. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If the active UL Tx beams are overlapping, the UE determines $A-MPR_{f,c,k=0}$ and $A-MPR_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-panel $A-MPR_{f,c}$, where $A-MPR_{f,c,k=0} = A-MPR_{f,c} + X1$ (dB) and $A-MPR_{f,c,k=1} = A-MPR_{f,c} + X2$ (dB). The UE determines X (dB) and (X1,X2) (dB) according to X-percent overlapping beam coverage and multi-DCI

with the same or different RB allocations, modulation order, waveform type and the additional emission requirement for each panel.

[00123] In one example, assuming the UE equipped with two panels, the network first broadcasts NS_202 value associated with band n257 indicated in RRC signaling to the UE. Then, the network entity configures the UE by multi-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. The UE first determine whether UL TCI#1 and UL TCI#2 are overlapping by checking the overlapping beam coverage is larger than 85-percent. If the active UL Tx beams are overlapping, the UE determines $A-MPR_{f,c,k=0}$ and $A-MPR_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel $A-MPR_{f,c}$, where $A-MPR_{f,c,k=0} = A-MPR_{f,c}$ (11 for Power Class1) + X_1 (dB) and $A-MPR_{f,c,k=1} = A-MPR_{f,c}$ (11 for Power Class1) + X_2 (dB). The UE determines $X=3$ (dB) and $(X_1,X_2)=(1,2)$ (dB) according to 85-percent overlapping beam coverage and multi-DCI with the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2), waveform type (e.g., DFT-s-OFDM) and the additional emission requirement NS_202 with n257, or $X=5$ (dB) and $(X_1,X_2)=(2,3)$ (dB) with the non-overlapping RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2 are non-overlapping), different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2), waveform type (e.g., DFT-s-OFDM) and the additional emission requirement NS_202 with n257, or $X=7$ (dB) and $(X_1,X_2)=(3,4)$ (dB) with the partial-overlapping RB allocations (e.g., 75RB for Panel-1 and 100RB for Panel-2 are partial-overlapping), different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2), waveform type (e.g., DFT-s-OFDM) and the additional emission requirement NS_202 with n257.

[00124] In some implementations, assuming the UE equipped with two panels, the network first broadcasts a NS value associated with an operating band indicated in RRC signaling to the UE. Then, the network entity configures simultaneous UL transmission with multi-panel by single-DCI or multi-DCI to the UE. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If the active UL Tx beams are not overlapping, the UE determines $A-MPR_{f,c,k=0} = A-MPR_{f,c}$ and $A-MPR_{f,c,k=1} = A-MPR_{f,c}$ according to single-DCI or multi-DCI with the same RB allocations, modulation order, waveform type and the additional emission requirement, or according to X-percent overlapping beam coverage and multi-DCI with the different

RB allocations, modulation order, waveform type and the additional emission requirement.

[00125] In one example, assuming the UE equipped with two panels, the network first broadcasts NS_202 value associated with band n257 indicated in RRC signaling to the UE. Then, the network entity configures the UE by multi-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. The UE first determine whether UL TCI#1 and UL TCI#2 are overlapping by checking the overlapping beam coverage is larger than 85-percent. If the active UL Tx beams are not overlapping, the UE determines $A-MPR_{f,c,k=0} = 11$ (dB) and $A-MPR_{f,c,k=1} = 11$ (dB) according to 85-percent overlapping beam coverage and single-DCI or multi-DCI with the same RB allocations (e.g., 50RB for Panel-1 and 50RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2), waveform type (e.g., DFT-s-OFDM), and the additional emission requirement NS_202 with n257 or determines $A-MPR_{f,c,k=0} = 13$ (dB) and $A-MPR_{f,c,k=1} = 15$ (dB) according to 85-percent overlapping beam coverage and multi-DCI with the different RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2), waveform type (e.g., DFT-s-OFDM), and the additional emission requirement NS_202 with n257.

[00126] In an embodiment, the UE first report *maxUplinkDutyCycle-FR2* in UE capability signaling to the network entity. The network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. Then, the network entity configures the percentage of uplink symbols transmitted within an evaluation period is larger than *maxUplinkDutyCycle-FR2*. The UE determine per-panel $P-MPR_{f,c,k}$ by applying the relaxation value to single-panel $P-MPR_{f,c}$. The UE should follow emission requirement and determine the relaxation value for STxMP according to at least one of the factors: RB allocations, modulation order, and waveform type.

[00127] In some implementations, assuming the UE equipped with two panels, the UE first report *maxUplinkDutyCycle-FR2=Z%* in UE capability signaling to the network entity. The network entity configures simultaneous UL transmission with multi-panel by single-DCI to the UE. Then, the network entity configures the percentage of uplink symbols transmitted within an evaluation period is larger than *maxUplinkDutyCycle-FR2=Z%*. The UE determines $P-MPR_{f,c,k=0}$ and $P-MPR_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel $P-MPR_{f,c}$, where $P-MPR_{f,c,k=0} = P-$

$\text{MPR}_{f,c} + X1$ (dB) and $\text{P-MPR}_{f,c,k=1} = \text{P-MPR}_{f,c} + X2$ (dB). The UE determines X (dB) and $(X1, X2)$ (dB) according to the same RB allocations in the scheduled single-DCI, modulation order in the scheduled single-DCI and waveform type for the scheduled channels.

[00128] In one example, assuming the UE equipped with two panels, the UE first report *maxUplinkDutyCycle-FR2=40%* in UE capability signaling to the network entity. The network entity configures the UE by single-DCI with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. Then, the network entity configures 60% of uplink symbols transmitted within an evaluation period 1 second is larger than *maxUplinkDutyCycle-FR2=40%*. The UE determines $\text{P-MPR}_{f,c,k=0}$ and $\text{P-MPR}_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-panel $\text{P-MPR}_{f,c}$, where $\text{P-MPR}_{f,c,k=0} = \text{P-MPR}_{f,c} + X1$ (dB) and $\text{P-MPR}_{f,c,k=1} = \text{P-MPR}_{f,c} + X2$ (dB). The UE determines $X=5$ (dB) and $(X1, X2)=(2, 3)$ (dB) according to the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping) in the scheduled single-DCI, modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) in the scheduled single-DCI and waveform type (e.g., DFT-s-OFDM) for the scheduled channels.

[00129] In some implementations, assuming the UE equipped with two panels, the UE first report *maxUplinkDutyCycle-FR2=Z%* in UE capability signaling to the network entity. The network entity configures simultaneous UL transmission with multi-panel by multi-DCI to the UE. Then, the network entity configures the percentage of uplink symbols transmitted within an evaluation period is larger than *maxUplinkDutyCycle-FR2=Z%*. The UE determines $\text{P-MPR}_{f,c,k=0}$ and $\text{P-MPR}_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-panel $\text{P-MPR}_{f,c}$, where $\text{P-MPR}_{f,c,k=0} = \text{P-MPR}_{f,c} + X1$ (dB) and $\text{P-MPR}_{f,c,k=1} = \text{P-MPR}_{f,c} + X2$ (dB). The UE determines X (dB) and $(X1, X2)$ (dB) according to at least one of the factors: multi-DCI with the same or different RB allocations, modulation order and waveform type.

[00130] In one example, assuming the UE equipped with two panels, the UE first report *maxUplinkDutyCycle-FR2=40%* in UE capability signaling to the network entity. The network entity configures the UE by multi-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. Then, the network entity configures 60% of uplink symbols transmitted within an evaluation period 1 second is larger than *maxUplinkDutyCycle-FR2=40%*. The UE determines $\text{P-MPR}_{f,c,k=0}$ and $\text{P-MPR}_{f,c,k=1}$ by applying the relaxation value $X=X1+X2$ (dB) to single-

panel $P\text{-MPR}_{f,c}$, where $P\text{-MPR}_{f,c,k=0} = P\text{-MPR}_{f,c} + X1$ (dB) and $P\text{-MPR}_{f,c,k=1} = P\text{-MPR}_{f,c} + X2$ (dB). The UE determines $X=3$ (dB) and $(X1,X2)=(1,2)$ (dB) according to the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping) in the scheduled multi-DCI, modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) in the scheduled multi-DCI and waveform type (e.g., DFT-s-OFDM) for the scheduled channel, or $X=5$ (dB) and $(X1,X2)=(2,3)$ (dB) with the non-overlapping RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2 are non-overlapping) in the scheduled multi-DCI, different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) in the scheduled multi-DCI and waveform type (e.g., DFT-s-OFDM) for the scheduled channel, or $(X1,X2)=(3,4)$ (dB) with the partial-overlapping RB allocations (e.g., 75RB for Panel-1 and 100RB for Panel-2 are partial-overlapping) in the scheduled multi-DCI, different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) in the scheduled multi-DCI and waveform type (e.g., DFT-s-OFDM) for the scheduled channel.

[00131] In some implementations, the UE can directly determine per-panel $P\text{-MPR}_{f,c,k}$ for overlapping transmission in STxMP by single-DCI or multi-DCI configuration with the same RB allocations, modulation order and waveform type, or by multi-DCI configuration with different RB allocations, modulation order and waveform type.

[00132] In some implementations, the UE can directly determine per-UE $P\text{-MPR}_{STxMP}$ for overlapping transmission in STxMP by single-DCI or multi-DCI configuration with the same RB allocations, modulation order and waveform type, or by multi-DCI configuration with different RB allocations, modulation order and waveform type.

[00133] In some implementations, the UE does not report *maxUplinkDutyCycle-FR2* in UE capability signaling to the network entity. The UE determines per-panel UE $P\text{-MPR}_{f,c,k}$ or per-UE $P\text{-MPR}_{STxMP}$ to configure the UE UL power is lower than (the percentage of uplink symbols transmitted within an evaluation period)*(supported power class) in order to ensuring compliance with applicable electromagnetic power density exposure requirements.

[00134] In some implementations, the UE determines per-panel UE $P\text{-MPR}_{f,c,k}$ or per-UE $P\text{-MPR}_{STxMP}$ due to proximity detection and/or unwanted emissions/self-desense requirements in case of simultaneous transmissions on multiple RAT(s) for scenarios not in scope of 3GPP RAN specifications.

- [00135] In some implementations, the UE can perform per-panel $P\text{-MPR}_{f,c,k}$ or $P\text{-MPR}_{STxMP}$ reporting in the PHR which can facilitate the scheduling decision for the network entity.
- [00136] In an embodiment, the UE first report $\text{maxUplinkDutyCycle-FR2}$ in UE capability signaling to the network entity. The network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. Then, the network entity configures the percentage of uplink symbols transmitted within an evaluation period is larger than $\text{maxUplinkDutyCycle-FR2}$. The UE determine per-panel $P\text{-MPR}_{f,c,k}$ applying the rule of single-panel $P\text{-MPR}_{f,c}$ according to RB allocations, modulation order, and waveform type.
- [00137] In some implementations, assuming the UE equipped with two panels, the UE first report $\text{maxUplinkDutyCycle-FR2}=Z\%$ in UE capability signaling to the network entity. The network entity configures simultaneous UL transmission with multi-panel by single-DCI or multi-DCI to the UE. Then, the network entity configures the percentage of uplink symbols transmitted within an evaluation period is larger than $\text{maxUplinkDutyCycle-FR2}=Z\%$. The UE determines $P\text{-MPR}_{f,c,k=0} = P\text{-MPR}_{f,c}$ and $P\text{-MPR}_{f,c,k=1} = P\text{-MPR}_{f,c}$ according to single-DCI or multi-DCI with the same RB allocations, modulation order and waveform type, or according to X-percent overlapping beam coverage and multi-DCI with the different RB allocations, modulation order and waveform type.
- [00138] In one example, assuming the UE equipped with two panels, the UE first report $\text{maxUplinkDutyCycle-FR2}=40\%$ in UE capability signaling to the network entity. The network entity configures the UE by single-DCI or multi-DCI with TCI#1 for Panel-1 PUSCH transmission and TCI#2 for Panel-2 PUSCH transmission. Then, the network entity configures 60% of uplink symbols transmitted within an evaluation period 1 second is larger than $\text{maxUplinkDutyCycle-FR2}=40\%$. The UE determines $P\text{-MPR}_{f,c,k=0} = 3$ (dB) and $P\text{-MPR}_{f,c,k=1} = 3$ (dB) according to single-DCI or multi-DCI with the same RB allocations (e.g., 50RB for Panel-1 and 50RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) and waveform type (e.g., DFT-s-OFDM) or determines $P\text{-MPR}_{f,c,k=0} = 3$ (dB) and $P\text{-MPR}_{f,c,k=1} = 5$ (dB) according to multi-DCI with the different RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) and waveform type (e.g., DFT-s-OFDM).

[00139] In an embodiment, the UE first report *maxUplinkDutyCycle-FR2* in UE capability signaling to the network entity. The network entity configures simultaneous UL transmission with multi-panel by multi-DCI or single-DCI to the UE. Then, the network entity configures the percentage of uplink symbols transmitted within an evaluation period is larger than *maxUplinkDutyCycle-FR2*. The UE first determines whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If or when the UE verifies that active UL Tx beams are overlapping, the UE determine per-panel P-MPR_{f,c,k} by applying the relaxation value to single-panel P-MPR_{f,c}. The UE should follow emission requirement and determine the relaxation value for STxMP according to RB allocations, modulation order, waveform type, and overlapping beam coverage. If or when the UE verifies that active UL Tx beams are not overlapping, the UE determine per-panel P-MPR_{f,c,k} applying the rule of single-panel P-MPR_{f,c} according to at least one of the factors: RB allocations, modulation order, and waveform type.

[00140] In some implementations, assuming the UE equipped with two panels, the UE first report *maxUplinkDutyCycle-FR2=Z%* in UE capability signaling to the network entity. The network entity configures simultaneous UL transmission with multi-panel by single-DCI to the UE. Then, the network entity configures the percentage of uplink symbols transmitted within an evaluation period is larger than *maxUplinkDutyCycle-FR2=Z%*. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If the active UL Tx beams are overlapping, the UE determines P-MPR_{f,c,k=0} and P-MPR_{f,c,k=1} by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel P-MPR_{f,c}, where $P-MPR_{f,c,k=0} = P-MPR_{f,c} + X_1$ (dB) and $P-MPR_{f,c,k=1} = P-MPR_{f,c} + X_2$ (dB). The UE determines X (dB) and (X₁,X₂) (dB) according to X-percent overlapping beam coverage and single-DCI with the same RB allocations, modulation order and waveform type for each panel.

[00141] In one example, assuming the UE equipped with two panels, the UE first report *maxUplinkDutyCycle-FR2=40%* in UE capability signaling to the network entity. The network entity configures the UE by single-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. Then, the network entity configures 60% of uplink symbols transmitted within an evaluation period 1 second is larger than *maxUplinkDutyCycle-FR2=40%*. The UE first determine whether UL TCI#1 and UL TCI#2 are overlapping by checking the overlapping beam

coverage is larger than 85-percent. If the active UL Tx beams are overlapping, the UE determines $P\text{-MPR}_{f,c,k=0}$ and $P\text{-MPR}_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel $P\text{-MPR}_{f,c}$, where $P\text{-MPR}_{f,c,k=0} = P\text{-MPR}_{f,c} + X_1$ (dB) and $P\text{-MPR}_{f,c,k=1} = P\text{-MPR}_{f,c} + X_2$ (dB). The UE determines X (dB) and $(X_1, X_2)=(2, 3)$ (dB) according to 85-percent overlapping beam coverage and single-DCI with the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are overlapping), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) and waveform type (e.g., DFT-s-OFDM).

[00142] In some implementations, assuming the UE equipped with two panels, the UE first report $\text{maxUplinkDutyCycle-FR2}=Z\%$ in UE capability signaling to the network entity. The network entity configures simultaneous UL transmission with multi-panel by multi-DCI to the UE. Then, the network entity configures the percentage of uplink symbols transmitted within an evaluation period is larger than $\text{maxUplinkDutyCycle-FR2}=Z\%$. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X -percent. If the active UL Tx beams are overlapping, the UE determines $P\text{-MPR}_{f,c,k=0}$ and $P\text{-MPR}_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel $P\text{-MPR}_{f,c}$, where $P\text{-MPR}_{f,c,k=0} = P\text{-MPR}_{f,c} + X_1$ (dB) and $P\text{-MPR}_{f,c,k=1} = P\text{-MPR}_{f,c} + X_2$ (dB). The UE determines X (dB) and (X_1, X_2) (dB) according to X -percent overlapping beam coverage and multi-DCI with the same or different RB allocations, modulation order and waveform type.

[00143] In one example, assuming the UE equipped with two panels, the UE first report $\text{maxUplinkDutyCycle-FR2}=40\%$ in UE capability signaling to the network entity. The network entity configures the UE by multi-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. Then, the network entity configures 60% of uplink symbols transmitted within an evaluation period 1 second is larger than $\text{maxUplinkDutyCycle-FR2}=40\%$. The UE first determine whether UL TCI#1 and UL TCI#2 are overlapping by checking the overlapping beam coverage is larger than 85-percent. If the active UL Tx beams are overlapping, the UE determines $P\text{-MPR}_{f,c,k=0}$ and $P\text{-MPR}_{f,c,k=1}$ by applying the relaxation value $X=X_1+X_2$ (dB) to single-panel $P\text{-MPR}_{f,c}$, where $P\text{-MPR}_{f,c,k=0} = P\text{-MPR}_{f,c} + X_1$ (dB) and $P\text{-MPR}_{f,c,k=1} = P\text{-MPR}_{f,c} + X_2$ (dB). The UE determines $X=3$ (dB) and $(X_1, X_2)=(1, 2)$ (dB) according to 85-percent overlapping beam coverage and multi-DCI with the same RB allocations (e.g., 100RB for Panel-1 and 100RB for Panel-2 are

overlapping), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) and waveform type (e.g., DFT-s-OFDM), or $X=5$ (dB) and $(X1,X2)=(2,3)$ (dB) with the non-overlapping RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2 are non-overlapping), different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) and waveform type (e.g., DFT-s-OFDM), or $X=7$ (dB) and $(X1,X2)=(3,4)$ (dB) with the partial-overlapping RB allocations (e.g., 75RB for Panel-1 and 100RB for Panel-2 are partial-overlapping), different modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) and waveform type (e.g., DFT-s-OFDM).

[00144] In some implementations, assuming the UE equipped with two panels, the UE first report $maxUplinkDutyCycle-FR2=Z\%$ in UE capability signaling to the network entity. The network entity configures simultaneous UL transmission with multi-panel by single-DCI or multi-DCI to the UE. Then, the network entity configures the percentage of uplink symbols transmitted within an evaluation period is larger than $maxUplinkDutyCycle-FR2=Z\%$. The UE first determine whether the active UL Tx beams among panels are overlapping by checking the overlapping beam coverage is larger than X-percent. If the active UL Tx beams are not overlapping, the UE determines $P-MPR_{f,c,k=0} = P-MPR_{f,c}$ and $P-MPR_{f,c,k=1} = P-MPR_{f,c}$ according to X-percent overlapping beam coverage and single-DCI or multi-DCI with the same RB allocations, modulation order and waveform type, or according to X-percent overlapping beam coverage and multi-DCI with the different RB allocations, modulation order and waveform type.

[00145] In one example, assuming the UE equipped with two panels, the UE first report $maxUplinkDutyCycle-FR2=40\%$ in UE capability signaling to the network entity. The network entity configures the UE by single-DCI or multi-DCI with UL TCI#1 for Panel-1 PUSCH transmission and UL TCI#2 for Panel-2 PUSCH transmission. Then, the network entity configures 60% of uplink symbols transmitted within an evaluation period 1 second is larger than $maxUplinkDutyCycle-FR2=40\%$. The UE first determine whether UL TCI#1 and UL TCI#2 are overlapping by checking the overlapping beam coverage is larger than 85-percent. If the active UL Tx beams are not overlapping, the UE determines $P-MPR_{f,c,k=0} = 3$ (dB) and $P-MPR_{f,c,k=1} = 3$ (dB) according to 85-percent overlapping beam coverage and single-DCI or multi-DCI with the same RB allocations (e.g., 50RB for Panel-1 and 50RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and QPSK for Panel-2) and waveform type (e.g., DFT-s-OFDM) or determines $P-MPR_{f,c,k=0} = 3$ (dB) and $P-MPR_{f,c,k=1} = 5$ (dB)

according to 85-percent overlapping beam coverage and multi-DCI with the different RB allocations (e.g., 50RB for Panel-1 and 75RB for Panel-2), modulation order (e.g., QPSK for Panel-1 and 16QAM for Panel-2) and waveform type (e.g., DFT-s-OFDM).

[00146] FIG. 4 illustrates a flowchart of a method 400 of wireless communication at a UE. With reference to FIGS. 1, 2, 3, and 6, the method may be performed by the UE 102, the UE apparatus 602, etc., which may include the memory 626', 606', 616, and which may correspond to the entire UE 102 or the entire UE apparatus 602, or a component of the UE 102 or the UE apparatus 602, such as the wireless baseband processor 626 and/or the application processor 606.

[00147] In FIG. 4, the UE optionally transmits 402 to a network entity a message indicating a UE capability in supporting STxMP overlapping. The UE optionally determines 405 whether active uplink transmission beams are overlapping. If so, the UE modifies or adjusts the maximum transmission power level and/or power reduction levels.

[00148] The UE receives 406 control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels (e.g., per-panel) and across the multiple antenna panels. (e.g., per-UE).

[00149] The UE optionally determines 408 per-UE and/or per-panel transmission power parameters. The UE optionally transmits 409 a power headroom report (PHR) including a first maximum transmission power across the multiple antenna panels and a second maximum transmission power for each of the multiple antenna panels. In some aspects, the UE modifies or adjusts the first and/or second maximum transmission power levels based on STxMP overlapping capability.

[00150] The UE then transmits 410, to the network entity, the uplink signal from the multiple antenna panels based on the power allocation. The UE optionally receives 415 updated power allocation from the network entity for configuring STxMP transmission.

[00151] FIG. 4 describes a method 400 from a UE-side of a wireless communication link, whereas FIG. 5 describes a method 500 from a network-side of the wireless communication link.

[00152] FIG. 5 illustrates the flowchart of a method 500 of wireless communication at a network entity. With reference to FIGS. 1, 2, 3, and 7, the method may be performed by one or more network entities 104, which may correspond to a base station or a unit of the base station, such as the RU 106, the DU 108, the CU 110, an RU processor

706, a DU processor 726, a CU processor 746, etc. The one or more network entities 104 may include memory 706'/726'/746', which may correspond to an entirety of the one or more network entities 104, or a component of the one or more network entities 104, such as the RU processor 706, the DU processor 726, or the CU processor 746.

[00153] In FIG. 5, the network entity optionally receives 502, from a UE, a message indicating a UE capability in supporting simultaneous transmission of multiple panels (STxMP) overlapping. Based on the overlapping status or capability, the network entity optionally determines 504 power allocation for the STxMP at the UE.

[00154] The network entity optionally transmits 506 control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels (e.g., per-panel) and across the multiple antenna panels (e.g., per-UE).

[00155] The network entity optionally receives 509 a power headroom report (PHR) including the first maximum transmission power and the second maximum transmission power. The network entity optionally receives 510, from the UE, the uplink signal from the multiple antenna panels based on the power allocation.

[00156] The network entity optionally modifies 512 the maximum power and/or power reduction to each of the multiple antenna panels and the UE overall, when the UE indicates STxMP overlapping capability or status.

[00157] The network entity may determine 514 per-panel uplink power allocation for PUSCH, PUCCH, PRACH, and SRS transmission in STxMP. The network entity then transmits 516 to the UE, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels. The network entity may receive the uplink signal from the multiple antenna panels based on the power allocation.

[00158] A UE apparatus 602, as described in FIG. 6, may perform the method of flowchart 400. The one or more network entities 104, as described in FIG. 7, may perform the method of flowchart 500.

[00159] FIG. 6 is a diagram 600 illustrating an example of a hardware implementation for a UE apparatus 602. The UE apparatus 602 may be the UE 102, a component of the UE 102, or may implement UE functionality. The UE apparatus 602 may include an application processor 606, which may have on-chip memory 606'. In examples, the

application processor 606 may be coupled to a secure digital (SD) card 608 and/or a display 610. The application processor 606 may also be coupled to a sensor(s) module 612, a power supply 614, an additional module of memory 616, a camera 618, and/or other related components. For example, the sensor(s) module 612 may control a barometric pressure sensor/altimeter, a motion sensor such as an inertial management unit (IMU), a gyroscope, accelerometer(s), a light detection and ranging (LIDAR) device, a radio-assisted detection and ranging (RADAR) device, a sound navigation and ranging (SONAR) device, a magnetometer, an audio device, and/or other technologies used for positioning.

[00160] The UE apparatus 602 may further include a wireless baseband processor 626, which may be referred to as a modem. The wireless baseband processor 626 may have on-chip memory 626'. Along with, and similar to, the application processor 606, the wireless baseband processor 626 may also be coupled to the sensor(s) module 612, the power supply 614, the additional module of memory 616, the camera 618, and/or other related components. The wireless baseband processor 626 may be additionally coupled to one or more subscriber identity module (SIM) card(s) 620 and/or one or more transceivers 630 (e.g., wireless RF transceivers).

[00161] Within the one or more transceivers 630, the UE apparatus 602 may include a Bluetooth module 632, a WLAN module 634, an SPS module 636 (e.g., GNSS module), and/or a cellular module 638. The Bluetooth module 632, the WLAN module 634, the SPS module 636, and the cellular module 638 may each include an on-chip transceiver (TRX), or in some cases, just a transmitter (TX) or just a receiver (RX). The Bluetooth module 632, the WLAN module 634, the SPS module 636, and the cellular module 638 may each include dedicated antennas and/or utilize antennas 640 for communication with one or more other nodes. For example, the UE apparatus 602 may communicate through the transceiver(s) 630 via the antennas 640 with another UE 102 (e.g., sidelink communication) and/or with a network entity 104 (e.g., uplink/downlink communication), where the network entity 104 may correspond to a base station or a unit of the base station, such as the RU 106, the DU 108, or the CU 110.

[00162] The wireless baseband processor 626 and the application processor 606 may each include a computer-readable medium / memory 626', 606', respectively. The additional module of memory 616 may also be considered a computer-readable medium / memory. Each computer-readable medium / memory 626', 606', 616 may

be non-transitory. The wireless baseband processor 626 and the application processor 606 may each be responsible for general processing, including execution of software stored on the computer-readable medium / memory 626', 606', 616. The software, when executed by the wireless baseband processor 626 / application processor 606, causes the wireless baseband processor 626 / application processor 606 to perform the various functions described herein. The computer-readable medium / memory may also be used for storing data that is manipulated by the wireless baseband processor 626 / application processor 606 when executing the software. The wireless baseband processor 626 / application processor 606 may be a component of the UE 102. The UE apparatus 602 may be a processor chip (e.g., modem and/or application) and include just the wireless baseband processor 626 and/or the application processor 606. In other examples, the UE apparatus 602 may be the entire UE 102 and include the additional modules of the apparatus 602.

[00163] As discussed, the STxMP power determination component 140 is configured to receive, from a network entity, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels. The power allocation is based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels. The STxMP power determination component 140 then transmits, to the network entity, the uplink signal from the multiple antenna panels based on the power allocation.

[00164] The STxMP power determination component 140 may be within the application processor 606 (e.g., at 140a), the wireless baseband processor 626 (e.g., at 140b), or both the application processor 606 and the wireless baseband processor 626. The STxMP power determination component 140a-140b may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by one or more processors configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by the one or more processors, or a combination thereof.

[00165] FIG. 7 is a diagram 700 illustrating an example of a hardware implementation for one or more network entities 104. The one or more network entities 104 may be a base station, a component of a base station, or may implement base station functionality. The one or more network entities 104 may include, or may correspond to, at least one of the RU 106, the DU, 108, or the CU 110. The CU 110 may include a CU processor 746, which may have on-chip memory 746'. In some aspects, the CU

110 may further include an additional module of memory 756 and/or a communications interface 748, both of which may be coupled to the CU processor 746. The CU 110 may communicate with the DU 108 through a midhaul link 162, such as an F1 interface between the communications interface 748 of the CU 110 and a communications interface 75 of the DU 108.

[00166] The DU 108 may include a DU processor 726, which may have on-chip memory 726'. In some aspects, the DU 108 may further include an additional module of memory 736 and/or the communications interface 75, both of which may be coupled to the DU processor 726. The DU 108 may communicate with the RU 106 through a fronthaul link 160 between the communications interface 75 of the DU 108 and a communications interface 708 of the RU 106.

[00167] The RU 106 may include an RU processor 706, which may have on-chip memory 706'. In some aspects, the RU 106 may further include an additional module of memory 716, the communications interface 708, and one or more transceivers 77, all of which may be coupled to the RU processor 706. The RU 106 may further include antennas 740, which may be coupled to the one or more transceivers 77, such that the RU 106 may communicate through the one or more transceivers 77 via the antennas 740 with the UE 102.

[00168] The on-chip memory 706', 726', 746' and the additional modules of memory 716, 736, 756 may each be considered a computer-readable medium / memory. Each computer-readable medium / memory may be non-transitory. Each of the processors 706, 726, 746 is responsible for general processing, including execution of software stored on the computer-readable medium / memory. The software, when executed by the corresponding processor(s) 706, 726, 746 causes the processor(s) 706, 726, 746 to perform the various functions described herein. The computer-readable medium / memory may also be used for storing data that is manipulated by the processor(s) 706, 726, 746 when executing the software. In examples, the STxMP power allocation component 150 may sit at any of the one or more network entities 104, such as at the CU 110; both the CU 110 and the DU 108; each of the CU 110, the DU 108, and the RU 106; the DU 108; both the DU 108 and the RU 106; or the RU 106.

[00169] As discussed, the STxMP power allocation component 150 is configured to transmit, to a UE, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels. The power allocation is based on parameters associated with each of the multiple antenna panels and across

the multiple antenna panels. The STxMP power allocation component 150 receives, from the UE, the uplink signal from the multiple antenna panels based on the power allocation.

[00170] The STxMP power allocation component 150 may be within one or more processors of the one or more network entities 104, such as the RU processor 706 (e.g., at 150a), the DU processor 726 (e.g., at 150b), and/or the CU processor 746 (e.g., at 150c). The STxMP power allocation component 150a-150c may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by one or more processors 706, 726, 746 configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by the one or more processors 706, 726, 746, or a combination thereof.

[00171] The specific order or hierarchy of blocks in the processes and flowcharts disclosed herein is an illustration of example approaches. Hence, the specific order or hierarchy of blocks in the processes and flowcharts may be rearranged. Some blocks may also be combined or deleted. Dashed lines may indicate implementational elements of the diagrams. The accompanying method claims present elements of the various blocks in an example order, and are not limited to the specific order or hierarchy presented in the claims, processes, and flowcharts.

[00172] The detailed description set forth herein describes various configurations in connection with the drawings and does not represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough explanation of various concepts. However, these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[00173] Aspects of wireless communication systems, such as telecommunication systems, are presented with reference to various apparatuses and methods. These apparatuses and methods are described in the following detailed description and are illustrated in the accompanying drawings by various blocks, components, circuits, processes, call flows, systems, algorithms, etc. (collectively referred to as “elements”). These elements may be implemented using electronic hardware, computer software, or combinations thereof. Whether such elements are implemented as hardware or

software depends upon the particular application and design constraints imposed on the overall system.

[00174] An element, or any portion of an element, or any combination of elements may be implemented as a “processing system” that includes one or more processors. Examples of processors include microprocessors, microcontrollers, graphics processing units (GPUs), central processing units (CPUs), application processors, digital signal processors (DSPs), reduced instruction set computing (RISC) processors, systems-on-chip (SoC), baseband processors, field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other similar hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software, which may be referred to as software, firmware, middleware, microcode, hardware description language, or otherwise. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software components, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, or any combination thereof.

[00175] If the functionality described herein is implemented in software, the functions may be stored on, or encoded as, one or more instructions or code on a computer-readable medium, such as a non-transitory computer-readable storage medium. Computer-readable media includes computer storage media and may include a random-access memory (RAM), a read-only memory (ROM), an electrically erasable programmable ROM (EEPROM), optical disk storage, magnetic disk storage, other magnetic storage devices, combinations of these types of computer-readable media, or any other medium that may be used to store computer executable code in the form of instructions or data structures that may be accessed by a computer. Storage media may be any available media that may be accessed by a computer.

[00176] Aspects, implementations, and/or use cases described herein may be implemented across many differing platform types, devices, systems, shapes, sizes, and packaging arrangements. For example, the aspects, implementations, and/or use cases may come about via integrated chip implementations and other non-module-component based devices, such as end-user devices, vehicles, communication devices, computing devices, industrial equipment, retail/purchasing devices, medical devices, artificial intelligence (AI)-enabled devices, machine learning (ML)-enabled devices, etc. The

aspects, implementations, and/or use cases may range from chip-level or modular components to non-modular or non-chip-level implementations, and further to aggregate, distributed, or original equipment manufacturer (OEM) devices or systems incorporating one or more techniques described herein.

[00177] Devices incorporating the aspects and features described herein may also include additional components and features for the implementation and practice of the claimed and described aspects and features. For example, transmission and reception of wireless signals necessarily includes a number of components for analog and digital purposes, such as hardware components, antennas, RF-chains, power amplifiers, modulators, buffers, processor(s), interleavers, adders/summers, etc. Techniques described herein may be practiced in a wide variety of devices, chip-level components, systems, distributed arrangements, aggregated or disaggregated components, end-user devices, etc., of varying configurations.

[00178] The description herein is provided to enable a person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not limited to the aspects described herein, but are to be interpreted in view of the full scope of the present disclosure consistent with the language of the claims.

[00179] Reference to an element in the singular does not mean “one and only one” unless specifically stated, but rather “one or more.” Terms such as “if,” “when,” and “while” do not imply an immediate temporal relationship or reaction. That is, these phrases, e.g., “when,” do not imply an immediate action in response to or during the occurrence of an action, but simply imply that if a condition is met then an action will occur, but without requiring a specific or immediate time constraint for the action to occur. The terms “may,” “might”, and “may”, as used in this disclosure, often carry certain connotations. For example, “may” refers to a permissible feature that may or may not occur, “might” refers to a feature that probably occurs, and “may” refers to a capability (e.g., capable of). The phrase “For example” often carries a similar connotation to “may” and, therefore, “may” is sometimes excluded from sentences that include “for example” or other similar phrases.

[00180] Unless specifically stated otherwise, the term “some” refers to one or more. Combinations such as “at least one of A, B, or C” or “one or more of A, B, or C” include any combination of A, B, and/or C, such as A and B, A and C, B and C,

or A and B and C, and may include multiples of A, multiples of B, and/or multiples of C, or may include A only, B only, or C only. Sets may be interpreted as a set of elements where the elements number one or more.

[00181] Unless otherwise specifically indicated, ordinal terms such as “first” and “second” do not necessarily imply an order in time, sequence, numerical value, etc., but are used to distinguish between different instances of a term or phrase that follows each ordinal term. Reference numbers, as used in the specification and figures, are sometimes cross-referenced among drawings to denote same or similar features. A feature that is exactly the same in multiple drawings may be labeled with the same reference number in the multiple drawings. A feature that is similar among the multiple drawings, but not exactly the same, may be labeled with reference numbers that have different leading numbers, but have one or more of the same trailing numbers (e.g., 206, 306, 406, etc., may refer to similar features in the drawings). Sometimes an “X” is used to universally denote multiple variations of a feature. For instance, “X06” may universally refer to all reference numbers that end in “06” (e.g., 206, 306, 406, etc.).

[00182] Structural and functional equivalents to elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are encompassed by the claims. The words “module,” “mechanism,” “element,” “device,” and the like may not be a substitute for the word “means.” As such, no claim element is to be construed as a means plus function unless the element is expressly recited using the phrase “means for.” As used herein, the phrase “based on” shall not be construed as a reference to a closed set of information, one or more conditions, one or more factors, or the like. In other words, the phrase “based on A”, where “A” may be information, a condition, a factor, or the like, shall be construed as “based at least on A” unless specifically recited differently.

[00183] The following examples are illustrative only and may be combined with other examples or teachings described herein, without limitation.

Example Aspects

Example 1. A method for wireless communications by a user equipment (UE), the method comprising:

receiving, from a network entity, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels; and

transmitting, to the network entity, the uplink signal from the multiple antenna panels based on the power allocation.

Example 2. The method of Example 1, wherein the parameters comprise at least one of:

a first maximum transmission power across the multiple antenna panels;

a second maximum transmission power for each of the multiple antenna panels;

a first power reduction across the multiple antenna panels; or

a second power reduction for each of the multiple antenna panels.

Example 3. The method of Example 1 or 2, further comprising transmitting (210) a power headroom report (PHR) including the first maximum transmission power and the second maximum transmission power.

Example 4. The method of Example 1 or 2, further comprising:

transmitting, to the network entity, an indication of whether respective beams of the multiple antenna panels overlap in the transmitting the uplink signal.

Example 5. The method of Example 4, wherein the respective beams of the multiple antenna panels correspond to at least one of:

a group of synchronization signal blocks (SSBs) or channel state information reference signals (CSI-RSs); or

a group of indicated transmission configuration indication (TCI) states.

Example 6. The method of any one of Examples 1 to 5, further comprising:

selecting the first power reduction or the second power reduction for calculating transmission power based on whether respective beams of the multiple antenna panels overlap.

Example 7. The method of Example 6, further comprising:

receiving, from the network entity, a configuration indicating whether the UE calculates transmission power for the multiple antenna panels according to the power allocation based on the first power reduction or the second power reduction.

Example 8. The method of Example 6, further comprising:

transmitting, to the network entity, a message indicating a UE capability in supporting transmission power calculation based on the first power reduction or the second power reduction.

Example 9. The method of any one of Examples 2 to 8, wherein the first and second power reduction comprise first and second maximum power reduction (MPR), respectively, the method further comprising:

calculating the first MPR and the second MPR based on at least one of:

allocated resource blocks (RBs) for at least one antenna panel for the uplink signal;
a modulation order for at least one antenna panel for the uplink signal; or
a waveform type for at least one antenna panel for the uplink signal.

Example 10. The method of any one of Examples 2 to 8, wherein the first and second power reduction comprise first and second additional-maximum-power-reduction (A-MPR), respectively, the method further comprising:

calculating the first A-MPR or the second A-MPR based on at least one of:

a configuration of an additional spectrum emission (ASE);
allocated resource blocks (RBs) for the uplink signal;
a modulation order for the uplink signal; or
a waveform type for the uplink signal.

Example 11. The method of any one of Examples 2 to 8, wherein the first and second power reduction comprise first and second power-management-maximum-output-power-reduction (P-MPR), respectively, the method further comprising:

calculating the first P-MPR or the second P-MPR based on at least one of:

- a maximum duty cycle for at least one antenna panel;
- allocated resource blocks (RB)s for the uplink signal;
- a modulation order for the uplink signal; or
- a waveform type for the uplink signal.

Example 12. The method of any one of Examples 2 to 11, further comprising:

determining (208/308) the parameters based on the control signaling that configures the simultaneous transmission of the uplink signal on the multiple antenna panels for two transmit-reception-points (TRPs).

Example 13. The method of any one of Examples 2 to 12, further comprising:

modifying (306), upon indicating that respective beams of the multiple antenna panels overlap in transmitting the uplink signal, the parameters for each of the multiple antenna panels to comply with a predetermined requirement.

Example 14. The method of any one of Examples 1-13, wherein the receiving the control signaling comprises receiving one or more downlink control information (DCI) to determine whether respective beams of the multiple antenna panels overlap in the transmitting the uplink signal, the method further comprising calculating the parameters based on a single antenna panel when the respective beams do not overlap.

Example 15. A method for wireless communications by a network entity, the method comprising:

transmitting, to a user equipment (UE), control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple

antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels.

Example 16. The method of Example 15, further comprising:
receiving (210), from a user equipment (UE), a report indicating uplink transmission power limits;

Example 17. The method of Example 15 or 16, further comprising:
receiving (210), from the UE, the uplink signal from the multiple antenna panels based on the power allocation.

Example 18. The method of any one of Examples 15 to 17, wherein the parameters comprise at least one of:

- a first maximum transmission power across the multiple antenna panels;
- a second maximum transmission power for each of the multiple antenna panels;
- a first power reduction across the multiple antenna panels; or
- a second power reduction for each of the multiple antenna panels.

Example 19. The method of any one of Examples 15 to 18, further comprising:
modifying (212), upon receiving from the UE an indication of a capability of respective beams of the multiple antenna panels overlapping in transmitting the uplink signal, the parameters for each of the multiple antenna panels to satisfy safety requirements.

Example 20. The method of any one of Examples 15 to 19, further comprising:
determining (214/312) the power allocation for each of the multiple antenna panels for at least one of:

- physical uplink shared channel (PUSCH);
- physical uplink control channel (PUCCH);
- physical random access channel (PRACH); or

sounding reference signal (SRS).

Example 21. The method of any one of Examples 15 to 20, further comprising:

receiving, from the UE, an indication of whether respective beams of the multiple antenna panels overlap in the transmitting the uplink signal.

Example 22. The method of Example 21, wherein the respective beams of the multiple antenna panels correspond to at least one of:

a group of synchronization signal blocks (SSBs) or channel state information reference signals (CSI-RSs); or
a group of indicated transmission configuration indication (TCI) states.

Example 23. The method of any one of Examples 15-22, further comprising:

receiving, from the UE, a message indicating a UE capability in supporting transmission power calculation based on the first power reduction or the second power reduction.

Example 24. The method of any one of Examples 15 to 23, wherein the first and second power reduction comprise first and second maximum power reduction (MPR), wherein the first MPR and the second MPR are calculated based on at least one of:

allocated resource blocks (RBs) for at least one antenna panel for the uplink signal;
a modulation order for at least one antenna panel for the uplink signal; or
a waveform type for at least one antenna panel for the uplink signal.

Example 25. The method of any one of Examples 15 to 23, wherein the first and second power reduction comprise first and second additional-maximum-power-reduction (A-MPR), respectively, wherein the first A-MPR or the second A-MPR are calculated based on at least one of:

a configuration of an additional spectrum emission (ASE);

- allocated resource blocks (RBs) for the uplink signal;
- a modulation order for the uplink signal; or
- a waveform type for the uplink signal.

Example 26. The method of any one of Examples 15 to 23, wherein the first and second power reduction comprise first and second power-management-maximum-output-power-reduction (P-MPR), respectively, wherein the first P-MPR or the second P-MPR are calculated based on at least one of:

- a maximum duty cycle for at least one antenna panel;
- allocated resource blocks (RB)s for the uplink signal;
- a modulation order for the uplink signal; or
- a waveform type for the uplink signal.

Example 27. An apparatus comprising:

- one or more radio frequency (RF) modems;
- a processor coupled to the one or more RF modems; and
- at least one memory storing executable instructions, the executable instructions to manipulate at least one of the processor or the one or more RF modems to perform the method of any of Examples 1 to 26.

Example 28. An apparatus, comprising a processor configured to cause a User Equipment (UE) to:

- receive a control signaling configuring simultaneous transmission from multiple panels for an uplink channel;
- transmit an uplink channel from multiple panels with a transmission power for each panel or a power headroom (PHR) based on at least one of the factors:
 - maximum transmission power across panels;
 - maximum transmission power for each panel;
 - maximum power reduction (MPR) across panels;
 - MPR per panel;
 - power management maximum output power reduction (P-MPR) across panels;
 - P-MPR per panel;
 - additional maximum power reduction (A-MPR) across panels;
 - A-MPR per panel.

Example 29. The apparatus according to Example 28, wherein the UE transmits the information indicating whether the uplink transmission beams for the multiple panels to transmit the uplink channel are overlapping or not.

Example 30. The apparatus according to Example 28, wherein the UE transmits the information indicating whether the uplink transmission beams for the multiple panels corresponding to a group of synchronization signal blocks (SSBs) or channel state information reference signals (CSI-RSs) are overlapping or not.

Example 31. The apparatus according to Example 28, wherein the UE transmits the information indicating whether the uplink transmission beams for the multiple panels corresponding to a group of indicated transmission configuration indication (TCI) states for the uplink channel are overlapping or not.

Example 32. The apparatus according to Example 29-31, wherein the UE transmits the information by at least one of the following:

- a UE capability;
- a radio resource control (RRC) signaling;
- a medium access control (MAC) control element (CE);
- an uplink control information (UCI) on physical uplink control channel (PUCCH);
- an uplink control information on physical uplink shared channel (PUSCH).

Example 33. The apparatus according to Example 28, wherein the UE determines the MPR across panels based on at least one of the following factors:

- allocated resource blocks (RBs) for at least one panel for the uplink channel;
- modulation order for at least one panel for the uplink channel;
- waveform type for at least one panel for the uplink channel.

Example 34. The apparatus according to Example 28, wherein the UE determines the MPR for a panel based on at least one of the following factors:

- allocated RBs for the panel for the uplink channel;
- modulation order for the panel for the uplink channel;

waveform type for the panel for the uplink channel.

Example 35. The apparatus according to Example 33-34, wherein the UE determines whether to determine the transmission power based on the MPR per panel or MPR across panels based on whether the uplink transmission beams for the panels are overlapping.

Example 36. The apparatus according to Example 33-34, wherein the UE receives configuration indicating whether to determine the transmission power based on the MPR per panel or MPR across panels.

Example 37. The apparatus according to Example 33-34, wherein the UE transmits the UE capability indicating whether the UE supports to determine the transmission power based on the MPR per panel or MPR across panels.

Example 38. The apparatus according to Example 28, wherein the UE determines the A-MPR across panels based on at least one of the following factors:

- configuration of additional spectrum emission for at least one panel;
- allocated RBs for at least one panel for the uplink channel;
- modulation order for at least one panel for the uplink channel;
- waveform type for at least one panel for the uplink channel.

Example 39. The apparatus according to Example 28, wherein the UE determines the A-MPR for a panel based on at least one of the following factors:

- configuration of additional spectrum emission for at least one panel;
- allocated RBs for the panel for the uplink channel;
- modulation order for the panel for the uplink channel;
- waveform type for the panel for the uplink channel.

Example 40. The apparatus according to Example 38-39, wherein the UE determines whether to determine the transmission power based on the A-MPR per panel or A-MPR across panels based on whether the uplink transmission beams for the panels are overlapping.

Example 41. The apparatus according to Example 38-39, wherein the UE receives configuration indicating whether to determine the transmission power based on the A-MPR per panel or A-MPR across panels.

Example 42. The apparatus according to Example 38-39, wherein the UE transmits the UE capability indicating whether the UE supports to determine the transmission power based on the A-MPR per panel or A-MPR across panels.

Example 43. The apparatus according to Example 28, wherein the UE determines the P-MPR across panels based on at least one of the following factors:

- maximum duty cycle for at least one panel;
- allocated RBs for at least one panel for the uplink channel;
- modulation order for at least one panel for the uplink channel;
- waveform type for at least one panel for the uplink channel.

Example 44. The apparatus according to Example 28, wherein the UE determines the P-MPR for a panel based on at least one of the following factors:

- maximum duty cycle for at least one panel;
- allocated RBs for the panel for the uplink channel;
- modulation order for the panel for the uplink channel;
- waveform type for the panel for the uplink channel.

Example 45. The apparatus according to Example 43-44, wherein the UE determines whether to determine the transmission power based on the P-MPR per panel or P-MPR across panels based on whether the uplink transmission beams for the panels are overlapping.

Example 46. The apparatus according to Example 43-44, wherein the UE receives configuration indicating whether to determine the transmission power based on the P-MPR per panel or P-MPR across panels.

Example 47. The apparatus according to Example 43-44, wherein the UE transmits the UE capability indicating whether the UE supports to determine the transmission power based on the P-MPR per panel or P-MPR across panels.

Example 48. An apparatus, comprising a processor configured to cause a Base Station (BS) to:

- transmit a control signaling configuring simultaneous transmission from multiple panels for an uplink channel;
- receive the uplink channel from multiple panels with a transmission power for each panel or a power headroom (PHR) based on at least one of the factors:
 - maximum transmission power across panels;
 - maximum transmission power for each panel;
 - maximum power reduction (MPR) across panels;
 - MPR per panel;
 - power management maximum output power reduction (P-MPR) across panels;
 - P-MPR per panel;
 - additional maximum power reduction (A-MPR) across panels;
 - A-MPR per panel.

Example 49. The apparatus according to Example 48, wherein the BS receives the information indicating whether the uplink transmission beams for the multiple panels to transmit the uplink channel are overlapping or not.

Example 50. The apparatus according to Example 48, wherein the BS receives the information indicating whether the uplink transmission beams for the multiple panels corresponding to a group of synchronization signal blocks (SSBs) or channel state information reference signals (CSI-RSs) are overlapping or not.

Example 51. The apparatus according to Example 48, wherein the BS receives the information indicating whether the uplink transmission beams for the multiple panels corresponding to a group of indicated transmission configuration indication (TCI) states for the uplink channel are overlapping or not.

Example 52. The apparatus according to Example 49-51, wherein the BS receives the information by at least one of the following:

- a UE capability;
- a radio resource control (RRC) signaling;

a medium access control (MAC) control element (CE);
an uplink control information (UCI) on physical uplink control channel (PUCCH);
an uplink control information on physical uplink shared channel (PUSCH).

Example 53. The apparatus according to Example 48, wherein the BS transmits configuration indicating whether to determine the transmission power based on the MPR per panel or MPR across panels.

Example 54. The apparatus according to Example 48, wherein the BS receives the UE capability indicating whether the UE supports to determine the transmission power based on the MPR per panel or MPR across panels.

Example 55. The apparatus according to Example 48, wherein the BS transmits the configuration of additional spectrum emission for at least a panel.

Example 56. The apparatus according to Example 48, wherein the BS transmits the configuration indicating whether to determine the transmission power based on the A-MPR per panel or A-MPR across panels.

Example 57. The apparatus according to Example 48, wherein the BS receives the UE capability indicating whether the UE supports to determine the transmission power based on the A-MPR per panel or A-MPR across panels.

Example 58. The apparatus according to Example 48, wherein the BS receives the UE report of maximum duty cycle for at least one panel.

Example 59. The apparatus according to Example 48, wherein the BS transmits the configuration indicating whether to determine the transmission power based on the P-MPR per panel or P-MPR across panels.

Example 60. The apparatus according to Example 48, wherein the BS receives the UE capability indicating whether the UE supports to determine the transmission power based on the P-MPR per panel or P-MPR across panels.

CLAIMS**WHAT IS CLAIMED IS:**

1. A method for wireless communications by a user equipment (UE), the method comprising:
 - receiving (206), from a network entity, control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels; and
 - transmitting (210), to the network entity, the uplink signal from the multiple antenna panels based on the power allocation.
2. The method of claim 1, wherein the parameters comprise at least one of:
 - a first maximum transmission power across the multiple antenna panels;
 - a second maximum transmission power for each of the multiple antenna panels;
 - a first power reduction across the multiple antenna panels; or
 - a second power reduction for each of the multiple antenna panels.
3. The method of claim 1 or 2, further comprising transmitting (210) a power headroom report (PHR) including the first maximum transmission power and the second maximum transmission power.
4. The method of claim 1 or 2, further comprising:
 - transmitting, to the network entity, an indication of whether respective beams of the multiple antenna panels overlap in the transmitting the uplink signal.
5. The method of claim 4, wherein the respective beams of the multiple antenna panels correspond to at least one of:
 - synchronization signal blocks (SSBs);
 - channel state information reference signals (CSI-RSs); or
 - transmission configuration indication (TCI) states.
6. The method of any one of claims 1 to 5, further comprising:

selecting the first power reduction or the second power reduction for calculating transmission power based on whether respective beams of the multiple antenna panels overlap.

7. The method of claim 6, further comprising:

receiving, from the network entity, a configuration indicating whether the UE calculates transmission power for the multiple antenna panels according to the power allocation based on the first power reduction or the second power reduction.

8. The method of claim 6, further comprising:

transmitting, to the network entity, a message indicating a UE capability in supporting transmission power calculation based on the first power reduction or the second power reduction.

9. The method of any one of claims 2 to 8, wherein the first and second power reduction comprise first and second maximum power reduction (MPR), respectively, the method further comprising:

calculating the first MPR and the second MPR based on at least one of:

allocated resource blocks (RBs) for at least one antenna panel for the uplink signal;

a modulation order for at least one antenna panel for the uplink signal; or

a waveform type for at least one antenna panel for the uplink signal.

10. The method of any one of claims 2 to 8, wherein the first and second power reduction comprise first and second additional-maximum-power-reduction (A-MPR), respectively, the method further comprising:

calculating the first A-MPR or the second A-MPR based on at least one of:

a configuration of an additional spectrum emission (ASE);

allocated resource blocks (RBs) for the uplink signal;

a modulation order for the uplink signal; or

a waveform type for the uplink signal.

11. The method of any one of claims 2 to 8, wherein the first and second power reduction comprise first and second power-management-maximum-output-power-reduction (P-MPR), respectively, the method further comprising:

calculating the first P-MPR or the second P-MPR based on at least one of:

- a maximum duty cycle for at least one antenna panel;
- allocated resource blocks (RB)s for the uplink signal;
- a modulation order for the uplink signal; or
- a waveform type for the uplink signal.

12. The method of any one of claims 2 to 11, further comprising:

determining (208/308) the parameters based on the control signaling that configures the simultaneous transmission of the uplink signal on the multiple antenna panels for multiple transmit-reception-points (TRPs).

13. The method of any one of claims 2 to 12, further comprising:

modifying (306), upon indicating that respective beams of the multiple antenna panels overlap in transmitting the uplink signal, the parameters for each of the multiple antenna panels to comply with a predetermined requirement.

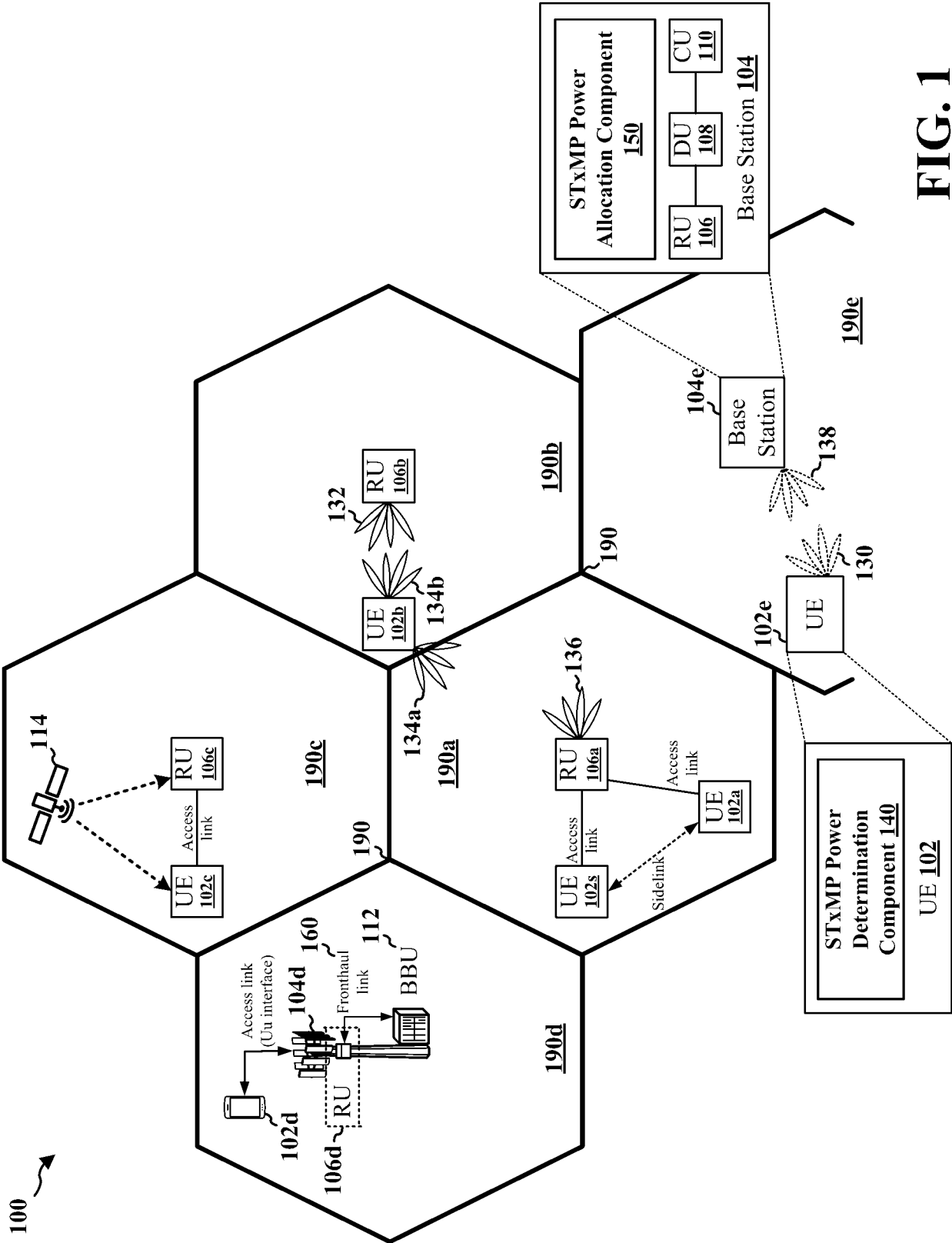
14. The method of any one of claims 1 to 13, wherein the receiving the control signaling comprises receiving one or more downlink control information (DCI) to determine whether respective beams of the multiple antenna panels overlap in the transmitting the uplink signal, the method further comprising calculating the parameters based on a single antenna panel when the respective beams do not overlap.

15. A method for wireless communications by a network entity, the method comprising:

transmitting (506), to a user equipment (UE), control signaling indicating power allocation for simultaneous transmission of an uplink signal on multiple antenna panels, the power allocation being based on parameters associated with each of the multiple antenna panels and across the multiple antenna panels; and

receiving (510), from the UE, the uplink signal from the multiple antenna panels based on the power allocation.

16. The method of any one of claims 15, wherein the parameters comprise at least one of:
- a first maximum transmission power across the multiple antenna panels;
 - a second maximum transmission power for each of the multiple antenna panels;
 - a first power reduction across the multiple antenna panels; or
 - a second power reduction for each of the multiple antenna panels.
17. The method of claim 15 or 16, further comprising:
- modifying, upon receiving from the UE an indication of a capability of respective beams of the multiple antenna panels overlapping in the transmitting the uplink signal, the parameters for each of the multiple antenna panels to comply with a predetermined requirement.
18. An apparatus comprising:
- one or more radio frequency (RF) modems;
 - a processor coupled to the one or more RF modems; and
 - at least one memory storing executable instructions, the executable instructions to manipulate at least one of the processor or the one or more RF modems to perform the method of any of claims 1 to 17.



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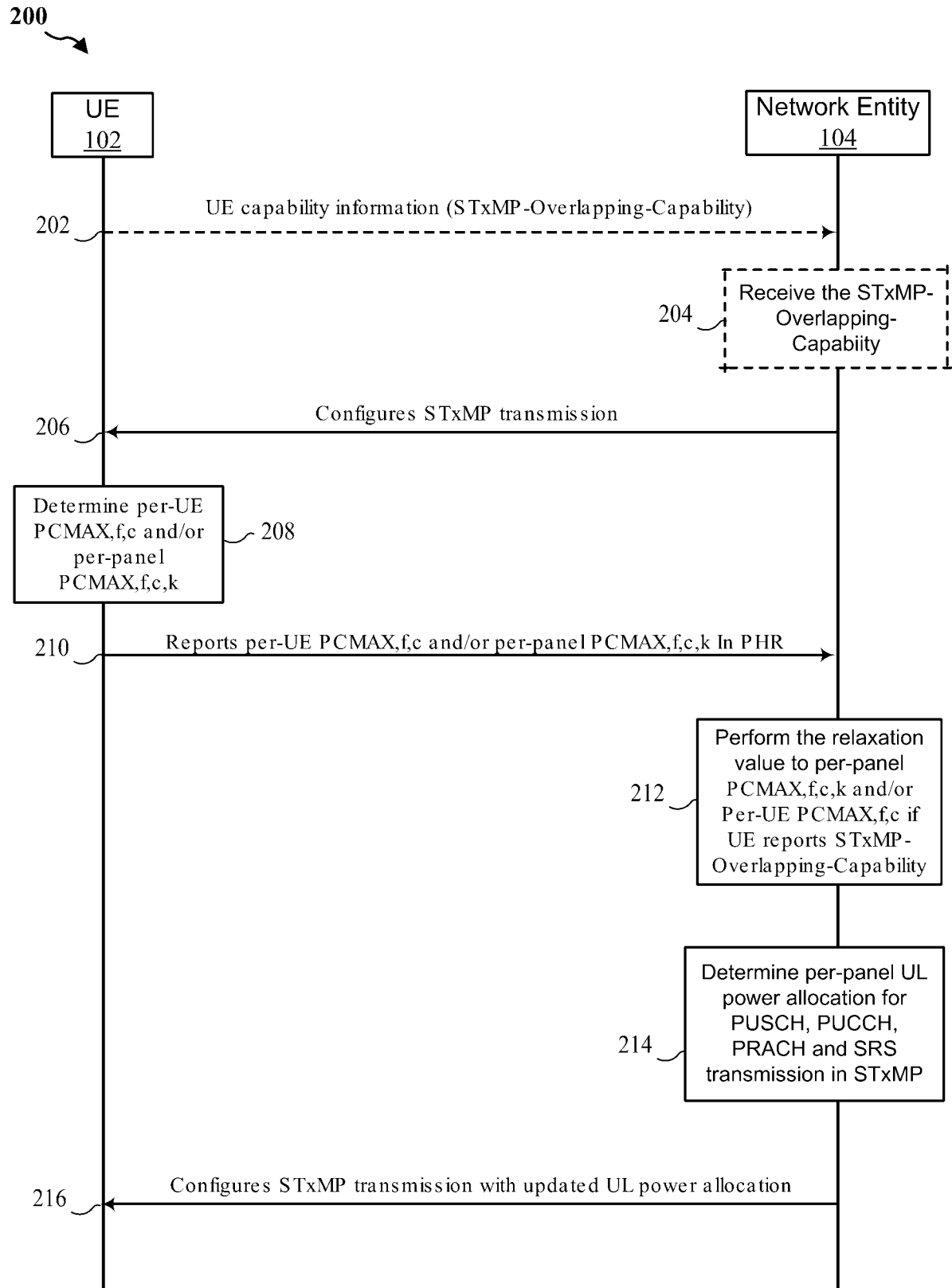


FIG. 2

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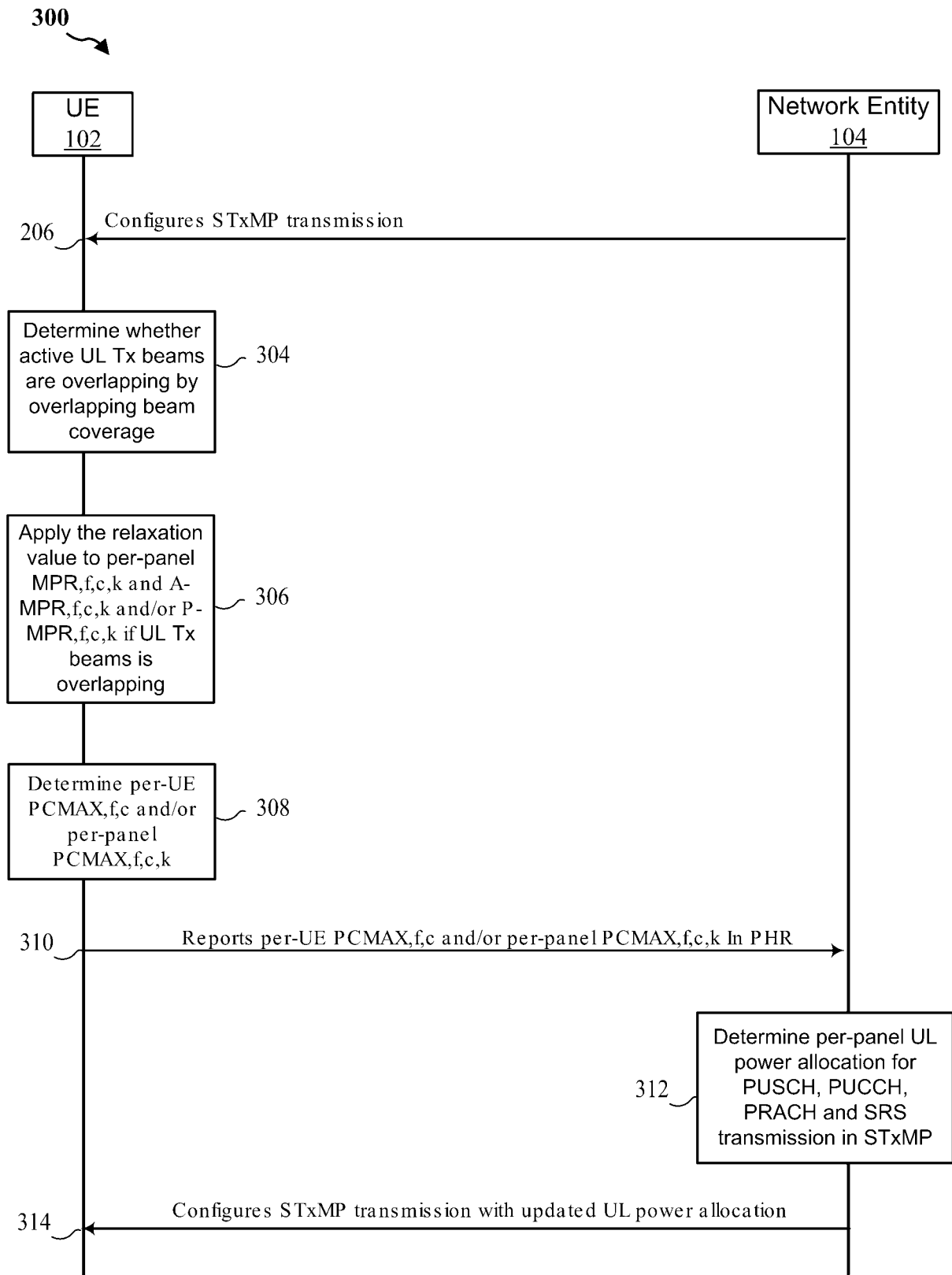


FIG. 3

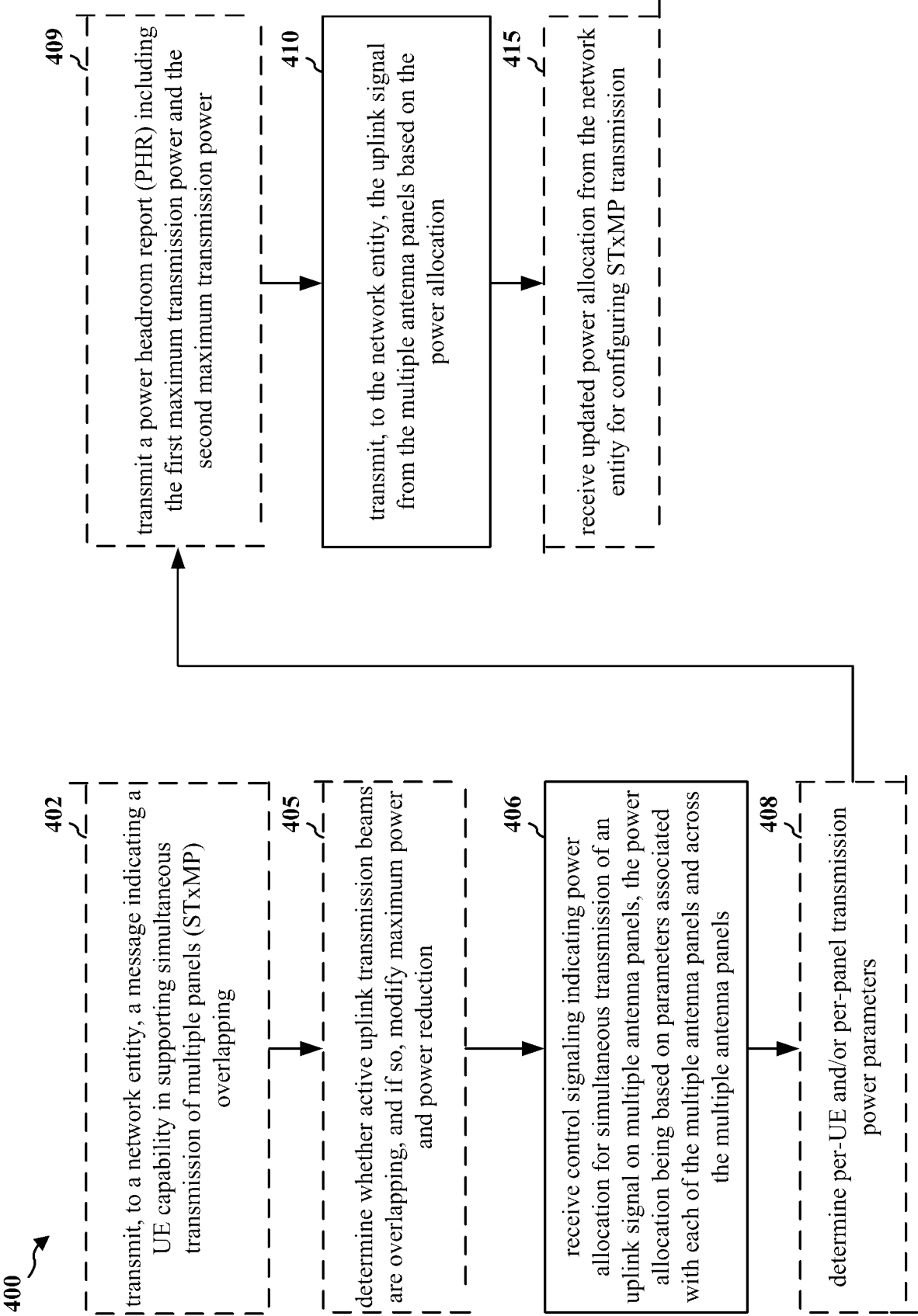


FIG. 4

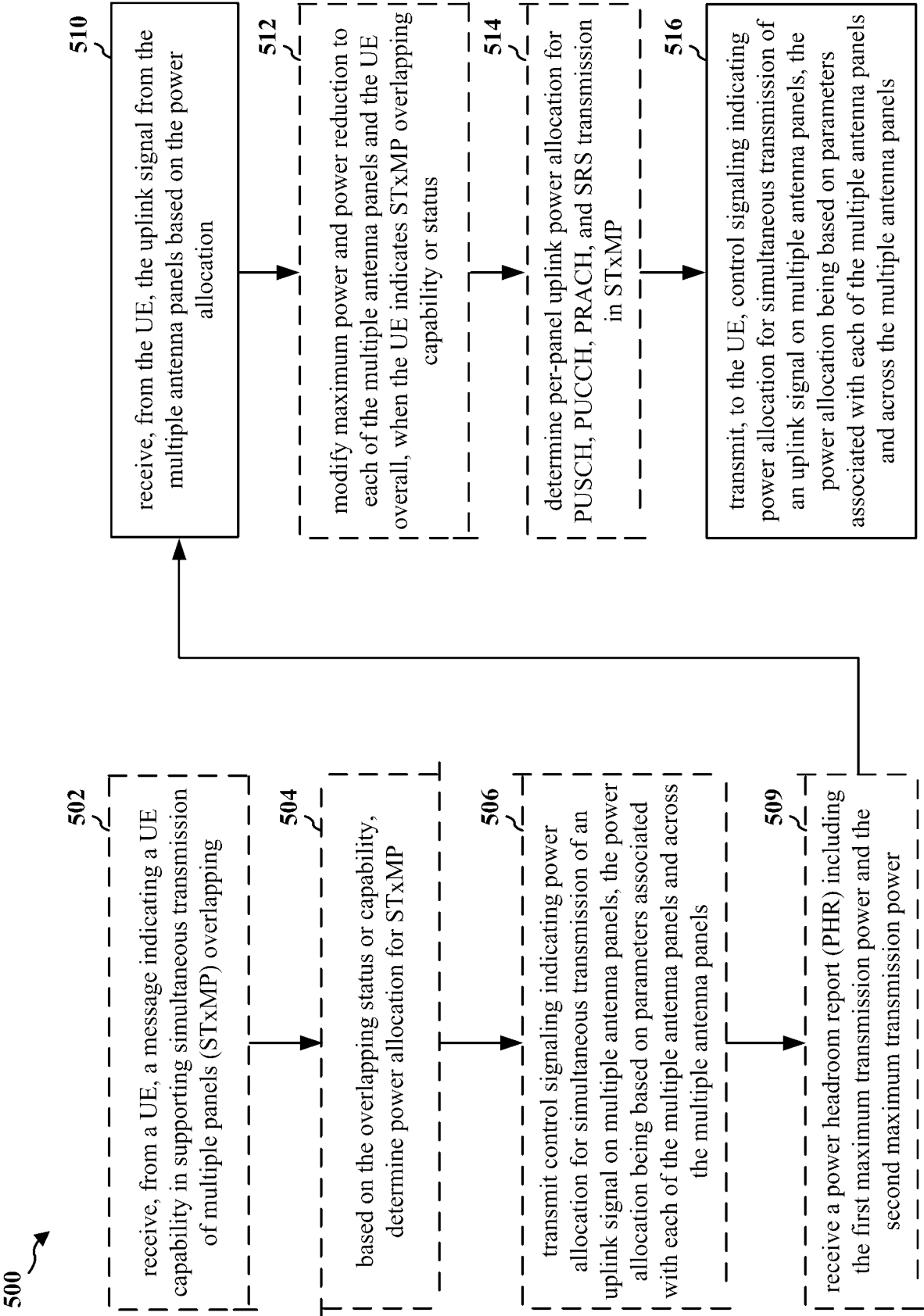


FIG. 5

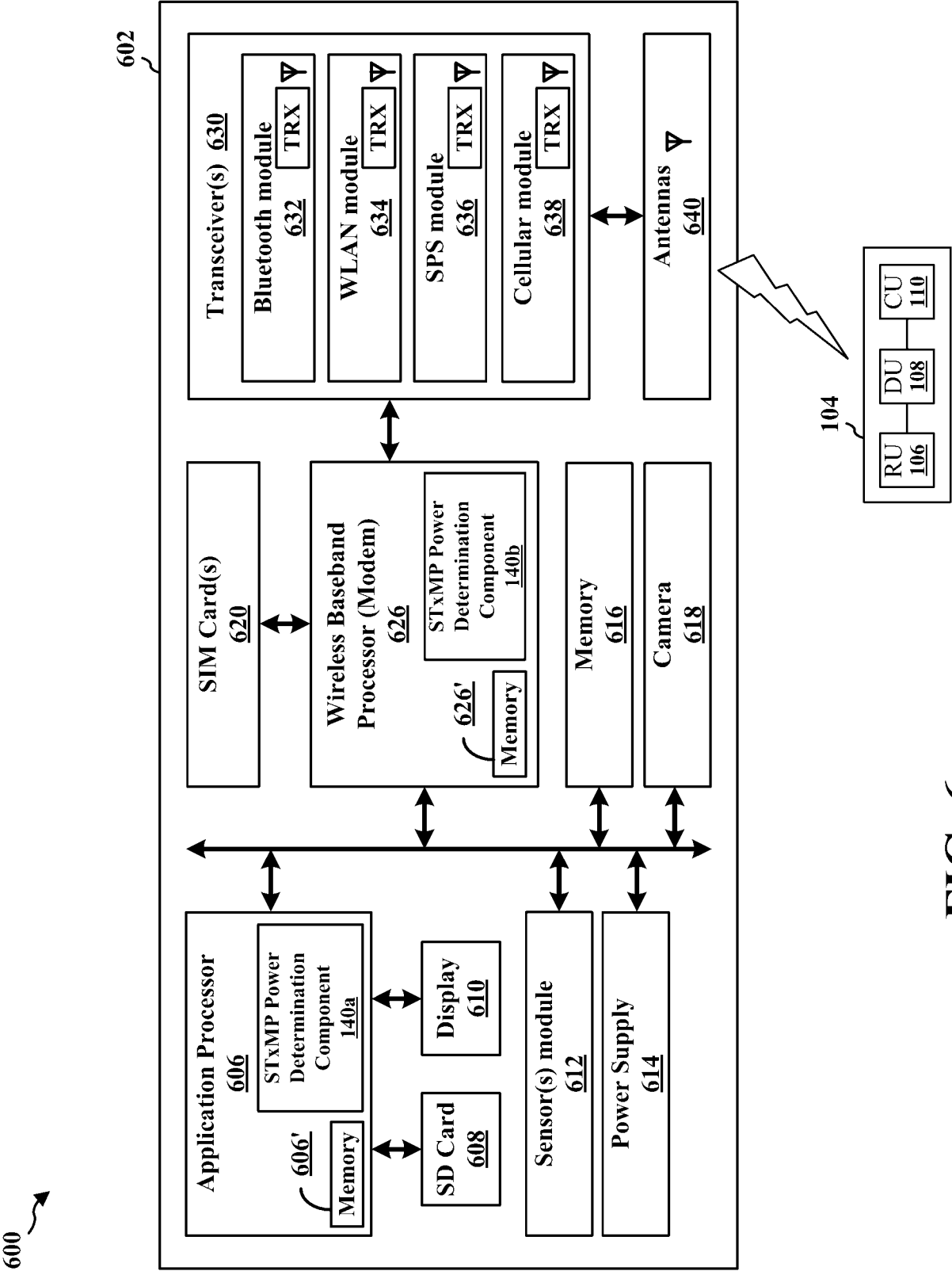


FIG. 6

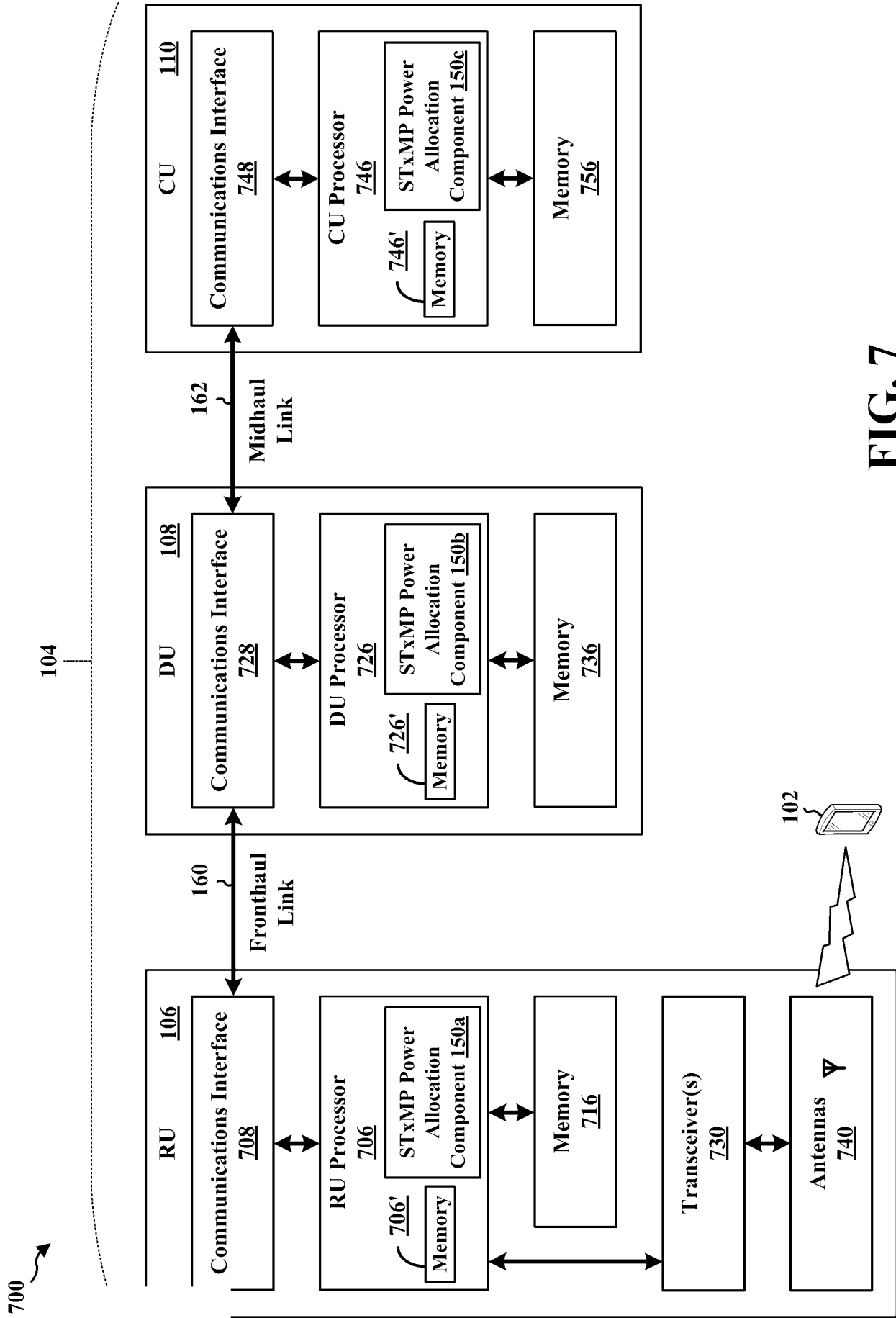


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/CN2023/112515

A. CLASSIFICATION OF SUBJECT MATTER INV. H04W52/14 H04B7/0404 H04B7/06 H04W52/42 ADD.		
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) H04W H04B 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) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CAROLYN TAYLOR ET AL: "Topic summary for [107] [146] NR_MIMO_evo_DL_UL_UERF", 3GPP DRAFT; R4-2310029; TYPE OTHER, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. 3GPP RAN 4, no. Incheon, KR; 20230522 - 20230526 20 May 2023 (2023-05-20), XP052318505, Retrieved from the Internet: URL:https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2310029.zip R4-2310029_Summary_[107] [146]_v01.docx [retrieved on 2023-05-20] paragraphs [0000], [1.1Interdigital], [1.1Nokia], [1.2.1], [1.2.2], [1.2.3] ----- -/--	1-18
☒ 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 "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 25 January 2024	Date of mailing of the international search report 06/02/2024	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Lustrini, Donato	

INTERNATIONAL SEARCH REPORT

International application No

PCT/CN2023/112515

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 116 368 872 A (BEIJING XIAOMI MOBILE SOFTWARE CO LTD) 30 June 2023 (2023-06-30) paragraphs [0004] - [0014], [0024], [0061] - [0070], [0093] - [0100] -----	1-18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/CN2023/112515

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