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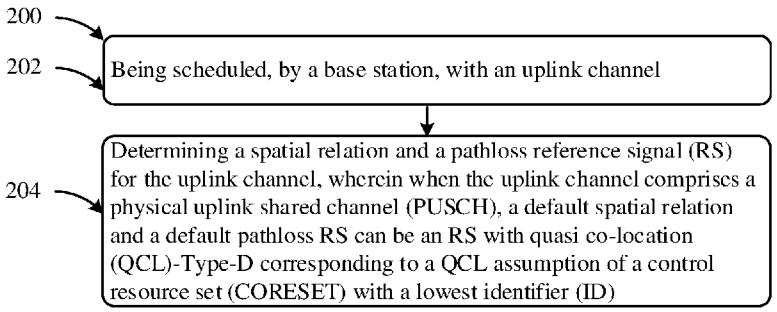

FIG. 3

(57) Abstract: An apparatus and a method of wireless communication are provided. The method by a user equipment (UE) includes being scheduled, by a base station, with an uplink channel and determining a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID). This can solve issues in the prior art, utilize multi-transmission/reception point (TRP) reception, improve uplink reliability, provide a good communication performance, and/or provide high reliability.

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APPARATUS AND METHOD OF WIRELESS COMMUNICATION

BACKGROUND OF DISCLOSURE

1. Field of the Disclosure

[0001] The present disclosure relates to the field of communication systems, and more particularly, to an apparatus and a method of wireless communication, which can provide a good communication performance and/or high reliability.

2. Description of the Related Art

[0002] New radio (NR) system introduces a multi-transmission/reception point (TRP) based non-coherent joint transmission. Multiple TRPs are connected through backhaul link for coordination. The backhaul link can be ideal or non-ideal. In the case of ideal backhaul, the TRPs can exchange dynamic physical downlink shared channel (PDSCH) scheduling information with short latency and thus different TRPs can coordinate a PDSCH transmission per PDSCH transmission. While, in non-ideal backhaul case, the information exchange between TRPs has large latency and thus the coordination between TRPs can only be semi-static or static.

[0003] In current methods, a default spatial relation for physical uplink control channel (PUCCH), sounding reference signal (SRS), and physical uplink shared channel (PUSCH) scheduled by downlink control information (DCI) format 0_0 in a multi-TRP system is not defined. That has couple of consequences. One consequence is a user equipment (UE) behavior is not clear on transmitting a PUCCH, an SRS, or a PUSCH scheduled by the DCI format 0_0 when a spatial relation is not provided to the UE. And the UE behavior on determining transmit power on signals and channels is not clear too. Furthermore, in the multi-TRP system, each PUCCH resource, SRS resource, or PUSCH scheduled by the DCI format 0_0 can be transmitted to the right TRP. But current method does not specify that.

[0004] Therefore, there is a need for an apparatus (such as a user equipment (UE) and/or a base station) and a method of wireless communication, which can solve issues in the prior art, utilize multi-transmission/reception point (TRP) reception, improve uplink reliability, provide a good communication performance, and/or provide high reliability.

SUMMARY

[0005] An object of the present disclosure is to propose an apparatus (such as a user equipment (UE) and/or a base station) and a method of wireless communication, which can solve issues in the prior art, utilize multi-transmission/reception point (TRP) reception, improve uplink reliability, provide a good communication performance, and/or provide high reliability.

[0006] In a first aspect of the present disclosure, a method of wireless communication by a user equipment (UE) comprises being scheduled, by a base station, with an uplink channel and determining a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID).

[0007] In a second aspect of the present disclosure, a method of wireless communication by a base station comprises scheduling, to a user equipment (UE), an uplink channel and determining a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID).

[0008] In a third aspect of the present disclosure, a user equipment comprises a memory, a transceiver, and a processor coupled to the memory and the transceiver. The processor is configured to be scheduled, by a base station, with an uplink channel. The processor is configured to determine a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation

and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID).

[0009] In a fourth aspect of the present disclosure, a base station comprises a memory, a transceiver, and a processor coupled to the memory and the transceiver. The processor is configured to schedule, to a user equipment (UE), an uplink channel. The processor is configured to determine a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID).

[0010] In a fifth aspect of the present disclosure, a non-transitory machine-readable storage medium has stored thereon instructions that, when executed by a computer, cause the computer to perform the above method.

[0011] In a sixth aspect of the present disclosure, a chip includes a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute the above method.

[0012] In a seventh aspect of the present disclosure, a computer readable storage medium, in which a computer program is stored, causes a computer to execute the above method.

[0013] In an eighth aspect of the present disclosure, a computer program product includes a computer program, and the computer program causes a computer to execute the above method.

[0014] In a ninth aspect of the present disclosure, a computer program causes a computer to execute the above method.

BRIEF DESCRIPTION OF DRAWINGS

[0015] In order to illustrate the embodiments of the present disclosure or related art more clearly, the following figures will be described in the embodiments are briefly introduced. It is obvious that the drawings are merely some embodiments of the present disclosure, a person having ordinary skill in this field can obtain other figures according to these figures without paying the premise.

[0016] FIG. 1A is a schematic diagram illustrating that example of multi-transmission/reception point (TRP) transmission according to an embodiment of the present disclosure.

[0017] FIG. 1B is a schematic diagram illustrating that example of multi-transmission/reception point (TRP) transmission according to an embodiment of the present disclosure.

[0018] FIG. 2 is a block diagram of one or more user equipments (UEs) and a base station (e.g., gNB or eNB) of communication in a communication network system according to an embodiment of the present disclosure.

[0019] FIG. 3 is a flowchart illustrating a method of wireless communication by a user equipment (UE) according to an embodiment of the present disclosure.

[0020] FIG. 4 is a flowchart illustrating a method of wireless communication by a base station according to an embodiment of the present disclosure.

[0021] FIG. 5 is a block diagram of a system for wireless communication according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0022] Embodiments of the present disclosure are described in detail with the technical matters, structural features, achieved objects, and effects with reference to the accompanying drawings as follows. Specifically, the terminologies in the embodiments of the present disclosure are merely for describing the purpose of the certain embodiment, but not to limit the disclosure.

[0023] In non-coherent joint transmission, different transmission/reception points (TRPs) use different physical downlink control channels (PDCCHs) to schedule physical downlink sharing channel (PDSCH) transmission independently.

Each TRP can send one downlink control information (DCI) to schedule one PDSCH transmission. PDSCHs from different TRPs can be scheduled in the same slot or different slots. Two different PDSCH transmissions from different TRPs can be fully overlapped or partially overlapped in PDSCH resource allocation. To support multi-TRP based non-coherent joint transmission, a user equipment (UE) is requested to receive PDCCH from multiple TRPs and then receive PDSCH sent from multiple TRPs. For each PDSCH transmission, the UE can feedback a hybrid automatic repeat request-acknowledge (HARQ-ACK) information to a network. In multi-TRP transmission, the UE can feedback the HARQ-ACK information for each PDSCH transmission to the TRP transmitting the PDSCH. The UE can also feedback the HARQ-ACK information for a PDSCH transmission sent from any TRP to one particular TRP.

[0024] An example of multi-TRP based non-coherent joint transmission is illustrated in FIG. 1A. A UE receives a PDSCH based on non-coherent joint transmission from two TRPs: TRP1 and TRP2. As illustrated in FIG. 1A, the TRP1 sends one DCI to schedule a transmission of PDSCH 1 to the UE and the TRP2 sends one DCI to schedule a transmission of PDSCH 2 to the UE. At the UE side, the UE receives and decodes DCI from both TRPs. Based on the DCI from the TRP1, the UE receives and decodes the PDSCH 1 and based on the DCI from the TRP2, the UE receives and decodes the PDSCH 2. In the example illustrated in FIG. 1A, the UE reports HARQ-ACK for PDSCH 1 and PDSCH2 to the TRP1 and the TRP 2, respectively. The TRP1 and the TRP 2 use different control resource sets (CORESETs) and search spaces to transmit DCI scheduling PDSCH transmission to the UE. Therefore, the network can configure multiple CORESETs and search spaces. Each TRP can be associated with one or more CORESETs and also the related search spaces. With such configuration, the TRP would use the associated CORESET to transmit DCI to schedule a PDSCH transmission to the UE. The UE can be requested to decode DCI in CORESETs associated with either TRP to obtain PDSCH scheduling information.

[0025] Another example of multi-TRP transmission is illustrated in FIG. 1B. A UE receives PDSCH based on non-coherent joint transmission from two TRPs: TRP1 and TRP2. As illustrated in FIG. 1B, the TRP1 sends one DCI to schedule a transmission of PDSCH 1 to the UE and the TRP2 sends one DCI to schedule the transmission of PDSCH 2 to the UE. At the UE side, the UE receives and decodes DCI from both TRPs. Based on the DCI from the TRP1, the UE receives and decodes the PDSCH 1 and based on the DCI from the TRP2, the UE receives and decodes the PDSCH 2. In the example illustrated in FIG. 1B, the UE reports HARQ-ACK for both PDSCH 1 and PDSCH2 to the TRP, which is different from the HARQ-ACK reporting in the example illustrated in FIG. 1A. The example illustrated in FIG. 1B needs ideal backhaul between the TRP 1 and the TRP 2, while the example illustrated in FIG. 1A can be deployed in the scenarios that the backhaul between the TRP 1 and the TRP 2 is ideal or non-ideal.

[0026] In new radio/5th generation (NR/5G) systems, a higher layer parameter CORSETPoolIndex is used to differentiate whether multi-TRP transmission is supported in one serving cell or not. In one serving cell, if multi-TRP transmission is supported, CORESETs in that serving cell would be configured with one of two different values for the higher layer parameter CORESETPoolIndex. In details, in one bandwidth part (BWP) of the serving cell, if the UE is provided with higher layer parameter CORESETPoolIndex with a value of 0 or not provided with higher layer parameter for some CORESETs and is provided with higher layer parameter CORESETPoolIndex with a value of 1 for other CORESET(s), then multi-TRP transmission is supported for that UE in the BWP of the serving cell.

[0027] When a spatial relation information is not configured to the PUCCH resource or SRS resource, the UE can derive a default spatial relation information for the transmission of PUCCH or SRS. For an SRS resource, the default spatial relation information is: If there is CORESET configured in the DL BWP in the CC, the UE can transmit the SRS resource with the same spatial domain transmission filter used for the reception of the CORESET with the lowest controlResourceSetId in the active DL BWP in the CC. If the UE is not configured with any CORESET in the CC, the UE can transmit the SRS resource with the same spatial domain transmission filter used for the reception of the activated TCI state with the lowest ID applicable to PDSCH in the active DL BWP of the CC.

[0028] For a PUCCH resource, the default spatial relation information is that: the UE transmits the PUCCH resource with a spatial setting for a PUCCH transmission from the UE is same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on the active DL BWP of the CC.

[0029] Default spatial relation for PUSCH scheduled by DCI 0_0 is also specified: For PUSCH scheduled by DCI format 0_0 on a cell and if the higher layer parameter enableDefaultBeamPlForPUSCH0_0 is set 'enabled', the UE is not configured with PUCCH resources on the active UL BWP and the UE is in RRC connected mode, the UE can transmit PUSCH according to the spatial relation, if applicable, with a reference to the RS with 'QCL-Type-D' corresponding to the QCL assumption of the CORESET with the lowest ID. For PUSCH scheduled by DCI format 0_0 on a cell and if the higher layer parameter enableDefaultBeamPlForPUSCH0_0 is set 'enabled', the UE is configured with PUCCH resources on the active UL BWP where all the PUCCH resource(s) are not configured with any spatial relation and the UE is in RRC connected mode, the UE can transmit PUSCH according to the spatial relation, if applicable, with a reference to the RS with 'QCL-Type-D' corresponding to the QCL assumption of the CORESET with the lowest ID in case CORESET(s) are configured on the CC.

[0030] Regarding the default pathloss RS for PUCCH, SRS and PUSCH, some embodiments have the following methods: For SRS: the default pathloss RS is the periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index, if CORESETs are provided in the active DL BWP and the active PDSCH TCI state with lowest ID, if CORESETs are not provided in the active DL BWP of the CC. For PUCCH: the default pathloss RS is periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the CC. For PUSCH scheduled by DCI 0_0, the default pathloss RS is determined as: If there is no PUCCH resource configured, the default pathloss RS is periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the scheduling cell for the serving cell. If there is PUCCH resource configured but the PUCCH resource is not configured with spatial relation info, the default pathloss RS is a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the CC.

[0031] FIG. 2 illustrates that, in some embodiments, one or more user equipments (UEs) 10 and a base station (e.g., gNB or eNB) 20 for transmission adjustment in a communication network system 30 according to an embodiment of the present disclosure are provided. The communication network system 30 includes the one or more UEs 10 and the base station 20. The one or more UEs 10 may include a memory 12, a transceiver 13, and a processor 11 coupled to the memory 12 and the transceiver 13. The base station 20 may include a memory 22, a transceiver 23, and a processor 21 coupled to the memory 22 and the transceiver 23. The processor 11 or 21 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of radio interface protocol may be implemented in the processor 11 or 21. The memory 12 or 22 is operatively coupled with the processor 11 or 21 and stores a variety of information to operate the processor 11 or 21. The transceiver 13 or 23 is operatively coupled with the processor 11 or 21, and the transceiver 13 or 23 transmits and/or receives a radio signal.

[0032] The processor 11 or 21 may include application-specific integrated circuit (ASIC), other chipset, logic circuit and/or data processing device. The memory 12 or 22 may include read-only memory (ROM), random access memory (RAM), flash memory, memory card, storage medium and/or other storage device. The transceiver 13 or 23 may include baseband circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein can be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The modules can be stored in the memory 12 or 22 and executed by the processor 11 or 21. The memory 12 or 22 can be implemented within the processor 11 or 21 or external to the processor 11 or 21 in which case those can be communicatively coupled to the processor 11 or 21 via various means as is known in the art.

[0033] In some embodiments, the processor 11 is configured to be scheduled, by the base station 20, with an uplink channel. The processor 11 is configured to determine a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID). This can solve issues in the prior art, utilize multi-transmission/reception point (TRP) reception, improve uplink reliability, provide a good communication performance, and/or provide high reliability.

[0034] In some embodiments, the processor 21 is configured to schedule, to the user equipment (UE) 10, an uplink channel. The processor 21 is configured to determine a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID). This can solve issues in the prior art, utilize multi-transmission/reception point (TRP) reception, improve uplink reliability, provide a good communication performance, and/or provide high reliability.

[0035] FIG. 3 illustrates a method 200 of wireless communication by a user equipment (UE) 10 according to an embodiment of the present disclosure. In some embodiments, the method 200 includes: a block 202, being scheduled, by a base station, with an uplink channel, and a block 204, determining a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID). This can solve issues in the prior art, utilize multi-transmission/reception point (TRP) reception, improve uplink reliability, provide a good communication performance, and/or provide high reliability.

[0036] FIG. 4 illustrates a method 300 of wireless communication by a base station 20 according to an embodiment of the present disclosure. In some embodiments, the method 300 includes: a block 302, scheduling, to a user equipment (UE), an uplink channel, and a block 304, determining a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID). This can solve issues in the prior art, utilize multi-transmission/reception point (TRP) reception, improve uplink reliability, provide a good communication performance, and/or provide high reliability.

[0037] In some embodiments, the PUSCH is scheduled by a downlink control information (DCI) format 0_0, and in a single-DCI based multi-transmission/reception point (TRP) system, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID. In some embodiments, for the PUSCH is scheduled by the DCI format 0_0, in a multi-DCI based multi-TRP, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP. In some embodiments, for a physical uplink control channel (PUCCH) resource, in a single-DCI based multi-TRP system, a default spatial relation can be same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on an active downlink (DL) bandwidth part (BWP) of the CC and a default pathloss RS is a periodic RS resource with the QCL-Type-D in a TCI state or the QCL assumption of the CORESET with a lowest index in the active DL BWP of the component carrier (CC). In some embodiments, for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH transmission triggered by a

DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

[0038] In some embodiments, for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH not triggered by a DCI, a default spatial relation and a default pathloss RS is a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP. In some embodiments, for a sounding reference signal (SRS) resource, in a single-DCI based multi-TRP system, a default spatial relation and a default pathloss RS can be the same to a QCL-Type-D RS in a TCI state or the QCL assumption of the CORESET with the lowest ID on an active DL BWP of a CC. In some embodiments, for an SRS resource, in a single-DCI based multi-TRP system, if there is no CORESET configured, a default spatial relation and a default pathloss RS is the same to a QCL-Type-D RS in an active physical downlink shared channel (PDSCH) TCI state with a lowest ID. In some embodiments, in a multi-DCI based multi-TRP system, for an aperiodic SRS transmission triggered by a DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP. In some embodiments, in a multi-DCI based multi-TRP system, for an SRS not triggered by a DCI, a default spatial relation and a default pathloss RS can be a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP.

[0039] Component 1: PUSCH of DCI 0_0:

[0040] In some embodiments, for a PUSCH scheduled by DCI format 0_0 in a multi-TRP system, if the UE is not provided with PUCCH resource in the active UL BWP and the UE is already in RRC connected mode, the UE can transmit the PUSCH according to a spatial relation with a reference to the RS of QCL-TypeD in the TCI-state or QCL assumption of the CORESET with the lowest ID of corresponding TRP. If the UE is provided with PUCCH rescore but all the PUCCH resources are not configured with spatial relation info, the UE can transmit the PUSCH according to a spatial relation with a reference to the RS of QCL-TypeD in the TCI-state or QCL assumption of the CORESET with the lowest ID of corresponding TRP. In some embodiments, in multi-DCI based multi-TRP system, the default spatial relation info can be the QCL-TypeD RS of the TCI-state or QCL assumption of the CORESET with lowest ID of all CORESETs with the same CORESETPoolIndex as the PDCCH scheduling that PUSCH transmission. In some embodiments, in single-DCI based multi-TRP system, the default spatial relation info can be the QCL-TypeD RS of the TCI-state or QCL assumption of the CORESET with lowest ID. Optionally, the UE can apply the same method to derive the default pathloss RS.

[0041] In a first example, for PUSCH scheduled by DCI format 0_0 on a cell and if the higher layer parameter *enableDefaultBeamPlForPUSCH0_0* is set 'enabled' and if the UE is provided at least one TCI codepoint mapped with two TCI states, the UE is not configured with PUCCH resources on the active UL BWP and the UE is in RRC connected mode, the UE can transmit PUSCH according to the spatial relation, if applicable, with a reference to the RS with 'QCL-TypeD' corresponding to the QCL assumption of the CORESET with the lowest ID on the active DL BWP of the cell. In some embodiments, for PUSCH scheduled by DCI format 0_0 on a cell and if the higher layer parameter *enableDefaultBeamPlForPUSCH0_0* is set 'enabled' and if the UE is provided at least one TCI codepoint mapped with two TCI states, the UE is configured with PUCCH resources on the active UL BWP where all the PUCCH resource(s) are not configured with any spatial relation and the UE is in RRC connected mode, the UE can transmit PUSCH according to the spatial relation, if applicable, with a reference to the RS with 'QCL-TypeD' corresponding to the QCL assumption of the CORESET with the lowest ID on the active DL BWP of the cell in case CORESET(s) are configured on the cell.

[0042] In a second example, for PUSCH scheduled by DCI format 0_0 on a cell and if the higher layer parameter *enableDefaultBeamPlForPUSCH0_0* is set 'enabled' and if a UE configured by higher layer parameter PDCCH-Config that contains two different values of *CORESETPoolIndex* in *ControlResourceSet*, the UE is not configured with PUCCH resources on the active UL BWP and the UE is in RRC connected mode, the UE can transmit PUSCH according to the

spatial relation, if applicable, with a reference to the RS with 'QCL-TypeD' corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs, which are configured with the same value of CORESETPoolIndex as the PDCCH scheduling that PUSCH on the active DL BWP of the cell. In some embodiments, for PUSCH scheduled by DCI format 0_0 on a cell and if the higher layer parameter *enableDefaultBeamPlForPUSCH0_0* is set 'enabled' and if the UE is configured by higher layer parameter PDCCH-Config that contains two different values of *CORESETPoolIndex* in *ControlResourceSet*, the UE is configured with PUCCH resources on the active UL BWP where all the PUCCH resource(s) are not configured with any spatial relation and the UE is in RRC connected mode, the UE can transmit PUSCH according to the spatial relation, if applicable, with a reference to the RS with 'QCL-TypeD' corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs, which are configured with the same value of CORESETPoolIndex as the PDCCH scheduling that PUSCH on the active DL BWP of the cell in case CORESET(s) are configured on the CC.

[0043] In a third example, the UE can determine the pathloss RS q_d for a PUSCH scheduled by DCI format 0_0 as follows: If the PUSCH transmission is scheduled by a DCI format 0_0, the UE is not provided PUCCH resources for the active UL BWP, and the UE is provided *enableDefaultBeamPlForPUSCH0_0* and if the UE is provided at least one TCI codepoint mapped with two TCI states, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the scheduling cell for the serving cell. If the PUSCH transmission is scheduled by a DCI format 0_0, the UE is not provided a spatial setting for PUCCH resources on the active UL BWP of the CC, and the UE is provided *enableDefaultBeamPlForPUSCH0_0* if the UE is provided at least one TCI codepoint mapped with two TCI states, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the scheduling cell for the serving cell.

[0044] In a fourth example, the UE can determine the pathloss RS q_d for a PUSCH scheduled by DCI format 0_0 as follows: If the PUSCH transmission is scheduled by a DCI format 0_0, the UE is not provided PUCCH resources for the active UL BWP, and the UE is provided *enableDefaultBeamPlForPUSCH0_0* and if the UE is configured by higher layer parameter PDCCH-Config that contains two different values of *CORESETPoolIndex* in *ControlResourceSet*, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index, among CORESETs, which are configured with the same value of CORESETPoolIndex as the PDCCH scheduling that PUSCH in the active DL BWP of the scheduling cell for the serving cell. If the PUSCH transmission is scheduled by a DCI format 0_0, the UE is not provided a spatial setting for PUCCH resources on the active UL BWP of the CC, and the UE is provided *enableDefaultBeamPlForPUSCH0_0* and if the UE is configured by higher layer parameter PDCCH-Config that contains two different values of *CORESETPoolIndex* in *ControlResourceSet*, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index among CORESETs, which are configured with the same value of CORESETPoolIndex as the PDCCH scheduling that PUSCH in the active DL BWP of the scheduling cell for the serving cell.

[0045] Component 2: PUCCH:

[0046] In some embodiments, for a PUCCH resource not configured with spatial relation info in a multi-TRP system, the UE can determine a default spatial relation setting and default pathloss RS for the PUCCH resource according one or more of the followings: In a single-DCI based multi-TRP system, the default spatial relation for the PUCCH resource can be the QCL-TypeD RS of TCI-state or QCL assumption for PDCCH reception in the CORESET with the lowest ID on the active BWP of the CC. The default pathloss RS for the PUCCH resource can be the QCL-TypeD RS of TCI-state or QCL

assumption for PDCCH reception in the CORESET with the lowest ID on the active BWP of the CC. In a multi-DCI based multi-TRP system, the default spatial relation for a PUCCH resource can be the QCL-TypeD RS of TCI-state or QCL assumption for PDCCH reception in the CORESET with the lowest ID among all the CORESETs associated with the TRP that is associated with the PUCCH resource. To determine the association between TRP and a PUCCH resource, the UE can determine a PUCCH resource is associated with a first TRP if the PUCCH resource transmission is triggered by a DCI that is sent from the first TRP. In one example, a higher layer parameter can be configured for a PUCCH transmission to indicate the association between the TRP and a PUCCH transmission. Optionally, the default pathloss RS for a PUCCH resource can be the QCL-TypeD RS of TCI-state or QCL assumption for PDCCH reception in the CORESET with the lowest ID among all the CORESETs associated with the TRP that is associated with the PUCCH resource.

[0047] In a first example, for a PUCCH transmission, if a UE is not provided *pathlossReferenceRSs* in *PUCCH-PowerControl*, is provided *enableDefaultBeamPlForPUCCH*, and is not provided *PUCCH-SpatialRelationInfo*, and if the UE is provided at least one TCI codepoint mapped with two TCI states, a spatial setting for a PUCCH transmission from the UE is same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on the active DL BWP of the PCell.

[0048] In a second example, to determine the pathloss RS q_d for a PUCCH transmission, If the UE is not provided pathlossReferenceRSs, and is not provided PUCCH-SpatialRelationInfo, and is provided enableDefaultBeamPlForPUCCH and if the UE is provided at least one TCI codepoint mapped with two TCI states, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the primary cell.

[0049] In a third example, if a UE is not provided *pathlossReferenceRSs* in *PUCCH-PowerControl*, is provided *enableDefaultBeamPlForPUCCH*, and is not provided *PUCCH-SpatialRelationInfo*, and if the UE is configured by higher layer parameter PDCCH-Config that contains two different values of CORESETPoolIndex in ControlResourceSet,

[0050] Optionally, for a PUCCH transmission triggered by PDCCH, a spatial setting for a PUCCH transmission from the UE is same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID among CORESETs, which are configured with the same value of CORESETPoolIndex as the PDCCH triggering that PUCCH in the active DL BWP of the scheduling cell for the serving cell. Optionally, for a PUCCH transmission not triggered by PDCCH, a spatial setting for a PUCCH transmission from the UE is same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID among CORESETs, which are configured with the same value of CORESETPoolIndex associated with that PUCCH transmission in the active DL BWP of the scheduling cell for the serving cell. Optionally, for a PUCCH transmission not triggered by PDCCH, a spatial setting for a PUCCH transmission from the UE is same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID among CORESETs, which are configured with the value of CORESETPoolIndex = 0 (another example 1) in the active DL BWP of the scheduling cell for the serving cell. Optionally, for a PUCCH transmission, a spatial setting for a PUCCH transmission from the UE is same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID among CORESETs, which are configured with the value of CORESETPoolIndex = 0 (another example 1) in the active DL BWP of the scheduling cell for the serving cell.

[0051] In an fourth example, to determine the pathloss RS q_d for a PUCCH transmission, If the UE is not provided pathlossReferenceRSs, and is not provided PUCCH-SpatialRelationInfo, and is provided enableDefaultBeamPlForPUCCH and if the UE is configured by higher layer parameter PDCCH-Config that contains two different values of CORESETPoolIndex in ControlResourceSet. Optionally, for a PUCCH transmission triggered by PDCCH, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index among CORESETs, which are configured with the same value of

CORESETPoolIndex as the PDCCH triggering that PUCCH in the active DL BWP of the scheduling cell for the serving cell. Optionally, for a PUCCH transmission not triggered by PDCCH, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index among CORESETs, which are configured with the same value of CORESETPoolIndex associated with that PUCCH transmission in the active DL BWP of the scheduling cell for the serving cell.

[0052] Optionally, for a PUCCH transmission not triggered by PDCCH, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index among CORESETs, which are configured with the value of CORESETPoolIndex = 0 (another example is 1) in the active DL BWP of the scheduling cell for the serving cell. Optionally, for a PUCCH transmission, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index among CORESETs, which are configured with the value of CORESETPoolIndex = 0 (another example is 1) in the active DL BWP of the scheduling cell for the serving cell.

[0053] Component 3: SRS:

[0054] In some embodiments, for a SRS resource that is not configured with spatial relation info in a multi-TRP system, the UE can determine a default spatial relation setting and default pathloss RS for the SRS resource according one or more of the followings: In a single-DCI based multi-TRP system, the default spatial relation for the SRS resource can be the QCL-TypeD RS of TCI-state or QCL assumption for PDCCH reception in the CORESET with the lowest ID on the active BWP of the CC and if there is CORESET configured, the default spatial relation is QCL-TypeD RS in the activated TCI state with the lowest ID applicable to PDSCH. The default pathloss RS for the SRS resource can same to the QCL-TypeD RS used as default spatial relation for the SRS resource.In a multi-DCI based multi-TRP system, the default spatial relation for a SRS resource can be the QCL-TypeD RS of TCI-state or QCL assumption for PDCCH reception in the CORESET with the lowest ID among all the CORESETs associated with the TRP that is associated with the SRS resource and if there is no CORESET configured, the default spatial relation for a SRS resource can be the QCL-TypeD RS of the active TCI state with lowest ID associated with the TRP that is associated with the SRS resource.To determine the association between TRP and a SRS resource, the UE can determine a PUCCH resource is associated with a first TRP if the SRS resource transmission is triggered by a DCI that is sent from the first TRP. In one example, a higher layer parameter can be configured for a SRS transmission to indicate the association between the TRP and a SRS transmission. Optionally, the default pathloss RS for a SRS resource can be the QCL-TypeD RS of TCI-state or QCL assumption for PDCCH reception in the CORESET with the lowest ID among all the CORESETs associated with the TRP that is associated with the SRS resource or the QCL-TypeD RS of the active TCI state with lowest ID associated with the TRP that is associated with the SRS transmission.

[0055] In a first example, for a SRS transmission, when the higher layer parameter enableDefaultBeamPlForSRS is set 'enabled', and if the higher layer parameter spatialRelationInfo for the SRS resource, except for the SRS resource with the higher layer parameter usage in SRS-ResourceSet set to 'beamManagement' or for the SRS resource with the higher layer parameter usage in SRS-ResourceSet set to 'nonCodebook' with configuration of associatedCSI-RS or for the SRS resource configured by the higher layer parameter [SRS-for-positioning], is not configured in FR2 and if the UE is not configured with higher layer parameter(s) pathlossReferenceRS, and if the UE is provided at least one TCI codepoint mapped with two TCI states, the UE can transmit the target SRS resource. 1. With the same spatial domain transmission filter used for the reception of the CORESET with the lowest controlResourceSetId in the active DL BWP in the CC. 2. With the same spatial domain transmission filter used for the reception of the activated TCI state with the lowest ID applicable to PDSCH in the active DL BWP of the CC if the UE is not configured with any CORESET in the CC.

[0056] In a second example, to determine a pathloss RS q_d for a SRS transmission, if the UE is not provided pathlossReferenceRS or SRS-PathlossReferenceRS, is not provided spatialRelationInfo, and is provided enableDefaultBeamPlForSRS and if the UE is provided at least one TCI codepoint mapped with two TCI states, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index, if CORESETs are provided in the active DL BWP or the active PDSCH TCI state with lowest ID, if CORESETs are not provided in the active DL BWP.

[0057] In a third example, for a SRS transmission, when the higher layer parameter enableDefaultBeamPlForSRS is set 'enabled', and if the higher layer parameter spatialRelationInfo for the SRS resource, except for the SRS resource with the higher layer parameter usage in SRS-ResourceSet set to 'beamManagement' or for the SRS resource with the higher layer parameter usage in SRS-ResourceSet set to 'nonCodebook' with configuration of associatedCSI-RS or for the SRS resource configured by the higher layer parameter [SRS-for-positioning], is not configured in FR2 and if the UE is not configured with higher layer parameter(s) pathlossReferenceRS, and if the UE is configured by higher layer parameter PDCCH-Config that contains two different values of *CORESETPoolIndex* in *ControlResourceSet,*

[0058] Optionally,for a SRS triggered by DCI, the UE can transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the CORESET with the lowest controlResourceSetId among CORESETs, which are configured with the same value of CORESETPoolIndex as the PDCCH triggering SRS transmission in the active DL BWP of the scheduling cell for the serving cell, and the UE can transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the activated TCI state with the lowest ID applicable to PDSCH associated with the same value of CORESETPoolIndex as the PDCCH triggering SRS transmission in the active DL BWP of the CC if the UE is not configured with any CORESET in the CC.

[0059] Optionally, for a SRS not triggered by DCI, the UE can transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the CORESET with the lowest controlResourceSetId among CORESETs, which are configured with the same value of CORESETPoolIndex that is associated with SRS transmission in the active DL BWP of the scheduling cell for the serving cell, and the UE can transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the activated TCI state with the lowest ID applicable to PDSCH associated with the same value of CORESETPoolIndex that is associated with the SRS transmission in the active DL BWP of the CC if the UE is not configured with any CORESET in the CC. Optionally,for an SRS not triggered by DCI, the UE can transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the CORESET with the lowest controlResourceSetId among CORESETs, which are configured with the value of CORESETPoolIndex = 0 (another example is 1)in the active DL BWP of the scheduling cell for the serving cell, and the UE can transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the activated TCI state with the lowest ID applicable to PDSCH associated with the value of CORESETPoolIndex =0 (another example is 1) in the active DL BWP of the CC if the UE is not configured with any CORESET in the CC.

[0060] Optionally, for an SRS transmission, the UE can transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the CORESET with the lowest controlResourceSetId among CORESETs, which are configured with the value of CORESETPoolIndex = 0 (another example is 1)in the active DL BWP of the scheduling cell for the serving cell, and the UE can transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the activated TCI state with the lowest ID applicable to PDSCH associated with the value of CORESETPoolIndex =0 (another example is 1) in the active DL BWP of the CC if the UE is not configured with any CORESET in the CC.

[0061] In a fourth example, to determine a pathloss RS q_d for an SRS transmission, if the UE is not provided pathlossReferenceRS or SRS-PathlossReferenceRS, is not provided spatialRelationInfo, and is provided enableDefaultBeamPlForSRS and if the UE is configured by higher layer parameter PDCCH-Config that contains two different values of *CORESETPoolIndex* in *ControlResourceSet*.

[0062] Optionally, for an SRS triggered by DCI, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or QCL assumption of a CORESET with the lowest controlResourceSetId among CORESETs, which are configured with the same value of CORESETPoolIndex as the PDCCH triggering SRS transmission in the active DL BWP of the scheduling cell for the serving cell, and the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the activated TCI state with the lowest ID applicable to PDSCH associated with the same value of CORESETPoolIndex as the PDCCH triggering SRS transmission in the active DL BWP of the CC if the UE is not configured with any CORESET in the CC.

[0063] Optionally, for an SRS not triggered by DCI, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or QCL assumption of a CORESET with the lowest controlResourceSetId among CORESETs, which are configured with the same value of CORESETPoolIndex that is associated with SRS transmission in the active DL BWP of the scheduling cell for the serving cell, and the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the activated TCI state with the lowest ID applicable to PDSCH associated with the same value of CORESETPoolIndex that is associated with the SRS transmission in the active DL BWP of the CC if the UE is not configured with any CORESET in the CC.

[0064] Optionally, for an SRS not triggered by DCI, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or QCL assumption of a CORESET with the lowest controlResourceSetId among CORESETs, which are configured with the value of CORESETPoolIndex = 0 (another example is 1) in the active DL BWP of the scheduling cell for the serving cell, and the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the activated TCI state with the lowest ID applicable to PDSCH associated with the value of CORESETPoolIndex =0 (another example is 1) in the active DL BWP of the CC if the UE is not configured with any CORESET in the CC.

[0065] Optionally, for an SRS transmission, the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the TCI state or QCL assumption of a CORESET with the lowest controlResourceSetId among CORESETs, which are configured with the value of CORESETPoolIndex = 0 (another example is 1) in the active DL BWP of the scheduling cell for the serving cell, and the UE determines a RS resource index q_d providing a periodic RS resource with 'QCL-TypeD' in the activated TCI state with the lowest ID applicable to PDSCH associated with the value of CORESETPoolIndex =0 (another example is 1) in the active DL BWP of the CC if the UE is not configured with any CORESET in the CC.

[0066] In summary, in some embodiments of this disclosure, the methods for determining spatial relation and pathloss RS for PUCCH, SRS, and PUSCH of DCI 0_0 is presented. Optionally, for PUSCH scheduled by DCI 0_0, the default spatial relation info and pathloss RS can be: 1. In single-DCI based multi-TRP system, the default spatial relation info and the default pathloss RS can be the RS with 'QCL-Type-D' corresponding to the QCL assumption of the CORESET with the lowest ID. 2. In multi-DCI based multi-TRP, the default spatial relation and the default pathloss RS can be the RS with 'QCL-Type-D' corresponding to the QCL assumption of the CORESET with the lowest ID among all the CORESETs of the scheduling TRP. Optionally, for a PUCCH resource, the default spatial relation info and default pathloss RS can be: 1.In

single-DCI based multi-TRP system, the default spatial relation info can be same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on the active DL BWP of the CC and the default pathloss RS is periodic RS resource with 'QCL-TypeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the CC. 2.In multi-DCI based multi-TRP system, optionally, for a PUCCH transmission triggered by a DCI, the default spatial relation and default pathloss RS can be the RS with 'QCL-Type-D' corresponding to the QCL assumption of the CORESET with the lowest ID among all the CORESETs of the scheduling TRP. Optionally, for PUCCH not triggered by DCI, one alternative is the default spatial relation and default pathloss RS is the QCL-typeD RS of the QCL assumption of the CORESET with the lowest ID among all the CORESETs of the first TRP. Optionally, for an SRS resource, the default spatial relation info and default pathloss RS can be: 1. In single-DCI based multi-TRP system, the default spatial relation info and default pathloss RS can be same to the QCL-TypeD RS in the TCI state or QCL assumption of the CORESET with the lowest ID on the active DL BWP of the CC. If there is no CORESET configured, the default spatial relation info and default pathloss RS is the same to the QCL-TypeD RS in the active PDSCH TCI state with lowest ID. 2. In multi-DCI based multi-TRP system, optionally, for an aperiodic SRS transmission triggered by a DCI, the default spatial relation and default pathloss RS can be the RS with 'QCL-Type-D' corresponding to the QCL assumption of the CORESET with the lowest ID among all the CORESETs of the scheduling TRP. Optionally, for SRS not triggered by DCI, one alternative is the default spatial relation and default pathloss RS is the QCL-typeD RS of the QCL assumption of the CORESET with the lowest ID among all the CORESETs of the first TRP.

[0067] The following 3GPP standards are incorporated in some embodiments of this disclosure by reference in their entireties: 3GPP TS 38.211 V16.1.0: "NR; Physical channels and modulation", 3GPP TS 38.212 V16.1.0: "NR; Multiplexing and channel coding", 3GPP TS 38.213 V16.1.0: "NR; Physical layer procedures for control", 3GPP TS 38.214 V16.1.0: "NR; Physical layer procedures for data", 3GPP TS 38.215 V16.1.0: "NR; Physical layer measurements", 3GPP TS 38.321 V16.1.0: "NR; Medium Access Control (MAC) protocol specification", and 3GPP TS 38.331 V16.1.0: "NR; Radio Resource Control (RRC) protocol specification".

[0068] The following table includes some abbreviations, which may be used in some embodiments of the present disclosure:

3GPP	3rd Generation Partnership Project
5G	5th Generation
NR	New Radio
gNB	Next generation NodeB
DL	Downlink
UL	Uplink
PUSCH	Physical Uplink Shared Channel
PUCCH	Physical Uplink Control Channel
PDSCH	Physical Downlink Shared Channel
PDCCH	Physical Downlink Control Channel
SRS	Sounding Reference Signal

CSI	Channel state information
CSI-RS	Channel state information reference signal
RS	Reference Signal
CORESET	Control Resource Set
DCI	Downlink control information
TRP	Transmission/reception point
ACK	Acknowledge
NACK	Non-Acknowledge
UCI	Uplink control information
RRC	Radio Resource Control
HARQ	Hybrid Automatic Repeat Request
MAC	Media Access Control
MAC CE	Media Access Control Control Element
CRC	Cyclic Redundancy Check
RNTI	Radio Network Temporary Identity
RB	Resource Block
PRB	Physical Resource Block
NW	Network
RSRP	Reference signal received power
L1-RSRP	Layer 1 Reference signal received power
TCI	Transmission Configuration Indicator
Tx	Transmission
Rx	Receive
QCL	Quasi co-location
SSB	SS/PBCH Block
SRI	SRS resource indicator

[0069] Commercial interests for some embodiments are as follows. 1. Solving issues in the prior art. 2. Utilizing multi-transmission/reception point (TRP) reception. 3. Improving uplink reliability. 4. Providing a good communication

performance. 5. Providing high reliability. 6. Some embodiments of the present disclosure are used by 5G-NR chipset vendors, V2X communication system development vendors, automakers including cars, trains, trucks, buses, bicycles, motobikes, helmets, and etc., drones (unmanned aerial vehicles), smartphone makers, communication devices for public safety use, AR/VR device maker for example gaming, conference/seminar, education purposes. The deployment scenarios include, but not limited to, indoor hotspot, dense urban, urban micro, urban macro, rural, factor hall, and indoor D2D scenarios. Some embodiments of the present disclosure are a combination of "techniques/processes" that can be adopted in 3GPP specification to create an end product. Some embodiments of the present disclosure could be adopted in 5G NR licensed and non-licensed or shared spectrum communications. Some embodiments of the present disclosure propose technical mechanisms. The present example embodiment is applicable to NR in unlicensed spectrum (NR-U). The present disclosure can be applied to other mobile networks, in particular to mobile network of any further generation cellular network technology (6G, etc.).

[0070] FIG. 5 is a block diagram of an example system 700 for wireless communication according to an embodiment of the present disclosure. Embodiments described herein may be implemented into the system using any suitably configured hardware and/or software. FIG. 5 illustrates the system 700 including a radio frequency (RF) circuitry 710, a baseband circuitry 720, an application circuitry 730, a memory/storage 740, a display 750, a camera 760, a sensor 770, and an input/output (I/O) interface 780, coupled with each other at least as illustrated. The application circuitry 730 may include a circuitry such as, but not limited to, one or more single-core or multi-core processors. The processors may include any combination of general-purpose processors and dedicated processors, such as graphics processors, application processors. The processors may be coupled with the memory/storage and configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems running on the system.

[0071] The baseband circuitry 720 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processors may include a baseband processor. The baseband circuitry may handle various radio control functions that enables communication with one or more radio networks via the RF circuitry. The radio control functions may include, but are not limited to, signal modulation, encoding, decoding, radio frequency shifting, etc. In some embodiments, the baseband circuitry may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[0072] In various embodiments, the baseband circuitry 720 may include circuitry to operate with signals that are not strictly considered as being in a baseband frequency. For example, in some embodiments, baseband circuitry may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency. The RF circuitry 710 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. In various embodiments, the RF circuitry 710 may include circuitry to operate with signals that are not strictly considered as being in a radio frequency. For example, in some embodiments, RF circuitry may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

[0073] In various embodiments, the transmitter circuitry, control circuitry, or receiver circuitry discussed above with respect to the user equipment, eNB, or gNB may be embodied in whole or in part in one or more of the RF circuitry, the baseband circuitry, and/or the application circuitry. As used herein, "circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or a

memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the electronic device circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, some or all of the constituent components of the baseband circuitry, the application circuitry, and/or the memory/storage may be implemented together on a system on a chip (SOC). The memory/storage 740 may be used to load and store data and/or instructions, for example, for system. The memory/storage for one embodiment may include any combination of suitable volatile memory, such as dynamic random access memory (DRAM)), and/or non-volatile memory, such as flash memory.

[0074] In various embodiments, the I/O interface 780 may include one or more user interfaces designed to enable user interaction with the system and/or peripheral component interfaces designed to enable peripheral component interaction with the system. User interfaces may include, but are not limited to a physical keyboard or keypad, a touchpad, a speaker, a microphone, etc. Peripheral component interfaces may include, but are not limited to, a non-volatile memory port, a universal serial bus (USB) port, an audio jack, and a power supply interface. In various embodiments, the sensor 770 may include one or more sensing devices to determine environmental conditions and/or location information related to the system. In some embodiments, the sensors may include, but are not limited to, a gyro sensor, an accelerometer, a proximity sensor, an ambient light sensor, and a positioning unit. The positioning unit may also be part of, or interact with, the baseband circuitry and/or RF circuitry to communicate with components of a positioning network, e.g., a global positioning system (GPS) satellite.

[0075] In various embodiments, the display 750 may include a display, such as a liquid crystal display and a touch screen display. In various embodiments, the system 700 may be a mobile computing device such as, but not limited to, a laptop computing device, a tablet computing device, a netbook, an ultrabook, a smartphone, an AR/VR glasses, etc. In various embodiments, system may have more or less components, and/or different architectures. Where appropriate, methods described herein may be implemented as a computer program. The computer program may be stored on a storage medium, such as a non-transitory storage medium.

[0076] A person having ordinary skill in the art understands that each of the units, algorithm, and steps described and disclosed in the embodiments of the present disclosure are realized using electronic hardware or combinations of software for computers and electronic hardware. Whether the functions run in hardware or software depends on the condition of application and design requirement for a technical plan. A person having ordinary skill in the art can use different ways to realize the function for each specific application while such realizations should not go beyond the scope of the present disclosure. It is understood by a person having ordinary skill in the art that he/she can refer to the working processes of the system, device, and unit in the above-mentioned embodiment since the working processes of the above-mentioned system, device, and unit are basically the same. For easy description and simplicity, these working processes will not be detailed.

[0077] It is understood that the disclosed system, device, and method in the embodiments of the present disclosure can be realized with other ways. The above-mentioned embodiments are exemplary only. The division of the units is merely based on logical functions while other divisions exist in realization. It is possible that a plurality of units or components are combined or integrated in another system. It is also possible that some characteristics are omitted or skipped. On the other hand, the displayed or discussed mutual coupling, direct coupling, or communicative coupling operate through some ports, devices, or units whether indirectly or communicatively by ways of electrical, mechanical, or other kinds of forms.

[0078] The units as separating components for explanation are or are not physically separated. The units for display are or are not physical units, that is, located in one place or distributed on a plurality of network units. Some or all of the units are used according to the purposes of the embodiments. Moreover, each of the functional units in each of the embodiments can be integrated in one processing unit, physically independent, or integrated in one processing unit with two or more than two units.

[0079] If the software function unit is realized and used and sold as a product, it can be stored in a readable storage medium in a computer. Based on this understanding, the technical plan proposed by the present disclosure can be essentially or partially realized as the form of a software product. Or, one part of the technical plan beneficial to the conventional technology can be realized as the form of a software product. The software product in the computer is stored in a storage medium, including a plurality of commands for a computational device (such as a personal computer, a server, or a network device) to run all or some of the steps disclosed by the embodiments of the present disclosure. The storage medium includes a USB disk, a mobile hard disk, a read-only memory (ROM), a random access memory (RAM), a floppy disk, or other kinds of media capable of storing program codes.

[0080] While the present disclosure has been described in connection with what is considered the most practical and preferred embodiments, it is understood that the present disclosure is not limited to the disclosed embodiments but is intended to cover various arrangements made without departing from the scope of the broadest interpretation of the appended claims.

What is claimed is:

1. A wireless communication method by a user equipment (UE), comprising:

being scheduled, by a base station, with an uplink channel; and

determining a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID).

2. The method of claim 1, wherein the PUSCH is scheduled by a downlink control information (DCI) format 0_0, and in a single-DCI based multi-transmission/reception point (TRP) system, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID.

3. The method of claim 1, wherein for the PUSCH is scheduled by the DCI format 0_0, in a multi-DCI based multi-TRP, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

4. The method of claim 1, wherein for a physical uplink control channel (PUCCH) resource, in a single-DCI based multi-TRP system, a default spatial relation can be same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on an active downlink (DL) bandwidth part (BWP) of the CC and a default pathloss RS is a periodic RS resource with the QCL-Type-D in a TCI state or the QCL assumption of the CORESET with a lowest index in the active DL BWP of the component carrier (CC).

5. The method of claim 1, wherein for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH transmission triggered by a DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

6. The method of claim 1, wherein for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH not triggered by a DCI, a default spatial relation and a default pathloss RS is a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP.

7. The method of claim 1, wherein for a sounding reference signal (SRS) resource, in a single-DCI based multi-TRP system, a default spatial relation and a default pathloss RS can be the same to a QCL-Type-D RS in a TCI state or the QCL assumption of the CORESET with the lowest ID on an active DL BWP of a CC.

8. The method of claim 1, wherein for an SRS resource, in a single-DCI based multi-TRP system, if there is no CORESET configured, a default spatial relation and a default pathloss RS is the same to a QCL-Type-D RS in an active physical downlink shared channel (PDSCH) TCI state with a lowest ID.

9. The method of claim 1, wherein in a multi-DCI based multi-TRP system, for an aperiodic SRS transmission triggered by a DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

10. The method of claim 1, wherein in a multi-DCI based multi-TRP system, for an SRS not triggered by a DCI, a default spatial relation and a default pathloss RS can be a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP.

11. A wireless communication method by a base station, comprising:

scheduling, to a user equipment (UE), an uplink channel; and

determining a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID).

12. The method of claim 11, wherein the PUSCH is scheduled by a downlink control information (DCI) format 0_0, and in

a single-DCI based multi-transmission/reception point (TRP) system, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID.

13. The method of claim 11, wherein for the PUSCH is scheduled by the DCI format 0_0, in a multi-DCI based multi-TRP, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

14. The method of claim 11, wherein for a physical uplink control channel (PUCCH) resource, in a single-DCI based multi-TRP system, a default spatial relation can be same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on an active downlink (DL) bandwidth part (BWP) of the CC and a default pathloss RS is a periodic RS resource with the QCL-Type-D in a TCI state or the QCL assumption of the CORESET with a lowest index in the active DL BWP of the component carrier (CC).

15. The method of claim 11, wherein for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH transmission triggered by a DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

16. The method of claim 11, wherein for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH not triggered by a DCI, a default spatial relation and a default pathloss RS is a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP.

17. The method of claim 11, wherein for a sounding reference signal (SRS) resource, in a single-DCI based multi-TRP system, a default spatial relation and a default pathloss RS can be the same to a QCL-Type-D RS in a TCI state or the QCL assumption of the CORESET with the lowest ID on an active DL BWP of a CC.

18. The method of claim 11, wherein for an SRS resource, in a single-DCI based multi-TRP system, if there is no CORESET configured, a default spatial relation and a default pathloss RS is the same to a QCL-Type-D RS in an active physical downlink shared channel (PDSCH) TCI state with a lowest ID.

19. The method of claim 11, wherein in a multi-DCI based multi-TRP system, for an aperiodic SRS transmission triggered by a DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

20. The method of claim 11, wherein in a multi-DCI based multi-TRP system, for an SRS not triggered by a DCI, a default spatial relation and a default pathloss RS can be a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP.

21. A user equipment (UE), comprising:

a memory;

a transceiver; and

a processor coupled to the memory and the transceiver;

wherein the processor is configured to be scheduled, by a base station, with an uplink channel; and

wherein the processor is configured to determine a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID).

22. The UE of claim 21, wherein the PUSCH is scheduled by a downlink control information (DCI) format 0_0, and in a single-DCI based multi-transmission/reception point (TRP) system, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID.

23. The UE of claim 21, wherein for the PUSCH is scheduled by the DCI format 0_0, in a multi-DCI based multi-TRP, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

24. The UE of claim 21, wherein for a physical uplink control channel (PUCCH) resource, in a single-DCI based multi-TRP system, a default spatial relation can be same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on an active downlink (DL) bandwidth part (BWP) of the CC and a default pathloss RS is a periodic RS resource with the QCL-Type-D in a TCI state or the QCL assumption of the CORESET with a lowest index in the active DL BWP of the component carrier (CC).

25. The UE of claim 21, wherein for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH transmission triggered by a DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

26. The UE of claim 21, wherein for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH not triggered by a DCI, a default spatial relation and a default pathloss RS is a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP.

27. The UE of claim 21, wherein for a sounding reference signal (SRS) resource, in a single-DCI based multi-TRP system, a default spatial relation and a default pathloss RS can be the same to a QCL-Type-D RS in a TCI state or the QCL assumption of the CORESET with the lowest ID on an active DL BWP of a CC.

28. The UE of claim 21, wherein for an SRS resource, in a single-DCI based multi-TRP system, if there is no CORESET configured, a default spatial relation and a default pathloss RS is the same to a QCL-Type-D RS in an active physical downlink shared channel (PDSCH) TCI state with a lowest ID.

29. The UE of claim 21, wherein in a multi-DCI based multi-TRP system, for an aperiodic SRS transmission triggered by a DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

30. The UE of claim 21, wherein in a multi-DCI based multi-TRP system, for an SRS not triggered by a DCI, a default spatial relation and a default pathloss RS can be a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP.

31. A base station, comprising:

a memory;

a transceiver; and

a processor coupled to the memory and the transceiver;

wherein the processor is configured to schedule, to a user equipment (UE), an uplink channel; and

wherein the processor is configured to determine a spatial relation and a pathloss reference signal (RS) for the uplink channel, wherein when the uplink channel comprises a physical uplink shared channel (PUSCH), a default spatial relation and a default pathloss RS can be an RS with quasi co-location (QCL)-Type-D corresponding to a QCL assumption of a control resource set (CORESET) with a lowest identifier (ID).

32. The base station of claim 31, wherein the PUSCH is scheduled by a downlink control information (DCI) format 0_0, and in a single-DCI based multi-transmission/reception point (TRP) system, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID.

33. The base station of claim 31, wherein for the PUSCH is scheduled by the DCI format 0_0, in a multi-DCI based multi-TRP, the default spatial relation and the default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

34. The base station of claim 31, wherein for a physical uplink control channel (PUCCH) resource, in a single-DCI based multi-TRP system, a default spatial relation can be same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on an active downlink (DL) bandwidth part (BWP) of the CC and a default pathloss RS is a periodic RS resource with the QCL-Type-D in a TCI state or the QCL assumption of the CORESET with a lowest index in

the active DL BWP of the component carrier (CC).

35. The base station of claim 31, wherein for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH transmission triggered by a DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

36. The base station of claim 31, wherein for a PUCCH resource, in a multi-DCI based multi-TRP system, for a PUCCH not triggered by a DCI, a default spatial relation and a default pathloss RS is a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP.

37. The base station of claim 31, wherein for a sounding reference signal (SRS) resource, in a single-DCI based multi-TRP system, a default spatial relation and a default pathloss RS can be the same to a QCL-Type-D RS in a TCI state or the QCL assumption of the CORESET with the lowest ID on an active DL BWP of a CC.

38. The base station of claim 31, wherein for an SRS resource, in a single-DCI based multi-TRP system, if there is no CORESET configured, a default spatial relation and a default pathloss RS is the same to a QCL-Type-D RS in an active physical downlink shared channel (PDSCH) TCI state with a lowest ID.

39. The base station of claim 31, wherein in a multi-DCI based multi-TRP system, for an aperiodic SRS transmission triggered by a DCI, a default spatial relation and a default pathloss RS can be the RS with the QCL-Type-D corresponding to the QCL assumption of the CORESET with the lowest ID among CORESETs of a scheduling TRP.

40. The base station of claim 31, wherein in a multi-DCI based multi-TRP system, for an SRS not triggered by a DCI, a default spatial relation and a default pathloss RS can be a QCL-type-D RS of the QCL assumption of the CORESET with the lowest ID among CORESETs of a first TRP.

41. A non-transitory machine-readable storage medium having stored thereon instructions that, when executed by a computer, cause the computer to perform the method of any one of claims 1 to 20.

42. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute the method of any one of claims 1 to 20.

43. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute the method of any one of claims 1 to 20.

44. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute the method of any one of claims 1 to 20.

45. A computer program, wherein the computer program causes a computer to execute the method of any one of claims 1 to 20.

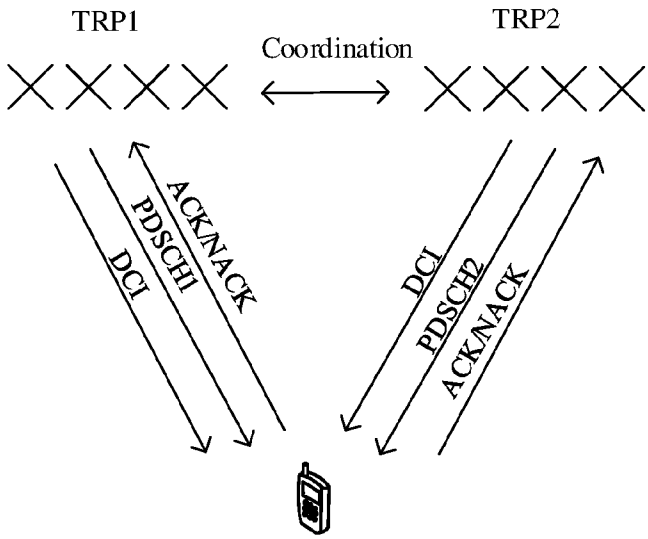

FIG. 1A

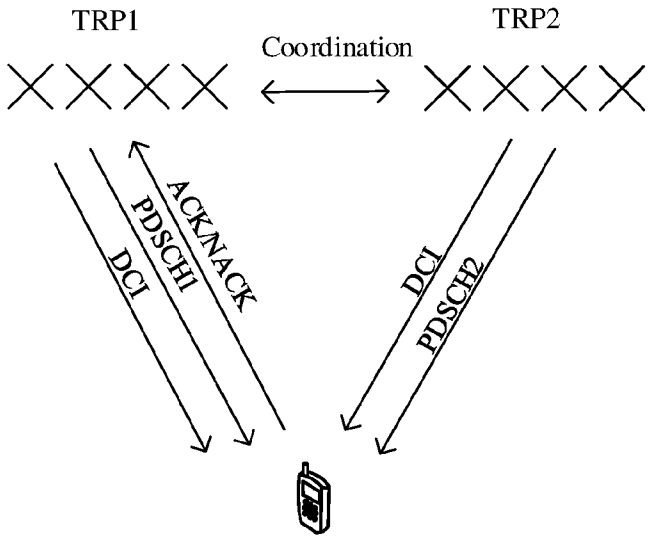

FIG. 1B

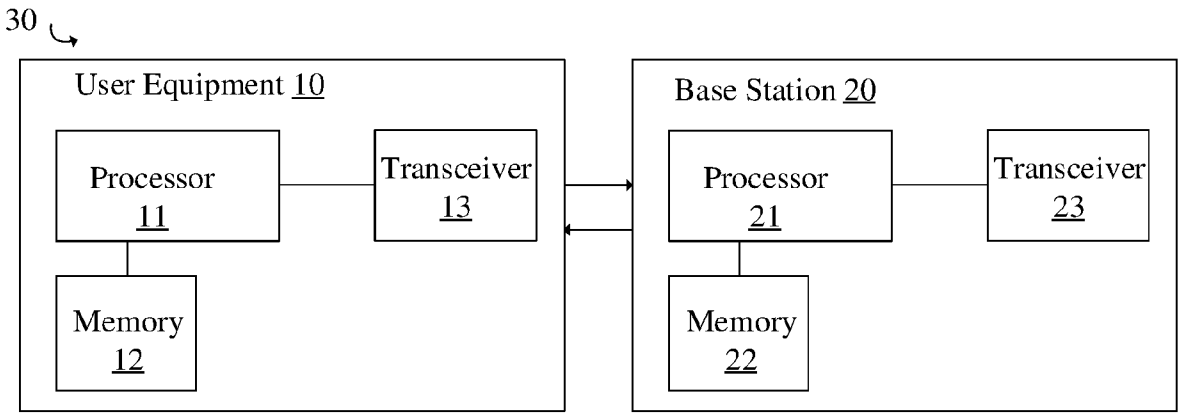

FIG. 2

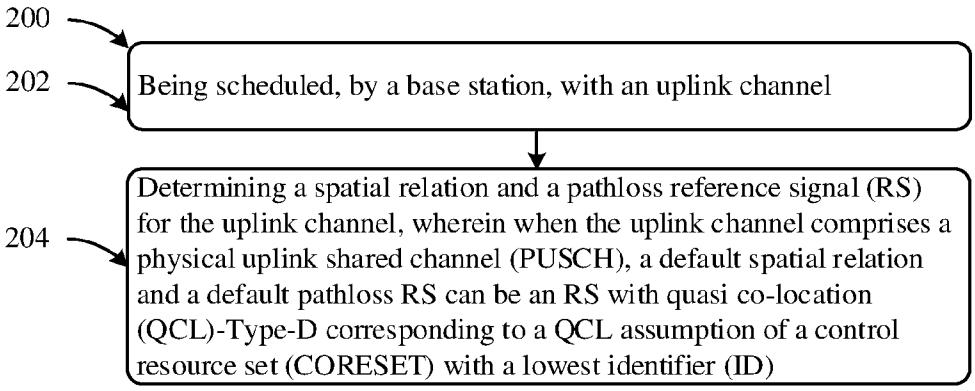

FIG. 3

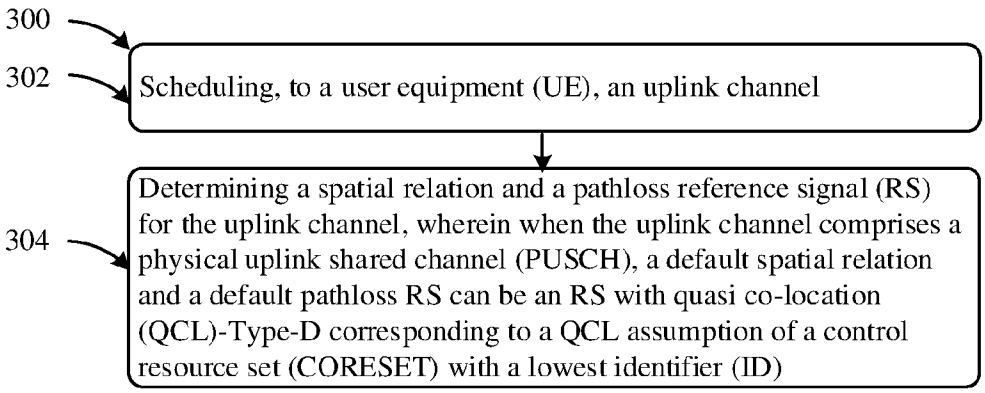

FIG. 4

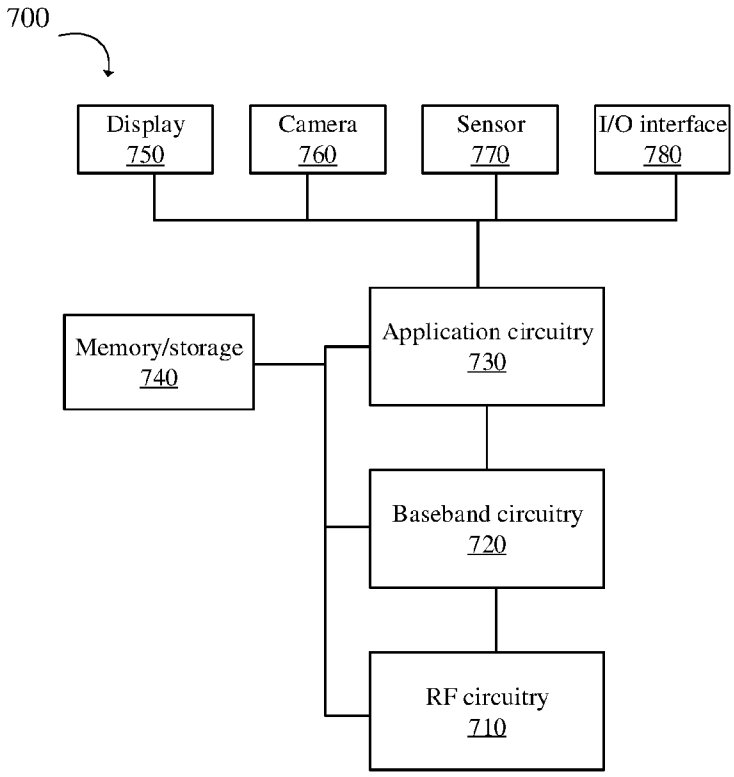

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/093636

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04L

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)

WPI;EPODOC;CNKI;CNPAT;3GPP:spatial 1w relation, TRP, PUSCH, pathloss, CORESET, QCL,quasi 1w co 1w location,control 1w resource 1w set, DCI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NTT DOCOMO, INC. "RAN WG's progress on NR WI in the April meeting 2018" *3GPP TSG-RAN WG2 #102 R2-1806852*, 25 May 2018 (2018-05-25), pages 26, 30	1-45
A	US 2019372806 A1 (LG ELECTRONICS INC.) 05 December 2019 (2019-12-05) the whole document	1-45
A	CN 109997398 A (HUAWEI TECHNOLOGIES CO., LTD.) 09 July 2019 (2019-07-09) the whole document	1-45

☐ 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	Date of mailing of the international search report
02 July 2021	**26 July 2021**
Name and mailing address of the ISA/CN **National Intellectual Property Administration, PRC** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **YANG,Liu** Telephone No. **86-(010)-53961798**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2021/093636

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		EP 3481113 A1	08 May 2019
		SG 11201903386W A	30 May 2019
		WO 2018203728 A1	08 November 2018
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		KR 20190039398 A	11 April 2019
		BR 112019015603 A2	17 March 2020
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		AU 2018263238 A1	16 May 2019
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CN 109997398 A	09 July 2019	EP 3692762 A1	12 August 2020
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		WO 2019085842 A1	09 May 2019
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