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(54) **Title:** MULTIPLE DOWNLINK CONTROL INFORMATION DESIGN FOR MULTIPLE TRANSCEIVER NODES

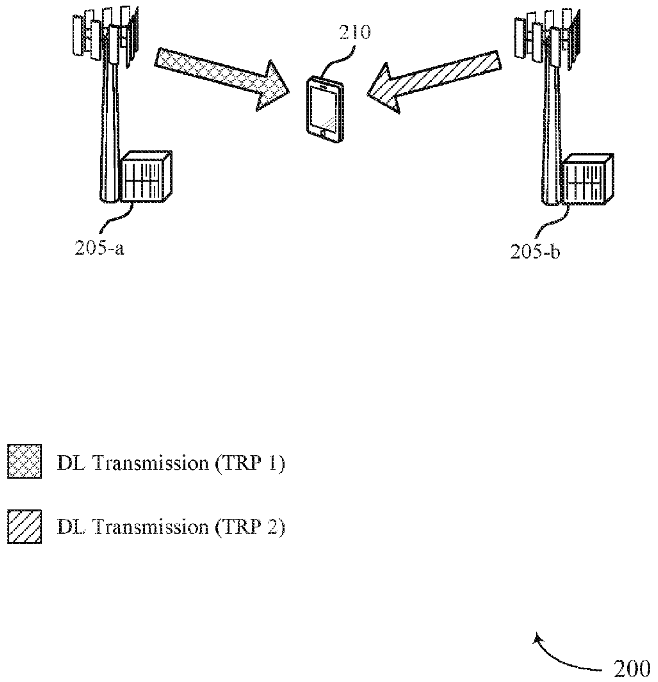

FIG. 2

(57) **Abstract:** Methods, systems, and devices for wireless communications are described. A user equipment (UE) may receive a first downlink control information (DCI) message comprising a first codeword (CW) configuration and a first demodulation reference signal (DMRS) port configuration. The UE may receive a second DCI message comprising a second CW configuration and a second DMRS port configuration. The UE may determine, based at least in part on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, wherein the transmission scheme comprises an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration. The UE may receive, according to the transmission scheme, the downlink transmissions.

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MULTIPLE DOWNLINK CONTROL INFORMATION DESIGN FOR MULTIPLE TRANSCEIVER NODES

BACKGROUND

[0001] The following relates generally to wireless communications, and more specifically to multiple downlink control information (DCI) design for multiple transceiver nodes.

[0002] Wireless communications systems are widely deployed to provide various types of communication content such as voice, video, packet data, messaging, broadcast, and so on. These systems may be capable of supporting communication with multiple users by sharing the available system resources (e.g., time, frequency, and power). Examples of such multiple-access systems include fourth generation (4G) systems such as Long Term Evolution (LTE) systems, LTE-Advanced (LTE-A) systems, or LTE-A Pro systems, and fifth generation (5G) systems which may be referred to as New Radio (NR) systems. These systems may employ technologies such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal frequency division multiple access (OFDMA), or discrete Fourier transform-spread-OFDM (DFT-S-OFDM). A wireless multiple-access communications system may include a number of base stations or network access nodes, each simultaneously supporting communication for multiple communication devices, which may be otherwise known as user equipment (UE).

[0003] Wireless communication systems may use various transmission schemes to support communications between a UE and base station. In some examples, the transmission schemes may support transmissions from multiple transmission/reception points (TRPS), which may also be referred to as transceiver nodes. That is, multiple transceiver nodes may be associated with a base station, or with multiple base stations, where each transceiver node transmits the same or different information to the UE according to the transmission scheme. In some aspects, a transmission scheme may refer to an association between one or more reference signal port(s) and one or more codewords (or transport block (TB) associated with a codeword). Examples of transmission schemes include, but are not limited to, each transceiver node transmitting a unique codeword to the UE, each transceiver node transmitting a different part of the same codeword to the UE, and/or each transceiver node transmitting a different version of the same codeword to the UE. Typically, conventional techniques require a separate downlink grant, e.g., a DCI, or some other mechanism for the transceiver nodes to indicate resources for the downlink transmission. However, this approach is inefficient and involves increased overhead in terms or signaling, resources, and the like. Moreover, DCI design in conventional systems is inefficient in terms of information conveyed and resources used.

SUMMARY

[0004] The described techniques relate to improved methods, systems, devices, and apparatuses that support multiple downlink control information (DCI) design for multiple transceiver nodes. Generally, the described techniques provide for a DCI design that improves efficiency and operations where multiple transceiver nodes are performing a downlink transmission to the UE. For example, a base station may determine that a downlink transmission is to occur for the UE. It is to be understood that references to the base station in this context may refer to one or more base stations that control, manage, monitor, or are otherwise associated with multiple transceiver nodes or transmission/reception points (TRPs). For example, the base station may configure each transceiver node for the downlink transmission and/or multiple base stations may configure their respective transceiver node for the downlink transmissions. The base station may identify or otherwise select the transmission scheme to use for the downlink transmission, with the transmission scheme generally referring to an association between one or more demodulation reference signal (DMRS) ports and one or more codewords being communicated in the downlink transmission. The base station may configure a DCI message for transmission to the UE from each transceiver node participating in the downlink transmission. For example, the base station may transmit a first DCI (e.g., from a first transceiver node) and a second DCI (e.g., from a second transceiver node) to the UE, with each DCI message carrying or otherwise conveying an indication of an associated codeword configuration and a DMRS port configuration. For example, the first DCI message may include a first codeword configuration and first DMRS port configuration and the second DCI message may include a second codeword configuration and a second DMRS port configuration. The UE may respond by determining the transmission scheme based on the first and second codeword configurations. Accordingly, the base station may transmit (e.g., via the respective transceiver nodes) and the UE may receive the downlink transmission according to the transmission scheme. Broadly, different transmission schemes may refer to which codeword, which

portion of a codeword, and/or which version of the codeword is being communicated to the UE during the downlink transmission.

[0005] A method of wireless communication at a UE is described. The method may include receiving a first DCI message including a first CW configuration and a first DMRS port configuration, receiving a second DCI message including a second CW configuration and a second DMRS port configuration, determining, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration, and receiving, according to the transmission scheme, the downlink transmissions.

[0006] An apparatus for wireless communication at a UE is described. The apparatus may include a processor, memory in electronic communication with the processor, and instructions stored in the memory. The instructions may be executable by the processor to cause the apparatus to receive a first DCI message including a first CW configuration and a first DMRS port configuration, receive a second DCI message including a second CW configuration and a second DMRS port configuration, determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration, and receive, according to the transmission scheme, the downlink transmissions.

[0007] Another apparatus for wireless communication at a UE is described. The apparatus may include means for receiving a first DCI message including a first CW configuration and a first DMRS port configuration, receiving a second DCI message including a second CW configuration and a second DMRS port configuration, determining, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration, and receiving, according to the transmission scheme, the downlink transmissions.

[0008] A non-transitory computer-readable medium storing code for wireless communication at a UE is described. The code may include instructions executable by a processor to receive a first DCI message including a first CW configuration and a first DMRS port configuration, receive a second DCI message including a second CW configuration and a second DMRS port configuration, determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration, and receive, according to the transmission scheme, the downlink transmissions.

[0009] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, each of the first DCI message and the second DCI message further includes an indication of at least one of a QCL information, a rate matching configuration, a HARQ process number, a HARQ timing parameter, a downlink assignment index, a frequency resource allocation, a time resource allocation, or a combination thereof, associated with the one or more DMRS ports of the corresponding DMRS port configuration.

[0010] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, each of the first CW configuration and the second CW configuration include one or more TB information fields, where each TB information field indicates parameters including at least one of a MCS, a NDI, and RV of a particular TB of a CW and the number of TB information fields may be based on a maximum number of CWs or TBs in a downlink transmission, where the maximum number of CWs or TBs in a downlink transmission may be configured via higher layer signaling.

[0011] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for decoding a first TB information field in the first DCI message, the first TB information field indicating one or more parameters for a first TB that may be associated with a first CW, decoding a second TB information field in the second DCI message, the second TB information field indicating one or more parameters for a second TB that may be associated with a second CW, determining, based on a determination that an index of the first TB information field in the first DCI message may be the same as the index of the second TB information field in the second DCI message, the first TB associated with the first CW being the same as the second TB associated with the second CW and determining, based on a determination that the index of the first TB information field in the first DCI message may be different from the index of the second TB information field in the second DCI message, the first TB associated with the first CW being different from the second TB associated with the second CW.

[0012] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, determining that the first TB associated with the first CW may be different from the second TB associated with the second CW may include operations, features, means, or instructions for determining that the transmission scheme includes receiving the first TB associated with the first CW using one or more DMRS ports and resource allocations configured in the first DCI message and receiving the second CW using one or more DMRS ports and resource allocations configured in the second DCI message, receiving the first CW based on a first QCL information and a first rate matching configuration indicated in the first DCI message and receiving the second CW based on a second QCL information and a second rate matching configuration indicated in the second DCI message.

[0013] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, a first data stream associated with the first TB that may be associated with the first CW may be mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports and a second data stream associated with the second TB that may be associated with the second CW may be mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order including a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of second one or more DMRS ports.

[0014] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, determining the first TB associated with the first CW may be the same as the second TB associated with the second CW may include operations, features, means, or instructions for identifying a MCS of the TB configured in the second DCI message being set to a first reserved value, determining that the transmission scheme may include operations, features, means, or instructions for receiving a first portion of the TB using one or more DMRS ports and resource allocation configured in the first DCI message and receiving a second portion of the TB using one or more DMRS ports and resource allocation configured in the second DCI message, receiving the first portion based on a first QCL information and a first rate matching configuration indicated in the first DCI message and receiving the second portion based on a second QCL information and a second rate matching configuration indicated in the second DCI message.

[0015] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, a first data stream associated with the first portion of the TB associated with the CW may be mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports and a second data stream associated with the second portion of the TB associated with the CW may be mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order including a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

[0016] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for aggregating, based on an index of each DMRS port of the first DMRS configuration and the second DMRS configuration, a first one or more DMRS ports of the first DMRS configuration and a second one or more DMRS ports of the second DMRS configuration to form an aggregated DMRS port, aggregating, based on an index of each resource element associated with the frequency resource allocation and time resource allocation configured in the first DCI and the second DCI, the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message to form an aggregated frequency resource allocation and an aggregated time resource allocation and mapping a data stream of the TB associated with the CW according to the order including one or more layers associated with the aggregated DMRS port, then the aggregated frequency resource allocation associated with the aggregated DMRS port, and then the aggregated time resource allocation associated with the aggregated DMRS port.

[0017] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for determining that both the first DCI message and the second DCI message may be decoded and transmitting a signal indicating a decoding result of the TB following a HARQ timing parameter indicated in the second DCI message.

[0018] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving a third DCI message including a third CW configuration, identifying that a third TB information field in the third DCI message indicates a third parameter for a third TB where an index of the third TB information field in the third DCI message may be the same as the index of the first TB information field in the first DCI message and may be the same as the index of the second TB information field in the second DCI message, determining that the third TB may be the same as the TB indicated by the first TB information field in the first DCI and the TB indicated by the second TB information field in the second DCI, identifying a MCS parameter for the third TB being set to a second reserved value, determining that the transmission scheme further includes receiving a third portion of the same TB using a third DMRS port configuration and resource allocation configured in the third DCI message and receiving the third portion based on the first QCL information and the first rate matching configuration indicated in the first DCI message.

[0019] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for determining that the first DCI message, the second DCI message and the third DCI message may be decoded, determining that the second reserved value indicated in the third CW configuration may be greater than the first reserved value indicated in the second CW configuration and transmitting, based on the second reserved value being greater than the first reserved value, a signal indicating a decoding result of the TB following a HARQ timing parameter indicated in the third DCI message.

[0020] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, determining the first TB associated with the first CW may be same as the second TB associated with the second CW further may include operations, features, means, or instructions for identifying a MCS parameter of the TB configured in the first DCI message being set to a value not equal to a reserved value, and the MCS of the TB configured in the second DCI message being set to a value not equal to a reserved value, determining that the transmission scheme may include operations, features, means, or instructions for receiving a first version of the TB using one or more DMRS ports and resource allocation configured in the first DCI message and receiving a second version of the TB using one or more DMRS ports and resource allocation configured in the second DCI message, receiving the first version based on a first QCL information and a first rate matching configuration indicated in the first DCI message and receiving the second version based on a second QCL information and a second rate matching configuration indicated in the second DCI message.

[0021] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, a first data stream associated with the first version of the TB associated with the CW may be mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports and a second data stream associated with the second version of the TB associated with the CW may be mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order including a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

[0022] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the transmit scheme includes a transmit diversity scheme.

[0023] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for identifying a frequency resource allocation and time resource allocation configured in the first DCI message as being the same as the frequency resource allocation and time resource allocation configured in the second DCI message and determining that the transmit diversity scheme includes spatial frequency block coding, where the first version of the TB and the second version of the TB may have the same RV, but the mapping between the first version and the first one or more DMRS ports follows a different mapping rule from the mapping between the second version and the second one or more DMRS ports.

[0024] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving a signal indicating a set of supported transmission schemes and determining the transmission scheme from the set of supported transmission schemes based on the first CW configuration and the second CW configuration.

[0025] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for identifying that a resource allocation configured in the first DCI message may be the same as the resource allocation configured in the second DCI message and determining that the DMRS ports configured in the first DCI message may be different from the DMRS ports configured in the second DCI message.

[0026] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for identifying that the DMRS ports configured in the first DCI message and the DMRS ports configured in the second DCI message share one or more common DMRS ports, applying at least one of a first QCL information, a first rate matching configuration, or a combination thereof, to the common DMRS ports using the resource allocation configured in the first DCI message and applying at least one of a second QCL information, a second rate matching configuration, or a combination thereof, to the common DMRS ports using the resource allocation configured in the second DCI message.

[0027] A method of wireless communication at a base station is described. The method may include determining a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration, transmitting, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration, and transmitting, according to the transmission scheme, the downlink transmissions.

[0028] An apparatus for wireless communication at a base station is described. The apparatus may include a processor, memory in electronic communication with the processor, and instructions stored in the memory. The instructions may be executable by the processor to cause the apparatus to determine a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration, transmit, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration, and transmit, according to the transmission scheme, the downlink transmissions.

[0029] Another apparatus for wireless communication at a base station is described. The apparatus may include means for determining a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration, transmitting, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration, and transmitting, according to the transmission scheme, the downlink transmissions.

[0030] A non-transitory computer-readable medium storing code for wireless communication at a base station is described. The code may include instructions executable by a processor to determine a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration, transmit, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration, and transmit, according to the transmission scheme, the downlink transmissions.

[0031] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, each of the first DCI message and the second DCI message further includes an indication of at least one of a QCL information, a rate matching configuration, a HARQ process number, a HARQ timing parameter, a downlink assignment index, a frequency resource allocation, a time resource allocation, or a combination thereof, associated with the one or more DMRS ports of the corresponding DMRS port configuration.

[0032] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, each of the first and second CW configurations include one or more TB information fields, where each TB information field indicates parameters including at least one of a MCS, a NDI and a RV of a particular TB of a CW and the number of TB information fields may be based on a maximum number of CWs or TBs in a downlink transmission, where the maximum number of CWs or TBs in the downlink transmission may be configured via higher layer signaling.

[0033] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, determining the transmission scheme further may include operations, features, means, or instructions for determining that a first TB associated with a first CW may be transmitted using one or more DMRS ports of the first DMRS configuration, and a second TB associated with a second CW may be transmitted using one or more DMRS ports of the second DMRS configuration, determining that the first TB associated with the first CW may be the different from the second TB associated with the second CW, transmitting, in a first TB information field in the first DCI message, an indication of one or more parameters for the first TB associated with the first CW and transmitting, in a second TB information field in the second DCI message, an indication of one or more parameters for the second TB associated with the second CW, where an index of the first TB information field in the first DCI message may be different from the index of the second TB information field in the second DCI message.

[0034] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting the first TB associated with the first CW using a first one or more DMRS ports and a first resource allocation indicated in the first DCI message, based on a first QCL information and a first rate matching configuration indicated in the first DCI message and transmitting the second TB associated with the second CW using a second one or more DMRS ports and a second resource allocation indicated in the second DCI message, based on a second QCL information and a second rate matching configuration indicated in the second DCI message.

[0035] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, a first data stream associated with the first TB that may be associated with the first CW may be mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports and a second data stream associated with the second TB that may be associated with the second CW may be mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order including a second layer of second one or more DMRS ports, then a frequency resource allocation of second one or more DMRS ports, and then a time resource allocation of second one or more DMRS ports.

[0036] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, determining the transmission scheme further may include operations, features, means, or instructions for determining a first portion of a TB associated with a CW may be transmitted using one or more DMRS ports of the first DMRS configuration, and a second portion of the TB associated with the CW may be transmitted using one or more DMRS ports of the second DMRS configuration, transmitting, in a first TB information field in the first DCI message, an indication of one or more parameters for the TB associated with the CW and transmitting, in a second TB information field in the second DCI message, an indication of one or more parameters for the TB associated with the CW, where the index of the first TB information field in the first DCI message may be the same as the index of the second TB information field in the second DCI message, and a MCS parameter provided in the second TB information field may be set to a reserved value.

[0037] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, a first data stream associated with the first portion of the TB associated with the CW may be mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports and a second data stream associated with the second portion of the TB associated with CW may be mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order including a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

[0038] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for aggregating, based on an index of each DMRS port of the first DMRS configuration and the second DMRS configuration, a first one or more DMRS ports of the first DMRS configuration and a second one or more DMRS ports of the second DMRS configuration to form an aggregated DMRS port, aggregating, based on an index of each resource element associated with the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message, the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message to form an aggregated frequency resource allocation and an aggregated time resource allocation and mapping a data stream of the TB associated with the CW according to the order including one or more layers associated with the aggregated DMRS port, then the aggregated frequency resource allocation associated with the aggregated DMRS port, and then the aggregated time resource allocation associated with the aggregated DMRS port.

[0039] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting a first HARQ timing in the first DCI message, transmitting a second HARQ timing in the second DCI message and receiving a decoding result of the TB associated with the CW.

[0040] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for determining that a third portion of the TB associated with the CW may be transmitted using a third one or more DMRS ports of a third DMRS configuration, transmitting a third DCI message including the third DMRS configuration, a third TB information field in the third DCI message indicating the parameters for the TB, where the index of the third TB information field in the third DCI message may be the same as the index of the first TB information field in the first DCI and may be the same as the index of the second TB information field in the second DCI message, the MCS parameter for the third TB being set to a second reserved value, a third QCL information, and a third rate matching configuration associated with the third DMRS configuration and transmitting the third portion of the TB associated with the CW based on the third QCL information and the third rate matching configuration.

[0041] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting a third HARQ timing in the third DCI message, determining that the second reserved value indicated in the third CW configuration may be greater than a first reserved value indicated in the second CW configuration and receiving, based on the second reserved value being greater than the first reserved value, a signal indicating a decoding result of the TB following a HARQ timing parameter indicated in the third DCI message.

[0042] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, determining the transmission scheme further may include operations, features, means, or instructions for determining that a first version of a TB associated with a CW may be transmitted using one or more DMRS ports of the first DMRS configuration, and a second version of the TB associated with the CW may be transmitted using one or more DMRS ports of the second DMRS configuration, transmitting, in a first TB information field in the first DCI message, an indication of one or more parameters for the TB associated with the CW, transmitting, in a second TB information field in the second DCI message, an indication of one or more parameters for the TB associated with the CW, where, the index of the first TB information field in the first DCI message may be the same as the index of the second TB information field in the second DCI message and a MCS parameter provided in the first TB information field may be not set to a reserved value, and the MCS parameter provided in the second TB information field may be not set to a reserved value.

[0043] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, a first data stream associated with the first version of the TB associated with the CW may be mapped to a first one or more DMRS port of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports and a second data stream associated with the second version of the TB associated with the CW may be mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order including a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

[0044] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the transmit scheme includes a transmit diversity scheme.

[0045] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for identifying a frequency resource allocation and time resource allocation configured in the first DCI message as being the same as the frequency resource allocation and time resource allocation configured in the second DCI message and determining that the transmit diversity scheme may be spatial frequency block coding, where the first version of the TB and the second version of the TB may have a same RV, but the mapping between the first version and the first one or more DMRS ports follows a different mapping rule from the mapping from the second version and the second one or more DMRS ports.

[0046] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting a signal indicating a set of supported transmission schemes and determining the transmission scheme from the set of supported transmission schemes based on the first CW configuration and the second CW configuration.

[0047] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for identifying that a resource allocation configured in the first DCI message may be the same as the resource allocation configured in the second DCI message and transmitting different DMRS ports configuration in the first DCI message than the DMRS ports configuration in the second DCI message.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048] FIG. 1 illustrates an example of a system for wireless communications that supports multiple downlink control information (DCI) design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0049] FIG. 2 illustrates an example of a wireless communication system that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0050] FIG. 3 illustrates an example of a DCI configuration that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0051] FIG. 4 illustrates an example of a codeword configuration that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0052] FIG. 5 illustrates an example of a DCI configuration that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0053] FIG. 6 illustrates an example of a process that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0054] FIGs. 7 and 8 show block diagrams of devices that support multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0055] FIG. 9 shows a block diagram of a communications manager that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0056] FIG. 10 shows a diagram of a system including a device that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0057] FIGs. 11 and 12 show block diagrams of devices that support multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0058] FIG. 13 shows a block diagram of a communications manager that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0059] FIG. 14 shows a diagram of a system including a device that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

[0060] FIGs. 15 through 17 show flowcharts illustrating methods that support multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0061] Wireless communication systems typically use a downlink control information (DCI) message to schedule downlink transmissions. Typically, the base station transmits the DCI message to a user equipment (UE) that indicates resources to be used for the downlink transmission. The UE is configured with a search space or control resource set that it monitors to determine whether a DCI is present for the UE. When detected, the UE decodes the DCI, identifies the resources for the downlink transmission, and then monitors the resources to receive the downlink transmission from the base station. While this process may be acceptable in some situations, other downlink transmissions may involve multiple transceiver nodes communicating information during the downlink transmission. For example, there may be multiple transceiver nodes (e.g., base stations, transmission/reception points (TRPs), and the like) that are configured for the downlink transmission, with each transceiver node communicating the same codeword, communicating a different codeword, communicating different portions of the same codeword, or different versions of the same codeword. In this situation, conventional DCI designs may be inefficient in terms of informing the UE of which transmission scheme is being used for the downlink transmission.

[0062] Aspects of the disclosure are initially described in the context of a wireless communications system. Generally, the described techniques provide for a DCI design that improves efficiency and operations where multiple transceiver nodes are performing a downlink transmission to the UE. For example, a base station may determine that a downlink transmission is to occur for the UE. It is to be understood that references to the base station in this context may refer to one or more base stations that control, manage, monitor, or are otherwise associated with multiple transceiver nodes or transmission/reception points (TRPs). For example, the base station may configure each transceiver node for the downlink transmission and/or multiple base stations may configure their respective transceiver nodes for the downlink transmissions. The base station may determine, identify or otherwise select the transmission scheme to use for the downlink transmission, with the transmission scheme generally including an association between one or more demodulation reference signal (DMRS) port configurations and one or more codewords being communicated in the downlink transmission. The base station may configure a DCI message for transmission to the UE from each transceiver node participating in the downlink transmission. For example, the base station may transmit a first DCI (e.g., from a first transceiver node) and a second DCI (e.g., from a second transceiver node) to the UE, with each DCI message carrying or otherwise conveying an indication of an associated codeword configuration and DMRS port configuration. For example, the first DCI message may include a first codeword configuration and first DMRS port configuration and the second DCI message may include a second codeword configuration and second DMRS port configuration. The UE may respond by determining the transmission scheme based on the first and second codeword configurations. Accordingly, the base station may transmit (e.g., via the respective transceiver nodes) and the UE may receive the downlink transmission according to the transmission scheme. Broadly, different transmission schemes may refer to which codeword, which portion of a codeword, and/or which version of the codeword is being communicated to the UE during the downlink transmission.

[0063] Aspects of the disclosure are further illustrated by and described with reference to apparatus diagrams, system diagrams, and flowcharts that relate to multiple DCI design for multiple transceiver nodes.

[0064] **FIG. 1** illustrates an example of a wireless communications system 100 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The wireless communications system 100 includes base stations 105, UEs 115, and a core network 130. In some examples, the wireless communications system 100 may be a Long Term Evolution (LTE) network, an LTE-Advanced (LTE-A) network, an

LTE-A Pro network, or a New Radio (NR) network. In some cases, wireless communications system 100 may support enhanced broadband communications, ultra-reliable (e.g., mission critical) communications, low latency communications, or communications with low-cost and low-complexity devices.

[0065] Base stations 105 may wirelessly communicate with UEs 115 via one or more base station antennas. Base stations 105 described herein may include or may be referred to by those skilled in the art as a base transceiver station, a radio base station, an access point, a radio transceiver, a NodeB, an eNodeB (eNB), a next-generation Node B or giga-nodeB (either of which may be referred to as a gNB), a Home NodeB, a Home eNodeB, or some other suitable terminology. Wireless communications system 100 may include base stations 105 of different types (e.g., macro or small cell base stations). The UEs 115 described herein may be able to communicate with various types of base stations 105 and network equipment including macro eNBs, small cell eNBs, gNBs, relay base stations, and the like.

[0066] Each base station 105 may be associated with a particular geographic coverage area 110 in which communications with various UEs 115 is supported. Each base station 105 may provide communication coverage for a respective geographic coverage area 110 via communication links 125, and communication links 125 between a base station 105 and a UE 115 may utilize one or more carriers. Communication links 125 shown in wireless communications system 100 may include uplink transmissions from a UE 115 to a base station 105, or downlink transmissions from a base station 105 to a UE 115. Downlink transmissions may also be called forward link transmissions while uplink transmissions may also be called reverse link transmissions.

[0067] The geographic coverage area 110 for a base station 105 may be divided into sectors making up only a portion of the geographic coverage area 110, and each sector may be associated with a cell. For example, each base station 105 may provide communication coverage for a macro cell, a small cell, a hot spot, or other types of cells, or various combinations thereof. In some examples, a base station 105 may be movable and therefore provide communication coverage for a moving geographic coverage area 110. In some examples, different geographic coverage areas 110 associated with different technologies may overlap, and overlapping geographic coverage areas 110 associated with different technologies may be supported by the same base station 105 or by different base stations 105.

The wireless communications system 100 may include, for example, a heterogeneous LTE/LTE-A/LTE-A Pro or NR network in which different types of base stations 105 provide coverage for various geographic coverage areas 110.

[0068] The term "cell" refers to a logical communication entity used for communication with a base station 105 (e.g., over a carrier), and may be associated with an identifier for distinguishing neighboring cells (e.g., a physical cell identifier (PCID), a virtual cell identifier (VCID)) operating via the same or a different carrier. In some examples, a carrier may support multiple cells, and different cells may be configured according to different protocol types (e.g., machine-type communication (MTC), narrowband Internet-of-Things (NB-IoT), enhanced mobile broadband (eMBB), or others) that may provide access for different types of devices. In some cases, the term "cell" may refer to a portion of a geographic coverage area 110 (e.g., a sector) over which the logical entity operates.

[0069] UEs 115 may be dispersed throughout the wireless communications system 100, and each UE 115 may be stationary or mobile. A UE 115 may also be referred to as a mobile device, a wireless device, a remote device, a handheld device, or a subscriber device, or some other suitable terminology, where the "device" may also be referred to as a unit, a station, a terminal, or a client. A UE 115 may also be a personal electronic device such as a cellular phone, a personal digital assistant (PDA), a tablet computer, a laptop computer, or a personal computer. In some examples, a UE 115 may also refer to a wireless local loop (WLL) station, an Internet of Things (IoT) device, an Internet of Everything (IoE) device, or an MTC device, or the like, which may be implemented in various articles such as appliances, vehicles, meters, or the like.

[0070] Some UEs 115, such as MTC or IoT devices, may be low cost or low complexity devices, and may provide for automated communication between machines (e.g., via Machine-to-Machine (M2M) communication). M2M communication or MTC may refer to data communication technologies that allow devices to communicate with one another or a base station 105 without human intervention. In some examples, M2M communication or MTC may include communications from devices that integrate sensors or meters to measure or capture information and relay that information to a central server or application program that can make use of the information or present the information to humans interacting with the program or application. Some UEs 115 may be designed to collect information or enable automated behavior of machines. Examples of applications for MTC devices include smart metering, inventory monitoring, water level monitoring, equipment monitoring, healthcare monitoring, wildlife monitoring, weather and geological event monitoring, fleet management and tracking, remote security sensing, physical access control, and transaction-based business charging.

[0071] Some UEs 115 may be configured to employ operating modes that reduce power consumption, such as half-duplex communications (e.g., a mode that supports one-way communication via transmission or reception, but not transmission and reception simultaneously). In some examples half-duplex communications may be performed at a reduced peak rate. Other power conservation techniques for UEs 115 include entering a power saving "deep sleep" mode when not engaging in active communications, or operating over a limited bandwidth (e.g., according to narrowband communications). In some cases, UEs 115 may be designed to support critical functions (e.g., mission critical functions), and a wireless communications system 100 may be configured to provide ultra-reliable communications for these functions.

[0072] In some cases, a UE 115 may also be able to communicate directly with other UEs 115 (e.g., using a peer-to-peer (P2P) or device-to-device (D2D) protocol). One or more of a group of UEs 115 utilizing D2D communications may be within the geographic coverage area 110 of a base station 105. Other UEs 115 in such a group may be outside the geographic coverage area 110 of a base station 105, or be otherwise unable to receive transmissions from a base station 105. In some cases, groups of UEs 115 communicating via D2D communications may utilize a one-to-many (1:M) system in which each UE 115 transmits to every other UE 115 in the group. In some cases, a base station 105 facilitates the scheduling of resources for D2D communications. In other cases, D2D communications are carried out between UEs 115 without the involvement of a base station 105.

[0073] Base stations 105 may communicate with the core network 130 and with one another. For example, base stations 105 may interface with the core network 130 through backhaul links 132 (e.g., via an S1, N2, N3, or other interface). Base stations 105 may communicate with one another over backhaul links 134 (e.g., via an X2, Xn, or other interface) either directly (e.g., directly between base stations 105) or indirectly (e.g., via core network 130).

[0074] The core network 130 may provide user authentication, access authorization, tracking, Internet Protocol (IP) connectivity, and other access, routing, or mobility functions. The core network 130 may be an evolved packet core (EPC), which may include at least one mobility management entity (MME), at least one serving gateway (S-GW), and at least one Packet Data Network (PDN) gateway (P-GW). The MME may manage non-access stratum (e.g., control plane) functions such as mobility, authentication, and bearer management for UEs 115 served by base stations 105 associated with the EPC. User IP packets may be transferred through the S-GW, which itself may be connected to the P-GW. The P-GW may provide IP address allocation as well as other functions. The P-GW may be connected to the network operators IP services. The operators IP services may include access to the Internet, Intranet(s), an IP Multimedia Subsystem (IMS), or a Packet-Switched (PS) Streaming Service.

[0075] At least some of the network devices, such as a base station 105, may include subcomponents such as an access network entity, which may be an example of an access node controller (ANC). Each access network entity may communicate with UEs 115 through a number of other access network transmission entities, which may be referred to as a radio head, a smart radio head, or a transmission/reception point (TRP). In some configurations, various functions of each access network entity or base station 105 may be distributed across various network devices (e.g., radio heads and access network controllers) or consolidated into a single network device (e.g., a base station 105).

[0076] Wireless communications system 100 may operate using one or more frequency bands, typically in the range of 300 MHz to 300 GHz. Generally, the region from 300 MHz to 3 GHz is known as the ultra-high frequency (UHF) region or decimeter band, since the wavelengths range from approximately one decimeter to one meter in length. UHF waves may be blocked or redirected by buildings and environmental features. However, the waves may penetrate structures sufficiently for a macro cell to provide service to UEs 115 located indoors. Transmission of UHF waves may be associated with smaller antennas and shorter range (e.g., less than 100 km) compared to transmission using the smaller frequencies and longer waves of the high frequency (HF) or very high frequency (VHF) portion of the spectrum below 300 MHz.

[0077] Wireless communications system 100 may also operate in a super high frequency (SHF) region using frequency bands from 3 GHz to 30 GHz, also known as the centimeter band. The SHF region includes bands such as the 5 GHz industrial, scientific, and medical (ISM) bands, which may be used opportunistically by devices that can tolerate interference from other users.

[0078] Wireless communications system 100 may also operate in an extremely high frequency (EHF) region of the spectrum (e.g., from 30 GHz to 300 GHz), also known as the millimeter band. In some examples, wireless communications system 100 may support millimeter wave (mmW) communications between UEs 115 and base stations 105, and EHF antennas of the respective devices may be even smaller and more closely spaced than UHF antennas. In some cases, this may facilitate use of antenna arrays within a UE 115. However, the propagation of EHF transmissions may be subject to even greater atmospheric attenuation and shorter range than SHF or UHF transmissions. Techniques disclosed herein may be employed across transmissions that use one or more different frequency regions, and designated use of bands across these frequency regions may differ by country or regulating body.

[0079] In some cases, wireless communications system 100 may utilize both licensed and unlicensed radio frequency spectrum bands. For example, wireless communications system 100 may employ License Assisted Access (LAA), LTE-Unlicensed (LTE-U) radio access technology, or NR technology in an unlicensed band such as the 5 GHz ISM band. When operating in unlicensed radio frequency spectrum bands, wireless devices such as base stations 105 and UEs 115 may employ listen-before-talk (LBT) procedures to ensure a frequency channel is clear before transmitting data. In some cases, operations in unlicensed bands may be based on a CA configuration in conjunction with CCs operating in a licensed band (e.g., LAA). Operations in unlicensed spectrum may include downlink transmissions, uplink transmissions, peer-to-peer transmissions, or a combination of these. Duplexing in unlicensed spectrum may be based on frequency division duplexing (FDD), time division duplexing (TDD), or a combination of both.

[0080] In some examples, base station 105 or UE 115 may be equipped with multiple antennas, which may be used to employ techniques such as transmit diversity, receive diversity, multiple-input multiple-output (MIMO) communications, or beamforming. For example, wireless communications system 100 may use a transmission scheme between a transmitting device (e.g., a base station 105) and a receiving device (e.g., a UE 115), where the transmitting device is equipped with multiple antennas and the receiving devices are equipped with one or more antennas. MIMO communications may employ multipath signal propagation to increase the spectral efficiency by transmitting or receiving multiple signals via different spatial layers, which may be referred to as spatial multiplexing. The multiple signals may, for example, be transmitted by the transmitting device via different antennas or different combinations of antennas. Likewise, the multiple signals may be received by the receiving device via different antennas or different combinations of antennas. Each of the multiple signals may be referred to as a separate spatial stream, and may carry bits associated with the same data stream (e.g., the same codeword) or different data streams. Different spatial layers may be associated with different antenna ports used for channel measurement and reporting. MIMO techniques include single-user MIMO (SU-MIMO) where multiple spatial layers are transmitted to the same receiving device, and multiple-user MIMO (MU-MIMO) where multiple spatial layers are transmitted to multiple devices.

[0081] Beamforming, which may also be referred to as spatial filtering, directional transmission, or directional reception, is a signal processing technique that may be used at a transmitting device or a receiving device (e.g., a base station 105 or a UE 115) to shape or steer an antenna beam (e.g., a transmit beam or receive beam) along a spatial path between the transmitting device and the receiving device. Beamforming may be achieved by combining the signals communicated via antenna elements of an antenna array such that signals propagating at particular orientations with respect to an antenna array experience constructive interference while others experience destructive interference. The adjustment of signals communicated via the antenna elements may include a transmitting device or a receiving device applying certain amplitude and phase offsets to signals carried via each of the antenna elements associated with the device. The adjustments associated with each of the antenna elements may be defined by a beamforming weight set associated with a particular orientation (e.g., with respect to the antenna array of the transmitting device or receiving device, or with respect to some other orientation).

[0082] In one example, a base station 105 may use multiple antennas or antenna arrays to conduct beamforming operations for directional communications with a UE 115. For instance, some signals (e.g. synchronization signals, reference signals, beam selection signals, or other control signals) may be transmitted by a base station 105 multiple times in different directions, which may include a signal being transmitted according to different beamforming weight sets associated with different directions of transmission. Transmissions in different beam directions may be used to identify (e.g., by the base station 105 or a receiving device, such as a UE 115) a beam direction for subsequent transmission and/or reception by the base station 105. Some signals, such as data signals associated with a particular receiving device, may be transmitted by a base station 105 in a single beam direction (e.g., a direction associated with the receiving device, such as a UE 115). In some examples, the beam direction associated with transmissions along a single beam direction may be determined based at least in in part on a signal that was transmitted in different beam directions. For example, a UE 115 may receive one or more of the signals transmitted by the base station 105 in different directions, and the UE 115 may report to the base station 105 an indication of the signal it received with a highest signal quality, or an otherwise acceptable signal quality. Although these techniques are described with reference to signals transmitted in one or more directions by a base station 105, a UE 115 may employ similar techniques for transmitting signals multiple times in different directions (e.g., for identifying a beam direction for subsequent transmission or reception by the UE 115), or transmitting a signal in a single direction (e.g., for transmitting data to a receiving device).

[0083] A receiving device (e.g., a UE 115, which may be an example of a mmW receiving device) may try multiple receive beams when receiving various signals from the base station 105, such as synchronization signals, reference signals, beam selection signals, or other control signals. For example, a receiving device may try multiple receive directions by receiving via different antenna subarrays, by processing received signals according to different antenna subarrays, by receiving according to different receive beamforming weight sets applied to signals received at a plurality of antenna elements of an antenna array, or by processing received signals according to different receive beamforming weight sets applied to signals received at a plurality of antenna elements of an antenna array, any of which may be referred to as "listening" according to different receive beams or receive directions. In some examples a receiving device may use a single receive beam to receive along a single beam direction (e.g., when receiving a data signal). The single receive beam may be aligned in a beam direction determined based at least in part on listening according to different receive beam directions (e.g., a beam direction determined to have a highest signal strength, highest signal-to-noise ratio, or otherwise acceptable signal quality based at least in part on listening according to multiple beam directions).

[0084] In some cases, the antennas of a base station 105 or UE 115 may be located within one or more antenna arrays, which may support MIMO operations, or transmit or receive beamforming. For example, one or more base station antennas or antenna arrays may be co-located at an antenna assembly, such as an antenna tower. In some cases, antennas or antenna arrays associated with a base station 105 may be located in diverse geographic locations. A base station 105 may have an antenna array with a number of rows and columns of antenna ports that the base station 105 may use to support beamforming of communications with a UE 115. Likewise, a UE 115 may have one or more antenna arrays that may support various MIMO or beamforming operations.

[0085] In some cases, wireless communications system 100 may be a packet-based network that operate according to a layered protocol stack. In the user plane, communications at the bearer or Packet Data Convergence Protocol (PDCP) layer may be IP-based. A Radio Link Control (RLC) layer may in some cases perform packet segmentation and reassembly to communicate over logical channels. A Medium Access Control (MAC) layer may perform priority handling and multiplexing of logical channels into transport channels. The MAC layer may also use hybrid automatic repeat request (HARQ) to provide retransmission at the MAC layer to improve link efficiency. In the control plane, the Radio Resource Control (RRC) protocol layer may provide establishment, configuration, and maintenance of an RRC connection between a UE 115 and a base station 105 or core network 130 supporting radio bearers for user plane data. At the Physical (PHY) layer, transport channels may be mapped to physical channels.

[0086] In some cases, UEs 115 and base stations 105 may support retransmissions of data to increase the likelihood that data is received successfully. HARQ feedback is one technique of increasing the likelihood that data is received correctly over a communication link 125. HARQ may include a combination of error detection (e.g., using a cyclic redundancy check (CRC)), forward error correction (FEC), and retransmission (e.g., automatic repeat request (ARQ)). HARQ may improve throughput at the MAC layer in poor radio conditions (e.g., signal-to-noise conditions). In some cases, a wireless device may support same-slot HARQ feedback, where the device may provide HARQ feedback in a specific slot for data received in a previous symbol in the slot. In other cases, the device may provide HARQ feedback in a subsequent slot, or according to some other time interval.

[0087] Time intervals in LTE or NR may be expressed in multiples of a basic time unit, which may, for example, refer to a sampling period of $T_s = 1/30,720,000$ seconds. Time intervals of a communications resource may be organized according to radio frames each having a duration of 10 milliseconds (ms), where the frame period may be expressed as $T_f = 307,200\ T_s$. The radio frames may be identified by a system frame number (SFN) ranging from 0 to 1023. Each frame may include 10 subframes numbered from 0 to 9, and each subframe may have a duration of 1 ms. A subframe may be further divided into 2 slots each having a duration of 0.5 ms, and each slot may contain 6 or 7 modulation symbol periods (e.g., depending on the length of the cyclic prefix prepended to each symbol period). Excluding the cyclic prefix, each symbol period may contain 2048 sampling periods. In some cases, a subframe may be the smallest scheduling unit of the wireless communications system 100, and may be referred to as a transmission time interval (TTI). In other cases, a smallest scheduling unit of the wireless communications system 100 may be shorter than a subframe or may be dynamically selected (e.g., in bursts of shortened TTIs (sTTIs) or in selected component carriers using sTTIs).

[0088] In some wireless communications systems, a slot may further be divided into multiple mini-slots containing one or more symbols. In some instances, a symbol of a mini-slot or a mini-slot may be the smallest unit of scheduling. Each symbol may vary in duration depending on the subcarrier spacing or frequency band of operation, for example. Further, some wireless communications systems may implement slot aggregation in which multiple slots or mini-slots are aggregated together and used for communication between a UE 115 and a base station 105.

[0089] The term "carrier" refers to a set of radio frequency spectrum resources having a defined physical layer structure for supporting communications over a communication link 125. For example, a carrier of a communication link 125 may include a portion of a radio frequency spectrum band that is operated according to physical layer channels for a given radio access technology. Each physical layer channel may carry user data, control information, or other signaling. A carrier may be associated with a pre-defined frequency channel (e.g., an E-UTRA absolute radio frequency channel number (EARFCN)), and may be positioned according to a channel raster for discovery by UEs 115. Carriers may be downlink or uplink (e.g., in an FDD mode), or be configured to carry downlink and uplink communications (e.g., in a TDD mode). In some examples, signal waveforms transmitted over a carrier may be made up of multiple sub-carriers (e.g., using multi-carrier modulation (MCM) techniques such as OFDM or DFT-s-OFDM).

[0090] The organizational structure of the carriers may be different for different radio access technologies (e.g., LTE, LTE-A, LTE-A Pro, NR, etc.). For example, communications over a carrier may be organized according to TTIs or slots, each of which may include user data as well as control information or signaling to support decoding the user data. A carrier may also include dedicated acquisition signaling (e.g., synchronization signals or system information, etc.) and control signaling that coordinates operation for the carrier. In some examples (e.g., in a carrier aggregation configuration), a carrier may also have acquisition signaling or control signaling that coordinates operations for other carriers.

[0091] Physical channels may be multiplexed on a carrier according to various techniques. A physical control channel and a physical data channel may be multiplexed on a downlink carrier, for example, using time division multiplexing (TDM) techniques, frequency division multiplexing (FDM) techniques, or hybrid TDM-FDM techniques. In some examples, control information transmitted in a physical control channel may be distributed between different control regions in a cascaded manner (e.g., between a common control region or common search space and one or more UE-specific control regions or UE-specific search spaces).

[0092] A carrier may be associated with a particular bandwidth of the radio frequency spectrum, and in some examples the carrier bandwidth may be referred to as a "system bandwidth" of the carrier or the wireless communications system 100. For example, the carrier bandwidth may be one of a number of predetermined bandwidths for carriers of a particular radio access technology (e.g., 1.4, 3, 5, 10, 15, 20, 40, or 80 MHz). In some examples, each served UE 115 may be configured for operating over portions or all of the carrier bandwidth. In other examples, some UEs 115 may be configured for operation using a narrowband protocol type that is associated with a predefined portion or range (e.g., set of subcarriers or RBs) within a carrier (e.g., "in-band" deployment of a narrowband protocol type).

[0093] In a system employing MCM techniques, a resource element may consist of one symbol period (e.g., a duration of one modulation symbol) and one subcarrier, where the symbol period and subcarrier spacing are inversely related. The number of bits carried by each resource element may depend on the modulation scheme (e.g., the order of the modulation scheme). Thus, the more resource elements that a UE 115 receives and the higher the order of the modulation scheme, the higher the data rate may be for the UE 115. In MIMO systems, a wireless communications resource may refer to a combination of a radio frequency spectrum resource, a time resource, and a spatial resource (e.g., spatial layers), and the use of multiple spatial layers may further increase the data rate for communications with a UE 115.

[0094] Devices of the wireless communications system 100 (e.g., base stations 105 or UEs 115) may have a hardware configuration that supports communications over a particular carrier bandwidth, or may be configurable to support communications over one of a set of carrier bandwidths. In some examples, the wireless communications system 100 may include base stations 105 and/or UEs 115 that can support simultaneous communications via carriers associated with more than one different carrier bandwidth.

[0095] Wireless communications system 100 may support communication with a UE 115 on multiple cells or carriers, a feature which may be referred to as carrier aggregation (CA) or multi-carrier operation. A UE 115 may be configured with multiple downlink CCs and one or more uplink CCs according to a carrier aggregation configuration. Carrier aggregation may be used with both FDD and TDD component carriers.

[0096] In some cases, wireless communications system 100 may utilize enhanced component carriers (eCCs). An eCC may be characterized by one or more features including wider carrier or frequency channel bandwidth, shorter symbol duration, shorter TTI duration, or modified control channel configuration. In some cases, an eCC may be associated with a carrier aggregation configuration or a dual connectivity configuration (e.g., when multiple serving cells have a suboptimal or non-ideal backhaul link). An eCC may also be configured for use in unlicensed spectrum or shared spectrum (e.g., where more than one operator is allowed to use the spectrum). An eCC characterized by wide carrier bandwidth may include one or more segments that may be utilized by UEs 115 that are not capable of monitoring the whole carrier bandwidth or are otherwise configured to use a limited carrier bandwidth (e.g., to conserve power).

[0097] In some cases, an eCC may utilize a different symbol duration than other CCs, which may include use of a reduced symbol duration as compared with symbol durations of the other CCs. A shorter symbol duration may be associated with increased spacing between adjacent subcarriers. A device, such as a UE 115 or base station 105, utilizing eCCs may transmit wideband signals (e.g., according to frequency channel or carrier bandwidths of 20, 40, 60, 80 MHz, etc.) at reduced symbol durations (e.g., 16.67 microseconds). A TTI in eCC may consist of one or multiple symbol periods. In some cases, the TTI duration (that is, the number of symbol periods in a TTI) may be variable.

[0098] Wireless communications systems such as an NR system may utilize any combination of licensed, shared, and unlicensed spectrum bands, among others. The flexibility of eCC symbol duration and subcarrier spacing may allow for the use of eCC across multiple spectrums. In some examples, NR shared spectrum may increase spectrum utilization and spectral efficiency, specifically through dynamic vertical (e.g., across the frequency domain) and horizontal (e.g., across the time domain) sharing of resources.

[0099] A UE 115 may receive a first DCI message comprising a first codeword configuration and a first DMRS port configuration. The UE 115 may receive a second DCI message comprising a second codeword configuration and a second DMRS port configuration. The UE 115 may determine, based at least in part on the first codeword configuration and the second codeword configuration, a transmission scheme to use for downlink transmissions. The transmission scheme includes an association between one or more DMRS ports and one or more codewords to be communicated in the downlink transmissions. The UE 115 may receive, according to the transmission scheme, the downlink transmissions.

[0100] A base station 105 may determine a transmission scheme to use for downlink transmissions. The transmission scheme includes an association between one or more codewords (CWs) to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration. The base station 105 may transmit, to the UE 115, a first DCI message comprising a first CW configuration and a first DMRS port configuration and a second DCI message comprising a second CW configuration and a second DMRS port configuration. The base station 105 may transmit, according to the transmission scheme, the downlink transmissions.

[0101] **FIG. 2** illustrates an example of a wireless communication system 200 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. In some examples, wireless communication system 200 may implement aspects of wireless communication system 100. Wireless communication system 200 may include a first transceiver node 205-a, a second transceiver node 205-b, and a UE 210, which may be examples of the corresponding devices described herein. In some aspects, the first transceiver node 205-a may also be referred to as TRP 1 or simply TRP1. In some aspects, the second transceiver node 205-b may also be referred to as TRP 2 or simply TRP2. In some aspects, the first transceiver node 205-a and the second transceiver node 205-b may be collectively referred to as a base station, e.g., a base station may manage one or more aspects of the first transceiver node 205-a and the second transceiver node 205-b.

[0102] Wireless communication system 200 may support downlink transmissions to UE 210 from both the first transceiver node 205-a and the second transceiver node 205-b. Generally, the downlink transmissions may be communicated according to one or more transmission schemes. In some aspects, the transmission scheme (which may also be referred to as "cases") may include each of transceiver nodes 205 communicating different codewords to UE 210 (e.g., case 1), communicating different portions (e.g., different layers, different parts, different portions, etc.) of the same codeword to UE 210 (e.g., case 2), and/or communicating different versions of the same codeword to UE 210 (e.g., case 3). Moreover, each transmission scheme may have variations within a particular case. In some aspects, the variations may be based on the maximum number of codewords being configured by the DCI messages, e.g., whether one or two codewords are being configured) Generally, the codeword may refer to a set of information bits that are encoded, modulated, and transmitted to UE 210. In some aspects, a transport block (TB) may be associated with a particular codeword, and therefore the terms TB and codeword may sometimes be used interchangeably. Generally, the downlink transmissions to UE 210 may be communicated using the same resources or using different resources between the transceiver nodes 205.

[0103] Conventional techniques may require each transceiver node to separately grant its own downlink transmission to UE 210. For example, conventional techniques require transceiver node 205-a to signal a grant message to UE 210 that identifies resources to use for the downlink transmission from transceiver node 205-a and also requires transceiver node 205-b to signal a separate grant message to UE 210 that identifies resources to use for the downlink transmission from transceiver node 205-b.

[0104] In some aspects, the conventional techniques may include a single DCI message being transmitted in one slot to schedule a downlink transmission (e.g., a physical downlink shared channel (PDSCH)). In that DCI message, only one DMRS configuration is provided, with one QCL and rate matching configuration being provided for those DMRS ports (e.g., the DMRS ports being configured by the DCI message). As a result, only one single TRP transmits the PDSCH. The UE may receive a higher layer signaling indicating a maximum number of codewords being scheduled by the DCI message. If this value is one, then the DCI message may only have one TB information field (which may also be referred to as a codeword information field) meaning that maximally one TB or codeword can be configured. If this value is two, then the DCI message may have two TB information fields, which means that the single TRP can transmit 1 or 2 TBs or codewords. If only one TB or codeword is transmitted, the first TB information field has the configuration, while the second TB information field is left blank/reserved. The UE 210 may decode the single TRP transmission of 1 or 2 TBs/codewords following the QCL, rate matching, and DMRS configuration configured by the DCI message. Then, the UE 210 may report the ACK/NACK feedback signaling following the configuration of HARQ process ID, HARQ timing, DAI, etc.

[0105] However, aspects of the described techniques provide for a DCI design that improves the information conveyed in the DCI messages. For example, the described techniques provide for a DCI design that not only identifies one or more resources/configurations for the downlink transmission, but also conveys an indication of the transmission scheme (or case) being used for the downlink transmission.

[0106] For example, the first transceiver node 205-a may determine that a downlink transmission is to occur for UE 210. The second transceiver node 205-b may also determine that a downlink transmission is to occur for UE 210. In some aspects, a base station may determine that the downlink transmission is to occur and manage one or more aspects of the downlink transmission for, or in conjunction with, the first transceiver node 205-a and the second transceiver node 205-b. For example, the base station may select which transmission scheme will be used for the downlink transmission. For example, the base station may determine whether the downlink transmission is a case 1 transmission, case 2 transmission, a case 3 transmission, or some variant thereof. Accordingly, the base station may configure and transmit (e.g., from the respective transceiver node 205) a first DCI message that carries or otherwise conveys an indication of a first codeword configuration and a first DMRS port configuration and also a second DCI message that also carries or otherwise conveys an indication of a second codeword configuration and a second DMRS port configuration. Broadly, each codeword configuration may include parameters for one or more codewords being communicated during the downlink transmission. For example, each codeword configuration may include parameters for a first codeword (CW1) (e.g., when the maximum number of codewords being configured by the DCI is one) and/or a second codeword (CW 2), when applicable (e.g., when the maximum number of codewords being configured by the DCI is two), being communicated during the downlink transmission from the first transceiver node 205-a and the second transceiver node 205-b. In some aspects, the parameters for the first codeword (CW1) and/or the second codeword (CW2) may also be referred to as TB information fields (e.g., a first TB information field (TB1) and a second TB information field (TB2), when applicable).

[0107] Generally, the first and/or second codeword configurations may carry or otherwise convey the indication of the transmission scheme being used for the downlink transmission. For example, the parameters for the first codeword and/or the second codeword (e.g., the respective TB information fields) may be selected or set according to a configuration that provides the indication of the transmission scheme, as well as conveys parameters for the codeword(s) being communicated.

[0108] In a first example for case 1, this may include the first codeword configuration indicating parameters for CW1, and the second codeword configuration not indicating parameters for CW1, but indicating parameters for CW2. In some aspects, a case 1 transmission scheme may be supported when the maximum number of codewords being configured by the DCI messages is two. For example, UE 210 may be configured via higher layer signaling (e.g., RRC signaling, MAC CE signaling, and the like) with a maximum number of codewords that may be configured by DCI message(s) as two. Accordingly, the first codeword configuration may include two codeword information fields (e.g., two TB information fields), with a first codeword information field indicating the parameters for CW1, but with the second codeword information field for CW2 being set to blank or reserved. Similarly, the second codeword configuration may include two codeword information fields (e.g., two TB information fields), with a second codeword information field indicating the parameters for CW2, but with the second codeword information field for CW1 being set to blank or reserved. This may convey the indication that the transmission scheme is case 1 where two different codewords (or two TBs associated with a respective codeword) is being communicated during the downlink transmission.

[0109] In a second example for case 2, this may include the first codeword configuration indicating parameters for CW1, and the second codeword configuration indicating parameters for CW1, but with an MCS field set to "reserve" or a reserve value. That is, case 2 may generally include different parts or portions of the same codeword (or TB associated with the codeword) being communicated during the downlink transmission. The MCS field being set to "reserve" for CW2 in the second codeword configuration may signal that the case 2 transmission scheme is being used for the downlink transmission.

[0110] In the example for case 2, several variations may also be supported. The variations may be based on the maximum number of codewords being configured by the DCI messages (e.g., whether the codeword configurations include one or two codeword information fields). As one example, case 2 discussed above may only be configured when the maximum number of codewords is one, and therefore there are no second codeword information fields in the respective codeword configurations indicated in the DCI messages. In an example 2.1, the maximum number of codewords may be set to two, and therefore each codeword configuration may include both the first codeword information field and the second codeword information field. In a pure case 2 transmission scheme where only different parts of the same codeword are being communicated, the second codeword information fields for case 2.1 may be set to blank or reserve in each of the first codeword configuration and the second codeword configuration.

[0111] Two other variations of case 2 may include cases 2.2 and 2.3. Each of cases 2.2 and 2.3 may be used when the maximum number of codewords is set to two. Accordingly, each of the first codeword configuration and the second codeword configuration will include first and second codeword information fields. The differences between cases 2/2.1 and 2.2/2.3 is that while two parts of a codeword are being communicated by each transceiver node 205 for each case, a second codeword is being communicated by at least one of the transceiver nodes 205 for cases 2.2 and 2.3. For example and for case 2.2, the first codeword information fields may be set or configured as described with respect to case 2, but the second codeword information field in the second codeword configuration may indicate parameters for communicating CW2 from the second transceiver node 205-b. For example and for case 2.3, the information indicated in the first codeword information fields as described with respect to case 2 may be moved to the second codeword information fields, but the first codeword information field in the first codeword configuration may indicate parameters for communicating CW1 from the first transceiver node 205-a.

[0112] In a third example for case 3, this may include the first codeword configuration indicating parameters for CW1 and the second codeword configuration indicating parameters for CW1. However, case 3 can be distinguished from case 2 in that the MCS field in the second codeword configuration (e.g., in the first codeword information field) being set to the same as indicated in the first codeword information field of the first codeword configuration. In case 3, the redundancy version (RV) field may be set to a different value with respect to the RV indicated in the first codeword configuration, or may be set to indicate the same value. One variation of case 3 is case 3.1 where the maximum number of codewords is set to two. In case 3.1, the second codeword information fields of the first and second codeword configurations may be set to blank or reserve. Thus, the MCS parameter field in the second codeword configuration may be used to separately indicate whether the transmission scheme is case 2 or case 3.

[0113] Accordingly, UE 210 may receive the first DCI message with the first codeword configuration and the second DCI message with the second codeword configuration and use each codeword configuration to identify or otherwise determine the transmission scheme being used for the downlink transmission. For example, UE 210 may identify one or more DMRS ports (e.g., one or more DMRS ports configured for each transceiver node 205 by the respective DCI message), where the DMRS ports are configured for communicating the codeword(s) being communicated in the downlink transmission.

[0114] In some aspects, UE 210 determining the transmission scheme from the first and second DCI messages may include identifying TB1 from the first codeword configuration and TB2 from the second codeword configuration. UE 210 may then determine whether TB1 and TB2 are configured using the same codeword information field. If TB1 and TB2 are configured using different codeword information fields, then UE 210 may determine that the transmission scheme comprises a case 1 transmission scheme. If TB1 and TB2 are configured using the same codeword information fields, then UE 210 may then determine that the transmission scheme is either a case 2 or case 3 transmission scheme. UE 210 may then use the MCS parameter field indicated in the second codeword configuration to distinguish between case 2 and case 3. For example, UE 210 may determine that the transmission scheme is a case 2 when the MCS is set to a reserve (or reserve value) in the second codeword configuration, but determine that the transmission scheme is a case 3 if the MCS is not set to a reserve (or reserve value) in the second codeword configuration. UE 210 may follow this procedure to distinguish the variations, e.g., cases 2.1, 2.2, 2.3, etc. In some aspects, UE 210 may additionally or alternatively determine the transmission scheme based on the maximum number of codewords (e.g., may rule out case 1 when only one codeword is configured).

[0115] Thus, UE 210 may receive the first DCI message and the second DCI message and determine, based on the codeword configurations, that the transmission scheme comprises a case 1 where each transceiver node 205 is communicating a different codeword during the downlink transmission. Accordingly, UE 210 may determine that CW1 is being transmitted based on the first codeword configuration indicated in the first DCI message using the resource allocation and DMRS ports indicated in the first DCI message from the first transceiver node 205-a. UE 210 may also determine that CW2 is being transmitted based on the second codeword configuration indicated in the second DCI message and using the resource allocation and DMRS ports indicated in the second DCI message from the second transceiver node 205-b.

[0116] In some aspects and for case 1, UE 210 may perform codeword to layer mapping where each codeword is mapped to layers indicated in the corresponding DCI message (e.g., for the associated transceiver node 205). The mapping may include the following order: layer-frequency-time, e.g., DMRS port (TRP1)-frequency (TRP1)-time (TRP1)-DMRS ports (TRP2)-frequency (TRP2)-time (TRP2). In some aspects, the first DCI message and the second DCI message may indicate that the same resource allocation (e.g., time and/or frequency) is provided for the transceiver nodes 205. Accordingly, UE 210 may determine that different DMRS ports are being configured for each transceiver node 205. Generally, DMRS ports may be considered different in that different DMRS ports may be configured for each transceiver node 205, with the DMRS ports using a different cover code (orthogonal cover code or cyclic shift), different DMRS sequences, different timing, and the like.

[0117] In some aspects, UE 210 may receive the first DCI message and the second DCI message and determine, based on the codeword configurations, that the transmission scheme comprises a case 2 where different portions of the same codeword are being communicated during the downlink transmission. As discussed above, there may be variants of case 2, such as where different parts of CW1 are communicated by the transceiver nodes 205 (case 2/2.1). In another variant, different parts of CW1 are communicated by the transceiver nodes 205, but CW2 is also communicated from one of the transceiver nodes 205 during the downlink transmission (case 2.2). In another variant, CW1 is communicated by one of the transceiver nodes 205, the different parts of CW2 are also communicated by each of the transceiver nodes 205 (case 2.3).

[0118] For example, in case 2.1 a first part of CW1 may be transmitted using the DMRS ports of the first transceiver node 205-a and the resource allocation indicated in the first DCI message and a second part of CW1 may be transmitted using the DMRS ports of the second transceiver node 205-b and the resource allocation indicated in the second DCI message. As another example, in case 2.2 a first part of CW1 may be transmitted using the DMRS ports of the first transceiver node 205-a and the resource allocation indicated in the first DCI message, a second part of CW1 may be transmitted using the first set of DMRS ports of the second transceiver node 205-b and the resource allocation indicated in the second DCI message, and CW2 may be transmitted using a second set of DMRS ports of the second transceiver node 205-b and the resource allocation indicated in the second DCI message. In yet another example, in case 2.3 CW1 may be transmitted using a first set of DMRS ports of the first transceiver node 205-a and the resource allocation indicated in the first DCI message, a first part of CW2 may be transmitted using a second set of DMRS ports of the first transceiver node 205-a and the resource allocation indicated in the first DCI message, and the second part of CW2 may be transmitted using the DMRS ports of the second transceiver node 205-b and the resource allocation indicated in the second DCI message.

[0119] In some aspects and for case 2, UE 210 may perform codeword to layer mapping where each codeword is mapped to layers indicated in the corresponding DCI message (e.g., for the associated transceiver node 205). In some examples, the codeword to layer mapping may be performed according to 2 alternatives. In a first alternative (Alt-1), the mapping may include UE 210 mapping a codeword to the DMRS ports and resource allocation of the first transceiver node 205-a and then mapping to the DMRS ports and resource allocation of the second transceiver node 205-b. For example, the mapping may include the following order: layer-frequency-time, e.g., DMRS port (TRP1)-frequency (TRP1)-time (TRP1)-DMRS ports (TRP2)-frequency (TRP2)-time (TRP2). In a second alternative (Alt-2), the mapping may include UE 210 aggregating the DMRS ports and resource allocations for the first transceiver node 205-a and the second transceiver node 205-b, and then mapping the codeword to the aggregated DMRS port/resource allocations. For example, the mapping may include the following order: DMRS ports-frequency-time. More particularly and for the situation where the same resource allocation is indicated in each DCI message, the mapping may include the following order: DMRS port (TRP1)-DMRS port (TRP2)-frequency-time. In the situation where different resource allocations are indicated in each DCI message, the mapping may include the following order: DMRS port (TRP1)-frequency (TRP1)-DMRS port (TRP2)-frequency (TRP2)-time.

[0120] In some aspects, the first DCI message and the second DCI message may indicate that the same resource allocation (e.g., time and/or frequency) is provided for the transceiver nodes 205. Accordingly, UE 210 may determine that different DMRS ports are being configured for each transceiver node 205. Generally, DMRS ports may be considered different in that different DMRS ports may be configured for each transceiver node 205, with the DMRS ports using a different cover code (orthogonal cover code or cyclic shift), a different DMRS sequences, different timing, and the like.

[0121] In some aspects, UE 210 may receive the first DCI message and the second DCI message and determine, based on the codeword configurations, that the transmission scheme comprises a case 3 where different versions of the same codeword are being communicated during the downlink transmission. As discussed above, there may be variants of case 3. For example, UE 210 may determine that a first version of CW1 is transmitted from the first transceiver node 205-a based on the first codeword configuration indicated in the first DCI message and using the resource allocation and DMRS ports indicated in the first DCI message. UE 210 may determine a second version of CW1 is transmitted from the second transceiver node 205-b based on the second codeword configuration indicated in the second DCI message and using the resource allocation and DMRS ports indicated in the second DCI message.

[0122] In some aspects and for case 3, UE 210 may perform codeword to layer mapping where each codeword is mapped to layers indicated in the corresponding DCI message (e.g., for the associated transceiver node 205). In some examples, the codeword to layer mapping may be performed according to the following order: layer-frequency-time. For example, the codeword to layer mapping may be performed according to: DMRS port (TRP1)-frequency (TRP1)-time (TRP1)-DMRS port (TRP2)-frequency (TRP2)-time (TRP2).

[0123] In some aspects, UE 210 may use the first and second DCI messages to determine a mapping (e.g., the association) between DMRS port(s) and a corresponding codeword. Broadly, each codeword may be mapped to DMRS port(s) and resource allocation of the corresponding transceiver node 205, e.g., for cases 1 and 3. For example, a codeword may be mapped to DMRS port(s) and resource allocation of transceiver node 205-a, and then mapped to DMRS port(s) and resource allocation of the second transceiver node 205-b (e.g., DMRS port (TRP1) – frequency (TRP1) – Time (TRP1) – DMRS port (TRP2) – frequency (TRP2) – time (TRP2)), for case 2.

[0124] More particularly, the mapping may comprise mapping using the order across layers first, then across frequency, and finally across time. As one non-limiting example, a transport block may have eight bits, and there may be two layers/subcarriers/symbols, two subcarriers/symbols, and two symbols, where layer 1 and layer 2 have the same subcarriers and symbols. In this instance, the mapping may be: bit 1 to layer 1 of subcarrier 1 and symbol 1, then bit 2 to layer 2 of subcarrier 1 and symbol 1, then bit 3 to layer 1 of subcarrier 2 and symbol 1, then bit 4 to layer 2 of subcarrier 2 and symbol 1, then bit 5 to layer 1 of subcarrier 1 and symbol 2, then bit 6 to layer 2 of subcarrier 1 and symbol 2, then bit 7 to layer 1 of subcarrier 2 and symbol 2, and then bit 8 to layer 2 of subcarrier 2 and symbol 2.

[0125] In the instance where layer 1 and layer 2 use different subcarriers, but the same symbols, the layer-frequency-time order after aggregating may be (assuming layer 1 uses subcarriers 1 and 2 and layer 2 use subcarriers 3 and 4): bit 1 to layer 1 of subcarrier 1 and symbol 1, then bit 2 to layer 1 of subcarrier 2 and symbol 1, then bit 3 to layer 2 of subcarrier

3 and symbol 1, then bit 4 to layer 2 of subcarrier 4 and symbol 1, then bit 5 to layer 1 of subcarrier 1 and symbol 2, then bit 6 to layer 2 of subcarrier 2 and symbol 2, then bit 7 to layer 1 of subcarrier 3 and symbol 2, and then bit 8 to layer 2 of subcarrier 4 and symbol 2.

[0126] For cases 1 and 3, the mapping order is first within a TRP, and then across TRPs. Assuming layer 1 is from TRP1 and layer 2 is from TRP2, and both DMRS ports have the same resource allocations, the mapping may be: bit 1 to layer 1 of subcarrier 1 and symbol 1, then bit 2 to layer 1 of subcarrier 2 and symbol 1, then bit 3 to layer 1 of subcarrier 1 and symbol 2, then bit 4 to layer 1 of subcarrier 2 and symbol 2, then bit 5 to layer 2 of subcarrier 1 and symbol 1, then bit 6 to layer 2 of subcarrier 2 and symbol 1, then bit 7 to layer 2 of subcarrier 1 and symbol 2, and then bit 8 to layer 2 of subcarrier 2 and symbol 2.

[0127] In some aspects, the first DCI message and the second DCI message may indicate that either the same resource allocation (e.g., time and/or frequency) is provided, or different resource allocations are provided, for the transceiver nodes 205. As one example where the same resource allocation is indicated in the first DCI message and the second DCI message, UE 210 may determine that different DMRS ports are being configured for each transceiver node 205, that the same RV values are indicated in the first DCI message and the second DCI message, and/or that the transmission scheme comprises a transmit diversity scheme. As another example where different resource allocations are indicated in the first DCI message and the second DCI message, UE 210 may determine that the first DCI message and the second DCI message indicates either the same RV or different RV values. Generally, DMRS ports may be considered different in that different DMRS ports may be configured for each transceiver node 205, with the DMRS ports using a different cover code (orthogonal cover code or cyclic shift), a different DMRS sequences, different timing, and the like.

[0128] Aspects of the described techniques may also support HARQ operations, e.g., ACK/NACK feedback signaling. For example, UE 210 may fail or otherwise be unable to decode either the first DCI message or the second DCI message. The HARQ operations adopted by UE 210 in this instance may depend upon the transmission scheme (e.g., case) being used for the downlink transmission. As one example and for case 1, UE 210 may detect both the first DCI message and the second DCI message and generate an ACK/NACK feedback signaling for each transport block (or each codeblock group associated with each transport block) and transmit the ACK/NACK signal following the HARQ timing indicated in the DCI message. When UE 210 is unable to detect or decode either the first DCI message of the second DCI message, UE 210 may generate and transmit a NACK signal for the missing transport block (or the associated codeblock group), and transmit ACK/NACK feedback signaling for the detected codeword and following the HARQ timing indicated in the decoded DCI message.

[0129] As another example and for case 2, when UE 210 detect both DCI messages, UE 210 may generate ACK/NACK feedback signaling for each transport block (or for each codeblock group associated with each transport block), and transmit ACK/NACK feedback signaling following the timing provided in the second DCI message. If UE 210 is unable to detect or successfully decode the second DCI message, but is able to successfully decode the first DCI message, then UE 210 may utilize the HARQ timing indicated in the first DCI message when transmitting ACK/NACK feedback signaling. In some instances, the base station made determine that no ACK/NACK feedback signaling was received in the HARQ timing indicated in the second DCI message and, in this case, prepare a retransmission accordingly. In the instance where UE 210 is unable to detect or successfully decode the first DCI message, UE 210 may transmit a NACK signal for the codeword with an MCS field set to "reserve" and transmit ACK/NACK feedback signaling when the MCS field is not set to "reserve." In this instance, UE 210 may transmit the feedback signaling according to the HARQ timing indicated in the second DCI message.

[0130] In yet another example and for case 3, when UE 210 is able to successfully decode both the first DCI message and the second DCI message, or when the UE is unable to detect or decode one of the DCI messages, UE 210 may transmit ACK/NACK feedback signaling for each transport block (or each codeblock group associated with each transport block) according to the HARQ timing indicated in the decoded DCI message. That is, as different versions of the same codeword are being communicated during the downlink transmission for case 3, UE 210 may be able to successfully recover at least one of the versions from the transceiver node 205 that is associated with the successfully decoded DCI message. Thus, in each of cases 1-3, UE 210 may be able to use the same HARQ process identifier. For cases 1 and 3, UE 210 may be able to use the same HARQ timing and/or DAI indicated in the DCI messages. For case 2, however, UE 210 may use different HARQ timing and, in some aspects, the DAI indicated in each DCI message may be associated with a particular HARQ timing.

[0131] Specific examples of the describes techniques will now be discussed below. It is to be understood that these examples are not limiting, and the associated features may be implemented in other manners. Moreover, aspects of some or all of the different examples may be combined in some situations.

[0132] In a first example (example 1), the first and second codeword configurations may indicate that the transmission scheme is a transmit diversity scheme, e.g., a space and frequency block coding (SFBC) scheme. Aspects of example 1 may be associated with a first format (format 1) for the DCI messages where the same resource allocations are indicated for both transceiver nodes 205. Aspects of example 1 may also be associated with a case 3 transmission scheme where different versions of the same codeword are communicated by the transceiver nodes 205. In some aspects, the first and second DCI messages may include corresponding codeword configurations that indicate parameters (e.g., MCS, NDI, RV) for the same transport block in the same TB information field (e.g., in the CW1 information field), with the resource allocations between the first and second DCI messages being the same. Generally, the codewords may be mapped to layers according to the order: layer – frequency – time. For example and when two DMRS ports are configured (e.g., one DMRS port per transceiver node 205), the codeword may be mapped to layers according to:

$$x^{(0)}(i) = d^{(0)}(2i)$$
$$x^{(1)}(i) = d^{(0)}(2i+1)$$

[0133] As another example where four DMRS ports are configured (e.g., two DMRS ports per transceiver node 205), the codeword may be mapped to layers according to:

$$x^{(0)}(i) = d^{(0)}(4i)$$
$$x^{(1)}(i) = d^{(0)}(4i+1)$$
$$x^{(2)}(i) = d^{(0)}(4i+2)$$
$$x^{(3)}(i) = d^{(0)}(4i+3)$$

[0134] The layers may then be mapped to DMRS port(s) of the first transceiver node 205-a sequentially, e.g., in order of x. This mapping may depend on the number of configured DMRS ports. In the example where two DMRS ports are configured (e.g., one DMRS port for each transceiver node 205), the layers may be mapped according to: $y^{(0)}(i) = x^{(0)}(i)$, $y^{(0)}(i+1) = x^{(1)}(i)$..., and so forth, for the first transceiver node 205-a. In the example where four DMRS ports are configured (e.g., two DMRS ports for each transceiver node 205), the layers may be mapped according to: $y^{(0)}(i)=x^{(0)}(i)$, $y^{(0)}(i+1)=x^{(1)}(i)$, $y^{(1)}(i+2)=x^{(2)}(i)$, $y^{(1)}(i+3)=x^{(3)}(i)$..., and so forth, for the first transceiver node 205-a. As one example, DMRS port 0 may be used for (i) and $(i+1)$ tones to carry layers 0 and 1, respectively.

[0135] In example 1, the layers may be mapped to DMRS ports for the second transceiver node 205-b in a different manner. In the example where two DMRS ports are configured (e.g., one DMRS port for each transceiver node 205), the layers may be mapped according to: $y^{(1)}(i)=x^{(1*)}(i)$, $y^{(1)}(i+1)=x^{(0*)}(i)$..., and so forth, for the second transceiver node 205-b. In the example where four DMRS ports are configured (e.g., two DMRS ports for each transceiver node 205), the layers may be mapped according to: $y^{(2)}(i)=x^{(1*)}(i)$, $y^{(2)}(i+1)=-x^{(0*)}(i)$, $y^{(3)}(i+2)=x^{(3*)}(i)$, $y^{(3)}(i+3)=-x^{(2*)}(i)$..., and so forth, for the second transceiver node 205-b.

[0136] In a second example (example 2), the first and second codeword configurations may indicate that the transmission scheme is a transmit diversity scheme. Aspects of example 2 may be associated with a second format (format 2) for the DCI messages where different resource allocations are indicated for each transceiver nodes 205. Aspects of example 2 may also be associated with a case 3 transmission scheme where different versions of the same codeword are communicated by the transceiver nodes 205. For example, one codeword may be configured, with the codeword being replicated and the two transceiver nodes 205 using different RVs for the codeword. In some aspects, the first and second DCI messages may include corresponding codeword configurations that indicate parameters (e.g., MCS, NDI, RV) for the same transport block in the same TB information field (e.g., in the CW1 information field), with the resource allocations between the first and second DCI messages being the different. Mapping in example 2 may include codeword to port mapping. For example, a first version of the codeword having the first RV may be transmitted on resources of the first transceiver node 205-a according to the following mapping order: DMRS port – frequency – time. A second version of the codeword having the second RV may be transmitted on resources of the second transceiver node 205-b according to the following mapping order: DMRS port – frequency – time.

[0137] In a third example (example 3), the first and second codeword configurations may indicate that the transmission scheme is a transmit diversity scheme, e.g., a resource element level transceiver node 205 cycling. Aspects of example 3 may also be associated with a case 2 transmission scheme where different portions of the same codeword are communicated by the transceiver nodes 205, e.g., a first portion of the codeword communicated by the first transceiver node 205-a and a second portion of the codeword communicated by the second transceiver node 205-b. In some aspects, the first and second DCI messages may include corresponding codeword configurations that indicate parameters (e.g., MCS, NDI, RV) for the same transport block in the same TB information field (e.g., in the CW1 information field), with the MCS set to reserve for the second TB information field, and with the resource allocations between the first and second DCI messages being the same. In some aspects, the first format (format 1) of the DCI messages may be used in example 3 where the same resource allocations are indicated for both transceiver nodes 205. For example, the DMRS port(s) of the first transceiver node 205-a may be active in even tones, whereas the DMRS port(s) of the second transceiver node 205-b may be active in the odd tones. Once configured, a first part of the codeword is transmitted using the resource allocation and DMRS port(s) of the first transceiver node 205-a and a second part of the codeword is transmitted using the resource allocation and DMRS port(s) of the second transceiver node 205-b.

[0138] In some aspects, two alternatives may be supported in example 3 for codeword to DMRS port mapping for a rank 1 transmission. In a first alternative (Alt-1), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) – frequency – time - DMRS port (TRP2) – frequency – time. In a second alternative (Alt-2), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) - DMRS port (TRP2) – frequency - time. More particularly, codeword mapping according to the first and second alternatives may be configured according to:

Rank-1 Transmission (one DMRS port/TRP)		Codeword-to-Layer (Codeword may have M QAM Symbols)	Layer-to-DMRS Port
Alt-	Alt-1.1	$x^0(i)=d^0(i), x^1(i)=d^0(i+1)$	$y^0(2i)=x^0(i), y^1(2i+1)=x^0(M/4+i)$

1			$y^0(2i+2) = x^1(i), y^1(2i+3) = x1(M/4+i)$
	Alt-1.2	$x^0(i) = d^0(i), x^1(i) = d^0(M/2+i)$	$y^0(2i) = x^0(i), y^1(2i+1) = x^1(i)$ $y^0(2i+2) = x^0(i+1), y^1(2i+3) = x^1(i+1)$
Alt-2		$x^0(i) = d^0(i), x^1(i) = d^0(i+1)$	$y^0(2i) = x^0(i), y^1(2i+1) = x^1(i)$ $y^0(2i+2) = x^0(i+1), y^1(2i+3) = x^1(i+1)$

[0139] In example 3, the first and second codeword configurations in the DCI messages may indicate a transmit diversity scheme, e.g., resource element level transceiver node 205 cycling. In some aspects, two alternatives may be supported in example 3 for codeword to DMRS port mapping for a rank 2 transmission. In a first alternative (Alt-1), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) – frequency – time - DMRS port (TRP2) – frequency – time. In a second alternative (Alt-2), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) - DMRS port (TRP2) – frequency - time. More particularly, codeword mapping according to the first and second alternatives for a rank 2 transmission may be configured according to:

Rank-2 Transmission (two DMRS ports/TRP		Codeword-to-Layer (Codeword may have M QAM Symbols)	Layer-to-DMRS Port
Alt-1	Alt-1.1	$x^0(i) = d^0(i), x^1(i) = d^0(i+1)$ $x^2(i) = d^0(i+2), x^3(i) = d^0(i+3)$	$\begin{bmatrix} y^0(2i) \\ y^1(2i) \end{bmatrix} = \begin{bmatrix} x^0(i) \\ x^1(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+1) \\ y^3(2i+1) \end{bmatrix} = \begin{bmatrix} x^0(M/4+i) \\ x1(M/4+i) \end{bmatrix},$ $\begin{bmatrix} y^0(2i+2) \\ y^1(2i+2) \end{bmatrix} = \begin{bmatrix} x^2(i) \\ x^3(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+3) \\ y^3(2i+3) \end{bmatrix} = \begin{bmatrix} x^2(M/4+i) \\ x^3(M/4+i) \end{bmatrix},$
	Alt-1.2	$x^0(i) = d^0(i), x^1(i) = d^0(i+1)$ $x^2(i) = d^0(M/2+i), x^3(i) = d^0(M/2\,i+1)$	$\begin{bmatrix} y^0(2i) \\ y^1(2i) \end{bmatrix} = \begin{bmatrix} x^0(i) \\ x^1(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+1) \\ y^3(2i+1) \end{bmatrix} = \begin{bmatrix} x^2(i) \\ x^3(i) \end{bmatrix},$ $\begin{bmatrix} y^0(2i+2) \\ y^1(2i+2) \end{bmatrix} = \begin{bmatrix} x^0(i+1) \\ x^1(i+1) \end{bmatrix}, \begin{bmatrix} y^2(2i+3) \\ y^3(2i+3) \end{bmatrix} = \begin{bmatrix} x^2(i+1) \\ x^3(i+1) \end{bmatrix},$

Alt-2	$x^0(i)=d^0(i),x^1(i)=d^0(i+1)$ $x^2(i)=d^0(i+2),x^3(i)=d^0(i+3)$	$\begin{bmatrix} y^0(2i) \\ y^1(2i) \end{bmatrix} = \begin{bmatrix} x^0(i) \\ x^1(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+1) \\ y^3(2i+1) \end{bmatrix} = \begin{bmatrix} x^2(i) \\ x^3(i) \end{bmatrix},$ $\begin{bmatrix} y^0(2i+2) \\ y^1(2i+2) \end{bmatrix} = \begin{bmatrix} x^0(i+1) \\ x^1(i+1) \end{bmatrix}, \begin{bmatrix} y^2(2i+3) \\ y^3(2i+3) \end{bmatrix} = \begin{bmatrix} x^2(i+1) \\ x^3(i+1) \end{bmatrix},$

[0140] In some aspects of example 3, the first and second codeword configurations in the first and second DCI messages may indicate a transmit diversity scheme, e.g., with resource element level TRP cycling for a case 2 transmission scheme. For example, precoder cycling within each TRP (e.g., each transceiver node 205 in a rank 2 case) may be supported. When the DMRS port(s) of TRP1 are used in even tones (e.g., 2*i*, 2*i*+2, 2*i*+4, etc.), for tones 2*i*, 2*i*+4, 2*i*+8, etc., the layer-to-DMRS port mapping may be based on $U_0 = \begin{bmatrix} 1,1 \\ 1,-1 \end{bmatrix}$ and for tones 2*i*, 2*i*+2, 2*i*+6, etc., the layer-to-DMRS port mapping may be based on $Un = \begin{bmatrix} 1,j \\ 1,-j \end{bmatrix}$. When the DMRS port(s) of TRP1 are used in odd tones (e.g., 2*i*+1, 2*i*+3, 2*i*+5, etc.), for tones 2*i*+1, 2*i*+5, 2*i*+9, etc., the layer-to-DMRS port mapping may be based on $U_n = \begin{bmatrix} 1,1 \\ 1,-1 \end{bmatrix}$ and for tones 2*i*+3, 2*i*+7, 2*i*+9, etc., the layer-to-DMRS port mapping may be based on $Uo = \begin{bmatrix} 1,j \\ 1,-j \end{bmatrix}$. In this case, the layer-to-DMRS port mapping may be configured according to:

Rank-2 Transmission (two DMRS ports/TRP		Layer-to-DMRS Port
Alt-1	Alt-1.1	$\begin{bmatrix} y^0(2i) \\ y^1(2i) \end{bmatrix} = U_0 \begin{bmatrix} x^0(i) \\ x^1(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+1) \\ y^3(2i+1) \end{bmatrix} = U_0 \begin{bmatrix} x^0(M/4+i) \\ x^1(M/4+i) \end{bmatrix},$ $\begin{bmatrix} y^0(2i+2) \\ y^1(2i+2) \end{bmatrix} = U_1 \begin{bmatrix} x^2(i) \\ x^3(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+3) \\ y^3(2i+3) \end{bmatrix} = U_1 \begin{bmatrix} x^2(M/4+i) \\ x^3(M/4+i) \end{bmatrix},$
	Alt-1.2	$\begin{bmatrix} y^0(2i) \\ y^1(2i) \end{bmatrix} = U_0 \begin{bmatrix} x^0(i) \\ x^1(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+1) \\ y^3(2i+1) \end{bmatrix} = U_0 \begin{bmatrix} x^2(i) \\ x^3(i) \end{bmatrix},$

		$\begin{bmatrix} y^0(2i+2) \\ y^1(2i+2) \end{bmatrix} = U_1 \begin{bmatrix} x^0(i+1) \\ x^1(i+1) \end{bmatrix}, \begin{bmatrix} y^2(2i+3) \\ y^3(2i+3) \end{bmatrix} = U_1 \begin{bmatrix} x^2(i+1) \\ x^3(i+1) \end{bmatrix},$
Alt-2		$\begin{bmatrix} y^0(2i) \\ y^1(2i) \end{bmatrix} = U_0 \begin{bmatrix} x^0(i) \\ x^1(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+1) \\ y^3(2i+1) \end{bmatrix} = U_0 \begin{bmatrix} x^2(i) \\ x^3(i) \end{bmatrix},$ $\begin{bmatrix} y^0(2i+2) \\ y^1(2i+2) \end{bmatrix} = U_1 \begin{bmatrix} x^0(i+1) \\ x^1(i+1) \end{bmatrix}, \begin{bmatrix} y^2(2i+3) \\ y^3(2i+3) \end{bmatrix} = U_1 \begin{bmatrix} x^2(i+1) \\ x^3(i+1) \end{bmatrix},$

[0141] In a fourth example (example 4), the first and second codeword configurations may indicate that the transmission scheme is a transmit diversity scheme, e.g., a sub-band/resource block level transceiver node 205 cycling. Aspects of example 4 may also be associated with a case 2 transmission scheme where different portions of the same codeword are communicated by the transceiver nodes 205, e.g., a first portion of the codeword communicated by the first transceiver node 205-a and a second portion of the codeword communicated by the second transceiver node 205-b. In some aspects, the first and second DCI messages may include corresponding codeword configurations that indicate parameters (e.g., MCS, NDI, RV) for the same transport block in the same TB information field (e.g., in the CW1 information field), with the MCS set to reserve for the second TB information field, and with the resource allocations between the first and second DCI messages being different. In some aspects, the second format (format 2) of the DCI messages may be used in example 4 where different resource allocations are indicated for the transceiver nodes 205. For example, the DMRS port(s) of the first transceiver node 205-a may be active in odd resource blocks, whereas the DMRS port(s) of the second transceiver node 205-b may be active in even resource blocks. Once configured, a first part of the codeword is transmitted using the resource allocation and DMRS port(s) of the first transceiver node 205-a and a second part of the codeword is transmitted using the resource allocation and DMRS port(s) of the second transceiver node 205-b.

[0142] In some aspects, two alternatives may be supported in example 4 for codeword to DMRS port mapping for a rank 1 transmission. In a first alternative (Alt-1), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) – frequency (TRP1) – time - DMRS port (TRP2) – frequency (TRP2) – time. In a second alternative (Alt-2), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) – frequency (TRP1) – DMRS port (TRP2) – frequency (TRP2) - time. More particularly, codeword mapping according to the first and second alternatives may be configured according to:

Rank-1 Transmission (one DMRS port/TRP)		Codeword-to-Layer (Codeword has M QAM Symbols)	Layer-to-DMRS Port (N is frequency offset of TRP2 relative to TRP1; N’ is the number of Resources for TRP1 in the assigned slot)
Alt-1	Alt-1.1	$x^0(i)=d^0(i), x^1(i)=d^0(i+1)$	$y^0(2i)=x^0(i), y^1(2i+N)=x^0(N'+i)$ $y^0(2i+1)=x^1(i), y^1(2i+N+1)=x^1(N'+i)$
	Alt-1.2	$x^0(i)=d^0(i), x^1(i)=d^0(N'+i)$	$y^0(2i)=x^0(i), y^1(2i+N)=x^1(i)$ $y^0(2i+1)=x^0(i+1), y^1(2i+N+1)=x^1(i+1)$
Alt-2		$z^0(i)=d^0(i)$ wherein $z^0(i)$ is 1) obtained by the aggregated resource allocations of TRP1 and TRP2, 2) index I is order based on the order frequency to time, and 3) in the resource allocation of TRP1, $z^0(i)=y^0(i)$ while in the resource allocation of TRP2, $z^0(i)=y^1(i)$	

[0143] In example 4, the first and second codeword configurations in the DCI messages may indicate a transmit diversity scheme, e.g., sub-band/resource block level transceiver node 205 cycling. In some aspects, two alternatives may be supported in example 4 for codeword to DMRS port mapping for a rank 2 transmission. Codeword mapping according to the first and second alternatives for a rank 2 transmission where four DMRS ports are configured may be configured according to:

Rank-2 Transmission (two DMRS ports/TRP		Codeword-to-Layer (Codeword may have M QAM Symbols and N’<M)	Layer-to-DMRS Port (N is frequency offset of TRP2 relative to TRP1; N’ is the number of resources for TRP1 in the assigned slot)
Alt-	Alt-1.1	$x^0(i)=d^0(i), x^1(i)=d^0(i+1)$	$\begin{bmatrix} y^0(2i) \\ y^1(2i) \end{bmatrix}=\begin{bmatrix} x^0(i) \\ x^1(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+N) \\ y^3(2i+N) \end{bmatrix}=\begin{bmatrix} x^0(N'+i) \\ x^1(N'+i) \end{bmatrix},$

1		$x^2(i)=d^0(i+2), x^3(i)=d^0(i+3)$	$\begin{bmatrix} y^0(2i+1) \\ y^1(2i+1) \end{bmatrix}=\begin{bmatrix} x^2(i) \\ x^3(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+N+1) \\ y^3(2i+N+1) \end{bmatrix}=\begin{bmatrix} x^2(N'+i) \\ x^3(N'+i) \end{bmatrix},$
	Alt-1.2	$x^0(i)=d^0(i), x^1(i)=d^0(i+1)$ $x^2(i)=d^0(2N'+i), x^3(i)=d^0(2N'+i+1)$	$\begin{bmatrix} y^0(2i) \\ y^1(2i) \end{bmatrix}=\begin{bmatrix} x^0(i) \\ x^1(i) \end{bmatrix}, \begin{bmatrix} y^2(2i+N) \\ y^3(2i+N) \end{bmatrix}=\begin{bmatrix} x^2(i) \\ x^3(i) \end{bmatrix},$ $\begin{bmatrix} y^0(2i+1) \\ y^1(2i+1) \end{bmatrix}=\begin{bmatrix} x^0(i+1) \\ x^1(i+1) \end{bmatrix}, \begin{bmatrix} y^2(2i+N+1) \\ y^3(2i+N+1) \end{bmatrix}=\begin{bmatrix} x^2(i+1) \\ x^3(i+1) \end{bmatrix},$
Alt-2		$\begin{bmatrix} z^0(i) \\ z^1(i) \end{bmatrix}=\begin{bmatrix} d^0(i) \\ d^1(i+1) \end{bmatrix}$, where $\begin{bmatrix} z^0(i) \\ z^1(i) \end{bmatrix}$ is 1) obtained by the aggregated resources of the resource allocations for TRP1 and TRP2, 2) index i is order based on the order frequency to time, and 3) in the resource allocation of TRP1, $\begin{bmatrix} z^0(i) \\ z^1(i) \end{bmatrix}=\begin{bmatrix} y^0(i) \\ y^1(i) \end{bmatrix}$, while in the resource allocation of TRP2 $\begin{bmatrix} z^0(i) \\ z^1(i) \end{bmatrix}=\begin{bmatrix} y^2(i) \\ y^3(i) \end{bmatrix}$	

[0144] In some aspects of example 4, the first and second codeword configurations in the DCI messages may indicate a transmit diversity scheme, e.g., with sub-band/resource block level TRP cycling for a case 2 transmission scheme. For example, precoder cycling within each TRP (e.g., a rank 2 case) may be supported. In the resources for TRP1 and for even tones, the layer-to-port mapping may be based on $U_0=\begin{bmatrix} 1,1 \\ 1,-1 \end{bmatrix}$, and for the odd tones the layer-to-port mapping may be based on $Un=\begin{bmatrix} 1,j \\ 1,-j \end{bmatrix}$. In the resources for TRP2 and for even tones, the layer-to-port mapping may be based on $U_0=\begin{bmatrix} 1,1 \\ 1,-1 \end{bmatrix}$, and for the odd tones the layer-to-port mapping may be based on $Un=\begin{bmatrix} 1,j \\ 1,-j \end{bmatrix}$.

[0145] In a fifth example (example 5), the first and second codeword configurations may indicate that the transmission scheme is a spatial multiplexing scheme. Aspects of example 5 may be associated with a first format (format 1) for the DCI messages where the same resource allocations are indicated for both transceiver nodes 205. Aspects of example 1 may also be associated with a case 1 transmission scheme where different codewords are communicated by each transceiver nodes 205. For example, CW1 may be transmitted using the DMRS port(s) of TRP1 and CW2 may be transmitted using the DMRS port(s) of TRP2. In some aspects, the first and second DCI messages may include corresponding codeword configurations that indicate parameters (e.g., MCS, NDI, RV) for different transport blocks in different TB information fields (e.g., in the CW1 information field and the CW2 information field), and with the resource allocations between the first and second DCI messages being the same. The order for the mapping may be: layer (CW1, TRP1) – frequency – time – layer (CW2, TRP2) – frequency – time. For example and when two DMRS ports are configured, one for each TRP, the codeword may be mapped to layers according to: $x^0(i) = d^0(i), x^1(i) = d^0(i+1)$ and $x^2(i) = d^1(i), x^3(i) = d^1(i+1)$. The layer-to-port mapping may include a one-to-one mapping according to: $y^0(i) = x^0(i), y^1(i) = x^1(i), y^2(i) = x^2(i), y^3(i) = x^3(i)$, wherein $y^P(i)$ refers to port P on subcarrier 1, and where index i is ordered following: frequency – time.

[0146] In a sixth example (example 6), the first and second codeword configurations may indicate that the transmission scheme is a spatial multiplexing scheme. Aspects of example 6 may be associated with a second format (format 2) for the DCI messages where different resource allocations are indicated for transceiver nodes 205. Aspects of example 6 may also be associated with a case 1 transmission scheme where different codewords are communicated by each transceiver nodes 205. For example, CW1 may be transmitted using the DMRS port(s) of TRP1 on a first resource allocation and CW2 may be transmitted using the DMRS port(s) of TRP2 on a second resource allocation. Each codeword may be mapped to DMRS port(s) associated with the corresponding TRP. In some aspects, the first and second DCI messages may include corresponding codeword configurations that indicate parameters (e.g., MCS, NDI, RV) for different transport blocks in different TB information fields (e.g., in the CW1 information field and the CW2 information field), and with the resource allocations between the first and second DCI messages being different. The order for the mapping may be: layer (CW1, TRP1) – frequency (TRP1) – time (TRP1) – layer (CW2, TRP2) – frequency (TRP2) – time (TRP2). For example and when two DMRS ports are configured, one for each TRP, the codeword may be mapped to layers according to: $x^0(i) = d^0(i), x^1(i) = d^0(i+1)$ and $x^2(i) = d^1(i), x^3(i) = d^1(i+1)$. The layer-to-port mapping may include a one-to-one mapping according to:

$y^0(i)=x^0(i), y^1(i)=x^1(i), y^2(i+N)=x^2(i), y^3(i+N)=x^3(i)$, wherein $y^P(i)$ refers to port P on subcarrier 1, and where index *i* is ordered following: frequency – time within each resource allocation. In some aspects, N may denote a sub-band offset of the resource allocation for TRP2 relative to TRP1. In some aspects, DMRS port 0 and 1 may be active on the first resource allocation for TRP1 whereas DMRS ports 2 and 3 may be active on the second resource allocation for TRP2.

[0147] In a seventh example (example 7), the first and second codeword configurations may indicate that the transmission scheme is a spatial multiplexing scheme. Aspects of example 7 may also be associated with a case 2 transmission scheme where different portions or parts of the same codeword are communicated by the transceiver nodes 205, e.g., a first portion of the codeword communicated using the DMRS port(s) of the first transceiver node 205-a and a second portion of the codeword communicated using the DMRS port(s) of the second transceiver node 205-b. In some aspects, the first and second DCI messages may include corresponding codeword configurations that indicate parameters (e.g., MCS, NDI, RV) for the same transport block in the same TB information field (e.g., in the CW1 information field), with the MCS set to reserve for the second TB information field, and with the resource allocations between the first and second DCI messages being the same. In some aspects, the first format (format 1) of the DCI messages may be used in example 7 where the same resource allocations are indicated for both transceiver nodes 205.

[0148] In some aspects, two alternatives may be supported in example 7 for codeword to DMRS port mapping. In a first alternative (Alt-1), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) – frequency – time - DMRS port (TRP2) – frequency – time. In a second alternative (Alt-2), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) - DMRS port (TRP2) – frequency - time. More particularly, codeword mapping according to the first and second alternatives may be configured according to:

Two DMRS ports/TRP	Codeword-to-Layer (Codeword may have M QAM Symbols)	Layer-to-DMRS Port

Alt-1	$\begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \end{bmatrix} = \begin{bmatrix} d^0(i) \\ d^0(i+1) \\ d^0(M/2+2) \\ d^0(M/2+i+2) \end{bmatrix}$	$\begin{bmatrix} y^0(i) \\ y^1(i) \\ y^2(i) \\ y^3(i) \end{bmatrix} = \begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \end{bmatrix}$
Alt-2	$\begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \end{bmatrix} = \begin{bmatrix} d^0(i) \\ d^0(i+1) \\ d^0(i+2) \\ d^0(i+3) \end{bmatrix}$	$\begin{bmatrix} y^0(i) \\ y^1(i) \\ y^2(i) \\ y^3(i) \end{bmatrix} = \begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \end{bmatrix}$

[0149] In an eighth example (example 8), the first and second codeword configurations may indicate that the transmission scheme is a spatial multiplexing scheme. Aspects of example 8 may also be associated with a case 2 transmission scheme where different portions or parts of the same codeword are communicated by the transceiver nodes 205, e.g., a first portion of the codeword communicated using the DMRS port(s) of the first transceiver node 205-a and a second portion of the codeword communicated using the DMRS port(s) of the second transceiver node 205-b. In some aspects, the first and second DCI messages may include corresponding codeword configurations that indicate parameters (e.g., MCS, NDI, RV) for the same transport block in the same TB information field (e.g., in the CW1 information field), with the MCS set to reserve for the second TB information field, and with the resource allocations between the first and second DCI messages being different. In some aspects, the second format (format 2) of the DCI messages may be used in example 8 where different resource allocations are indicated for the transceiver nodes 205.

[0150] In some aspects, two alternatives may be supported in example 8 for codeword to DMRS port mapping. In a first alternative (Alt-1), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) – frequency (TRP1) – time - DMRS port (TRP2) – frequency (TRP2) – time. In a second alternative (Alt-2), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) – frequency (TRP1) – DMRS port (TRP2) – frequency (TRP2) - time. More particularly, codeword mapping according to the first and second alternatives may be configured according to:

Two DMRS ports/TRP	Codeword-to-Layer	Layer-to-DMRS Port

	(Codeword may have M QAM Symbols)	
Alt-1	$\begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \end{bmatrix} = \begin{bmatrix} d^0(i) \\ d^0(i+1) \\ d^0(2N'+i) \\ d^0(2N'+i+1) \end{bmatrix}$	$\begin{bmatrix} y^0(i) \\ y^1(i) \\ y^2(i+N) \\ y^3(i+N) \end{bmatrix} = \begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \end{bmatrix}$
Alt-2	$\begin{bmatrix} y^0(i) \\ y^1(i) \end{bmatrix} = \begin{bmatrix} x^0(i) \\ x^1(i) \end{bmatrix} = \begin{bmatrix} d^0(i) \\ d^1(i+1) \end{bmatrix}$, where index i is obtained by aggregating the first resource allocation for TRP1 and the second resource allocation for TRP2 following the order: frequency to time; in the first resource allocation, $y^0(i)$ and $y^1(i)$ are the port of TRP1; in the second resource allocation, $y^0(i)$ and $y^1(i)$ are the port of TRP2.	

[0151] In a ninth example (example 9), the first and second codeword configurations may indicate that the transmission scheme is a spatial multiplexing scheme. Aspects of example 9 may also be associated with a case 2.2 transmission scheme where different portions or parts of the same codeword (CW1) are communicated by the transceiver nodes 205, as well as CW2 being communicated by the second transceiver node 205-b That is, a first portion of CW1 communicated using the DMRS port(s) of the first transceiver node 205-a, a second portion of CW1 may be communicated using a first set of DMRS port(s) of the second transceiver node 205-b, and CW2 may be communicated using a second set of DMRS port(s) of the second transceiver node 205-b. In some aspects, the first and second DCI messages may include corresponding codeword configurations that indicate parameters (e.g., MCS, NDI, RV) for the same transport block in the same TB information field (e.g., in the CW1 information field), with the MCS set to reserve for the second TB information field, and with the resource allocations between the first and second DCI messages being the same. The second codeword configuration may also indicate parameters for the second codeword being communicated by the second transceiver node 205-b. In some aspects, the DCI messages may be used in example 9 where the same resource allocations are indicated for the transceiver nodes 205

[0152] In some aspects, UE 210 may determine the first and second set of DMRS ports of TRP2. For example, UE 210 may aggregate the DMRS port(s) according to: DMRS port (TRP1) – DMRS port (TRP2). UE 210 may then determine the association between the aggregated ports and the codewords, such as in a single TRP case, e.g., for layers/DMRS ports 1-4 - one codeword; for layers/DMRS ports > four - two codewords. More particularly, according to (3,2), (3.3), (4,3), (4,3), wherein the first number indicates the layer for CW1 and the second number indicates the layer for CW2.

[0153] In some aspects, two alternatives may be supported in example 9 for codeword to DMRS port mapping for CW1. In a first alternative (Alt-1), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1) – frequency – time - DMRS port (TRP2) – frequency – time. In a second alternative (Alt-2), codeword to DMRS port mapping may be configured according to: DMRS port (TRP1)– DMRS port (TRP2) – frequency - time. More particularly, codeword mapping according to the first and second alternatives may be configured according to:

TRP1 – 2 DMRS Ports TRP2 – 4 DMRS Ports	Codeword-to-Layer (Codeword has M QAM Symbols)	Layer-to-DMRS Port
Alt-1	$\begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \\ x^4(i) \\ x^5(i) \end{bmatrix} = \begin{bmatrix} d^0(i) \\ d^0(i+1) \\ d^0(2M/3+i) \\ d^1(i) \\ d^1(i+1) \\ d^1(i+2) \end{bmatrix}$	$\begin{bmatrix} y^0(i) \\ y^1(i) \\ y^2(i) \\ y^3(i) \\ y^4(i) \\ y^5(i) \end{bmatrix} = \begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \\ x^4(i) \\ x^5(i) \end{bmatrix}$
Alt-2	$\begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \\ x^4(i) \\ x^5(i) \end{bmatrix} = \begin{bmatrix} d^0(i) \\ d^0(i+1) \\ d^0(i+2) \\ d^1(i) \\ d^1(i+1) \\ d^1(i+2) \end{bmatrix}$	$\begin{bmatrix} y^0(i) \\ y^1(i) \\ y^2(i) \\ y^3(i) \\ y^4(i) \\ y^5(i) \end{bmatrix} = \begin{bmatrix} x^0(i) \\ x^1(i) \\ x^2(i) \\ x^3(i) \\ x^4(i) \\ x^5(i) \end{bmatrix}$

[0154] For CW2 mapping in example 9, the DMRS port mapping may be configured according to: DMRS port – frequency – time.

[0155] Based on the information determined above (e.g., the first and second codeword configurations and one or more of the DMRS ports configured by the DMRS port configurations indicated in the first DCI message and/or second DCI message), UE 210 may receive the downlink transmissions from the first transceiver node 205-a and the second transceiver node 205-b according to the determined transmission scheme, QCL information, rate matching configuration, resource allocation, and the like. UE 210 may transmit feedback signaling information based on its success or failure to decode the DCI message(s) and/or downlink transmission from each transceiver node 205.

[0156] **FIG. 3** illustrates an example of a DCI configuration 300 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. In some examples, DCI configuration 300 may implement aspects of wireless communication systems 100/200. Aspects of DCI configuration 300 may be implemented by a base station and/or UE, which may be examples of the corresponding devices described herein. Generally, DCI configuration 300 illustrates a design for a DCI message that may be used to indicate the transmission scheme being used during a downlink transmission.

[0157] As discussed above, the UE may receive a first DCI message and a second DCI message that carries or otherwise conveys an indication of a corresponding codeword configuration usable by the UE to determine the transmission scheme being used for the downlink transmissions. Generally, each DCI message may additional carry or otherwise indicate various communication parameters for the corresponding TRP participating in the downlink transmission to use. DCI configuration 300 illustrates one example of how either (or both) of the DCI messages can be configured for transmission to the UE, and used by the UE to determine the transmission scheme and/or associated communication parameters to use during the downlink transmission.

[0158] DCI configuration 300 may include a CW1 information field 305, a CW2 information field 310, a resource allocation field 315, a QCL information field 320, a rate matching configuration field 325, a HARQ process number field 330, and a downlink assignment index (DAI) field 340. Generally, the CW1 information field 305 and the CW2 information field 310 may be considered the codeword configuration for the associated DCI message. For example, the CW1 information field 305 and the CW2 information field 310 may be considered the first codeword configuration for the first DCI message and the second codeword configuration for the second DCI message. In some aspects, the CW1 information field 305 and/or CW2 information field 310 may also be referred to as TB information fields. Generally, the CW2 information field 310 may only be included in the DCI configuration 300 when the maximum number of codewords is set to two.

[0159] Broadly, the CW1 information field 305 and/or CW2 information field 310 may explicitly or implicitly indicate a transmission scheme or mode being used for the downlink transmission. For example, the CW1 information field 305 and/or CW2 information field 310 may generally convey an indication of one or more codeword communication parameters being used for the downlink transmission. Each codeword information field 305 and/or 310 may carry or otherwise provide an indication of a MCS, a new data indicator (NDI), a RV, and the like, for the respective TRP. In some examples, one or more of the CW1 information field 305 and/or CW2 information field 310 may be blank or set to reserve. When blank or set to reserve, this may implicitly signal one or more aspects of the transmission scheme being used for the downlink transmission. In some examples, one or more parameters indicated within the CW1 information field 305 and/or CW2 information field 310 may be set to a particular value or other information to again implicitly indicate one or more aspects of the transmission scheme being used for the downlink transmission. More detailed discussions with respect to contents and configuration for the CW1 information field 305 and the CW2 information field 310 are discussed with respect to FIG. 4. Generally, the transmission scheme may indicate or otherwise be associated with a link or association between a codeword and a DMRS port(s) for one or more TRPs participating in the downlink transmission.

[0160] Generally, the resource allocation field 305 may carry or otherwise convey an indication of one or more resources (e.g., time and/or frequency resources) for the respective TRP to use during the downlink transmission. In some aspects, the first DCI message and the second DCI message may indicate that the same resources are allocated for each TRP participating in the downlink transmission or that different resources are allocated for each TRP participating in the downlink transmission.

[0161] The QCL information field 320 may generally carry or otherwise convey an indication of one or more QCL parameters for the respective TRP to use during the downlink transmission. For example, the QCL parameters may include QCL information with respect to one or more DMRS ports being used during the downlink transmission.

[0162] The rate matching configuration field 325 generally carries or otherwise conveys an indication of the rate matching configuration or pattern that is used for the downlink transmission. For example, the UE may perform rate matching operations during the downlink transmission according to the information indicated in the rate matching configuration field 325.

[0163] The HARQ process number field 330 generally carries or otherwise conveys an indication of a number or identifier associated with each HARQ process configured by the DCI. Moreover, the HARQ timing field 335 generally carries or otherwise conveys an indication of a timing parameter for each HARQ process, e.g., an indication of timing for transmission of a feedback signal.

[0164] Broadly, the DAI field 340 may carry or otherwise convey an indication of a number or index identifying all of the downlink data being communicated during the downlink transmission that has been bundled into one HARQ ACK/NACK transmission.

[0165] Generally, each TRP participating in the downlink transmission may transmit a respective DCI message configured according to DCI configuration 300. As is discussed above, the DCI messages received from each TRP may have one or more parameters that are different from parameters indicated in the DCI message from the other TRP(s). In some aspects, this may include the base station common to the TRPs participating in the downlink transmission, e.g., where the base station configures each DCI message for each TRP. Collectively, the information conveyed in the codeword configuration (e.g., the CW1 information field 305 and the CW2 information field 310) for each DCI message conveys an indication, at least to some degree, of the transmission scheme being used for the downlink transmission.

[0166] Accordingly, the UE may receive the first and second DCI messages configured according to DCI configuration 300 and use the codeword configurations to determine the transmission scheme for the downlink transmission and use the communication parameters to identify the QCL information, the rate matching configuration, the resource allocation, and the like, for the DMRS port(s). The UE may receive the downlink transmission from TRP1 and TRP2 according to the transmission scheme and other parameters identified from DCI configuration 300.

[0167] **FIG. 4** illustrates an example of a codeword configuration 400 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. In some examples, codeword configuration 400 may implement aspects of wireless communication systems 100/200 and/or DCI configuration 300. Aspects of codeword configuration 400 may be implemented by a UE and/or a base station, which may be examples of the corresponding devices described herein.

[0168] Generally, codeword configuration 400 illustrates various examples of how the codeword configurations for a first DCI message 405 and the second DCI message 410 may be configured in order to convey an indication of the transmission scheme being used during a downlink transmission. As is discussed above, each transmission scheme may be associated with a case (case 1, case 2, or case 3), with some cases having one or more variants. It is to be understood that the codeword configuration indicated for each DCI message generally corresponds to the CW1 information field 305 and the CW2 information field 310 discussed with respect to FIG 3. Again, each CW information field may also be referred to as a TB information field.

[0169] In some aspects, the maximum number of codewords being configured by the first and second DCI message may determine the contents of the respective codeword information fields. For example, cases 1 and 3 may correspond to the maximum number of codewords being set to one, and therefore the CW2 information fields may not be included in the respective DCI messages. As another example, cases 1, 2.1, 2.2, 2.3, and 3.1 may correspond to the maximum number of codewords being set to two, and therefore the CW2 information fields are included in the respective DCI messages.

[0170] As discussed above, case 1 generally refers to a transmission scheme where different codewords are communicated from each TRP during the downlink transmission. Accordingly, each TRP may configure the codeword configuration for its own DCI message according to the example illustrated in the first row. For example, TRP1 may configure the first DCI message 405 to indicate parameters for CW1 (e.g., MCS1, NDI1, RV1, in the CW1 information field), but not indicate parameters for CW2 (e.g., in the CW2 information field). TRP2 may configure the second DCI message 410 to indicate parameters for CW2 (e.g., MCS2, NDI2, RV2, in the CW2 information field), but not to indicate parameters for CW1 (e.g., in the CW1 information field). Accordingly, the UE may receive the first DCI message 405 and the second DCI message 410 and decode the corresponding codeword configuration (e.g., the CW1 and/or CW2 information fields) in order to determine that transmission scheme being used for the downlink transmission is a case 1.

[0171] Case 2 generally refers to a transmission scheme where different portions or parts of the same codeword are being communicated from each TRP. Accordingly, each TRP may configure the codeword configuration for its own DCI message according to the example illustrated in rows 2-5. For example, TRP1 may configure the first DCI message 405 to indicate parameters in the CW1 information field and TRP2 may configure the second DCI message 410 to indicate parameters in the CW2 information field, but may use an MCS field set to "reserve" to implicitly convey an indication that the transmission scheme is a case 2. In the example case 2 transmission scheme, the maximum number of codewords may be set to one, and therefore the first DCI message 405 and the second DCI message 410 may not include CW2 information fields.

[0172] In case 2.1, the maximum number of codewords may be set to two, but the CW2 information fields in the first DCI message 405 and the second DCI message 410 may be blank or set to reserve.

[0173] In cases 2.2 and 2.3, each TRP may transmit a portion of a codeword, but one TRP may transmit a second codeword. For example, in case 2.2 a first portion of CW1 may be transmitted by TRP1, and a second portion of CW1 may be transmitted by TRP2, and CW2 may be transmitted by TRP2. For example, the first portion of CW1 may be transmitted by TRP1 using DMRS port(s) configured in the first DCI message 405 and the second portion of CW1 may be transmitted by TRP2 using a first set of DMRS ports of TRP2. CW2 may be communicated using a second set of DMRS ports of TRP2. Accordingly, for case 2.2 and for the first DCI message 405 the CW1 information field may indicate parameters for communicating the first portion of CW1, whereas the CW2 information field may be set to blank or reserve. For the second DCI message 410, the CW1 information field may indicate parameters (with the MCS being set to "reserve" or a reserve value), whereas the CW2 information field may indicate parameters for communicating CW2.

[0174] In case 2.3, CW1 may be transmitted by TRP1 using a first set of the DMRS ports, a first portion of CW2 may be transmitted by TRP1 using a second set of DMRS ports, and the second portion of CW2 may be transmitted by TRP 2. For example, the first portion of CW2 may be transmitted by TRP1 using a first set of DMRS port(s) configured in the first DCI message 405 and the second portion of CW2 may be transmitted by TRP2 using a the DMRS ports of TRP2. CW1 may be communicated using a second set of DMRS ports of TRP1. Accordingly, for case 2.3 and for the first DCI message 405 the CW1 information field may indicate parameters for communicating CW1, whereas the CW2 information field may indicate parameters for communicating the first part of CW2. For the second DCI message 410, the CW1 information field may be set to blank or reserve, whereas the CW2 information field may indicate parameters (with the MCS being set to "reserve" or a reserve value) for communicating the second portion of CW2.

[0175] Case 3 generally involves a transmission scheme where different versions of the same codeword (e.g., CW1) are communicated by each TRP. For example and as shown in case 3, the CW1 information field of the first DCI message 405 may indicate parameters for communicating the first version of CW1 from TRP1. For the second DCI message 410, the CW1 information field may indicate parameters for communicating the second version of CW1, but may not set the MCS parameter to "reserve" to differentiate case 3 from case 2. In some aspects, the RV information field in the first DCI message 405 may be set to the same or to a different RV value as the RV information field in the second DCI message 410 is set to. Accordingly, the UE may receive the first DCI message 405 and the second DCI message 410 and decode the respective codeword configurations to determine that the transmission scheme comprises a case 3 transmission scheme.

[0176] Case 3.1 generally corresponds to case 3, but with the maximum number of codewords being set to two. Accordingly, each of the first DCI message 405 and second DCI message 410 may include the CW2 information fields, with both CW2 information fields being set to blank or reserve.

[0177] Thus, in DCI configuration 400 the codeword information fields in the respective DCI messages may indicate (e.g., explicitly and/or in implicitly) each codeword being communicated during the downlink transmission in the DCI message from the associated TRP using a corresponding field based on the codeword index. Cases 2 and 3 may be differentiated in the codeword configuration by providing the MCS parameter set to "reserve" in at least one of the DCI messages. Moreover, the RV information field indicated in the codeword configuration may also signal implicitly whether the transmission scheme is case 2 or case 3.

[0178] Accordingly, the UE may receive the first DCI message 405 and the second DCI message 410 and use the associated codeword configurations to identify or otherwise determine the transmission scheme being used for the downlink transmission. For example, the UE may determine or otherwise identify the association between one or more DMRS port(s) (as configured by the DMRS port configurations carried in the respective DCI message) and the one or more codewords being communicated in the downlink transmission. The base station (e.g., TRP1 and TRP2) may transmit the downlink transmissions according to the transmission scheme.

[0179] **FIG. 5** illustrates an example of a DCI configuration 500 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. In some examples, DCI configuration 500 may implement aspects of wireless communication system 100/200, DCI configuration 300, and/or codeword configuration 400. Aspects of DCI configuration 500 may be implemented by a base station and/or a UE, which may be examples of the corresponding devices described herein.

[0180] Generally, DCI configuration 500 illustrates an example where three TRPs are participating in the downlink transmission to a UE. Accordingly, each TRP may transmit its own DCI message to the UE, and the UE may use the codeword configurations indicated in the respective DCI messages to determine the transmission scheme for the downlink transmission. In some aspects, DCI configuration 500 may be used where the transmission scheme is a case 2 (e.g., different parts of the same codeword are communicated from each TRP participating in the downlink transmission). For example, TRP1 may transmit a first DCI message 505, TRP2 may transmit a second DCI message 510, and TRP3 may transmit a third DCI message 515. The first DCI message 505 may include a first codeword configuration that configures one or more parameters for CW1. The second DCI message 510 may configure one or more parameters for CW1, and set an MCS parameter to "reserve" to implicitly indicate that this is a case 2 transmission scheme. The third DCI message 515 may configure one or more parameters for CW1, and set an MCS parameter to "reserve 2."

[0181] In some aspects, TRP 3 may configure other parameters in the third DCI message 515 depended upon the transmission scheme. For example, in case 2 the HARQ process ID may be the same as is indicated in the first DCI message 505 and the second DCI message 510. Moreover, the HARQ timing in the third DCI message 515 may be different from the HARQ timing indicated in the first DCI message 505 and the second DCI message 510. In some aspects, the DAI field may be associated with the HARQ timing indicated in the third DCI message 515. Accordingly, the UE may receive the three DCI messages and determine that CW1 is being transmitted from three TRPs using the DMRS port(s) on the corresponding resources of each TRP.

[0182] HARQ procedures implemented in accordance with DCI configuration 500 may include 2 alternatives. The first alternative may rely on the relationship between the reserve value in the DCI index. For example a base station may detect an ACK/NACK feedback signal on the HARQ timing indicated in the third DCI message 515 if "reserve 2" is greater than "reserve." If "reserve 2" is less than "reserve," then the base station may detect an ACK/NACK feedback signal on the HARQ timing indicated in the second DCI message 510. That is, based on the value of "reserve 2," the UE may identify or otherwise determine that this is the third part of the transmission and, if the UE does not detect and decode the first DCI message 505 and/or the second DCI message 510, the UE may transmit a NACK on the HARQ timing indicated in the third DCI message 515. In the instance where the UE is unable to decode the third DCI message 515, the UE may transmit ACK/NACK feedback signaling on the HARQ timing information indicated in the first DCI message 505 or the second DCI message 510. The base station, not receiving ACK/NACK feedback signaling on the HARQ timing indicated in the third DCI message 515 may determine or interpret this as a NACK and perform a retransmission accordingly.

[0183] The second alternative may not rely on a relationship between the "reserve" value and the DCI index. For example, the base station may detect an ACK/NACK feedback signaling on the HARQ timing indicated in both the second DCI message 510 and third DCI message 515. In the second alternative, if the UE is unable to decode the first DCI message 505, the UE may transmit a NACK signal on the HARQ timing indicated in the second DCI message 510 and the third DCI message 515. If the UE is unable to decode the second DCI message 510 and/or the third DCI message 515, this may indicate that the UE cannot transmit ACK/NACK feedback signaling at the HARQ timing in the missed DCI message.

Accordingly, if the base station detects an ACK on one HARQ timing, and a NACK in another HARQ timing, this may be interpreted as a NACK by the base station, which then may schedule retransmission accordingly.

[0184] **FIG. 6** illustrates an example of a process 600 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. In some examples, process 600 may implement aspects of wireless communication systems 100/200, DCI configurations 300/500, and/or codeword configuration 400. Aspects of process 600 may be implement a by a first transceiver node 605, a UE 610, and a second transceiver node 615, which may be examples of the corresponding devices described herein. For example, the first transceiver node 605 and the second transceiver node 615 may be referred to collectively as a base station in some examples, or separately as TRP1 and TRP2, respectively.

[0185] At 620, the first transceiver node 605 may transmit (and UE 610 may receive) the first DCI message that carries or otherwise conveys an indication of a first codeword configuration. At 625, the second transceiver node 615 may transmit (and UE 610 may receive) the second DCI message that carries or otherwise conveys an indication of a second codeword configuration. In some aspects, the first DCI message and/or the second DCI message may further convey an indication of a DMRS port configuration, a QCL information, a rate matching configuration, a HARQ process number, a HARQ timing parameter, DAI information field, a frequency resource allocation, and/or a time resource allocation for the respective transceiver node (e.g., TRP) to use during the downlink transmission. It is to be understood that the functions perform at 620 and 625 may be performed at same time or at different times by the respective transceiver node.

[0186] At 630, UE 610 may determine or otherwise identify, based at least in part on the first codeword configuration and the second codeword configuration, the transmission scheme to be used during the downlink transmission. In some aspects, the transmission scheme may include an association between one or more DMRS port(s) and one or more codewords being communicated in the downlink transmission. Examples of transmission schemes include, but are not limited to, case 1, case 2, and/or case 3, or some variant thereof, as is described herein.

[0187] At 635, transceiver node 605 may transmit (and UE 610 may receive) the downlink transmission according to the transmission scheme. At 640, the second transceiver node 615 may transmit (and UE 610 may receive) the downlink transmission according to the transmission scheme.

[0188] In some aspects, UE 610 may determine that the first codeword configuration indicates a parameter for communicating a first TB associated with a first codeword (e.g., one or more parameters for CW1) and that the second codeword configuration indicates parameters for communicating a second TB associated with the second codeword (e.g., one or more parameters for CW2), e.g., case 1. In this instance, UE 610 may receive the first codeword according to a QCL information and/or rate matching configuration indicated in the first DCI message and receive a second codeword according to the QCL information and/or rate matching configuration indicated in the second DCI message. In this example, the UE may determine that different time and/or frequency allocations are configured for the first DMRS port(s) and second DMRS port(s), and therefore determine that each of the first and second DMRS port configurations are configured with different DMRS ports.

[0189] In some aspects, this may include the UE 610 determining that one or more DMRS ports are shared between the first DMRS port configuration and the second DMRS port configuration, but that different time and/or frequency resources are allocated in the respective DCI messages. Accordingly, UE 610 may apply the QCL information and/or rate matching configuration indicated in the first DCI message to the shared DMRS ports using a frequency resource allocation and/or time resource allocation that is associated with the second DMRS port configuration.

[0190] **FIG. 7** shows a block diagram 700 of a device 705 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The device 705 may be an example of aspects of a UE 115 as described herein. The device 705 may include a receiver 710, a communications manager 715, and a transmitter 720. The device 705 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0191] The receiver 710 may receive information such as packets, user data, or control information associated with various information channels (e.g., control channels, data channels, and information related to multiple DCI design for multiple transceiver nodes, etc.). Information may be passed on to other components of the device 705. The receiver 710 may be an example of aspects of the transceiver 1020 described with reference to FIG. 10. The receiver 710 may utilize a single antenna or a set of antennas.

[0192] The communications manager 715 may receive a first DCI message including a first CW configuration and a first DMRS port configuration, receive a second DCI message including a second CW configuration and a second DMRS port configuration, determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration, and receive, according to the transmission scheme, the downlink transmissions. The communications manager 715 may be an example of aspects of the communications manager 1010 described herein.

[0193] The communications manager 715, or its sub-components, may be implemented in hardware, code (e.g., software or firmware) executed by a processor, or any combination thereof. If implemented in code executed by a processor, the functions of the communications manager 715, or its sub-components may be executed by a general-purpose processor, a DSP, an application-specific integrated circuit (ASIC), a FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described in the present disclosure.

[0194] The communications manager 715, or its sub-components, may be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations by one or more physical components. In some examples, the communications manager 715, or its sub-components, may be a separate and distinct component in accordance with various aspects of the present disclosure. In some examples, the communications manager 715, or its sub-components, may be combined with one or more other hardware components, including but not limited to an input/output (I/O) component, a transceiver, a network server, another computing device, one or more other components described in the present disclosure, or a combination thereof in accordance with various aspects of the present disclosure.

[0195] The transmitter 720 may transmit signals generated by other components of the device 705. In some examples, the transmitter 720 may be collocated with a receiver 710 in a transceiver module. For example, the transmitter 720 may be an example of aspects of the transceiver 1020 described with reference to FIG. 10. The transmitter 720 may utilize a single antenna or a set of antennas.

[0196] **FIG. 8** shows a block diagram 800 of a device 805 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The device 805 may be an example of aspects of a device 705, or a UE 115 as described herein. The device 805 may include a receiver 810, a communications manager 815, and a transmitter 835. The device 805 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0197] The receiver 810 may receive information such as packets, user data, or control information associated with various information channels (e.g., control channels, data channels, and information related to multiple DCI design for multiple transceiver nodes, etc.). Information may be passed on to other components of the device 805. The receiver 810 may be an example of aspects of the transceiver 1020 described with reference to FIG. 10. The receiver 810 may utilize a single antenna or a set of antennas.

[0198] The communications manager 815 may be an example of aspects of the communications manager 715 as described herein. The communications manager 815 may include a DCI message manager 820, a transmission scheme manager 825, and a downlink transmission manager 830. The communications manager 815 may be an example of aspects of the communications manager 1010 described herein.

[0199] The DCI message manager 820 may receive a first DCI message including a first CW configuration and a first DMRS port configuration and receive a second DCI message including a second CW configuration and a second DMRS port configuration.

[0200] The transmission scheme manager 825 may determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration.

[0201] The downlink transmission manager 830 may receive, according to the transmission scheme, the downlink transmissions.

[0202] The transmitter 835 may transmit signals generated by other components of the device 805. In some examples, the transmitter 835 may be collocated with a receiver 810 in a transceiver module. For example, the transmitter 835 may be an example of aspects of the transceiver 1020 described with reference to FIG. 10. The transmitter 835 may utilize a single antenna or a set of antennas.

[0203] **FIG. 9** shows a block diagram 900 of a communications manager 905 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The communications manager 905 may be an example of aspects of a communications manager 715, a communications manager 815, or a communications manager 1010 described herein. The communications manager 905 may include a DCI message manager 910, a transmission scheme manager 915, a downlink transmission manager 920, a transport block manager 925, a transmission scheme configuration manager 930, a resource allocation manager 935, and a port manager 940. Each of these modules may communicate, directly or indirectly, with one another (e.g., via one or more buses).

[0204] The DCI message manager 910 may receive a first DCI message including a first CW configuration and a first DMRS port configuration. In some examples, the DCI message manager 910 may receive a second DCI message including a second CW configuration and a second DMRS port configuration. In some cases, each of the first DCI message and the second DCI message further includes an indication of at least one of a QCL information, a rate matching configuration, a HARQ process number, a HARQ timing parameter, a downlink assignment index, a frequency resource allocation, a time resource allocation, or a combination thereof, associated with the one or more DMRS ports of the corresponding DMRS port configuration.

[0205] In some cases, each of the first CW configuration and the second CW configuration include one or more TB information fields, where each TB information field indicates parameters including at least one of a MCS, a NDI, and RV of a particular TB of a CW. In some cases, the number of TB information fields is based on the maximum number of CWs or TBs in a downlink transmission, where the maximum number of CWs or TBs in a downlink transmission is configured via higher layer signaling.

[0206] The transmission scheme manager 915 may determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration.

[0207] The downlink transmission manager 920 may receive, according to the transmission scheme, the downlink transmissions.

[0208] The transport block manager 925 may decode a first TB information field in the first DCI message, the first TB information field indicating one or more parameters for a first TB that is associated with a first CW. In some examples, the transport block manager 925 may decode a second TB information field in the second DCI message, the second TB information field indicating one or more parameters for a second TB that is associated with a second CW. In some examples, the transport block manager 925 may determine, based on a determination that an index of the first TB information field in the first DCI message is the same as the index of the second TB information field in the second DCI message, the first TB associated with the first CW being the same as the second TB associated with the second CW.

[0209] In some examples, the transport block manager 925 may determine, based on a determination that the index of the first TB information field in the first DCI message is different from the index of the second TB information field in the second DCI message, the first TB associated with the first CW being different from the second TB associated with the second CW. In some examples, determining that the transmission scheme includes receiving the first TB associated with the first CW using one or more DMRS ports and resource allocation configured in the first DCI message and receiving the second CW using one or more DMRS ports and resource allocation configured in the second DCI message.

[0210] In some examples, the transport block manager 925 may receive the first CW based on a first QCL information and a first rate matching configuration indicated in the first DCI message. In some examples, the transport block manager 925 may receive the second CW based on a second QCL information and a second rate matching configuration indicated in the second DCI message. In some examples, determining the first TB associated with the first CW is the same as the second TB associated with the second CW includes.

[0211] In some examples, the transport block manager 925 may identify a MCS of the TB configured in the second DCI message being set to a first reserved value. In some examples, determining that the transmission scheme includes receiving a first portion of the TB using one or more DMRS ports and resource allocation configured in the first DCI message and receiving a second portion of the TB using one or more DMRS ports and resource allocation configured in the second DCI message.

[0212] In some examples, the transport block manager 925 may receive the first portion based on a first QCL information and a first rate matching configuration indicated in the first DCI message. In some examples, the transport block manager 925 may receive the second portion based on a second QCL information and a second rate matching configuration indicated in the second DCI message. In some examples, the transport block manager 925 may aggregate, based on an index of each DMRS port of the first DMRS configuration and the second DMRS configuration, a first one or more DMRS ports of the first DMRS configuration and a second one or more DMRS ports of the second DMRS configuration to form an aggregated DMRS port.

[0213] In some examples, the transport block manager 925 may aggregate, based on an index of each resource element associated with the frequency resource allocation and time resource allocation configured in the first DCI and the second DCI, the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message to form an aggregated frequency resource allocation and an aggregated time resource allocation.

[0214] In some examples, the transport block manager 925 may map a data stream of the TB associated with the CW according to the order including one or more layers associated with the aggregated DMRS port, then the aggregated frequency resource allocation associated with the aggregated DMRS port, and then the aggregated time resource allocation associated with the aggregated DMRS port. In some examples, the transport block manager 925 may determine that both the first DCI message and the second DCI message are decoded. In some examples, the transport block manager 925 may transmit a signal indicating a decoding result of the TB following a HARQ timing parameter indicated in the second DCI message. In some examples, the transport block manager 925 may receive a third DCI message including a third CW configuration.

[0215] In some examples, the transport block manager 925 may identify that a third TB information field in the third DCI message indicates a third parameters for a third TB where an index of the third TB information field in the third DCI message is the same as the index of the first TB information field in the first DCI message and is the same as the index of the second TB information field in the second DCI message. In some examples, the transport block manager 925 may determine that the third TB is the same as the TB indicated by the first TB information field in the first DCI and the TB indicated by the second TB information field in the second DCI. In some examples, the transport block manager 925 may identify a MCS parameter for the third TB being set to a second reserved value. In some examples, determining that the transmission scheme further includes receiving a third portion of the same TB using a third DMRS port configuration and resource allocation configured in the third DCI message.

[0216] In some examples, the transport block manager 925 may receive the third portion based on the first QCL information and the first rate matching configuration indicated in the first DCI message. In some examples, the transport block manager 925 may determine that the first DCI message, the second DCI message and the third DCI message are decoded. In some examples, the transport block manager 925 may determine that the second reserved value indicated in the third CW configuration is greater than the first reserved value indicated in the second CW configuration. In some examples, the transport block manager 925 may transmit, based on the second reserved value being greater than the first reserved value, a signal indicating a decoding result of the TB following a HARQ timing parameter indicated in the third DCI message. In some examples, determining the first TB associated with the first CW is same as the second TB associated with the second CW further includes. In some examples, the transport block manager 925 may identify a MCS parameter of the TB configured in the first DCI message being set to a value not equal to a reserved value, and the MCS of the TB configured in the second DCI message being set to a value not equal to a reserved value.

[0217] In some examples, determining that the transmission scheme includes receiving a first version of the TB using one or more DMRS ports and resource allocation configured in the first DCI message and receiving a second version of the TB using one or more DMRS ports and resource allocation configured in the second DCI message. In some examples, the transport block manager 925 may receive the first version based on a first QCL information and a first rate matching configuration indicated in the first DCI message. In some examples, the transport block manager 925 may receive the second version based on a second QCL information and a second rate matching configuration indicated in the second DCI message.

[0218] In some examples, the transport block manager 925 may identify a frequency resource allocation and time resource allocation configured in the first DCI message as being the same as the frequency resource allocation and time resource allocation configured in the second DCI message. In some examples, determining that the transmit diversity scheme includes spatial frequency block coding, where the first version of the TB and the second version of the TB have the same RV, but the mapping between the first version and the first one or more DMRS ports follows a different mapping rule from the mapping between the second version and the second one or more DMRS ports. In some cases, a first data stream associated with the first TB that is associated with the first CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports. In some cases, a second data stream associated with the second TB that is associated with the second CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order including a second layer of second one or more DMRS ports, then a frequency resource allocation of second one or more DMRS ports, and then a time resource allocation of second one or more DMRS ports.

[0219] In some cases, a first data stream associated with the first portion of the TB associated with the CW is mapped to a first one or more DMRS port of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS port, then a frequency resource allocation of the first one or more DMRS port, and then a time resource allocation of the first one or more DMRS port. In some cases, a second data stream associated with the second portion of the TB associated with the CW is mapped to a second one or more DMRS port of the second DMRS port configuration according to an order including a second layer of the second one or more DMRS port, then a frequency resource allocation of the second one or more DMRS port, and then a time resource allocation of the second one or more DMRS port.

[0220] In some cases, a first data stream associated with the first version of the TB associated with the CW is mapped to a first one or more DMRS port of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS port, then a frequency resource allocation of the first one or more DMRS port, and then a time resource allocation of the first one or more DMRS port. In some cases, a second data stream associated with the second version of the TB associated with the CW is mapped to a second one or more DMRS port of the second DMRS port configuration according to an order including a second layer of the second one or more DMRS port, then a frequency resource allocation of the second one or more DMRS port, and then a time resource allocation of the second one or more DMRS port. In some cases, the transmit scheme includes a transmit diversity scheme.

[0221] The transmission scheme configuration manager 930 may receive a signal indicating a set of supported transmission schemes. In some examples, the transmission scheme configuration manager 930 may determine the transmission scheme from the set of supported transmission schemes based on the first CW configuration and the second CW configuration.

[0222] The resource allocation manager 935 may identify that a resource allocation configured in the first DCI message is the same as the resource allocation configured in the second DCI message. In some examples, the resource allocation manager 935 may determine that the DMRS ports configured in the first DCI message are different from the DMRS ports configured in the second DCI message.

[0223] The port manager 940 may identify that the DMRS ports configured in the first DCI message and the DMRS ports configured in the second DCI message share one or more common DMRS ports. In some examples, the port manager 940 may apply at least one of a first QCL information, a first rate matching configuration, or a combination thereof, to the common DMRS ports using the resource allocation configured in the first DCI message. In some examples, the port manager 940 may apply at least one of a second QCL information, a second rate matching configuration, or a combination thereof, to the common DMRS ports using the resource allocation configured in the second DCI message.

[0224] **FIG. 10** shows a diagram of a system 1000 including a device 1005 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The device 1005 may be an example of or include the components of device 705, device 805, or a UE 115 as described herein. The device 1005 may include components for bi-directional voice and data communications including components for transmitting and receiving communications, including a communications manager 1010, an I/O controller 1015, a transceiver 1020, an antenna 1025, memory 1030, and a processor 1040. These components may be in electronic communication via one or more buses (e.g., bus 1045).

[0225] The communications manager 1010 may receive a first DCI message including a first CW configuration and a first DMRS port configuration, receive a second DCI message including a second CW configuration and a second DMRS port configuration, determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration, and receive, according to the transmission scheme, the downlink transmissions.

[0226] The I/O controller 1015 may manage input and output signals for the device 1005. The I/O controller 1015 may also manage peripherals not integrated into the device 1005. In some cases, the I/O controller 1015 may represent a physical connection or port to an external peripheral. In some cases, the I/O controller 1015 may utilize an operating system such as iOS®, ANDROID®, MS-DOS®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In other cases, the I/O controller 1015 may represent or interact with a modem, a keyboard, a mouse, a touchscreen, or a similar device. In some cases, the I/O controller 1015 may be implemented as part of a processor. In some cases, a user may interact with the device 1005 via the I/O controller 1015 or via hardware components controlled by the I/O controller 1015.

[0227] The transceiver 1020 may communicate bi-directionally, via one or more antennas, wired, or wireless links as described above. For example, the transceiver 1020 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 1020 may also include a modem to modulate the packets and provide the modulated packets to the antennas for transmission, and to demodulate packets received from the antennas.

[0228] In some cases, the wireless device may include a single antenna 1025. However, in some cases the device may have more than one antenna 1025, which may be capable of concurrently transmitting or receiving multiple wireless transmissions.

[0229] The memory 1030 may include RAM and ROM. The memory 1030 may store computer-readable, computer-executable code 1035 including instructions that, when executed, cause the processor to perform various functions described herein. In some cases, the memory 1030 may contain, among other things, a BIOS which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0230] The processor 1040 may include an intelligent hardware device, (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some cases, the processor 1040 may be configured to operate a memory array using a memory controller. In other cases, a memory controller may be integrated into the processor 1040. The processor 1040 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 1030) to cause the device 1005 to perform various functions (e.g., functions or tasks supporting multiple DCI design for multiple transceiver nodes).

[0231] The code 1035 may include instructions to implement aspects of the present disclosure, including instructions to support wireless communications. The code 1035 may be stored in a non-transitory computer-readable medium such as system memory or other type of memory. In some cases, the code 1035 may not be directly executable by the processor 1040 but may cause a computer (e.g., when compiled and executed) to perform functions described herein.

[0232] **FIG. 11** shows a block diagram 1100 of a device 1105 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The device 1105 may be an example of aspects of a base station 105 as described herein. The device 1105 may include a receiver 1110, a communications manager 1115, and a transmitter

1120. The device 1105 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0233] The receiver 1110 may receive information such as packets, user data, or control information associated with various information channels (e.g., control channels, data channels, and information related to multiple DCI design for multiple transceiver nodes, etc.). Information may be passed on to other components of the device 1105. The receiver 1110 may be an example of aspects of the transceiver 1420 described with reference to FIG. 14. The receiver 1110 may utilize a single antenna or a set of antennas.

[0234] The communications manager 1115 may determine a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration, transmit, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration, and transmit, according to the transmission scheme, the downlink transmissions. The communications manager 1115 may be an example of aspects of the communications manager 1410 described herein.

[0235] The communications manager 1115, or its sub-components, may be implemented in hardware, code (e.g., software or firmware) executed by a processor, or any combination thereof. If implemented in code executed by a processor, the functions of the communications manager 1115, or its sub-components may be executed by a general-purpose processor, a DSP, an ASIC, a FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described in the present disclosure.

[0236] The communications manager 1115, or its sub-components, may be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations by one or more physical components. In some examples, the communications manager 1115, or its sub-components, may be a separate and distinct component in accordance with various aspects of the present disclosure. In some examples, the communications manager 1115, or its sub-components, may be combined with one or more other hardware components, including but not limited to an I/O component, a transceiver, a network server, another computing device, one or more other components described in the present disclosure, or a combination thereof in accordance with various aspects of the present disclosure.

[0237] The transmitter 1120 may transmit signals generated by other components of the device 1105. In some examples, the transmitter 1120 may be collocated with a receiver 1110 in a transceiver module. For example, the transmitter 1120 may be an example of aspects of the transceiver 1420 described with reference to FIG. 14. The transmitter 1120 may utilize a single antenna or a set of antennas.

[0238] **FIG. 12** shows a block diagram 1200 of a device 1205 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The device 1205 may be an example of aspects of a device 1105, or a base station 105 as described herein. The device 1205 may include a receiver 1210, a communications manager 1215, and a transmitter 1235. The device 1205 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0239] The receiver 1210 may receive information such as packets, user data, or control information associated with various information channels (e.g., control channels, data channels, and information related to multiple DCI design for multiple transceiver nodes, etc.). Information may be passed on to other components of the device 1205. The receiver 1210 may be an example of aspects of the transceiver 1420 described with reference to FIG. 14. The receiver 1210 may utilize a single antenna or a set of antennas.

[0240] The communications manager 1215 may be an example of aspects of the communications manager 1115 as described herein. The communications manager 1215 may include a transmission scheme manager 1220, a DCI message manager 1225, and a downlink transmission manager 1230. The communications manager 1215 may be an example of aspects of the communications manager 1410 described herein.

[0241] The transmission scheme manager 1220 may determine a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration.

[0242] The DCI message manager 1225 may transmit, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration.

[0243] The downlink transmission manager 1230 may transmit, according to the transmission scheme, the downlink transmissions.

[0244] The transmitter 1235 may transmit signals generated by other components of the device 1205. In some examples, the transmitter 1235 may be collocated with a receiver 1210 in a transceiver module. For example, the transmitter 1235 may be an example of aspects of the transceiver 1420 described with reference to FIG. 14. The transmitter 1235 may utilize a single antenna or a set of antennas.

[0245] **FIG. 13** shows a block diagram 1300 of a communications manager 1305 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The communications manager 1305 may be an example of aspects of a communications manager 1115, a communications manager 1215, or a communications manager 1410 described herein. The communications manager 1305 may include a transmission scheme manager 1310, a DCI message manager 1315, a downlink transmission manager 1320, a transmission scheme case manager 1325, a transport block manager 1330, a transmission scheme configuration manager 1335, and a port manager 1340. Each of these modules may communicate, directly or indirectly, with one another (e.g., via one or more buses).

[0246] The transmission scheme manager 1310 may determine a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration.

[0247] The DCI message manager 1315 may transmit, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration.

[0248] In some cases, each of the first DCI message and the second DCI message further includes an indication of at least one of a QCL information, a rate matching configuration, a

HARQ process number, a HARQ timing parameter, a downlink assignment index, a frequency resource allocation, a time resource allocation, or a combination thereof, associated with the one or more DMRS ports of the corresponding DMRS port configuration.

[0249] In some cases, each of the first and second CW configurations include one or more TB information fields, where each TB information field indicates parameters including at least one of a MCS, a NDI and a RV of a particular TB of a CW and the number of TB information fields is based on a maximum number of CWs or TBs in a downlink transmission, where the maximum number of CWs or TBs in the downlink transmission is configured via higher layer signaling.

[0250] The downlink transmission manager 1320 may transmit, according to the transmission scheme, the downlink transmissions.

[0251] The transmission scheme case manager 1325 may determine that a first TB associated with a first CW is transmitted using one or more DMRS ports of the first DMRS configuration, and a second TB associated with a second CW is transmitted using one or more DMRS ports of the second DMRS configuration. In some examples, the transmission scheme case manager 1325 may determine that the first TB associated with the first CW is the different than the second TB associated with the second CW. In some examples, the transmission scheme case manager 1325 may transmit, in a first TB information field in the first DCI message, an indication of one or more parameters for the first TB associated with the first CW.

[0252] In some examples, the transmission scheme case manager 1325 may transmit, in a second TB information field in the second DCI message, an indication of one or more parameters for the second TB associated with the second CW, where an index of the first TB information field in the first DCI message is different from the index of the second TB information field in the second DCI message. In some examples, the transmission scheme case manager 1325 may transmit the first TB associated with the first CW using a first one or more DMRS ports and a first resource allocation indicated in the first DCI message, based on a first QCL information and a first rate matching configuration indicated in the first DCI message.

[0253] In some examples, the transmission scheme case manager 1325 may transmit the second TB associated with the second CW using a second one or more DMRS ports and a second resource allocation indicated in the second DCI message, based on a second QCL information and a second rate matching configuration indicated in the second DCI message.

[0254] In some examples, the transmission scheme case manager 1325 may determine a first portion of a TB associated with a CW is transmitted using one or more DMRS ports of the first DMRS configuration, and a second portion of the TB associated with the CW is transmitted using one or more DMRS ports of the second DMRS configuration.

[0255] In some examples, the transmission scheme case manager 1325 may transmit, in a first TB information field in the first DCI message, an indication of one or more parameters for the TB associated with the CW. In some examples, the transmission scheme case manager 1325 may transmit, in a second TB information field in the second DCI message, an indication of one or more parameters for the TB associated with the CW, where the index of the first TB information field in the first DCI message is the same as the index of the second TB information field in the second DCI message, and a MCS parameter provided in the second TB information field is set to a reserved value.

[0256] In some examples, the transmission scheme case manager 1325 may aggregate, based on an index of each DMRS port of the first DMRS configuration and the second DMRS configuration, a first one or more DMRS ports of the first DMRS configuration and a second one or more DMRS ports of the second DMRS configuration to form an aggregated DMRS port. In some examples, the transmission scheme case manager 1325 may aggregate, based on an index of each resource element associated with the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message, the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message to form an aggregated frequency resource allocation and an aggregated time resource allocation.

[0257] In some examples, the transmission scheme case manager 1325 may map a data stream of the TB associated with the CW according to the order including one or more layers associated with the aggregated DMRS port, then the aggregated frequency resource allocation associated with the aggregated DMRS port, and then the aggregated time resource allocation associated with the aggregated DMRS port. In some examples, the transmission scheme case manager 1325 may transmit a first HARQ timing in the first DCI message.

[0258] In some examples, the transmission scheme case manager 1325 may transmit a second HARQ timing in the second DCI message. In some examples, the transmission scheme case manager 1325 may receive a decoding result of the TB associated with the CW. In some examples, the transmission scheme case manager 1325 may determine that a third portion the TB associated with the CW is transmitted using a third one or more DMRS ports of a third DMRS configuration. In some examples, the transmission scheme case manager 1325 may transmit a third DCI message including the third DMRS configuration, a third TB information field in the third DCI message indicating the parameters for the TB, where the index of the third TB information field in the third DCI message is the same as the index of the first TB information field in the first DCI and is the same as the index of the second TB information field in the second DCI message, the MCS parameter for the third TB being set to a second reserved value, a third QCL information, and a third rate matching configuration associated with the third DMRS configuration.

[0259] In some examples, the transmission scheme case manager 1325 may transmit the third portion of the TB associated with the CW based on the third QCL information and the third rate matching configuration. In some examples, the transmission scheme case manager 1325 may transmit a third HARQ timing in the third DCI message. In some examples, the transmission scheme case manager 1325 may determine that the second reserved value indicated in the third CW configuration is greater than the first reserved value indicated in the second CW configuration. In some examples, the transmission scheme case manager 1325 may receive, based on the second reserved value being greater than the first reserved value, a signal indicating a decoding result of the TB following a HARQ timing parameter indicated in the third DCI message.

[0260] In some cases, a first data stream associated with the first TB that is associated with the first CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports.

[0261] In some cases, a second data stream associated with the second TB that is associated with the second CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order including a second layer of second one or more DMRS ports, then a frequency resource allocation of second one or more DMRS ports, and then a time resource allocation of second one or more DMRS ports.

[0262] In some cases, a first data stream associated with the first portion of the TB associated with the CW is mapped to a first one or more DMRS port of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS port, then a frequency resource allocation of the first one or more DMRS port, and then a time resource allocation of the first one or more DMRS port.

[0263] In some cases, a second data stream associated with the second portion of the TB associated with CW is mapped to a second one or more DMRS port of the second DMRS port configuration according to an order including a second layer of the second one or more DMRS port, then a frequency resource allocation of the second one or more DMRS port, and then a time resource allocation of the second one or more DMRS port.

[0264] The transport block manager 1330 may determine that a first version of a TB associated with a CW is transmitted using one or more DMRS ports of the first DMRS configuration, and a second version of the TB associated with the CW is transmitted using one or more DMRS ports of the second DMRS configuration. In some examples, the transport block manager 1330 may transmit, in a first TB information field in the first DCI message, an indication of one or more parameters for the TB associated with the CW.

[0265] In some examples, the transport block manager 1330 may transmit, in a second TB information field in the second DCI message, an indication of one or more parameters for the TB associated with the CW, where. In some examples, the transport block manager 1330 may identify a frequency resource allocation and time resource allocation configured in the first DCI message as being the same as the frequency resource allocation and time resource allocation configured in the second DCI message. In some examples, the transport block manager 1330 may determine that the transmit diversity scheme is spatial frequency block coding, where the first version of the TB and the second version of the TB have a same RV, but the mapping between the first version and the first one or more DMRS ports follows a different mapping rule from the mapping from the second version and the second one or more DMRS ports.

[0266] In some cases, the index of the first TB information field in the first DCI message is the same as the index of the second TB information field in the second DCI message. In some cases, a MCS parameter provided in the first TB information field is not set to a reserved value, and the MCS parameter provided in the second TB information field is not set to a reserved value. In some cases, a first data stream associated with the first version of the TB associated with the CW is mapped to a first one or more DMRS port of the first DMRS port configuration according to an order including a first layer of the first one or more DMRS port, then a frequency resource allocation of the first one or more DMRS port, and then a time resource allocation of the first one or more DMRS port. In some cases, a second data stream associated with the second version of the TB associated with the CW is mapped to a second one or more DMRS port of the second DMRS port configuration according to an order including a second layer of the second one or more DMRS port, then a frequency resource allocation of the second one or more DMRS port, and then a time resource allocation of the second one or more DMRS port. In some cases, the transmit scheme includes a transmit diversity scheme.

[0267] The transmission scheme configuration manager 1335 may transmit a signal indicating a set of supported transmission schemes. In some examples, the transmission scheme configuration manager 1335 may determine the transmission scheme from the set of supported transmission schemes based on the first CW configuration and the second CW configuration.

[0268] The port manager 1340 may identify that a resource allocation configured in the first DCI message is the same as the resource allocation configured in the second DCI message. In some examples, the port manager 1340 may transmit different DMRS ports configuration in the first DCI message than the DMRS ports configuration in the second DCI message.

[0269] **FIG. 14** shows a diagram of a system 1400 including a device 1405 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The device 1405 may be an example of or include the components of device 1105, device 1205, or a base station 105 as described herein. The device 1405 may include components for bi-directional voice and data communications including components for transmitting and receiving communications, including a communications manager 1410, a network communications manager 1415, a transceiver 1420, an antenna 1425, memory 1430, a processor 1440, and an inter-station communications manager 1445. These components may be in electronic communication via one or more buses (e.g., bus 1450).

[0270] The communications manager 1410 may determine a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration, transmit, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration, and transmit, according to the transmission scheme, the downlink transmissions.

[0271] The network communications manager 1415 may manage communications with the core network (e.g., via one or more wired backhaul links). For example, the network communications manager 1415 may manage the transfer of data communications for client devices, such as one or more UEs 115.

[0272] The transceiver 1420 may communicate bi-directionally, via one or more antennas, wired, or wireless links as described above. For example, the transceiver 1420 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 1420 may also include a modem to modulate the packets and provide the modulated packets to the antennas for transmission, and to demodulate packets received from the antennas.

[0273] In some cases, the wireless device may include a single antenna 1425. However, in some cases the device may have more than one antenna 1425, which may be capable of concurrently transmitting or receiving multiple wireless transmissions.

[0274] The memory 1430 may include RAM, ROM, or a combination thereof. The memory 1430 may store computer-readable code 1435 including instructions that, when executed by a processor (e.g., the processor 1440) cause the device to perform various functions described herein. In some cases, the memory 1430 may contain, among other things, a BIOS which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0275] The processor 1440 may include an intelligent hardware device, (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some cases, the processor 1440 may be configured to operate a memory array using a memory controller. In some cases, a memory controller may be integrated into processor 1440. The processor 1440 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 1430) to cause the device #{device} to perform various functions (e.g., functions or tasks supporting multiple DCI design for multiple transceiver nodes).

[0276] The inter-station communications manager 1445 may manage communications with other base station 105, and may include a controller or scheduler for controlling communications with UEs 115 in cooperation with other base stations 105. For example, the inter-station communications manager 1445 may coordinate scheduling for transmissions to UEs 115 for various interference mitigation techniques such as beamforming or joint transmission. In some examples, the inter-station communications manager 1445 may provide an X2 interface within an LTE/LTE-A wireless communication network technology to provide communication between base stations 105.

[0277] The code 1435 may include instructions to implement aspects of the present disclosure, including instructions to support wireless communications. The code 1435 may be stored in a non-transitory computer-readable medium such as system memory or other type of memory. In some cases, the code 1435 may not be directly executable by the processor 1440 but may cause a computer (e.g., when compiled and executed) to perform functions described herein.

[0278] **FIG. 15** shows a flowchart illustrating a method 1500 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The operations of method 1500 may be implemented by a UE 115 or its components as described herein. For example, the operations of method 1500 may be performed by a communications manager as described with reference to FIGs. 7 through 10. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the functions described below. Additionally or alternatively, a UE may perform aspects of the functions described below using special-purpose hardware.

[0279] At 1505, the UE may receive a first DCI message including a first CW configuration and a first DMRS port configuration. The operations of 1505 may be performed according to the methods described herein. In some examples, aspects of the operations of 1505 may be performed by a DCI message manager as described with reference to FIGs. 7 through 10.

[0280] At 1510, the UE may receive a second DCI message including a second CW configuration and a second DMRS port configuration. The operations of 1510 may be performed according to the methods described herein. In some examples, aspects of the operations of 1510 may be performed by a DCI message manager as described with reference to FIGs. 7 through 10.

[0281] At 1515, the UE may determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration. The operations of 1515 may be performed according to the methods described herein. In some examples, aspects of the operations of 1515 may be performed by a transmission scheme manager as described with reference to FIGs. 7 through 10.

[0282] At 1520, the UE may receive, according to the transmission scheme, the downlink transmissions. The operations of 1520 may be performed according to the methods described herein. In some examples, aspects of the operations of 1520 may be performed by a downlink transmission manager as described with reference to FIGs. 7 through 10.

[0283] **FIG. 16** shows a flowchart illustrating a method 1600 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The operations of method 1600 may be implemented by a UE 115 or its components as described herein. For example, the operations of method 1600 may be performed by a communications manager as described with reference to FIGs. 7 through 10. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the functions described below. Additionally or alternatively, a UE may perform aspects of the functions described below using special-purpose hardware.

[0284] At 1605, the UE may receive a signal indicating a set of supported transmission schemes. The operations of 1605 may be performed according to the methods described herein. In some examples, aspects of the operations of 1605 may be performed by a transmission scheme configuration manager as described with reference to FIGs. 7 through 10.

[0285] At 1610, the UE may receive a first DCI message including a first CW configuration and a first DMRS port configuration. The operations of 1610 may be performed according to the methods described herein. In some examples, aspects of the operations of 1610 may be performed by a DCI message manager as described with reference to FIGs. 7 through 10.

[0286] At 1615, the UE may receive a second DCI message including a second CW configuration and a second DMRS port configuration. The operations of 1615 may be performed according to the methods described herein. In some examples, aspects of the operations of 1615 may be performed by a DCI message manager as described with reference to FIGs. 7 through 10.

[0287] At 1620, the UE may determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration. The operations of 1620 may be performed according to the methods described herein. In some examples, aspects of the operations of 1620 may be performed by a transmission scheme manager as described with reference to FIGs. 7 through 10.

[0288] At 1625, the UE may determine the transmission scheme from the set of supported transmission schemes based on the first CW configuration and the second CW configuration. The operations of 1625 may be performed according to the methods described herein. In some examples, aspects of the operations of 1625 may be performed by a transmission scheme configuration manager as described with reference to FIGs. 7 through 10.

[0289] At 1630, the UE may receive, according to the transmission scheme, the downlink transmissions. The operations of 1630 may be performed according to the methods described herein. In some examples, aspects of the operations of 1630 may be performed by a downlink transmission manager as described with reference to FIGs. 7 through 10.

[0290] **FIG. 17** shows a flowchart illustrating a method 1700 that supports multiple DCI design for multiple transceiver nodes in accordance with aspects of the present disclosure. The operations of method 1700 may be implemented by a base station 105 or its components as described herein. For example, the operations of method 1700 may be performed by a communications manager as described with reference to FIGs. 11 through 14. In some examples, a base station may execute a set of instructions to control the functional elements of the base station to perform the functions described below. Additionally or alternatively, a base station may perform aspects of the functions described below using special-purpose hardware.

[0291] At 1705, the base station may determine a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration. The operations of 1705 may be performed according to the methods described herein. In some examples, aspects of the operations of 1705 may be performed by a transmission scheme manager as described with reference to FIGs. 11 through 14.

[0292] At 1710, the base station may transmit, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration. The operations of 1710 may be performed according to the methods described herein. In some examples, aspects of the operations of 1710 may be performed by a DCI message manager as described with reference to FIGs. 11 through 14.

[0293] At 1715, the base station may transmit, according to the transmission scheme, the downlink transmissions. The operations of 1715 may be performed according to the methods described herein. In some examples, aspects of the operations of 1715 may be performed by a downlink transmission manager as described with reference to FIGs. 11 through 14.

[0294] It should be noted that the methods described herein describe possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[0295] Techniques described herein may be used for various wireless communications systems such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), and other systems. A CDMA system may implement a radio technology such as CDMA2000, Universal Terrestrial Radio Access (UTRA), etc. CDMA2000 covers IS-2000, IS-95, and IS-856 standards. IS-2000 Releases may be commonly referred to as CDMA2000 1X, 1X, etc. IS-856 (TIA-856) is commonly referred to as CDMA2000 1xEV-DO, High Rate Packet Data (HRPD), etc. UTRA includes Wideband CDMA (WCDMA) and other variants of CDMA. A TDMA system may implement a radio technology such as Global System for Mobile Communications (GSM).

[0296] An OFDMA system may implement a radio technology such as Ultra Mobile Broadband (UMB), Evolved UTRA (E-UTRA), Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, etc. UTRA and E-UTRA are part of Universal Mobile Telecommunications System (UMTS). LTE, LTE-A, and LTE-A Pro are releases of UMTS that use E-UTRA. UTRA, E-UTRA, UMTS, LTE, LTE-A, LTE-A Pro, NR, and GSM are described in documents from the organization named "3rd Generation Partnership Project" (3GPP). CDMA2000 and UMB are described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). The techniques described herein may be used for the systems and radio technologies mentioned herein as well as other systems and radio technologies. While aspects of an LTE, LTE-A, LTE-A Pro, or NR system may be described for purposes of example, and LTE, LTE-A, LTE-A Pro, or NR terminology may be used in much of the description, the techniques described herein are applicable beyond LTE, LTE-A, LTE-A Pro, or NR applications.

[0297] A macro cell generally covers a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by UEs 115 with service subscriptions with the network provider. A small cell may be associated with a lower-powered base station 105, as compared with a macro cell, and a small cell may operate in the same or different (e.g., licensed, unlicensed, etc.) frequency bands as macro cells. Small cells may include pico cells, femto cells, and micro cells according to various examples. A pico cell, for example, may cover a small geographic area and may allow unrestricted access by UEs 115 with service subscriptions with the network provider. A femto cell may also cover a small geographic area (e.g., a home) and may provide restricted access by UEs 115 having an association with the femto cell (e.g., UEs 115 in a closed subscriber group (CSG), UEs 115 for users in the home, and the like). An eNB for a macro cell may be referred to as a macro eNB. An eNB for a small cell may be referred to as a small cell eNB, a pico eNB, a femto eNB, or a home eNB. An eNB may support one or multiple (e.g., two, three, four, and the like) cells, and may also support communications using one or multiple component carriers.

[0298] The wireless communications system 100 or systems described herein may support synchronous or asynchronous operation. For synchronous operation, the base stations 105 may have similar frame timing, and transmissions from different base stations 105 may be approximately aligned in time. For asynchronous operation, the base stations 105 may have different frame timing, and transmissions from different base stations 105 may not be aligned in time. The techniques described herein may be used for either synchronous or asynchronous operations.

[0299] Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0300] The various illustrative blocks and modules described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device (PLD), discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration).

[0301] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein can be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[0302] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that can be accessed by a general purpose or special purpose computer. By way of example, and not limitation, non-transitory computer-readable media may include random-access memory (RAM), read-only memory (ROM), electrically erasable programmable read only memory (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that can be used to carry or store desired program code means in the form of instructions or data structures and that can be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, include CD, laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above are also included within the scope of computer-readable media.

[0303] As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an exemplary step that is described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on."

[0304] In the appended figures, similar components or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If just the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label, or other subsequent reference label.

[0305] The description set forth herein, in connection with the appended drawings, describes example configurations and does not represent all the examples that may be implemented or that are within the scope of the claims. The term "exemplary" used herein means "serving as an example, instance, or illustration," and not "preferred" or "advantageous over other examples." The detailed description includes specific details for the purpose of providing an understanding of the described techniques. These techniques, however, may be practiced without these specific details. In some instances, well-known structures and devices are shown in block diagram form in order to avoid obscuring the concepts of the described examples.

[0306] The description herein is provided to enable a person skilled in the art to make or use the disclosure. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein, but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

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

receiving a first downlink control information (DCI) message comprising a first codeword (CW) configuration and a first demodulation reference signal (DMRS) port configuration;

receiving a second DCI message comprising a second CW configuration and a second DMRS port configuration;

determining, based at least in part on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, wherein the transmission scheme comprises an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration; and

receiving, according to the transmission scheme, the downlink transmissions.

2. The method of claim 1, wherein each of the first DCI message and the second DCI message further comprises an indication of at least one of a quasi-co-located (QCL) information, a rate matching configuration, a hybrid automatic repeat/request (HARQ) process number, a HARQ timing parameter, a downlink assignment index, a frequency resource allocation, a time resource allocation, or a combination thereof, associated with the one or more DMRS ports of the corresponding DMRS port configuration.

3. The method of claim 1, wherein:

each of the first CW configuration and the second CW configuration comprise one or more transport block (TB) information fields, wherein each TB information field indicates parameters comprising at least one of a modulation and coding scheme (MCS), a new data indicator (NDI), and redundancy version (RV) of a particular TB of a CW; and

the number of TB information fields is based at least in part on a maximum number of CWs or TBs in a downlink transmission, wherein the maximum number of CWs or TBs in a downlink transmission is configured via higher layer signaling.

4. The method of claim 1, further comprising:

decoding a first transport block (TB) information field in the first DCI message, the first TB information field indicating one or more parameters for a first TB that is associated with a first CW;

decoding a second TB information field in the second DCI message, the second TB information field indicating one or more parameters for a second TB that is associated with a second CW;

determining, based at least in part on a determination that an index of the first TB information field in the first DCI message is the same as the index of the second TB information field in the second DCI message, the first TB associated with the first CW being the same as the second TB associated with the second CW; and

determining, based at least in part on a determination that the index of the first TB information field in the first DCI message is different from the index of the second TB information field in the second DCI message, the first TB associated with the first CW being different from the second TB associated with the second CW.

5. The method of claim 4, wherein determining that the first TB associated with the first CW is different from the second TB associated with the second CW comprises:

determining that the transmission scheme comprises receiving the first TB associated with the first CW using one or more DMRS ports and resource allocations configured in the first DCI message and receiving the second CW using one or more DMRS ports and resource allocations configured in the second DCI message;

receiving the first CW based at least in part on a first quasi-co-located (QCL) information and a first rate matching configuration indicated in the first DCI message; and

receiving the second CW based at least in part on a second QCL information and a second rate matching configuration indicated in the second DCI message.

6. The method of claim 5, wherein:

a first data stream associated with the first TB that is associated with the first CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and

a second data stream associated with the second TB that is associated with the second CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of second one or more DMRS ports.

7. The method of claim 4, wherein determining the first TB associated with the first CW is the same as the second TB associated with the second CW comprises:

identifying a modulation and coding scheme (MCS) of the TB configured in the second DCI message being set to a first reserved value;

determining that the transmission scheme comprises receiving a first portion of the TB using one or more DMRS ports and resource allocation configured in the first DCI message and receiving a second portion of the TB using one or more DMRS ports and resource allocation configured in the second DCI message;

receiving the first portion based at least in part on a first quasi-co-located (QCL) information and a first rate matching configuration indicated in the first DCI message; and

receiving the second portion based at least in part on a second QCL information and a second rate matching configuration indicated in the second DCI message.

8. The method of claim 7, wherein:

a first data stream associated with the first portion of the TB associated with the CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and

a second data stream associated with the second portion of the TB associated with the CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

9. The method of claim 7, further comprising:

aggregating, based at least in part on an index of each DMRS port of the first DMRS configuration and the second DMRS configuration, a first one or more DMRS ports of the first DMRS configuration and a second one or more DMRS ports of the second DMRS configuration to form an aggregated DMRS port;

aggregating, based at least in part on an index of each resource element associated with the frequency resource allocation and time resource allocation configured in the first DCI and the second DCI, the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message to form an aggregated frequency resource allocation and an aggregated time resource allocation; and

mapping a data stream of the TB associated with the CW according to the order comprising one or more layers associated with the aggregated DMRS port, then the aggregated frequency resource allocation associated with the aggregated DMRS port, and then the aggregated time resource allocation associated with the aggregated DMRS port.

10. The method of claim 7, further comprising:

determining that both the first DCI message and the second DCI message are decoded; and

transmitting a signal indicating a decoding result of the TB following a hybrid automatic repeat/request (HARQ) timing parameter indicated in the second DCI message.

11. The method of claim 7, further comprising:

receiving a third DCI message comprising a third CW configuration;

identifying that a third TB information field in the third DCI message indicates a third parameter for a third TB wherein an index of the third TB information field in the third DCI message is the same as the index of the first TB information field in the first DCI message and is the same as the index of the second TB information field in the second DCI message;

determining that the third TB is the same as the TB indicated by the first TB information field in the first DCI and the TB indicated by the second TB information field in the second DCI;

identifying a modulation and coding scheme (MCS) parameter for the third TB being set to a second reserved value;

determining that the transmission scheme further comprises receiving a third portion of the same TB using a third DMRS port configuration and resource allocation configured in the third DCI message; and

receiving the third portion based at least in part on the first QCL information and the first rate matching configuration indicated in the first DCI message.

12. The method of claim 11, further comprising:

determining that the first DCI message, the second DCI message and the third DCI message are decoded;

determining that the second reserved value indicated in the third CW configuration is greater than the first reserved value indicated in the second CW configuration; and

transmitting, based at least in part on the second reserved value being greater than the first reserved value, a signal indicating a decoding result of the TB following a hybrid automatic repeat/request (HARQ) timing parameter indicated in the third DCI message.

13. The method of claim 4, wherein determining the first TB associated with the first CW is same as the second TB associated with the second CW further comprises:

identifying a modulation and coding scheme (MCS) parameter of the TB configured in the first DCI message being set to a value not equal to a reserved value, and the MCS of the TB configured in the second DCI message being set to a value not equal to a reserved value;

determining that the transmission scheme comprises receiving a first version of the TB using one or more DMRS ports and resource allocation configured in the first DCI message and receiving a second version of the TB using one or more DMRS ports and resource allocation configured in the second DCI message;

receiving the first version based at least in part on a first quasi-co-located (QCL) information and a first rate matching configuration indicated in the first DCI message; and

receiving the second version based at least in part on a second QCL information and a second rate matching configuration indicated in the second DCI message.

14. The method of claim 13, wherein:

a first data stream associated with the first version of the TB associated with the CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and

a second data stream associated with the second version of the TB associated with the CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

15. The method of claim 13, wherein the transmit scheme comprises a transmit diversity scheme.

16. The method of claim 15, further comprising:

identifying a frequency resource allocation and time resource allocation configured in the first DCI message as being the same as the frequency resource allocation and time resource allocation configured in the second DCI message; and

determining that the transmit diversity scheme comprises spatial frequency block coding, wherein the first version of the TB and the second version of the TB have the same redundancy version (RV), but the mapping between the first version and the first one or more DMRS ports follows a different mapping rule from the mapping between the second version and the second one or more DMRS ports.

17. The method of claim 1, further comprising:

receiving a signal indicating a set of supported transmission schemes; and

determining the transmission scheme from the set of supported transmission schemes based at least in part on the first CW configuration and the second CW configuration.

18. The method of claim 1, further comprising:

identifying that a resource allocation configured in the first DCI message is the same as the resource allocation configured in the second DCI message; and determining that the DMRS ports configured in the first DCI message are different from the DMRS ports configured in the second DCI message.

19. The method of claim 1, further comprising:

identifying that the DMRS ports configured in the first DCI message and the DMRS ports configured in the second DCI message share one or more common DMRS ports;

applying at least one of a first quasi-co-located (QCL) information, a first rate matching configuration, or a combination thereof, to the common DMRS ports using the resource allocation configured in the first DCI message; and

applying at least one of a second QCL information, a second rate matching configuration, or a combination thereof, to the common DMRS ports using the resource allocation configured in the second DCI message.

20. A method for wireless communication at a base station, comprising:

determining a transmission scheme to use for downlink transmissions, wherein the transmission scheme comprises an association between one or more codewords (CWs) to be communicated in the downlink transmissions and one or more demodulation reference signal (DMRS) ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration;

transmitting, to the user equipment (UE), a first downlink control information (DCI) message comprising a first CW configuration and a first DMRS port configuration and a second DCI message comprising a second CW configuration and a second DMRS port configuration; and

transmitting, according to the transmission scheme, the downlink transmissions.

21. The method of claim 20, wherein each of the first DCI message and the second DCI message further comprises an indication of at least one of a quasi-co-located (QCL) information, a rate matching configuration, a hybrid automatic repeat/request (HARQ) process number, a HARQ timing parameter, a downlink assignment index, a frequency resource allocation, a time resource allocation, or a combination thereof, associated with the one or more DMRS ports of the corresponding DMRS port configuration.

22. The method of claim 20, wherein each of the first and second CW configurations comprise one or more transport block (TB) information fields, wherein each TB information field indicates parameters comprising at least one of a modulation and coding scheme (MCS), a new data indicator (NDI) and a redundancy version (RV) of a particular TB of a CW and the number of TB information fields is based at least in part on a maximum number of CWs or TBs in a downlink transmission, wherein the maximum number of CWs or TBs in the downlink transmission is configured via higher layer signaling.

23. The method of claim 20, wherein determining the transmission scheme further comprises:

determining that a first transport block (TB) associated with a first CW is transmitted using one or more DMRS ports of the first DMRS configuration, and a second TB associated with a second CW is transmitted using one or more DMRS ports of the second DMRS configuration;

determining that the first TB associated with the first CW is the different from the second TB associated with the second CW;

transmitting, in a first TB information field in the first DCI message, an indication of one or more parameters for the first TB associated with the first CW; and

transmitting, in a second TB information field in the second DCI message, an indication of one or more parameters for the second TB associated with the second CW, wherein an index of the first TB information field in the first DCI message is different from the index of the second TB information field in the second DCI message.

24. The method of claim 23, further comprising:

transmitting the first TB associated with the first CW using a first one or more DMRS ports and a first resource allocation indicated in the first DCI message, based at least in part on a first quasi-co-located (QCL) information and a first rate matching configuration indicated in the first DCI message; and

transmitting the second TB associated with the second CW using a second one or more DMRS ports and a second resource allocation indicated in the second DCI message, based at least in part on a second QCL information and a second rate matching configuration indicated in the second DCI message.

25. The method of claim 24, wherein:

a first data stream associated with the first TB that is associated with the first CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and

a second data stream associated with the second TB that is associated with the second CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of second one or more DMRS ports, then a frequency resource allocation of second one or more DMRS ports, and then a time resource allocation of second one or more DMRS ports.

26. The method of claim 20, wherein determining the transmission scheme further comprises:

determining a first portion of a transport block (TB) associated with a CW is transmitted using one or more DMRS ports of the first DMRS configuration, and a second portion of the TB associated with the CW is transmitted using one or more DMRS ports of the second DMRS configuration;

transmitting, in a first TB information field in the first DCI message, an indication of one or more parameters for the TB associated with the CW; and

transmitting, in a second TB information field in the second DCI message, an indication of one or more parameters for the TB associated with the CW, wherein the index of the first TB information field in the first DCI message is the same as the index of the second TB information field in the second DCI message, and a modulation and coding scheme (MCS) parameter provided in the second TB information field is set to a reserved value.

27. The method of claim 26, wherein:

a first data stream associated with the first portion of the TB associated with the CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and a second data stream associated with the second portion of the TB associated with CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

28. The method of claim 26, further comprising:

aggregating, based at least in part on an index of each DMRS port of the first DMRS configuration and the second DMRS configuration, a first one or more DMRS ports of the first DMRS configuration and a second one or more DMRS ports of the second DMRS configuration to form an aggregated DMRS port;

aggregating, based at least in part on an index of each resource element associated with the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message, the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message to form an aggregated frequency resource allocation and an aggregated time resource allocation; and

mapping a data stream of the TB associated with the CW according to the order comprising one or more layers associated with the aggregated DMRS port, then the aggregated frequency resource allocation associated with the aggregated DMRS port, and then the aggregated time resource allocation associated with the aggregated DMRS port.

29. The method of claim 26, further comprising:

transmitting a first hybrid automatic repeat/request (HARQ) timing in the first DCI message;

transmitting a second HARQ timing in the second DCI message; and

receiving a decoding result of the TB associated with the CW.

30. The method of claim 26, further comprising:

determining that a third portion of the TB associated with the CW is transmitted using a third one or more DMRS ports of a third DMRS configuration;

transmitting a third DCI message comprising the third DMRS configuration, a third TB information field in the third DCI message indicating the parameters for the TB, wherein the index of the third TB information field in the third DCI message is the same as the index of the first TB information field in the first DCI and is the same as the index of the second TB information field in the second DCI message, the MCS parameter for the third TB being set to a second reserved value, a third QCL information, and a third rate matching configuration associated with the third DMRS configuration; and

transmitting the third portion of the TB associated with the CW based at least in part on the third QCL information and the third rate matching configuration.

31. The method of claim 30, further comprising:

transmitting a third hybrid automatic repeat/request (HARQ) timing in the third DCI message;

determining that the second reserved value indicated in the third CW configuration is greater than a first reserved value indicated in the second CW configuration; and

receiving, based at least in part on the second reserved value being greater than the first reserved value, a signal indicating a decoding result of the TB following a HARQ timing parameter indicated in the third DCI message.

32. The method of claim 20, wherein determining the transmission scheme further comprises:

determining that a first version of a transport block (TB) associated with a CW is transmitted using one or more DMRS ports of the first DMRS configuration, and a second version of the TB associated with the CW is transmitted using one or more DMRS ports of the second DMRS configuration;

transmitting, in a first TB information field in the first DCI message, an indication of one or more parameters for the TB associated with the CW;

transmitting, in a second TB information field in the second DCI message, an indication of one or more parameters for the TB associated with the CW, wherein;

the index of the first TB information field in the first DCI message is the same as the index of the second TB information field in the second DCI message; and

a modulation and coding scheme (MCS) parameter provided in the first TB information field is not set to a reserved value, and the MCS parameter provided in the second TB information field is not set to a reserved value.

33. The method of claim 32, wherein:

a first data stream associated with the first version of the TB associated with the CW is mapped to a first one or more DMRS port of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and

a second data stream associated with the second version of the TB associated with the CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

34. The method of claim 32, wherein the transmit scheme comprises a transmit diversity scheme.

35. The method of claim 34, further comprising:

identifying a frequency resource allocation and time resource allocation configured in the first DCI message as being the same as the frequency resource allocation and time resource allocation configured in the second DCI message; and

determining that the transmit diversity scheme is spatial frequency block coding, wherein the first version of the TB and the second version of the TB have a same redundancy version (RV), but the mapping between the first version and the first one or more DMRS ports follows a different mapping rule from the mapping from the second version and the second one or more DMRS ports.

36. The method of claim 20, further comprising:

transmitting a signal indicating a set of supported transmission schemes; and

determining the transmission scheme from the set of supported transmission schemes based at least in part on the first CW configuration and the second CW configuration.

37. The method of claim 20, further comprising:

identifying that a resource allocation configured in the first DCI message is the same as the resource allocation configured in the second DCI message; and transmitting different DMRS ports configuration in the first DCI message than the DMRS ports configuration in the second DCI message.

38. An apparatus for wireless communication at a user equipment (UE), comprising:

a processor,

memory in electronic communication with the processor; and

instructions stored in the memory and executable by the processor to cause the apparatus to:

receive a first downlink control information (DCI) message comprising a first codeword (CW) configuration and a first demodulation reference signal (DMRS) port configuration;

receive a second DCI message comprising a second CW configuration and a second DMRS port configuration;

determine, based at least in part on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, wherein the transmission scheme comprises an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration; and

receive, according to the transmission scheme, the downlink transmissions.

39. The apparatus of claim 38, wherein each of the first DCI message and the second DCI message further comprises an indication of at least one of a quasi-co-located (QCL) information, a rate matching configuration, a hybrid automatic repeat/request (HARQ) process number, a HARQ timing parameter, a downlink assignment index, a frequency resource allocation, a time resource allocation, or a combination thereof, associated with the one or more DMRS ports of the corresponding DMRS port configuration.

40. The apparatus of claim 38, wherein:

each of the first CW configuration and the second CW configuration comprise one or more transport block (TB) information fields, wherein each TB information field indicates parameters comprising at least one of a modulation and coding scheme (MCS), a new data indicator (NDI), and redundancy version (RV) of a particular TB of a CW; and

the number of TB information fields is based at least in part on the maximum number of CWs or TBs in a downlink transmission, wherein the maximum number of CWs or TBs in a downlink transmission is configured via higher layer signaling.

41. The apparatus of claim 38, wherein the instructions are further executable by the processor to cause the apparatus to:

decode a first transport block (TB) information field in the first DCI message, the first TB information field indicating one or more parameters for a first TB that is associated with a first CW;

decode a second TB information field in the second DCI message, the second TB information field indicating one or more parameters for a second TB that is associated with a second CW;

determine, based at least in part on a determination that an index of the first TB information field in the first DCI message is the same as the index of the second TB information field in the second DCI message, the first TB associated with the first CW being the same as the second TB associated with the second CW; and

determine, based at least in part on a determination that the index of the first TB information field in the first DCI message is different from the index of the second TB information field in the second DCI message, the first TB associated with the first CW being different from the second TB associated with the second CW.

42. The apparatus of claim 41, wherein the instructions to determine that the first TB associated with the first CW is different from the second TB associated with the second CW are executable by the processor to cause the apparatus to:

the instructions to determine the transmission scheme are further executable by the processor to cause the apparatus to receive the first TB associated with the first CW using one or more DMRS ports and resource allocation configured in the first DCI message and receive the second CW using one or more DMRS ports and resource allocation configured in the second DCI message;

receive the first CW based at least in part on a first quasi-co-located (QCL) information and a first rate matching configuration indicated in the first DCI message; and receive the second CW based at least in part on a second QCL information and a second rate matching configuration indicated in the second DCI message.

43. The apparatus of claim 42, wherein:

a first data stream associated with the first TB that is associated with the first CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and

a second data stream associated with the second TB that is associated with the second CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of second one or more DMRS ports, then a frequency resource allocation of second one or more DMRS ports, and then a time resource allocation of second one or more DMRS ports.

44. The apparatus of claim 41, wherein the instructions are further executable by the processor to cause the apparatus to:

determine the first TB associated with the first CW is the same as the second TB associated with the second CW comprises;

identify a modulation and coding scheme (MCS) of the TB configured in the second DCI message being set to a first reserved value;

the instructions to determine the transmission scheme are further executable by the processor to cause the apparatus to receive a first portion of the TB using one or more DMRS ports and resource allocation configured in the first DCI message and receive a second portion of the TB using one or more DMRS ports and resource allocation configured in the second DCI message;

receive the first portion based at least in part on a first quasi-co-located (QCL) information and a first rate matching configuration indicated in the first DCI message; and

receive the second portion based at least in part on a second QCL information and a second rate matching configuration indicated in the second DCI message.

45. The apparatus of claim 44, wherein:

a first data stream associated with the first portion of the TB associated with the CW is mapped to a first one or more DMRS port of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS port, then a frequency resource allocation of the first one or more DMRS port, and then a time resource allocation of the first one or more DMRS port; and

a second data stream associated with the second portion of the TB associated with the CW is mapped to a second one or more DMRS port of the second DMRS port configuration according to an order comprising a second layer of the second one or more DMRS port, then a frequency resource allocation of the second one or more DMRS port, and then a time resource allocation of the second one or more DMRS port.

46. The apparatus of claim 44, wherein the instructions are further executable by the processor to cause the apparatus to:

aggregate, based at least in part on an index of each DMRS port of the first DMRS configuration and the second DMRS configuration, a first one or more DMRS ports of the first DMRS configuration and a second one or more DMRS ports of the second DMRS configuration to form an aggregated DMRS port;

aggregate, based at least in part on an index of each resource element associated with the frequency resource allocation and time resource allocation configured in the first DCI and the second DCI, the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message to form an aggregated frequency resource allocation and an aggregated time resource allocation; and

map a data stream of the TB associated with the CW according to the order comprising one or more layers associated with the aggregated DMRS port, then the aggregated frequency resource allocation associated with the aggregated DMRS port, and then the aggregated time resource allocation associated with the aggregated DMRS port.

47. The apparatus of claim 44, wherein the instructions are further executable by the processor to cause the apparatus to:

determine that both the first DCI message and the second DCI message are decoded; and

transmit a signal indicating a decoding result of the TB following a hybrid automatic repeat/request (HARQ) timing parameter indicated in the second DCI message.

48. The apparatus of claim 44, wherein the instructions are further executable by the processor to cause the apparatus to:

receive a third DCI message comprising a third CW configuration;

identify that a third TB information field in the third DCI message indicates a third parameters for a third TB wherein an index of the third TB information field in the third DCI message is the same as the index of the first TB information field in the first DCI message and is the same as the index of the second TB information field in the second DCI message;

determine that the third TB is the same as the TB indicated by the first TB information field in the first DCI and the TB indicated by the second TB information field in the second DCI;

identify a modulation and coding scheme (MCS) parameter for the third TB being set to a second reserved value;

the instructions to determine the transmission scheme are further executable by the processor to cause the apparatus to receive a third portion of the same TB using a third DMRS port configuration and resource allocation configured in the third DCI message; and

receive the third portion based at least in part on the first QCL information and the first rate matching configuration indicated in the first DCI message.

49. The apparatus of claim 48, wherein the instructions are further executable by the processor to cause the apparatus to:

determine that the first DCI message, the second DCI message and the third DCI message are decoded;

determine that the second reserved value indicated in the third CW configuration is greater than the first reserved value indicated in the second CW configuration; and

transmit, based at least in part on the second reserved value being greater than the first reserved value, a signal indicating a decoding result of the TB following a hybrid automatic repeat/request (HARQ) timing parameter indicated in the third DCI message.

50. The apparatus of claim 41, wherein:

determine the first TB associated with the first CW is same as the second TB associated with the second CW further comprises;

identify a modulation and coding scheme (MCS) parameter of the TB configured in the first DCI message being set to a value not equal to a reserved value, and the

MCS of the TB configured in the second DCI message being set to a value not equal to a reserved value;

the instructions to determine that the transmission scheme are executable by the processor to cause the apparatus to receive a first version of the TB using one or more DMRS ports and resource allocation configured in the first DCI message and receiving a second version of the TB using one or more DMRS ports and resource allocation configured in the second DCI message;

receive the first version based at least in part on a first quasi-co-located (QCL) information and a first rate matching configuration indicated in the first DCI message; and

receive the second version based at least in part on a second QCL information and a second rate matching configuration indicated in the second DCI message.

51. The apparatus of claim 50, wherein:

a first data stream associated with the first version of the TB associated with the CW is mapped to a first one or more DMRS port of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS port, then a frequency resource allocation of the first one or more DMRS port, and then a time resource allocation of the first one or more DMRS port; and

a second data stream associated with the second version of the TB associated with the CW is mapped to a second one or more DMRS port of the second DMRS port configuration according to an order comprising a second layer of the second one or more DMRS port, then a frequency resource allocation of the second one or more DMRS port, and then a time resource allocation of the second one or more DMRS port.

52. The apparatus of claim 50, wherein the transmit scheme comprises a transmit diversity scheme.

53. The apparatus of claim 52, wherein the instructions are further executable by the processor to cause the apparatus to:

identify a frequency resource allocation and time resource allocation configured in the first DCI message as being the same as the frequency resource allocation and time resource allocation configured in the second DCI message; and

determine that the transmit diversity scheme comprises spatial frequency block coding, wherein the first version of the TB and the second version of the TB have the same redundancy version (RV), but the mapping between the first version and the first one or more DMRS ports follows a different mapping rule from the mapping between the second version and the second one or more DMRS ports.

54. The apparatus of claim 38, wherein the instructions are further executable by the processor to cause the apparatus to:

receive a signal indicating a set of supported transmission schemes; and

determine the transmission scheme from the set of supported transmission schemes based at least in part on the first CW configuration and the second CW configuration.

55. The apparatus of claim 38, wherein the instructions are further executable by the processor to cause the apparatus to:

identify that a resource allocation configured in the first DCI message is the same as the resource allocation configured in the second DCI message; and

determine that the DMRS ports configured in the first DCI message are different from the DMRS ports configured in the second DCI message.

56. The apparatus of claim 38, wherein the instructions are further executable by the processor to cause the apparatus to:

identify that the DMRS ports configured in the first DCI message and the DMRS ports configured in the second DCI message share one or more common DMRS ports;

apply at least one of a first quasi-co-located (QCL) information, a first rate matching configuration, or a combination thereof, to the common DMRS ports using the resource allocation configured in the first DCI message; and

apply at least one of a second QCL information, a second rate matching configuration, or a combination thereof, to the common DMRS ports using the resource allocation configured in the second DCI message.

57. An apparatus for wireless communication at a base station, comprising:

a processor,

memory in electronic communication with the processor; and

instructions stored in the memory and executable by the processor to cause the apparatus to:

determine a transmission scheme to use for downlink transmissions, wherein the transmission scheme comprises an association between one or more codewords (CWs) to be communicated in the downlink transmissions and one or more demodulation reference signal (DMRS) ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration;

transmit, to the user equipment (UE), a first downlink control information (DCI) message comprising a first CW configuration and a first DMRS port configuration and a second DCI message comprising a second CW configuration and a second DMRS port configuration; and

transmit, according to the transmission scheme, the downlink transmissions.

58. The apparatus of claim 57, wherein each of the first DCI message and the second DCI message further comprises an indication of at least one of a quasi-co-located (QCL) information, a rate matching configuration, a hybrid automatic repeat/request (HARQ) process number, a HARQ timing parameter, a downlink assignment index, a frequency resource allocation, a time resource allocation, or a combination thereof, associated with the one or more DMRS ports of the corresponding DMRS port configuration.

59. The apparatus of claim 57, wherein each of the first and second CW configurations comprise one or more transport block (TB) information fields, wherein each TB information field indicates parameters comprising at least one of a modulation and coding scheme (MCS), a new data indicator (NDI) and a redundancy version (RV) of a particular TB of a CW and the number of TB information fields is based at least in part on a maximum number of CWs or TBs in a downlink transmission, wherein the maximum number of CWs or TBs in the downlink transmission is configured via higher layer signaling.

60. The apparatus of claim 57, wherein the instructions to determine the transmission scheme further are executable by the processor to cause the apparatus to:

determine that a first transport block (TB) associated with a first CW is transmitted using one or more DMRS ports of the first DMRS configuration, and a second TB associated with a second CW is transmitted using one or more DMRS ports of the second DMRS configuration;

determine that the first TB associated with the first CW is the different from the second TB associated with the second CW;

transmit, in a first TB information field in the first DCI message, an indication of one or more parameters for the first TB associated with the first CW; and

transmit, in a second TB information field in the second DCI message, an indication of one or more parameters for the second TB associated with the second CW, wherein an index of the first TB information field in the first DCI message is different from the index of the second TB information field in the second DCI message.

61. The apparatus of claim 60, wherein the instructions are further executable by the processor to cause the apparatus to:

transmit the first TB associated with the first CW using a first one or more DMRS ports and a first resource allocation indicated in the first DCI message, based at least in part on a first quasi-co-located (QCL) information and a first rate matching configuration indicated in the first DCI message; and

transmit the second TB associated with the second CW using a second one or more DMRS ports and a second resource allocation indicated in the second DCI message, based at least in part on a second QCL information and a second rate matching configuration indicated in the second DCI message.

62. The apparatus of claim 61, wherein:

a first data stream associated with the first TB that is associated with the first CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and

a second data stream associated with the second TB that is associated with the second CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of second one or more DMRS ports, then a frequency resource allocation of second one or more DMRS ports, and then a time resource allocation of second one or more DMRS ports.

63. The apparatus of claim 57, wherein the instructions to determine the transmission scheme further are executable by the processor to cause the apparatus to:

determine a first portion of a transport block (TB) associated with a CW is transmitted using one or more DMRS ports of the first DMRS configuration, and a second portion of the TB associated with the CW is transmitted using one or more DMRS ports of the second DMRS configuration;

transmit, in a first TB information field in the first DCI message, an indication of one or more parameters for the TB associated with the CW; and

transmit, in a second TB information field in the second DCI message, an indication of one or more parameters for the TB associated with the CW, wherein the index of the first TB information field in the first DCI message is the same as the index of the second TB information field in the second DCI message, and a modulation and coding scheme (MCS) parameter provided in the second TB information field is set to a reserved value.

64. The apparatus of claim 63, wherein:

a first data stream associated with the first portion of the TB associated with the CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and

a second data stream associated with the second portion of the TB associated with CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of the second one or more DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

65. The apparatus of claim 63, wherein the instructions are further executable by the processor to cause the apparatus to:

aggregate, based at least in part on an index of each DMRS port of the first DMRS configuration and the second DMRS configuration, a first one or more DMRS ports of the first DMRS configuration and a second one or more DMRS ports of the second DMRS configuration to form an aggregated DMRS port;

aggregate, based at least in part on an index of each resource element associated with the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message, the frequency resource allocation and time resource allocation configured in the first DCI message and the second DCI message to form an aggregated frequency resource allocation and an aggregated time resource allocation; and

map a data stream of the TB associated with the CW according to the order comprising one or more layers associated with the aggregated DMRS port, then the aggregated frequency resource allocation associated with the aggregated DMRS port, and then the aggregated time resource allocation associated with the aggregated DMRS port.

66. The apparatus of claim 63, wherein the instructions are further executable by the processor to cause the apparatus to:

transmit a first hybrid automatic repeat/request (HARQ) timing in the first DCI message;

transmit a second HARQ timing in the second DCI message; and

receive a decoding result of the TB associated with the CW.

67. The apparatus of claim 63, wherein the instructions are further executable by the processor to cause the apparatus to:

determine that a third portion the TB associated with the CW is transmitted using a third one or more DMRS ports of a third DMRS configuration;

transmit a third DCI message comprising the third DMRS configuration, a third TB information field in the third DCI message indicating the parameters for the TB, wherein the index of the third TB information field in the third DCI message is the same as the index of the first TB information field in the first DCI and is the same as the index of the second TB information field in the second DCI message, the MCS parameter for the third TB being set to a second reserved value, a third QCL information, and a third rate matching configuration associated with the third DMRS configuration; and

transmit the third portion of the TB associated with the CW based at least in part on the third QCL information and the third rate matching configuration.

68. The apparatus of claim 67, wherein the instructions are further executable by the processor to cause the apparatus to:

transmit a third hybrid automatic repeat/request (HARQ) timing in the third DCI message;

determine that the second reserved value indicated in the third CW configuration is greater than the first reserved value indicated in the second CW configuration; and

receive, based at least in part on the second reserved value being greater than the first reserved value, a signal indicating a decoding result of the TB following a HARQ timing parameter indicated in the third DCI message.

69. The apparatus of claim 57, wherein the instructions to determine the transmission scheme further are executable by the processor to cause the apparatus to:

determine that a first version of a transport block (TB) associated with a CW is transmitted using one or more DMRS ports of the first DMRS configuration, and a second version of the TB associated with the CW is transmitted using one or more DMRS ports of the second DMRS configuration;

transmit, in a first TB information field in the first DCI message, an indication of one or more parameters for the TB associated with the CW;

transmit, in a second TB information field in the second DCI message, an indication of one or more parameters for the TB associated with the CW, wherein;

the index of the first TB information field in the first DCI message is the same as the index of the second TB information field in the second DCI message; and

a modulation and coding scheme (MCS) parameter provided in the first TB information field is not set to a reserved value, and the MCS parameter provided in the second TB information field is not set to a reserved value.

70. The apparatus of claim 69, wherein:

a first data stream associated with the first version of the TB associated with the CW is mapped to a first one or more DMRS ports of the first DMRS port configuration according to an order comprising a first layer of the first one or more DMRS ports, then a frequency resource allocation of the first one or more DMRS ports, and then a time resource allocation of the first one or more DMRS ports; and

a second data stream associated with the second version of the TB associated with the CW is mapped to a second one or more DMRS ports of the second DMRS port configuration according to an order comprising a second layer of the second one or more

DMRS ports, then a frequency resource allocation of the second one or more DMRS ports, and then a time resource allocation of the second one or more DMRS ports.

71. The apparatus of claim 69, wherein the transmit scheme comprises a transmit diversity scheme.

72. The apparatus of claim 71, wherein the instructions are further executable by the processor to cause the apparatus to:

identify a frequency resource allocation and time resource allocation configured in the first DCI message as being the same as the frequency resource allocation and time resource allocation configured in the second DCI message; and

determine that the transmit diversity scheme is spatial frequency block coding, wherein the first version of the TB and the second version of the TB have a same redundancy version (RV), but the mapping between the first version and the first one or more DMRS ports follows a different mapping rule from the mapping from the second version and the second one or more DMRS ports.

73. The apparatus of claim 57, wherein the instructions are further executable by the processor to cause the apparatus to:

transmit a signal indicating a set of supported transmission schemes; and

determine the transmission scheme from the set of supported transmission schemes based at least in part on the first CW configuration and the second CW configuration.

74. The apparatus of claim 57, wherein the instructions are further executable by the processor to cause the apparatus to:

identify that a resource allocation configured in the first DCI message is the same as the resource allocation configured in the second DCI message; and

transmit different DMRS ports configuration in the first DCI message than the DMRS ports configuration in the second DCI message.

75. An apparatus for wireless communication at a user equipment (UE), comprising:

means for receiving a first downlink control information (DCI) message comprising a first codeword (CW) configuration and a first demodulation reference signal (DMRS) port configuration;

means for receiving a second DCI message comprising a second CW configuration and a second DMRS port configuration;

means for determining, based at least in part on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, wherein the transmission scheme comprises an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration; and

means for receiving, according to the transmission scheme, the downlink transmissions.

76. An apparatus for wireless communication at a base station, comprising:

means for determining a transmission scheme to use for downlink transmissions, wherein the transmission scheme comprises an association between one or more codewords (CWs) to be communicated in the downlink transmissions and one or more demodulation reference signal (DMRS) ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration;

means for transmitting, to the user equipment (UE), a first downlink control information (DCI) message comprising a first CW configuration and a first DMRS port configuration and a second DCI message comprising a second CW configuration and a second DMRS port configuration; and

means for transmitting, according to the transmission scheme, the downlink transmissions.

77. A non-transitory computer-readable medium storing code for wireless communication at a user equipment (UE), the code comprising instructions executable by a processor to:

receive a first downlink control information (DCI) message comprising a first codeword (CW) configuration and a first demodulation reference signal (DMRS) port configuration;

receive a second DCI message comprising a second CW configuration and a second DMRS port configuration;

determine, based at least in part on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, wherein the transmission scheme comprises an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration; and

receive, according to the transmission scheme, the downlink transmissions.

78. A non-transitory computer-readable medium storing code for wireless communication at a base station, the code comprising instructions executable by a processor to:

determine a transmission scheme to use for downlink transmissions, wherein the transmission scheme comprises an association between one or more codewords (CWs) to be communicated in the downlink transmissions and one or more demodulation reference signal (DMRS) ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration;

transmit, to the user equipment (UE), a first downlink control information (DCI) message comprising a first CW configuration and a first DMRS port configuration and a second DCI message comprising a second CW configuration and a second DMRS port configuration; and

transmit, according to the transmission scheme, the downlink transmissions.

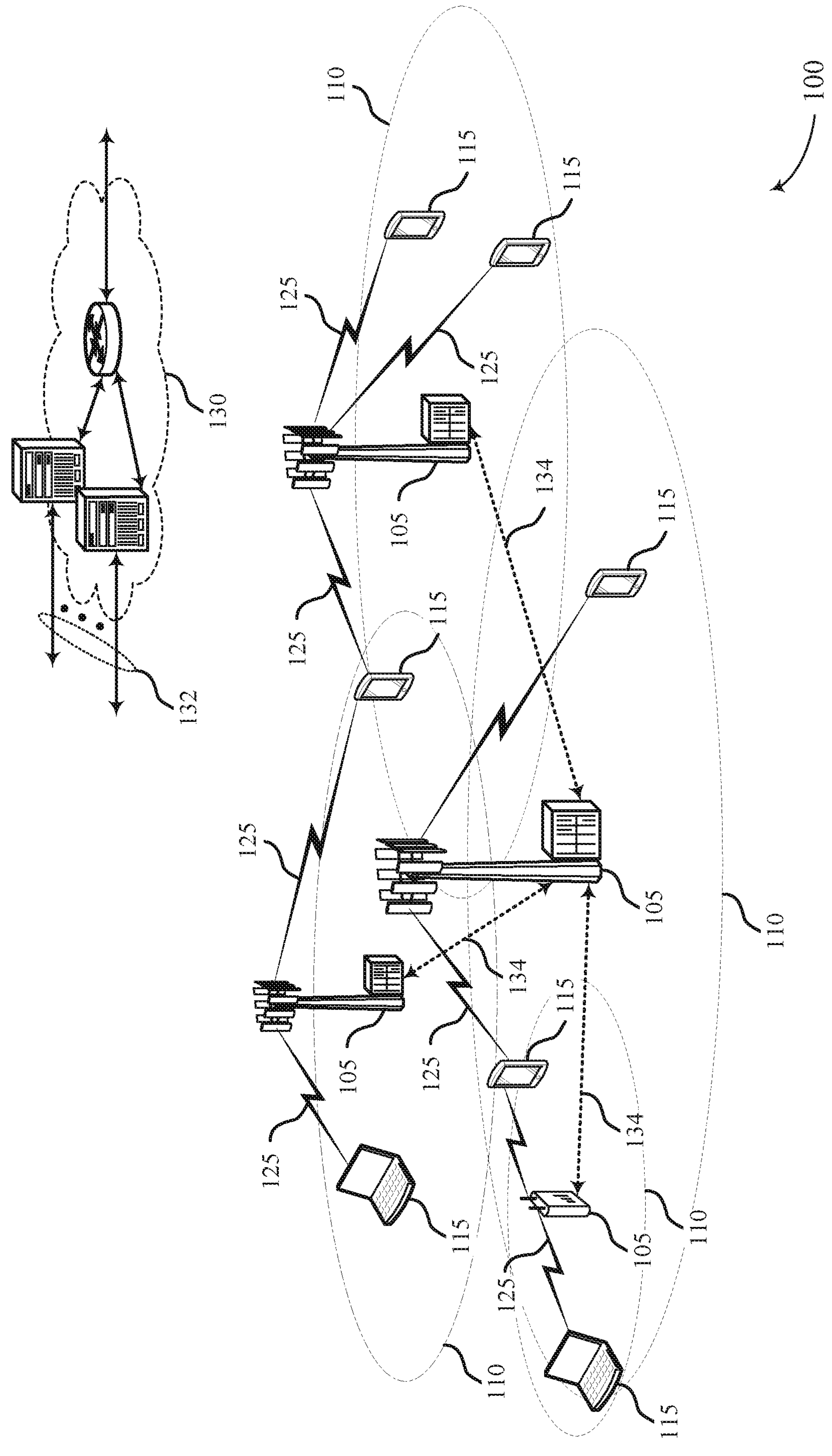

FIG. 1

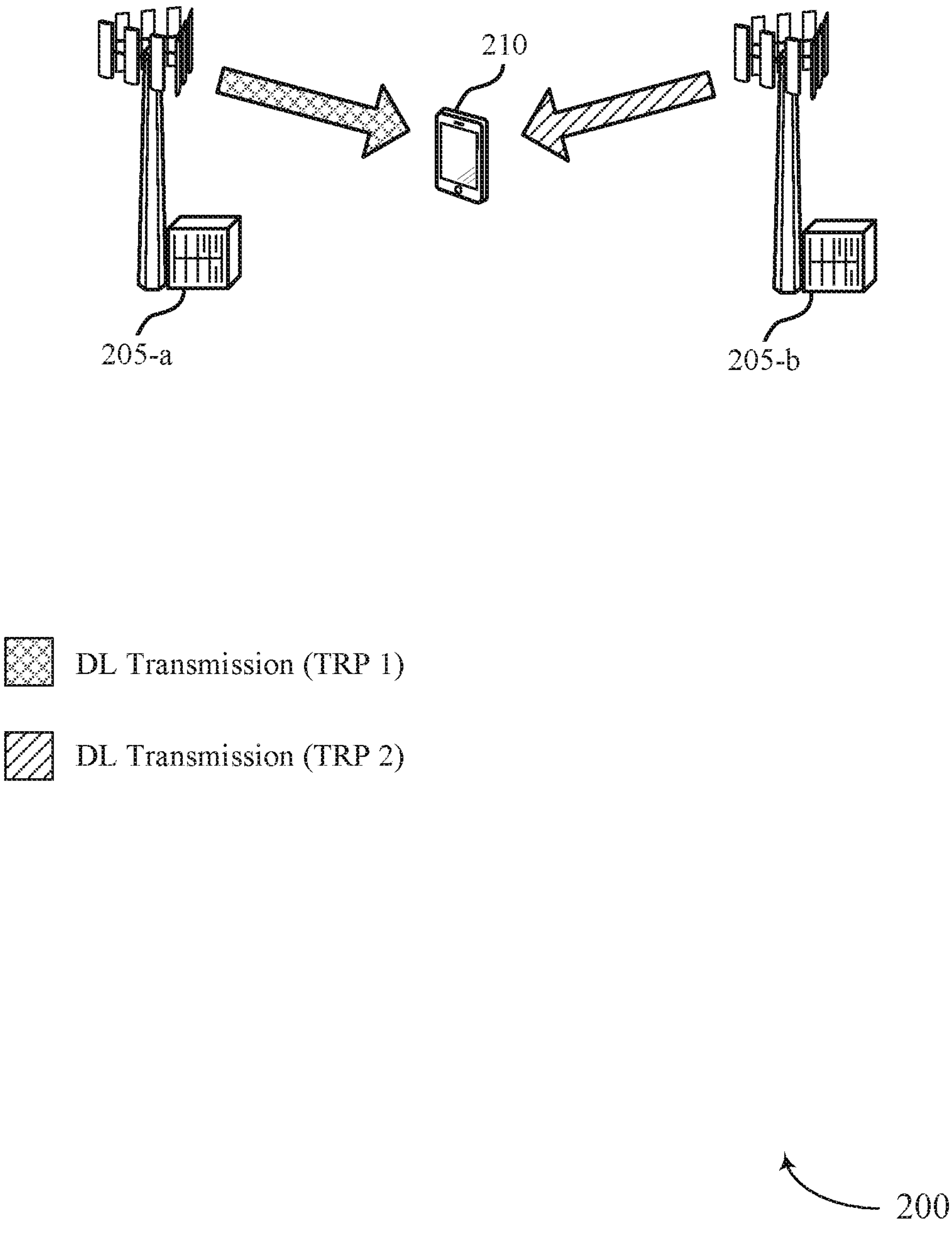
210
205-a
205-b
DL Transmission (TRP 1)
DL Transmission (TRP 2)
200

FIG. 2

DCI Bit(s)/Field	Contents
CW1 Information 305	MCS, NDI, RV, etc., for CW1
CW2 Information 310	MCS, NDI, RV, etc., for CW2
Resource Allocation 315	Time and/or Frequency Resource Allocation
QCL (TCI) Information 320	QCL Information for DL Transmission
Rate Matching Configuration 325	Rate Matching Information for DL Transmission
HARQ Process Number 330	An identifier for each HARQ process
HARQ Timing 335	A timing parameter for each HARQ process
DL Assignment Index 340	An Index identifying all of the downlink data communicated during the downlink transmission that has been bundled into one HARQ ACK/NACK feedback transmission

300

FIG. 3

	DCI 1 405	DCI 2 410
Case 1	CW1: MCS1, NDI1, RV1 CW2: N/A	CW1: N/A CW2: MCS2, NDI2, RV2
Case 2	CW1: MCS1, NDI1, RV1	CW1: MCS=”reserved,” NDI1, RV1
Case 2.1	CW1: MCS1, NDI1, RV1 CW2: N/A	CW1: MCS=”reserved,” NDI1, RV1 CW2: N/A
Case 2.2	CW1: MCS1, NDI1, RV1 CW2: N/A	CW1: MCS=”reserved,” NDI1, RV1 CW2: MCS2, NDI2, RV2
Case 2.3	CW1: MCS1, NDI1, RV1 CW2: MCS2, NDI2, RV2	CW1: N/A CW2: MCS2=”reserved”, NDI2, RV2
Case 3	CW1: MCS1, NDI1, RV1	CW1: MCS1, NDI1, RV1(or2)
Case 3.1	CW1: MCS1, NDI1, RV1 CW2: N/A	CW1: MCS1, NDI1, RV1 CW2: N/A

400

FIG. 4

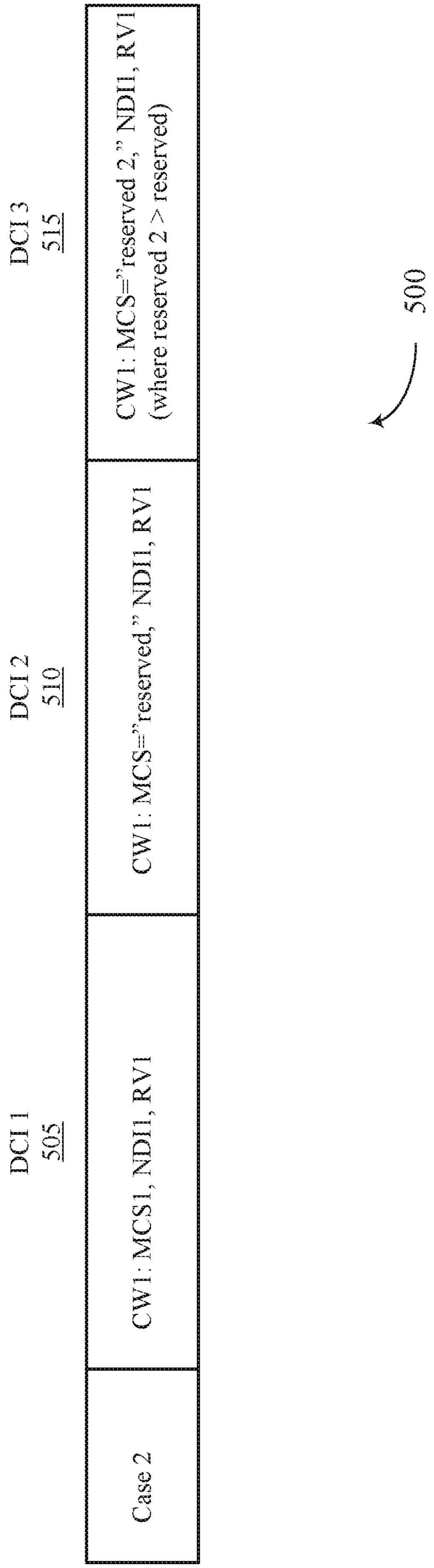
Case 2
DCI 1
505
CW1: MCS1, NDI1, RV1
DCI 2
510
CW1: MCS="reserved," NDI1, RV1
DCI 3
515
CW1: MCS="reserved 2," NDI1, RV1
(where reserved 2 > reserved)
500

FIG. 5

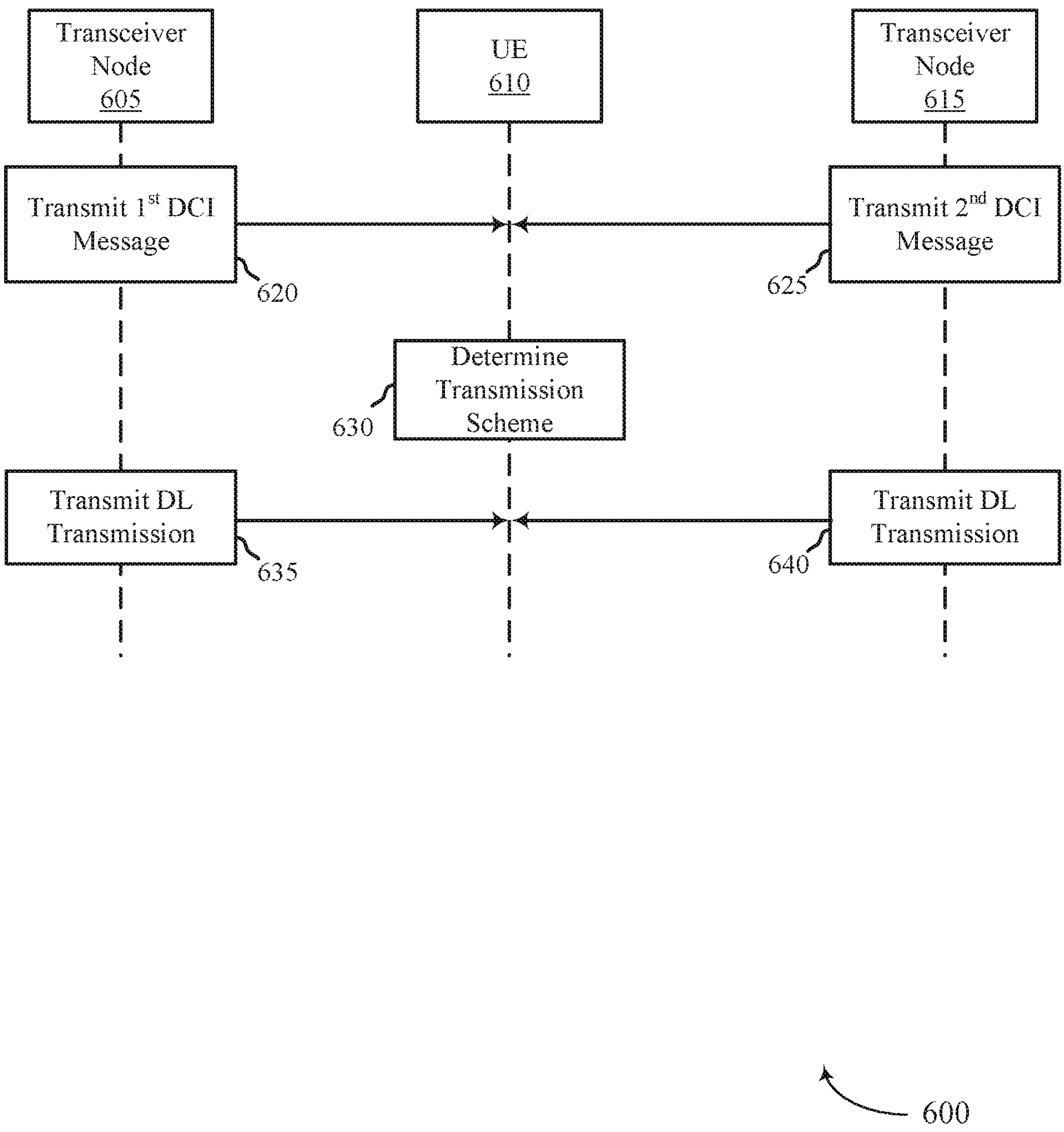
Transceiver Node 605
UE 610
Transceiver Node 615
Transmit 1st DCI Message
620
Transmit 2nd DCI Message
625
Determine Transmission Scheme
630
Transmit DL Transmission
635
Transmit DL Transmission
640
600

FIG. 6

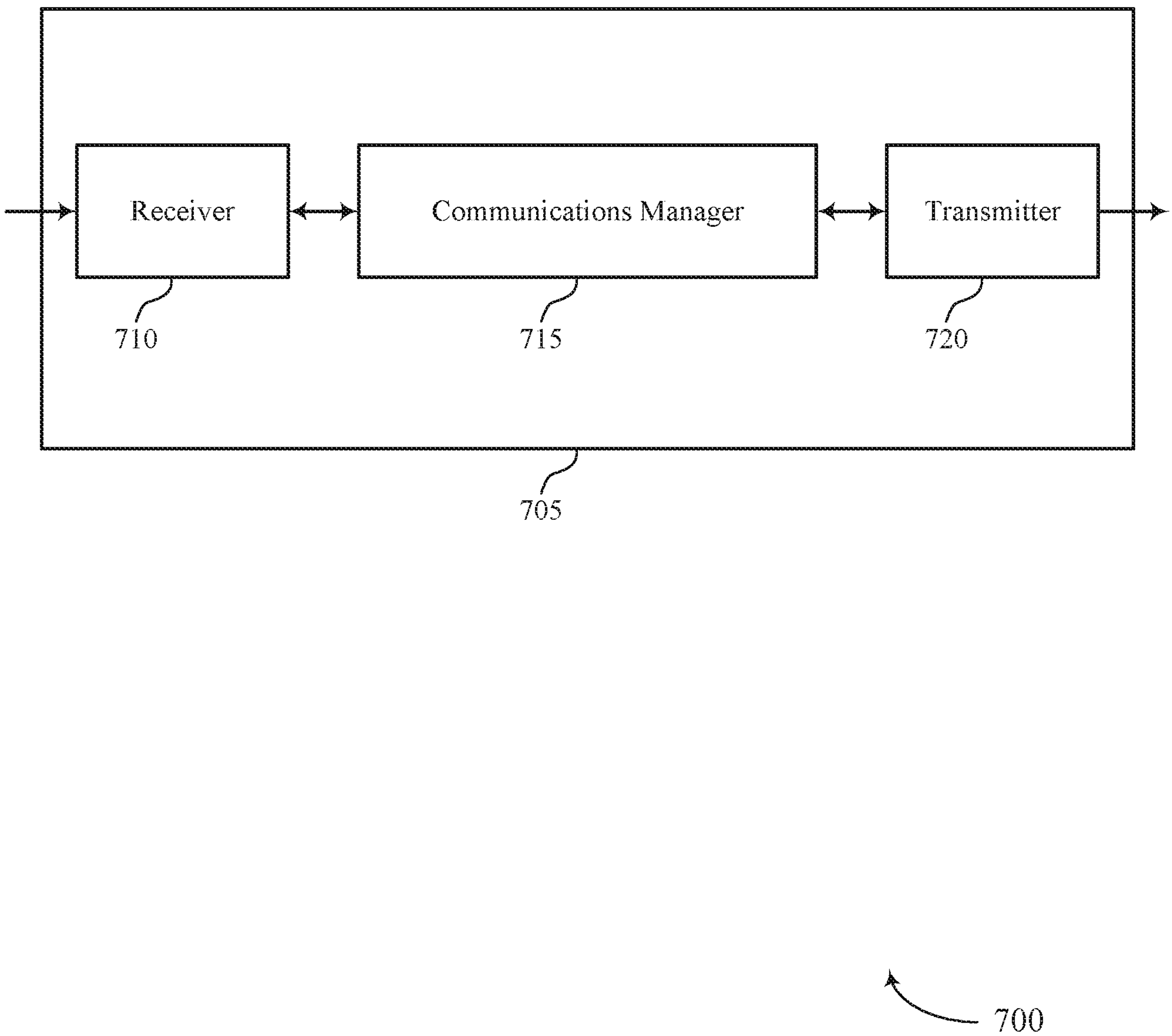
Receiver
Communications Manager
Transmitter
710
715
720
705
700

FIG. 7

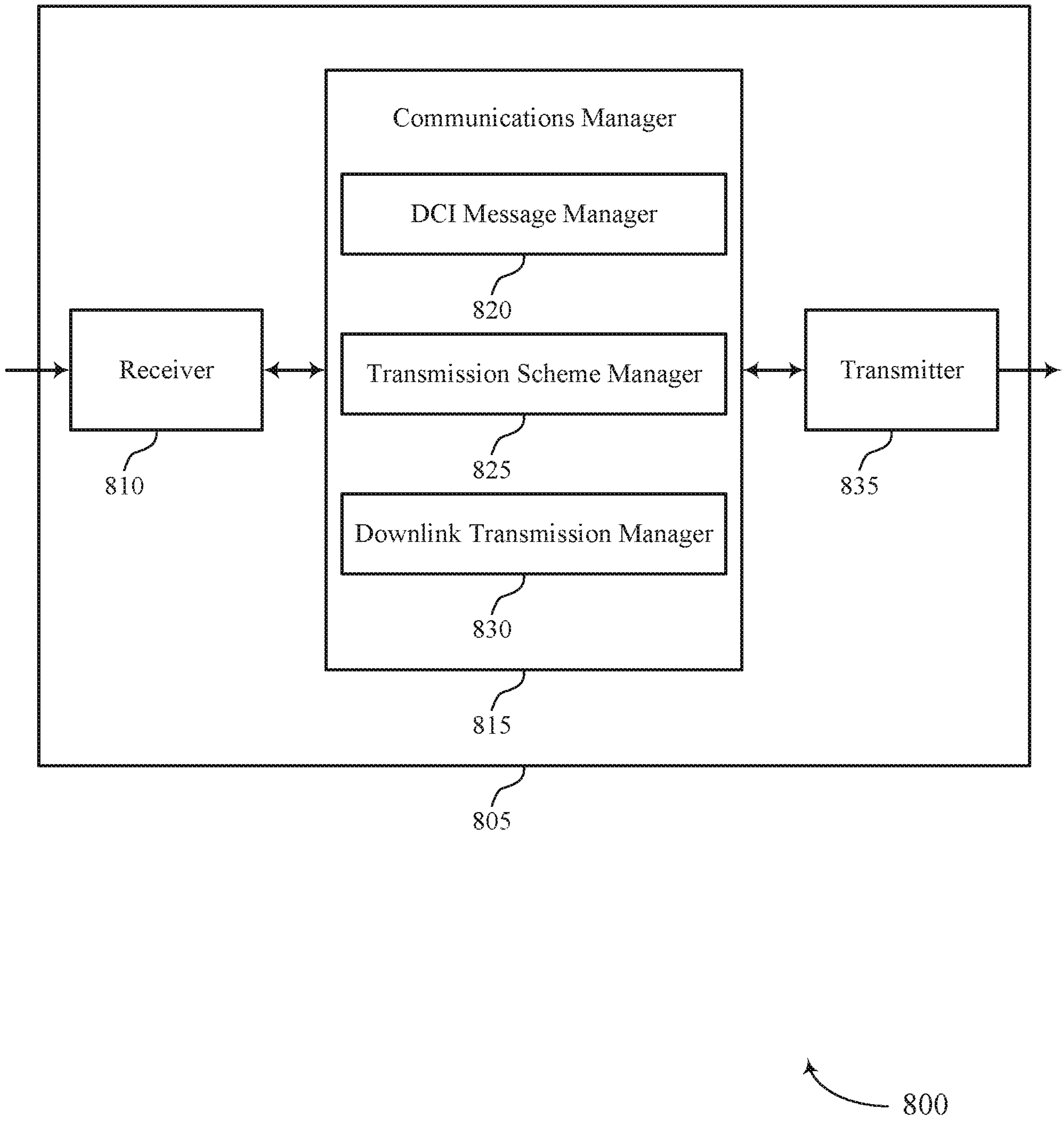
Communications Manager
DCI Message Manager
820
Receiver
Transmission Scheme Manager
Transmitter
810
825
835
Downlink Transmission Manager
830
815
805
800

FIG. 8

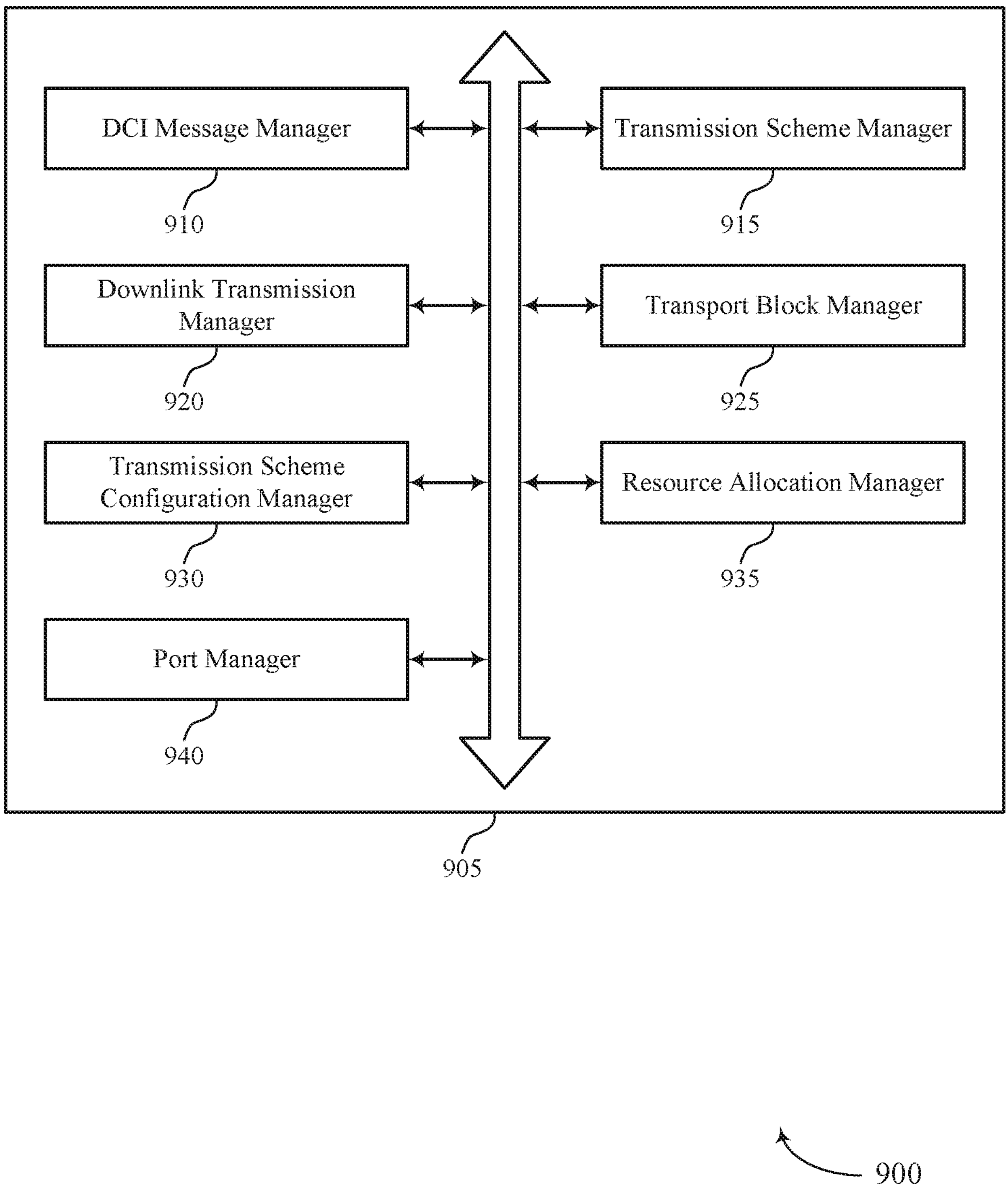
DCI Message Manager
Transmission Scheme Manager
910
915
Downlink Transmission Manager
Transport Block Manager
920
925
Transmission Scheme Configuration Manager
Resource Allocation Manager
930
935
Port Manager
940
905
900

FIG. 9

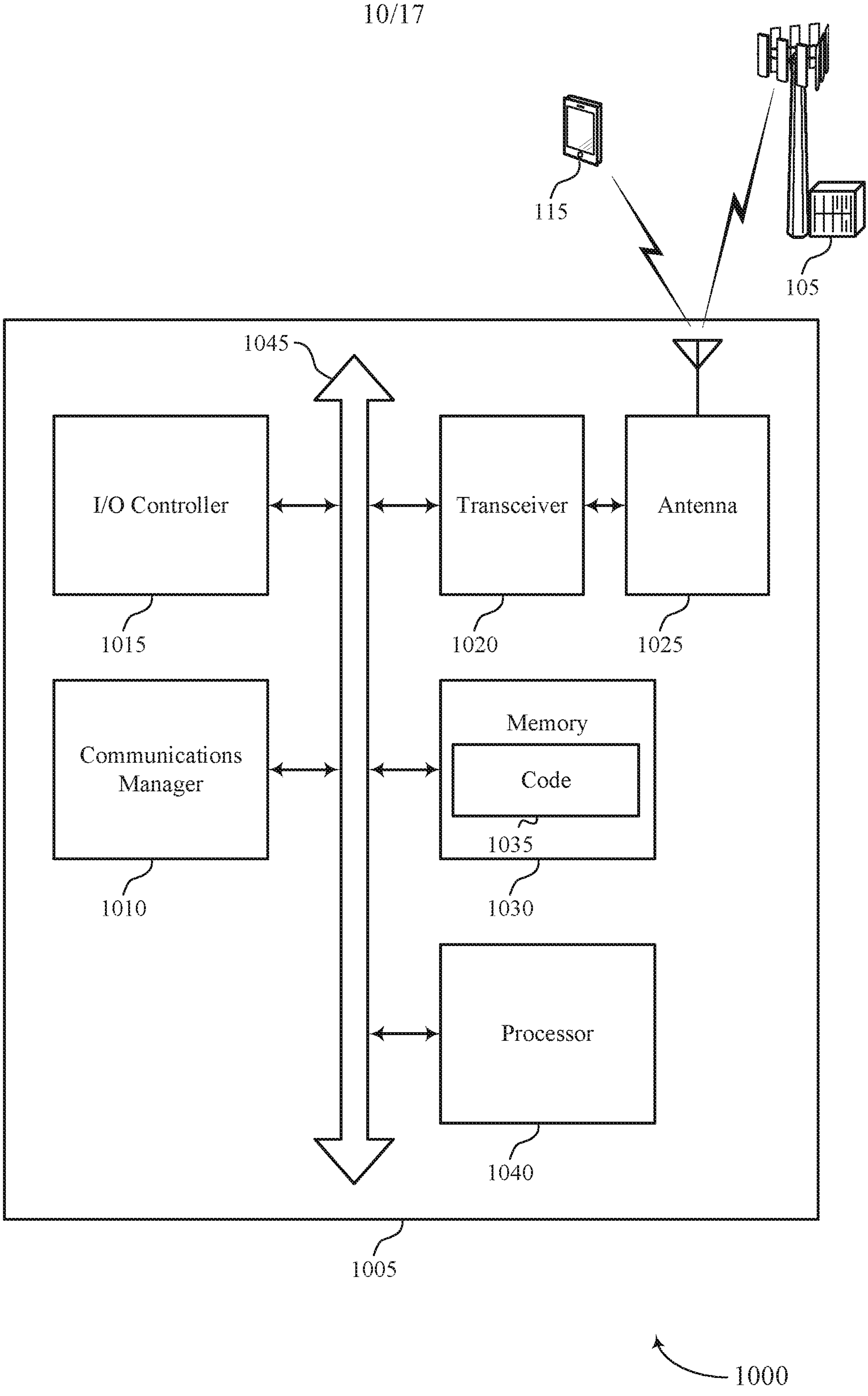
115
105
1045
I/O Controller
Transceiver
Antenna
1015
1020
1025
Communications Manager
Memory
Code
1035
1010
1030
Processor
1040
1005
1000

FIG. 10

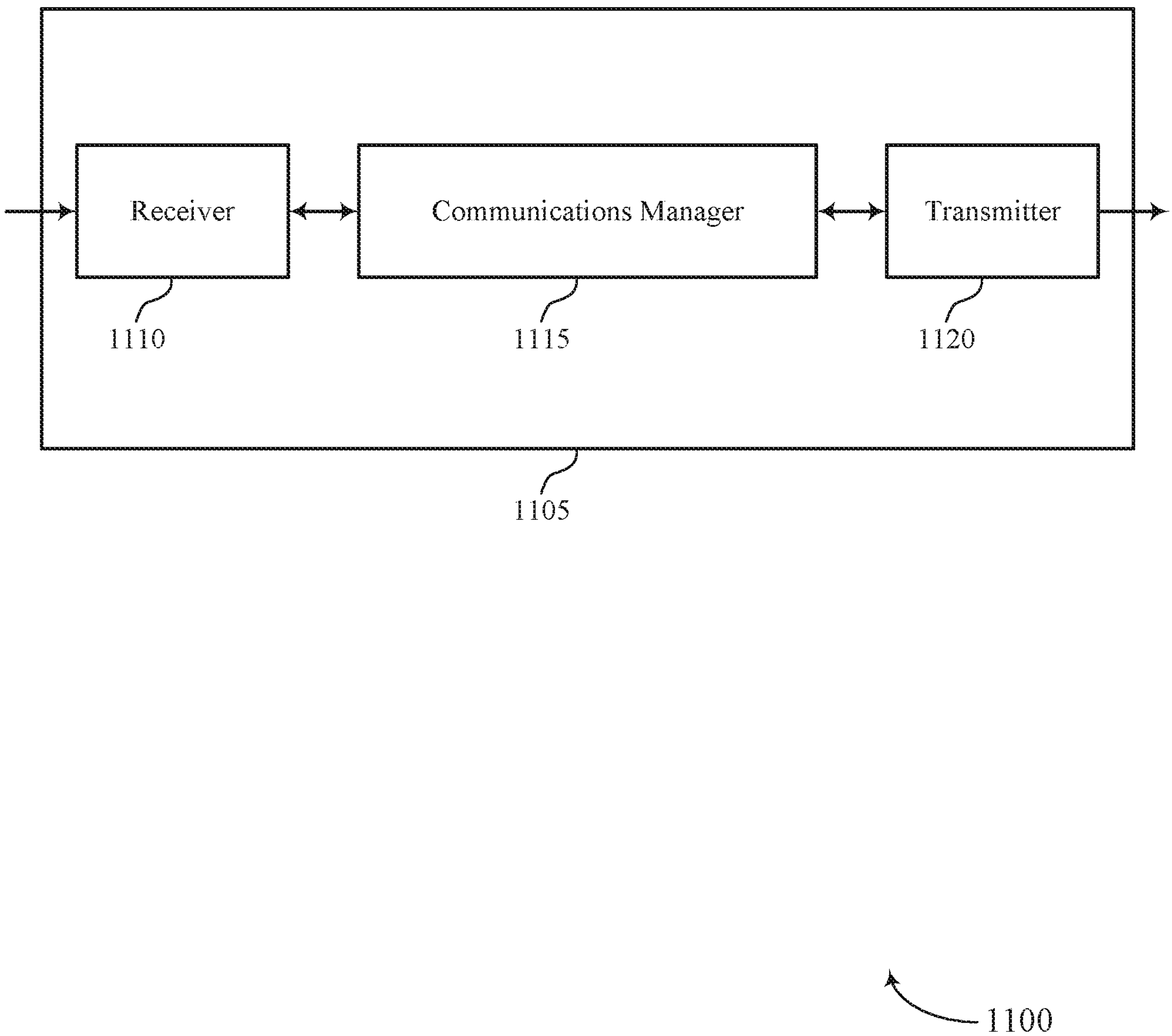
Receiver
Communications Manager
Transmitter
1110
1115
1120
1105
1100

FIG. 11

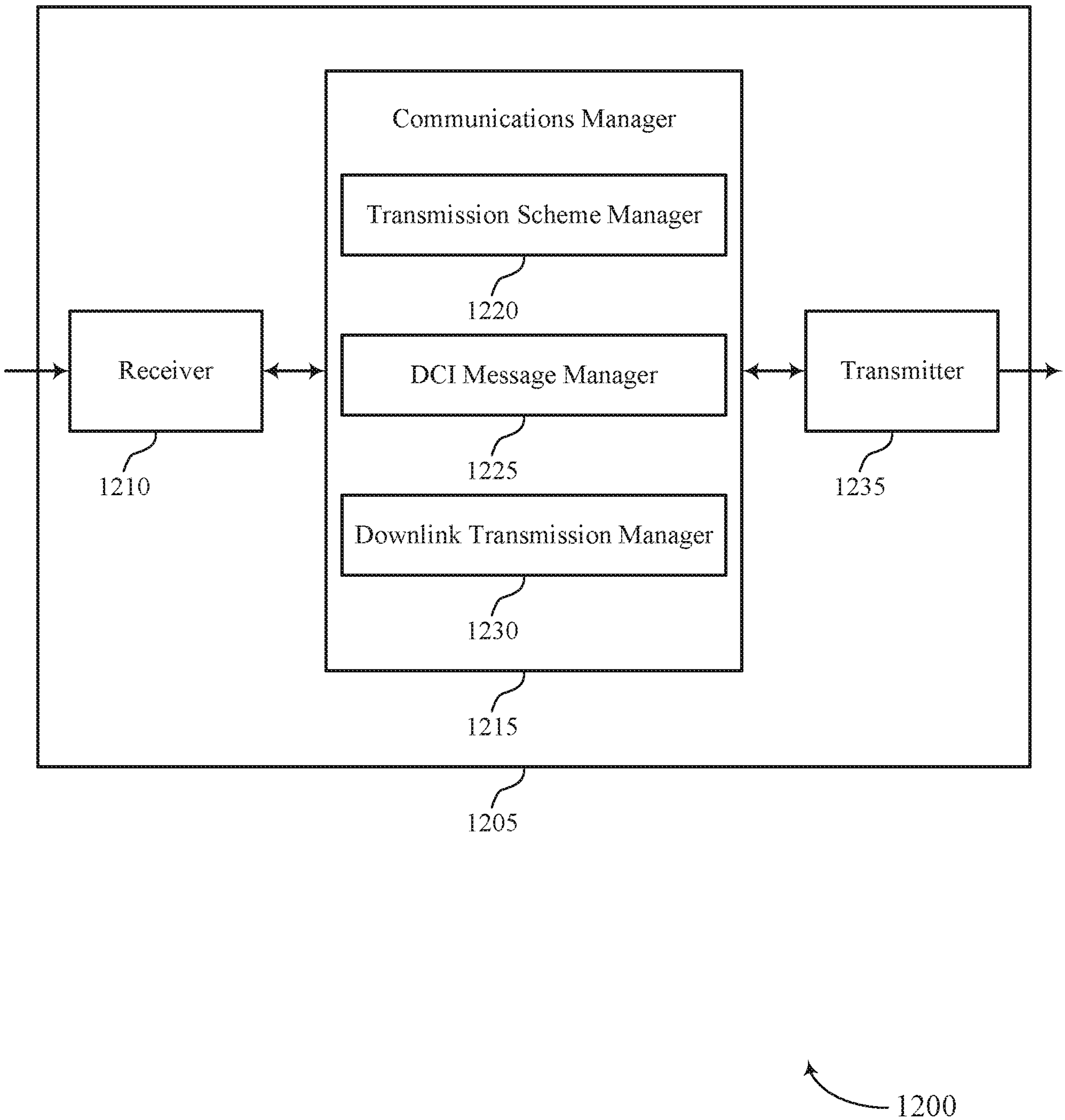
Communications Manager
Transmission Scheme Manager
1220
Receiver
DCI Message Manager
Transmitter
1225
1210
1235
Downlink Transmission Manager
1230
1215
1205
1200

FIG. 12

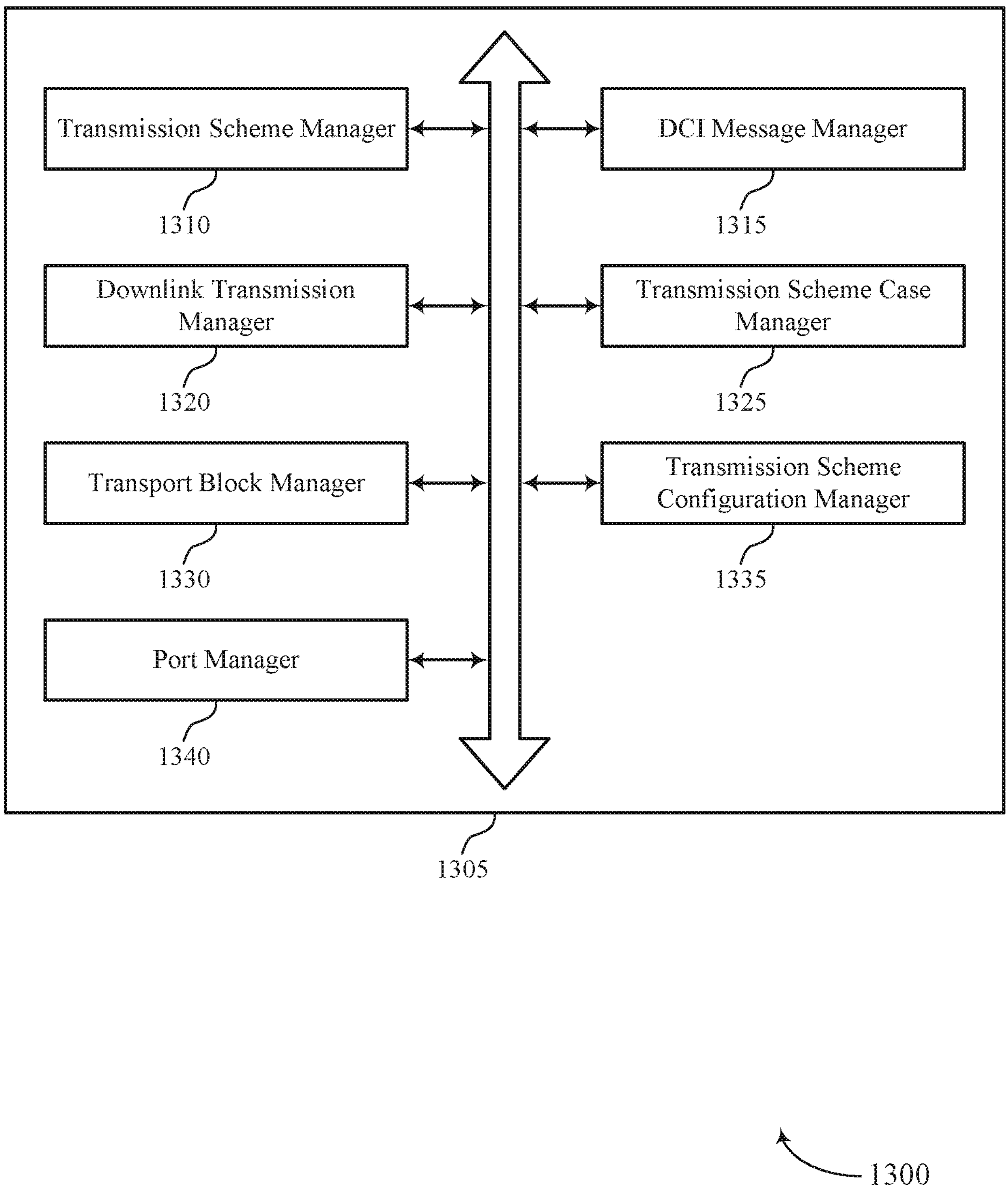
Transmission Scheme Manager
1310
DCI Message Manager
1315
Downlink Transmission Manager
1320
Transmission Scheme Case Manager
1325
Transport Block Manager
1330
Transmission Scheme Configuration Manager
1335
Port Manager
1340
1305
1300

FIG. 13

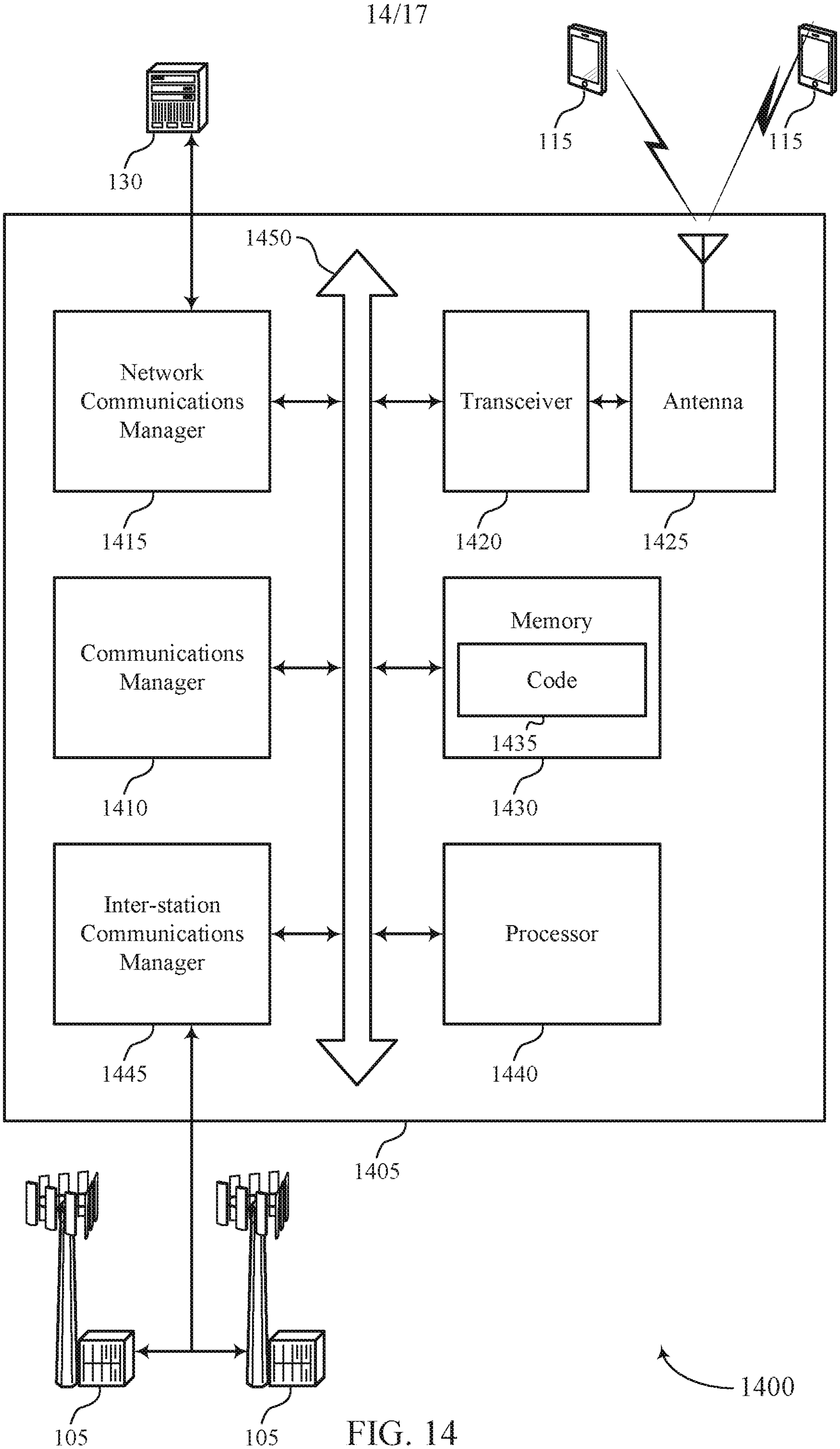
115
115
130
1450
Network Communications Manager
Transceiver
Antenna
1415
1420
1425
Communications Manager
Memory
Code
1435
1410
1430
Inter-station Communications Manager
Processor
1445
1440
1405
105
105
1400

FIG. 14

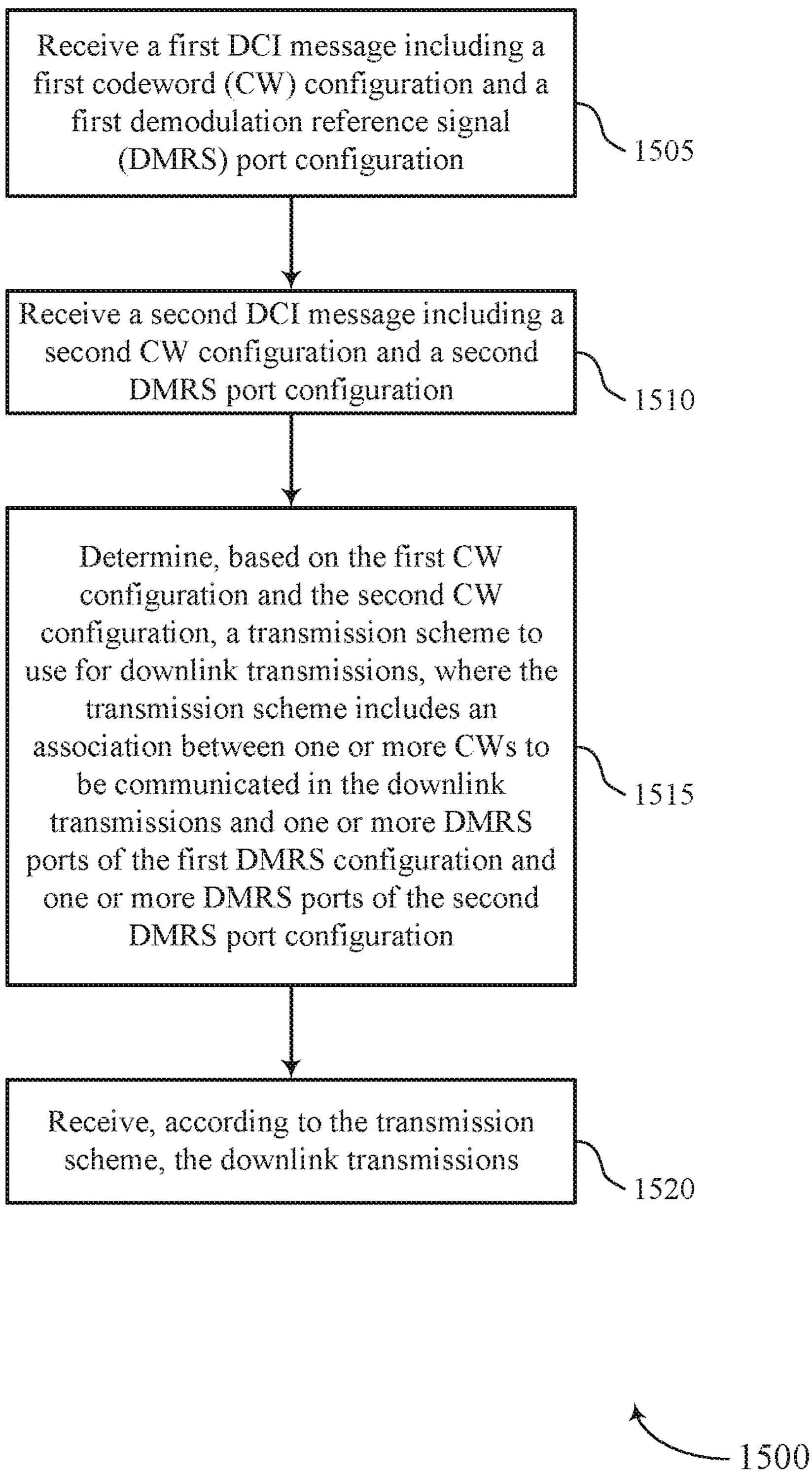
Receive a first DCI message including a first codeword (CW) configuration and a first demodulation reference signal (DMRS) port configuration
1505
Receive a second DCI message including a second CW configuration and a second DMRS port configuration
1510
Determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration
1515
Receive, according to the transmission scheme, the downlink transmissions
1520
1500

FIG. 15

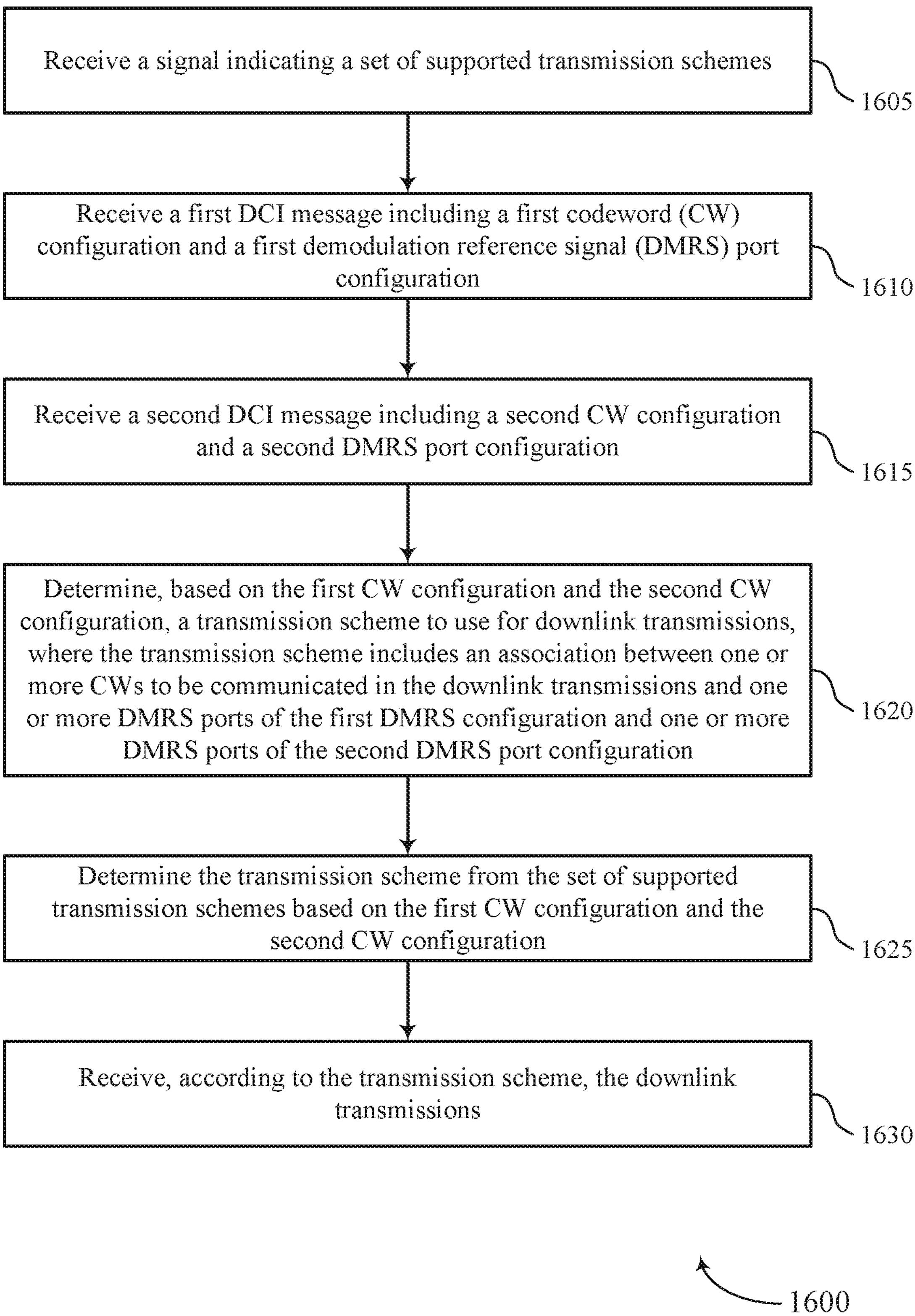
Receive a signal indicating a set of supported transmission schemes
1605
Receive a first DCI message including a first codeword (CW) configuration and a first demodulation reference signal (DMRS) port configuration
1610
Receive a second DCI message including a second CW configuration and a second DMRS port configuration
1615
Determine, based on the first CW configuration and the second CW configuration, a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more CWs to be communicated in the downlink transmissions and one or more DMRS ports of the first DMRS configuration and one or more DMRS ports of the second DMRS port configuration
1620
Determine the transmission scheme from the set of supported transmission schemes based on the first CW configuration and the second CW configuration
1625
Receive, according to the transmission scheme, the downlink transmissions
1630
1600

FIG. 16

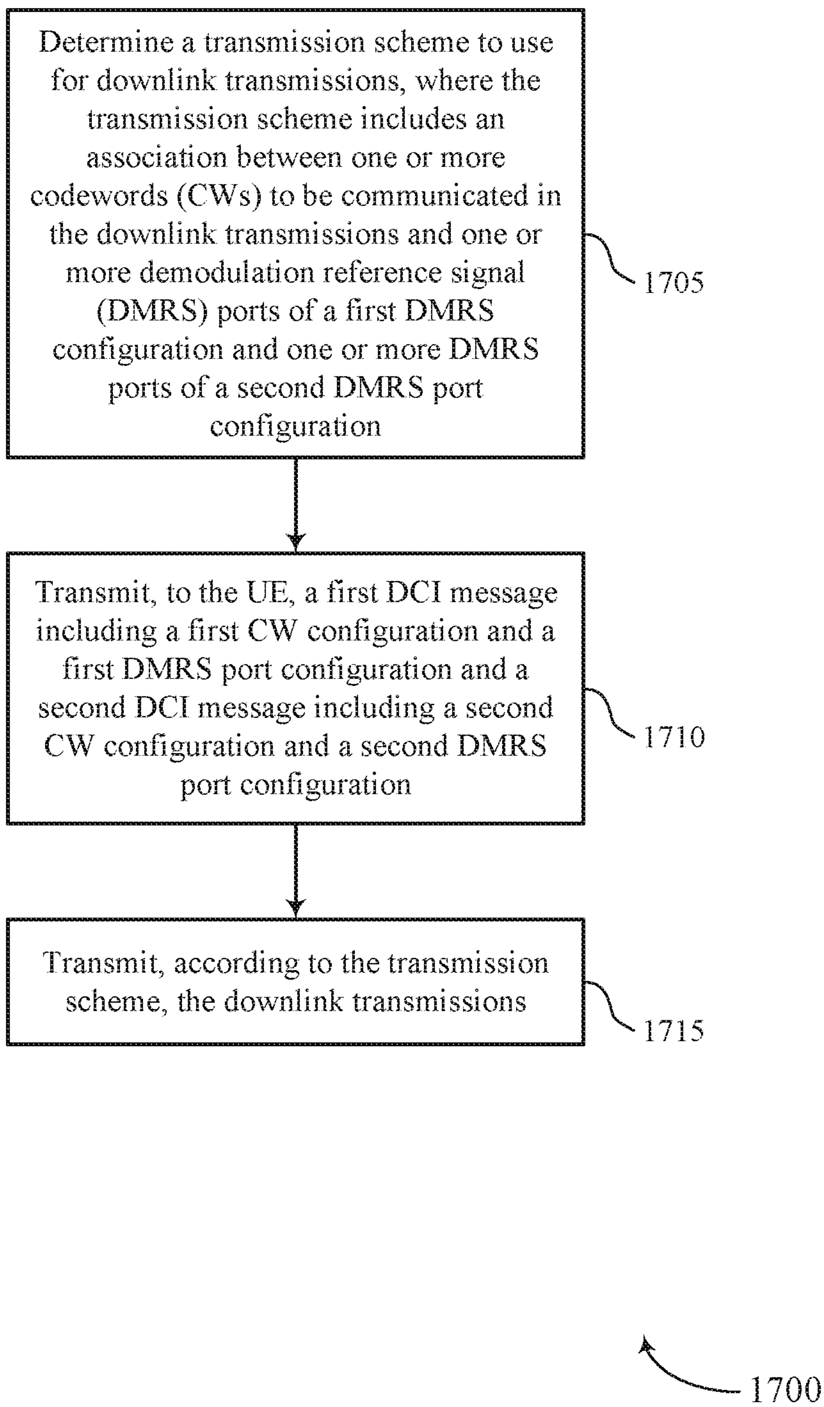
Determine a transmission scheme to use for downlink transmissions, where the transmission scheme includes an association between one or more codewords (CWs) to be communicated in the downlink transmissions and one or more demodulation reference signal (DMRS) ports of a first DMRS configuration and one or more DMRS ports of a second DMRS port configuration
1705
Transmit, to the UE, a first DCI message including a first CW configuration and a first DMRS port configuration and a second DCI message including a second CW configuration and a second DMRS port configuration
1710
Transmit, according to the transmission scheme, the downlink transmissions
1715
1700

FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/103073

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i; H04B 7/04(2017.01)n; H04L 5/00(2006.01)n

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; 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)

CNABS,CNTXT,CNKI,VEN,WOTXT,USTXT,EPTXT,3GPP:DCI, first, primary, second+, slavery, codeword, CW, DMRS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2017095470 A1 (INTEL IP CORP.) 08 June 2017 (2017-06-08) see description, paragraphs [0016], [0059]-[0109], and figures 6-9	1-78
A	CN 106537979 A (HUAWEI TECHNOLOGIES CO., LTD.) 22 March 2017 (2017-03-22) the whole document	1-78
A	CN 107888236 A (HUAWEI TECHNOLOGIES CO., LTD.) 06 April 2018 (2018-04-06) the whole document	1-78
A	CN 108024355 A (HUAWEI TECHNOLOGIES CO., LTD.) 11 May 2018 (2018-05-11) the whole document	1-78
A	CN 105790814 A (CHINA TELECOM. CORP. LTD.) 20 July 2016 (2016-07-20) the whole document	1-78

☐ 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
09 May 2019	**17 May 2019**

Name and mailing address of the ISA/CN	Authorized officer
National Intellectual Property Administration, PRC **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**FU,Qi**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(010)-62089143**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/103073

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2017095470	A1	08 June 2017	TW	201722182	A	16 June 2017
CN	106537979	A	22 March 2017	EP	3158792	A1	26 April 2017
				EP	3158792	A4	26 April 2017
				US	9912504	B2	06 March 2018
				WO	2016015648	A1	04 February 2016
				US	2016037524	A1	04 February 2016
					IN201747003584	A	26 May 2017
					VN52007	A	25 April 2017
CN	107888236	A	06 April 2018	WO	2018059210	A1	05 April 2018
CN	108024355	A	11 May 2018		None		
CN	105790814	A	20 July 2016	CN	105790814	B	25 December 2018