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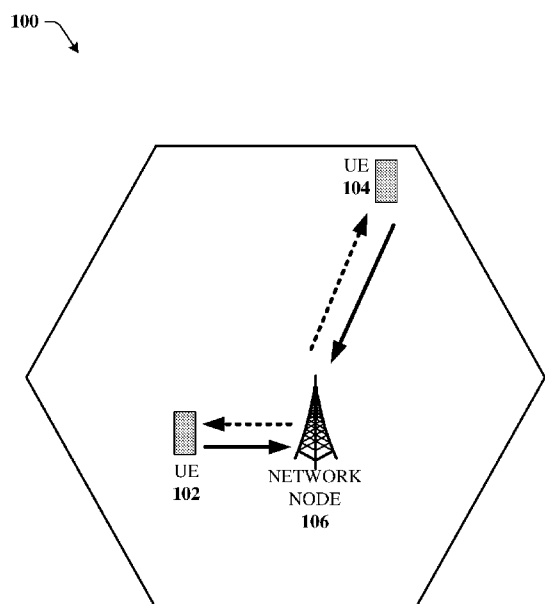


FIG. 1

(57) Abstract: A base station device can transmit data via multiple data channels to a single user equipment device. Each of the multiple data channels can be configured and scheduled via respective downlink control channels to the user equipment device. In an embodiment, the first data channel can be mapped to multiple layers, with a modulation and coding scheme (MCS) assigned based on the average channel quality indicator (CQI) of the layers. One or more of the layers can have a higher CQI however, capable of supporting an additional transmission. The base station device can then facilitate establishing a second data channel to the layer with the higher CQI. The MCS assigned to the second data traffic channel can be based on the CQI of the layer, or based on a difference between the average CQI of the layers and the CQI of the layer.

IMPROVING THE PERFORMANCE OF 5G MIMO

CROSS REFERENCE TO RELATED APPLICATION

[0001] The subject application claims priority to U. S. Non-Provisional Application Serial No. 16/016,085 filed June 22, 2018 entitled, "IMPROVING THE PERFORMANCE OF 5G MIMO" which application is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present application relates generally to the field of mobile communications and more specifically to facilitating multiple channels on one or more layers in a next generation wireless network.

BACKGROUND

[0003] To meet the huge demand for data centric applications, *Third Generation Partnership Project* (3GPP) systems and systems that employ one or more aspects of the specifications of the Fourth Generation (4G) standard for wireless communications will be extended to a Fifth Generation (5G) standard for wireless communications. Unique challenges exist to provide levels of service associated with forthcoming 5G and other next generation network standards.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Non-limiting and non-exhaustive embodiments of the subject disclosure are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various views unless otherwise specified.

[0005] **FIG. 1** illustrates an example wireless communication system in accordance with various aspects and embodiments of the subject disclosure.

[0006] **FIG. 2** illustrates an example message sequence chart for single user super positioning in accordance with various aspects and embodiments of the subject disclosure.

[0007] **FIG. 3** illustrates an example block diagram of a coding structure in accordance with various aspects and embodiments of the subject disclosure.

[0008] FIG. 4 illustrates an example table showing channel and layer mappings in accordance with various aspects and embodiments of the subject disclosure.

[0009] FIG. 5 illustrates an example table showing channel and layer mappings in accordance with various aspects and embodiments of the subject disclosure.

[0010] FIG. 6 illustrates an example block diagram of a base station device in accordance with various aspects and embodiments of the subject disclosure.

[0011] FIG. 7 illustrates an example method for transmitting multiple downlink transmissions on different channels from a base station device to a single user equipment device in accordance with various aspects and embodiments of the subject disclosure.

[0012] FIG. 8 illustrates an example block diagram of an example user equipment that can be a mobile handset in accordance with various aspects and embodiments of the subject disclosure.

[0013] FIG. 9 illustrates an example block diagram of a non-limiting embodiment of a mobile network platform in accordance with various aspects described herein.

[0014] FIG. 10 illustrates an example block diagram of a computer that can be operable to execute processes and methods in accordance with various aspects and embodiments of the subject disclosure.

DETAILED DESCRIPTION

[0015] One or more embodiments are now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the various embodiments. It is evident, however, that the various embodiments can be practiced without these specific details (and without applying to any particular networked environment or standard).

[0016] Various embodiments disclosed herein provide for a base station device that can transmit data via multiple data channels to a single user equipment device. Each of the multiple data channels can be configured and scheduled via respective downlink control channels to the user equipment device. In an embodiment, the downlink control information and data can be processed in the

transmitter via separate coding structures, and then the separate channel data can be combined for transmission to the mobile equipment. In an embodiment, the first data channel can be mapped to multiple layers, with a modulation and coding scheme (MCS) assigned based on the average channel quality indicator (CQI) of the layers. One or more of the layers can have a higher CQI, however, capable of supporting an additional transmission. The base station device can then facilitate establishing a second data channel to the layer with the higher CQI. The MCS assigned to the second data traffic channel can be based on the CQI of the layer, or based on a difference between the average CQI of the layers and the CQI of the layer. In an embodiment, the MCS assigned to the second data channel can have a lower data rate than the MCS assigned to the first data channel.

[0017] In an embodiment, the first data channel can be mapped to each of the layers except for the layer with the highest CQI. The second data channel can then be mapped to the layer with the highest CQI, and a MCS assigned to the second data channel can have a MCS that is the same or with a higher data rate than the MCS assigned to the first data channel.

[0018] In various embodiments, a base station device can comprise a processor and a memory that stores executable instructions that, when executed by the processor facilitate performance of operations. The operations can comprise receiving channel state information from a user equipment device wherein the channel state information comprises a rank indicator that indicates a first group of layers available for a downlink transmission. The operations can also comprise based on the channel state information, determining first downlink control information associated with a first data channel to the user equipment device, wherein the first downlink control information is associated with a second group of layers selected from the first group of layers. The operations can also comprise based on the channel state information, determining second downlink control information associated with a second data channel to the user equipment device, wherein the second downlink control information is associated with a layer of the first group of layers, wherein the layer corresponds to a layer indicator in the channel state information. The operations can also comprise transmitting the first downlink control information via a first downlink control channel and the second downlink control information via a second downlink control channel to the user equipment device.

[0019] In another embodiment, method comprises receiving, by a base station device comprising a processor, channel state information comprising a channel

quality indicator that indicates a channel quality of a channel, and a rank indicator that indicates a group of layers available for a downlink transmission. Based on the channel quality indicator, the method can also comprise determining, by the base station device, first downlink control information to facilitate a first data channel to a user equipment device, wherein the data channel is associated with the group of layers and determining, by the base station device, second downlink control information to facilitate a second data channel to the user equipment device, wherein the second data channel is associated with a layer of the group of layers, wherein the layer corresponds to a layer indicator in the channel state information. The method can also comprise transmitting, by the base station device, the first downlink control information via a first downlink control channel and the second downlink control information via a second downlink control channel to the user equipment device.

[0020] In another embodiment, a machine-readable storage medium can comprise executable instructions that, when executed by a processor of a device, facilitate performance of operations. The operations can include receiving channel state information from a user equipment device, wherein the channel state information comprises a rank indicator that indicates a first group of layers available for a downlink transmission. The operations can comprise determining first downlink control information associated with a first data channel to the user equipment device, wherein the first downlink control information is based on the channel state information and is associated with a second group of layers selected from the first group of layers. The operations can also comprise determining second downlink control information associated with a second data channel to the user equipment device, wherein the second downlink control information is based on the channel state information and is associated with a layer of the first group of layers, wherein the layer corresponds to a layer indicator in the channel state information. The operations can also include transmitting the first downlink control information via a first downlink control channel and the second downlink control information via a second downlink control channel to the user equipment device.

[0021] As used in this disclosure, in some embodiments, the terms “component,” “system” and the like are intended to refer to, or comprise, a computer-related entity or an entity related to an operational apparatus with one or more specific functionalities, wherein the entity can be either hardware, a combination of hardware and software, software, or software in execution. As an example, a component may be, but is not limited to being, a process running on a processor, a processor, an

object, an executable, a thread of execution, computer-executable instructions, a program, and/or a computer. By way of illustration and not limitation, both an application running on a server and the server can be a component.

[0022] One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers. In addition, these components can execute from various computer readable media having various data structures stored thereon. The components may communicate via local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network such as the Internet with other systems via the signal). As another example, a component can be an apparatus with specific functionality provided by mechanical parts operated by electric or electronic circuitry, which is operated by a software application or firmware application executed by a processor, wherein the processor can be internal or external to the apparatus and executes at least a part of the software or firmware application. As yet another example, a component can be an apparatus that provides specific functionality through electronic components without mechanical parts, the electronic components can comprise a processor therein to execute software or firmware that confers at least in part the functionality of the electronic components. While various components have been illustrated as separate components, it will be appreciated that multiple components can be implemented as a single component, or a single component can be implemented as multiple components, without departing from example embodiments.

[0023] Further, the various embodiments can be implemented as a method, apparatus or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware or any combination thereof to control a computer to implement the disclosed subject matter. The term “article of manufacture” as used herein is intended to encompass a computer program accessible from any computer-readable (or machine-readable) device or computer-readable (or machine-readable) storage/communications media. For example, computer readable storage media can comprise, but are not limited to, magnetic storage devices (e.g., hard disk, floppy disk, magnetic strips), optical disks (e.g., compact disk (CD), digital versatile disk (DVD)), smart cards, and flash memory devices (e.g., card, stick, key drive). Of course, those skilled in the art will recognize many modifications can be

made to this configuration without departing from the scope or spirit of the various embodiments.

[0024] Moreover, terms such as “mobile device equipment,” “mobile station,” “mobile,” “subscriber station,” “access terminal,” “terminal,” “handset,” “communication device,” “mobile device” (and/or terms representing similar terminology) can refer to a wireless device utilized by a subscriber or mobile device of a wireless communication service to receive or convey data, control, voice, video, sound, gaming or substantially any data-stream or signaling-stream. The foregoing terms are utilized interchangeably herein and with reference to the related drawings. Likewise, the terms “access point (AP),” “Base Station (BS),” “BS transceiver,” “BS device,” “cell site,” “cell site device,” “gNode B (gNB),” “evolved Node B (eNode B),” “home Node B (HNB)” and the like, are utilized interchangeably in the application, and refer to a wireless network component or appliance that transmits and/or receives data, control, voice, video, sound, gaming or substantially any data-stream or signaling-stream from one or more subscriber stations. Data and signaling streams can be packetized or frame-based flows.

[0025] Furthermore, the terms “device,” “communication device,” “mobile device,” “subscriber,” “customer entity,” “consumer,” “customer entity,” “entity” and the like are employed interchangeably throughout, unless context warrants particular distinctions among the terms. It should be appreciated that such terms can refer to human entities or automated components supported through artificial intelligence (e.g., a capacity to make inference based on complex mathematical formalisms), which can provide simulated vision, sound recognition and so forth.

[0026] Embodiments described herein can be exploited in substantially any wireless communication technology, comprising, but not limited to, wireless fidelity (Wi-Fi), global system for mobile communications (GSM), universal mobile telecommunications system (UMTS), worldwide interoperability for microwave access (WiMAX), enhanced general packet radio service (enhanced GPRS), third generation partnership project (3GPP) long term evolution (LTE), third generation partnership project 2 (3GPP2) ultra mobile broadband (UMB), high speed packet access (HSPA), Z-Wave, Zigbee and other 802.XX wireless technologies and/or legacy telecommunication technologies.

[0027] **FIG. 1** illustrates an example wireless communication system 100 in accordance with various aspects and embodiments of the subject disclosure. In one or more embodiments, system 100 can comprise one or more user equipment UEs 104

and 102, which can have one or more antenna panels having vertical and horizontal elements. A UE 102 can be a mobile device such as a cellular phone, a smartphone, a tablet computer, a wearable device, a virtual reality (VR) device, a heads-up display (HUD) device, a smart car, a machine-type communication (MTC) device, and the like. UE 102 can also refer to any type of wireless device that communicates with a radio network node in a cellular or mobile communication system. Examples of UE 102 are target device, device to device (D2D) UE, machine type UE or UE capable of machine to machine (M2M) communication, PDA, Tablet, mobile terminals, smart phone, laptop embedded equipped (LEE), laptop mounted equipment (LME), USB dongles etc. User equipment UE 102 can also comprise IOT devices that communicate wirelessly. In various embodiments, system 100 is or comprises a wireless communication network serviced by one or more wireless communication network providers. In example embodiments, a UE 102 can be communicatively coupled to the wireless communication network via a network node 106.

[0028] The non-limiting term network node (or radio network node) is used herein to refer to any type of network node serving a UE 102 and UE 104 and/or connected to other network node, network element, or another network node from which the UE 102 or 104 can receive a radio signal. Network nodes can also have multiple antennas for performing various transmission operations (e.g., MIMO operations). A network node can have a cabinet and other protected enclosures, an antenna mast, and actual antennas. Network nodes can serve several cells, also called sectors, depending on the configuration and type of antenna. Examples of network nodes (e.g., network node 106) can comprise but are not limited to: NodeB devices, base station (BS) devices, access point (AP) devices, and radio access network (RAN) devices. The network node 106 can also comprise multi-standard radio (MSR) radio node devices, including but not limited to: an MSR BS, an eNode B, a network controller, a radio network controller (RNC), a base station controller (BSC), a relay, a donor node controlling relay, a base transceiver station (BTS), a transmission point, a transmission node, an RRU, an RRH, nodes in distributed antenna system (DAS), and the like. In 5G terminology, the node 106 can be referred to as a gNodeB device.

[0029] Wireless communication system 100 can employ various cellular technologies and modulation schemes to facilitate wireless radio communications between devices (e.g., the UE 102 and 104 and the network node 106). For example, system 100 can operate in accordance with a UMTS, long term evolution (LTE), high speed packet access (HSPA), code division multiple access (CDMA), time division

multiple access (TDMA), frequency division multiple access (FDMA), multi-carrier code division multiple access (MC-CDMA), single-carrier code division multiple access (SC-CDMA), single-carrier FDMA (SC-FDMA), OFDM, (DFT)-spread OFDM or SC-FDMA)), FBMC, ZT DFT-s-OFDM, GFDM, UFMC, UW DFT-Spread-OFDM, UW-OFDM, CP-OFDM, resource-block-filtered OFDM, and UFMC. However, various features and functionalities of system 100 are particularly described wherein the devices (e.g., the UEs 102 and 104 and the network device 106) of system 100 are configured to communicate wireless signals using one or more multi carrier modulation schemes, wherein data symbols can be transmitted simultaneously over multiple frequency subcarriers (e.g., OFDM, CP-OFDM, DFT-spread OFDM, UFMC, FBMC, etc.).

[0030] In various embodiments, system 100 can be configured to provide and employ 5G wireless networking features and functionalities. 5G wireless communication networks are expected to fulfill the demand of exponentially increasing data traffic and to allow people and machines to enjoy gigabit data rates with virtually zero latency. Compared to 4G, 5G supports more diverse traffic scenarios. For example, in addition to the various types of data communication between conventional UEs (e.g., phones, smartphones, tablets, PCs, televisions, Internet enabled televisions, etc.) supported by 4G networks, 5G networks can be employed to support data communication between smart cars in association with driverless car environments, as well as machine type communications (MTCs).

[0031] In an embodiment, network node 106 can send data to each of UE 102 and UE 104 via multiple data channels. As an example, network node 106, in order to capitalize on a channel with high SINR with UE 102, can send data to UE 102 via more than one data channel (e.g., more than one Physical Downlink Shared Channel “PDSCH”). Each of the data channels can have multiple layers, thus maximizing the data transfer between devices. Each of the data channels can be scheduled and configured by respective downlink control channels.

[0032] Even though we can get higher throughput for 5G NR (New Radio) systems, the performance is impacted due to the single codeword multiple input, multiple output (MIMO) system. Since NR uses a single codeword for reported ranks less than or equal to 4, the CQI is generally computed either the minimum of the SINR of all the layers or average of all the layers. Once the network receives this information, it will schedule MCS based on the reported CQI value, hence it does not know even though some of the layers have the high SINR compared to report CQI

(SINR). This in turn reduces the potential improvement in the performance of NR MIMO system. Hence the efficient solution disclosed herein of improving NR MIMO performance by super positioning data channels.

[0033] In this disclosure, the UE (e.g., UE 102) can be scheduled with multiple PDSCHs where the one PDSCH uses one set of demodulation reference signal (DMRS) ports for data transmission as reported similar to the conventional procedure in legacy systems, while the second PDSCH schedules a different set of DMRS ports such that higher layer transmission is possible. Since the second PDSCH uses a different DMRS ports, hence the transmission rank is increased compared to the conventional techniques. In our proposed method the network uses multiple downlink control channels to indicate the number of layers or DMRS ports for the first PDSCH and the DMRS ports and the number of layers for the second PDSCH. By using multiple downlink control channels to indicate the MCS and layers, the network can use resources more efficiently. The disclosure comprises multiple embodiments which can be implemented both at the network node and at the UE.

[0034] A principle behind the proposed technique is that the network can use multiple and/or respective downlink control channels to convey information about the corresponding data traffic channels. Each data traffic channel can use the same or partially overlapping resources as indicated by the downlink control channel. Note that the two data traffic channels can be differentiated in at least one parameter such as DMRS ports, constellation or beam forming matrix etc.

[0035] In an embodiment, the UE reports the channel quality indicator, rank indicator, precoding matrix indicator, and layer indicator as part of the channel station information reporting. Since NR uses a single codeword for reported ranks less than or equal to 4, the CQI is generally computed either as the minimum of the signal to interference plus noise (SINR) (or generally referred to herein as signal to noise "SNR") of all the layers or average of all the layers. Once the network receives this information, it can assign a modulation and coding scheme (MCS) based on the reported CQI value. Some of the layers may have a high SINR or CQI relative to the reported CQI, and so those layers may be able to support additional bandwidth. Since assigning these layers the same MCS as the lower SINR layers, this can reduce the potential improvement in the performance of NR MIMO system. Hence, this disclosure proposes transmitting a second data channel on the layer or layers with the highest SINR in order to efficiently maximize bandwidth.

[0036] In other embodiments, the network node 106 can schedule a first data transmission on all the layers available except for the layer with the highest SINR. Then the network node 106 can schedule a second data channel on the layer with the highest SINR and use a MCS with a higher data rate than if the network node 106 had scheduled the first data channel on all the layers.

[0037] In our proposed method the network uses multiple downlink control channels to indicate the number of layers for the first PDSCH and the layer indication for the second PDSCH. By using multiple downlink control channels to indicate the MCS and layers, the network can use resources more efficiently. The invention comprises multiple embodiments which can be implemented both at the network node and at the UE. The main principle behind the proposed disclosure is that rather than using single scheduling grant/downlink control channel for scheduling, the network uses multiple scheduling grants/downlink control channels where the first downlink control indicated scheduling of one or more layers using the conventional MCS and the additional downlink control channel indicates the one layer and a lowest or lower MCS in the MCS table. Hence, we can improve the conventional NR MIMO single codeword system by using an additional downlink control channel and additional PDSCH. Note that for the additional PDSCH, the layer information is obtained from the **LI** obtained from the CSI report.

[0038] Once the UE 102 or 104 receives multiple downlink control channels and multiple data traffic channels, the UE 102 or 104 can decode the data traffic channels individually to decode each transport blocks to determine whether each transport block is pass or not. In one embodiment, the UE uses conventional receiver for each PDSCH. However, the performance is improved if the UE removes the interference for one PDSCH as it can reconstruct the transmitted signal as it knows the scheduling parameters for the PDSCH.

[0039] Turning now to **FIG. 2**, illustrated is an example message sequence chart 200 for single user super positioning in accordance with various aspects and embodiments of the subject disclosure.

[0040] In an embodiment, a gNB 202 can send a cell specific/UE specific reference signal 206 to UE 204. The UE 204 can compute the channel state information (CSI) from the reference signals at 208 and send it back to the gNB 202 via a feedback channel 210.

[0041] At 212, the gNB 202 can determine the parameters for DL transmissions (including, but not limited to, modulation and coding schemes, power,

physical resource blocks, etc.) based on the CSI. The gNB 202 can then send a first set of downlink control information via downlink control channel 214 to the UE 204 and, simultaneously or sequentially, transmit a second group of downlink control information via downlink control channel 216 to the UE 204. The two group of downlink control information can respectively configure and establish data traffic channel 1 218 and data traffic channel 2 220. It is to be appreciated that in other embodiments, gNB 202 can establish more than two data traffic channels, each with respective downlink control channels to configure the multiple data traffic channels.

[0042] Since the UE 204 receives two scheduling grants and it knows the interference of each of the data traffic channels 218 and 220 as it is conveyed in the scheduling grant as part of the downlink control channel. Hence, the UE 204 can first decode the primary traffic channel and checks if the packet passes the decoding. If the packet passes, the then UE 204 can regenerate the transmission and then subtract the decoded first data from the transmission to remove interference, and then decode the second data traffic channel. Hence by using an interference cancellation receiver the network capacity can be improved significantly. In other embodiments, if the gNB 202 does not use overlapping resource elements, and the channels are sent via different resource blocks, beams, or other ways of distinguishing the beams, the interference is reduced, and the UE 204 can decode both beams without needing to perform interference cancellation.

[0043] Once the UE 204 receives multiple downlink control channels and multiple data traffic channels, the UE 204 can decode the data traffic channels individually to decode each transport blocks to determine whether each transport block is pass or not. In one embodiment, the UE 204 uses a conventional receiver for each PDSCH. However, the performance is improved if the UE 204 removes the interference for one PDSCH as it can reconstruct the transmitted signal as it knows the scheduling parameters for the PDSCH.

[0044] Turning now to **FIG. 3**, illustrated is an example block diagram 300 of a coding structure in accordance with various aspects and embodiments of the subject disclosure.

[0045] In the embodiment shown in **FIG. 3**, the transmitter is a MIMO transmitter with N Antennas, and there are two coding chain for transmission of two downlink control channels and two data traffic channels. In other embodiments, the transmitter can be single output antenna and/or there can be more than two coding chains for different numbers of data traffic channels.

[0046] In the embodiment shown in **FIG. 3**, the coding chain 302 for a first transport block for the first data channel can include blocks for encoding and scrambling, interleaver and modulator blocks, layer mapper blocks, precoder blocks, and adaptive controller blocks. A remapper 304 can also be included in the coding chain (remapper 304 is highlighted here for ease of identification). After the remapper 304 performs the functions of the remapper 304, the output of another remapper 308 and coding chain 306 for a second data traffic channel can be combined, and an Inverse Fast Fourier Transform (IFFT) block 310 can transform the combination for transmission to Antenna 1.

[0047] Similarly, for Antenna N, coding chain 312 for a second transport block for the first data channel can include blocks for encoding and scrambling, interleaver and modulator blocks, layer mapper blocks, precoder blocks, and adaptive controller blocks. After the remapper 314 performs the functions of the remapper 314, the output of another remapper 318 and coding chain 316 for a second data traffic channel can be combined, and an IFFT block 320 can transform the combination for transmission to Antenna 2.

[0048] The transmission of conventional PDSCH is same (e.g., it uses the number of layers as indicated by the UE), however there is a second block is added after the remappers 304 and 314, where a second PDSCH coding chain with a same or different number of layers compared to the first PDSCH is transmitted with a modulating and coding scheme (MCS) less than the conventional MCS. Note that the HARQ process number field in the PDCCH field of the second PDSCH and second PDCCH can be the same or different. In one embodiment the HARQ process number of each PDSCH is same, in another embodiment it can be different.

[0049] Once the UE receives multiple downlink control channels and multiple data traffic channels, the UE can decode the data traffic channels individually to decode each transport blocks to determine whether each transport block is pass or not. In one embodiment, the UE uses conventional receiver for each PDSCH. However, the performance is improved if the UE removes the interference for one PDSCH as it can reconstruct the transmitted signal as it knows the scheduling parameters for the PDSCH.

[0050] Turning now to **FIG. 4**, illustrated is an example table 400 showing channel and layer mappings in accordance with various aspects and embodiments of the subject disclosure. In the embodiment shown in **FIG. 4**, a first data channel PDSCH A 402 can be mapped to layers 1-4 (406, 408, 410, and 412). The CSI report

received from the UE can indicate that 4 layers are possible (e.g., RI of 4). The base station device can assign a MCS based on the CQI report from the CSI report and PDSCH A 402 can have corresponding downlink control information indicating the layers and MCS transmitted to the UE. The base station device can also determine that layer 2 has a higher SINR than the average SINR indicated in the CQI report, and in fact is capable of supporting an additional PDSCH. The base station device can then establish a second downlink control channel and data channel 404 on layer 2 408. The MCS assigned to the PDSCH B 404 can have a lower data rate than the MCS assigned to PDSCH A.

[0051] It is to be appreciated that while reference is made to transmissions having 4 layers in these and other embodiments, in yet other embodiments of the disclosure other numbers of layers are possible including but not limited to 2, 6, 8, and etc.

[0052] In another embodiment shown in **FIG. 5**, the base station device can assign the first downlink control information and data channel 502 to layers 1, 3, and 5 (506, 510, and 512), when layer 2 508 has the highest associated SINR. A separate data channel 504 can be assigned to layer 2 508 with a higher data rate MCS than that assigned to PDSCH B 404 in the embodiment shown in **FIG. 4**. The base station device can determine which embodiment to perform based on the relative SINR values of the layers and which embodiment achieves a higher overall data rate.

[0053] Turning now to **FIG. 6**, illustrated is a block diagram 400 of an example base station device 602 in accordance with various aspects and embodiments of the subject disclosure.

[0054] A base station device 602 can include a channel quality component 604 that determines a quality of an uplink channel from a user equipment device. The channel quality component 604 can monitor the channel quality of communication links between the base station device and the UE based on analyzing channel state information (CSI) reports received from the UE, or based on other metrics. In some embodiments, the channel quality component 604 can estimate the channel quality based on distance of the UE from the base station device 602. Channel quality component 604 can also measure the channel quality based on path loss, known or estimated associated with each communication link with the mobile devices or based on reported or determined SINR.

[0055] The DCI component 606 can be provided to prepare downlink control information for two different data channels. The layer mapper component 408 can

determine which layer of the layers has the highest SINR rate, and then assign the second downlink control channel and data channel to the layer with the highest SINR. The layer mapper component 608 can also either assign the first data channel to each of the layers, or each of the layers except the layer with the highest SINR. The DCI component 606 can determine MCS for each of the data channels and based on the average CQI of all the layers and the CQI of the layer with the highest SINR.

[0056] **FIG. 7** illustrates a process in connection with the aforementioned systems. The processes in **FIG. 7** can be implemented for example by the systems in **FIGS. 1-6** respectively. While for purposes of simplicity of explanation, the methods are shown and described as a series of blocks, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the blocks, as some blocks may occur in different orders and/or concurrently with other blocks from what is depicted and described herein. Moreover, not all illustrated blocks may be required to implement the methods described hereinafter.

[0057] **FIG. 7** illustrates an example method 700 for transmitting multiple downlink transmissions on different channels from a base station device to a single user equipment device in accordance with various aspects and embodiments of the subject disclosure.

[0058] Method 700 can begin at 702 where the method includes receiving, by a base station device comprising a processor, channel state information comprising a channel quality indicator that indicates a channel quality of a channel, and a rank indicator that indicates a group of layers available for a downlink transmission.

[0059] At 704, the method includes based on the channel quality indicator, determining, by the base station device, first downlink control information to facilitate a first data channel to a user equipment device, wherein the data channel is associated with the group of layers.

[0060] At 706, the method includes based on the channel quality indicator, determining, by the base station device, second downlink control information to facilitate a second data channel to the user equipment device, wherein the second data channel is associated with a layer of the group of layers, wherein the layer corresponds to a layer indicator in the channel state information.

[0061] At 708, the method includes transmitting, by the base station device, the first downlink control information via a first downlink control channel and the second downlink control information via a second downlink control channel to the user equipment device.

[0062] Referring now to **FIG. 8**, illustrated is a schematic block diagram of an example end-user device such as a user equipment) that can be a mobile device 800 capable of connecting to a network in accordance with some embodiments described herein. Although a mobile handset 800 is illustrated herein, it will be understood that other devices can be a mobile device, and that the mobile handset 800 is merely illustrated to provide context for the embodiments of the various embodiments described herein. The following discussion is intended to provide a brief, general description of an example of a suitable environment 800 in which the various embodiments can be implemented. While the description includes a general context of computer-executable instructions embodied on a machine-readable storage medium, those skilled in the art will recognize that the various embodiments also can be implemented in combination with other program modules and/or as a combination of hardware and software.

[0063] Generally, applications (*e.g.*, program modules) can include routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the methods described herein can be practiced with other system configurations, including single-processor or multiprocessor systems, minicomputers, mainframe computers, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

[0064] A computing device can typically include a variety of machine-readable media. Machine-readable media can be any available media that can be accessed by the computer and includes both volatile and non-volatile media, removable and non-removable media. By way of example and not limitation, computer-readable media can comprise computer storage media and communication media. Computer storage media can include volatile and/or non-volatile media, removable and/or non-removable media implemented in any method or technology for storage of information, such as computer-readable instructions, data structures, program modules or other data. Computer storage media can include, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD ROM, digital video disk (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the computer.

[0065] Communication media typically embodies computer-readable instructions, data structures, program modules or other data in a modulated data signal such as a carrier wave or other transport mechanism, and includes any information delivery media. The term “modulated data signal” means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media. Combinations of the any of the above may also be included within the scope of computer-readable media.

[0066] The handset 800 includes a processor 802 for controlling and processing all onboard operations and functions. A memory 804 interfaces to the processor 802 for storage of data and one or more applications 806 (e.g., a video player software, user feedback component software, *etc.*). Other applications can include voice recognition of predetermined voice commands that facilitate initiation of the user feedback signals. The applications 806 can be stored in the memory 804 and/or in a firmware 808, and executed by the processor 802 from either or both the memory 804 or/and the firmware 808. The firmware 808 can also store startup code for execution in initializing the handset 800. A communications component 810 interfaces to the processor 802 to facilitate wired/wireless communication with external systems, e.g., cellular networks, VoIP networks, and so on. Here, the communications component 810 can also include a suitable cellular transceiver 811 (e.g., a GSM transceiver) and/or an unlicensed transceiver 813 (e.g., Wi-Fi, WiMax) for corresponding signal communications. The handset 800 can be a device such as a cellular telephone, a PDA with mobile communications capabilities, and messaging-centric devices. The communications component 810 also facilitates communications reception from terrestrial radio networks (e.g., broadcast), digital satellite radio networks, and Internet-based radio services networks.

[0067] The handset 800 includes a display 812 for displaying text, images, video, telephony functions (e.g., a Caller ID function), setup functions, and for user input. For example, the display 812 can also be referred to as a “screen” that can accommodate the presentation of multimedia content (e.g., music metadata, messages, wallpaper, graphics, *etc.*). The display 812 can also display videos and can facilitate the generation, editing and sharing of video quotes. A serial I/O interface 814 is provided in communication with the processor 802 to facilitate wired and/or wireless serial communications (e.g., USB, and/or IEEE 1394) through a hardwire connection,

and other serial input devices (e.g., a keyboard, keypad, and mouse). This supports updating and troubleshooting the handset 800, for example. Audio capabilities are provided with an audio I/O component 816, which can include a speaker for the output of audio signals related to, for example, indication that the user pressed the proper key or key combination to initiate the user feedback signal. The audio I/O component 816 also facilitates the input of audio signals through a microphone to record data and/or telephony voice data, and for inputting voice signals for telephone conversations.

[0068] The handset 800 can include a slot interface 818 for accommodating a SIC (Subscriber Identity Component) in the form factor of a card Subscriber Identity Module (SIM) or universal SIM 820, and interfacing the SIM card 820 with the processor 802. However, it is to be appreciated that the SIM card 820 can be manufactured into the handset 800, and updated by downloading data and software.

[0069] The handset 800 can process IP data traffic through the communication component 810 to accommodate IP traffic from an IP network such as, for example, the Internet, a corporate intranet, a home network, a person area network, etc., through an ISP or broadband cable provider. Thus, VoIP traffic can be utilized by the handset 800 and IP-based multimedia content can be received in either an encoded or decoded format.

[0070] A video processing component 822 (e.g., a camera) can be provided for decoding encoded multimedia content. The video processing component 822 can aid in facilitating the generation, editing and sharing of video quotes. The handset 800 also includes a power source 824 in the form of batteries and/or an AC power subsystem, which power source 824 can interface to an external power system or charging equipment (not shown) by a power I/O component 826.

[0071] The handset 800 can also include a video component 830 for processing video content received and, for recording and transmitting video content. For example, the video component 830 can facilitate the generation, editing and sharing of video quotes. A location tracking component 832 facilitates geographically locating the handset 800. As described hereinabove, this can occur when the user initiates the feedback signal automatically or manually. A user input component 834 facilitates the user initiating the quality feedback signal. The user input component 834 can also facilitate the generation, editing and sharing of video quotes. The user input component 834 can include such conventional input device technologies such as a keypad, keyboard, mouse, stylus pen, and/or touch screen, for example.

[0072] Referring again to the applications 806, a hysteresis component 836 facilitates the analysis and processing of hysteresis data, which is utilized to determine when to associate with the access point. A software trigger component 838 can be provided that facilitates triggering of the hysteresis component 838 when the Wi-Fi transceiver 813 detects the beacon of the access point. A SIP client 840 enables the handset 800 to support SIP protocols and register the subscriber with the SIP registrar server. The applications 806 can also include a client 842 that provides at least the capability of discovery, play and store of multimedia content, for example, music.

[0073] The handset 800 can include an indoor network radio transceiver 813 (e.g., Wi-Fi transceiver). This function supports the indoor radio link, such as IEEE 802.11, for the dual-mode GSM handset 1500. The handset 800 can accommodate at least satellite radio services through a handset that can combine wireless voice and digital radio chipsets into a single handheld device.

[0074] **FIG. 9** presents an example embodiment 900 of a mobile network platform 910 that can implement and exploit one or more aspects of the disclosed subject matter described herein. Generally, wireless network platform 910 can include components, e.g., nodes, gateways, interfaces, servers, or disparate platforms, that facilitate both packet-switched (PS) (e.g., internet protocol (IP), frame relay, asynchronous transfer mode (ATM) and circuit-switched (CS) traffic (e.g., voice and data), as well as control generation for networked wireless telecommunication. As a non-limiting example, wireless network platform 910 can be included in telecommunications carrier networks, and can be considered carrier-side components as discussed elsewhere herein. Mobile network platform 910 includes CS gateway node(s) 912 which can interface CS traffic received from legacy networks like telephony network(s) 940 (e.g., public switched telephone network (PSTN), or public land mobile network (PLMN)) or a signaling system #7 (SS7) network 960. Circuit switched gateway node(s) 912 can authorize and authenticate traffic (e.g., voice) arising from such networks. Additionally, CS gateway node(s) 912 can access mobility, or roaming, data generated through SS7 network 970; for instance, mobility data stored in a visited location register (VLR), which can reside in memory 930. Moreover, CS gateway node(s) 912 interfaces CS-based traffic and signaling and PS gateway node(s) 918. As an example, in a 3GPP UMTS network, CS gateway node(s) 912 can be realized at least in part in gateway GPRS support node(s) (GGSN). It should be appreciated that functionality and specific operation of CS

gateway node(s) 912, PS gateway node(s) 918, and serving node(s) 916, is provided and dictated by radio technology(ies) utilized by mobile network platform 910 for telecommunication. Mobile network platform 910 can also include the MMEs, HSS/PCRFs, SGWs, and PGWs disclosed herein.

[0075] In addition to receiving and processing CS-switched traffic and signaling, PS gateway node(s) 918 can authorize and authenticate PS-based data sessions with served mobile devices. Data sessions can include traffic, or content(s), exchanged with networks external to the wireless network platform 910, like wide area network(s) (WANs) 950, enterprise network(s) 970, and service network(s) 980, which can be embodied in local area network(s) (LANs), can also be interfaced with mobile network platform 910 through PS gateway node(s) 918. It is to be noted that WANs 950 and enterprise network(s) 960 can embody, at least in part, a service network(s) like IP multimedia subsystem (IMS). Based on radio technology layer(s) available in technology resource(s) 917, packet-switched gateway node(s) 918 can generate packet data protocol contexts when a data session is established; other data structures that facilitate routing of packetized data also can be generated. To that end, in an aspect, PS gateway node(s) 918 can include a tunnel interface (e.g., tunnel termination gateway (TTG) in 3GPP UMTS network(s) (not shown)) which can facilitate packetized communication with disparate wireless network(s), such as Wi-Fi networks.

[0076] In embodiment 900, wireless network platform 910 also includes serving node(s) 916 that, based upon available radio technology layer(s) within technology resource(s) 917, convey the various packetized flows of data streams received through PS gateway node(s) 918. It is to be noted that for technology resource(s) 917 that rely primarily on CS communication, server node(s) can deliver traffic without reliance on PS gateway node(s) 918; for example, server node(s) can embody at least in part a mobile switching center. As an example, in a 3GPP UMTS network, serving node(s) 916 can be embodied in serving GPRS support node(s) (SGSN).

[0077] For radio technologies that exploit packetized communication, server(s) 914 in wireless network platform 910 can execute numerous applications that can generate multiple disparate packetized data streams or flows, and manage (e.g., schedule, queue, format ...) such flows. Such application(s) can include add-on features to standard services (for example, provisioning, billing, customer support ...) provided by wireless network platform 910. Data streams (e.g., content(s) that are

part of a voice call or data session) can be conveyed to PS gateway node(s) 918 for authorization/authentication and initiation of a data session, and to serving node(s) 916 for communication thereafter. In addition to application server, server(s) 914 can include utility server(s), a utility server can include a provisioning server, an operations and maintenance server, a security server that can implement at least in part a certificate authority and firewalls as well as other security mechanisms, and the like. In an aspect, security server(s) secure communication served through wireless network platform 910 to ensure network's operation and data integrity in addition to authorization and authentication procedures that CS gateway node(s) 912 and PS gateway node(s) 918 can enact. Moreover, provisioning server(s) can provision services from external network(s) like networks operated by a disparate service provider; for instance, WAN 950 or Global Positioning System (GPS) network(s) (not shown). Provisioning server(s) can also provision coverage through networks associated to wireless network platform 910 (e.g., deployed and operated by the same service provider), such as femto-cell network(s) (not shown) that enhance wireless service coverage within indoor confined spaces and offload RAN resources in order to enhance subscriber service experience within a home or business environment by way of UE 975.

[0078] It is to be noted that server(s) 914 can include one or more processors configured to confer at least in part the functionality of macro network platform 910. To that end, the one or more processor can execute code instructions stored in memory 930, for example. It should be appreciated that server(s) 914 can include a content manager 915, which operates in substantially the same manner as described hereinbefore.

[0079] In example embodiment 900, memory 930 can store information related to operation of wireless network platform 910. Other operational information can include provisioning information of mobile devices served through wireless platform network 910, subscriber databases; application intelligence, pricing schemes, e.g., promotional rates, flat-rate programs, couponing campaigns; technical specification(s) consistent with telecommunication protocols for operation of disparate radio, or wireless, technology layers; and so forth. Memory 930 can also store information from at least one of telephony network(s) 940, WAN 950, enterprise network(s) 960, or SS7 network 970. In an aspect, memory 930 can be, for example, accessed as part of a data store component or as a remotely connected memory store.

[0080] Referring now to **FIG. 10**, there is illustrated a block diagram of a computer 1000 operable to execute the functions and operations performed in the described example embodiments. For example, a network node (e.g., network node 106, gNB 202, e.g.) may contain components as described in **FIG. 10**. The computer 1000 can provide networking and communication capabilities between a wired or wireless communication network and a server and/or communication device. In order to provide additional context for various aspects thereof, **FIG. 10** and the following discussion are intended to provide a brief, general description of a suitable computing environment in which the various aspects of the embodiments can be implemented to facilitate the establishment of a transaction between an entity and a third party. While the description above is in the general context of computer-executable instructions that can run on one or more computers, those skilled in the art will recognize that the various embodiments also can be implemented in combination with other program modules and/or as a combination of hardware and software.

[0081] Generally, program modules include routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the inventive methods can be practiced with other computer system configurations, including single-processor or multiprocessor computer systems, minicomputers, mainframe computers, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

[0082] The illustrated aspects of the various embodiments can also be practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

[0083] Computing devices typically include a variety of media, which can include computer-readable storage media or communications media, which two terms are used herein differently from one another as follows.

[0084] Computer-readable storage media can be any available storage media that can be accessed by the computer and includes both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer-readable storage media can be implemented in connection with any method or technology for storage of information such as computer-readable instructions,

program modules, structured data, or unstructured data. Computer-readable storage media can include, but are not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disk (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or other tangible and/or non-transitory media which can be used to store desired information. Computer-readable storage media can be accessed by one or more local or remote computing devices, e.g., via access requests, queries or other data retrieval protocols, for a variety of operations with respect to the information stored by the medium.

[0085] Communications media can embody computer-readable instructions, data structures, program modules or other structured or unstructured data in a data signal such as a modulated data signal, e.g., a carrier wave or other transport mechanism, and includes any information delivery or transport media. The term “modulated data signal” or signals refers to a signal that has one or more of its characteristics set or changed in such a manner as to encode information in one or more signals. By way of example, and not limitation, communication media include wired media, such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media.

[0086] Referring now to **FIG. 10**, there is illustrated a block diagram of a computer 1000 operable to execute the functions and operations performed in the described example embodiments. For example, a network node (e.g., network node 106, gNB 202, e.g.) may contain components as described in **FIG. 10**. The computer 1000 can provide networking and communication capabilities between a wired or wireless communication network and a server and/or communication device. In order to provide additional context for various aspects thereof, **FIG. 10** and the following discussion are intended to provide a brief, general description of a suitable computing environment in which the various aspects of the embodiments can be implemented to facilitate the establishment of a transaction between an entity and a third party. While the description above is in the general context of computer-executable instructions that can run on one or more computers, those skilled in the art will recognize that the various embodiments also can be implemented in combination with other program modules and/or as a combination of hardware and software.

[0087] Generally, program modules include routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the inventive methods

can be practiced with other computer system configurations, including single-processor or multiprocessor computer systems, minicomputers, mainframe computers, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

[0088] The illustrated aspects of the various embodiments can also be practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

[0089] Computing devices typically include a variety of media, which can include computer-readable storage media or communications media, which two terms are used herein differently from one another as follows.

[0090] Computer-readable storage media can be any available storage media that can be accessed by the computer and includes both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer-readable storage media can be implemented in connection with any method or technology for storage of information such as computer-readable instructions, program modules, structured data, or unstructured data. Computer-readable storage media can include, but are not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disk (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or other tangible and/or non-transitory media which can be used to store desired information. Computer-readable storage media can be accessed by one or more local or remote computing devices, e.g., via access requests, queries or other data retrieval protocols, for a variety of operations with respect to the information stored by the medium.

[0091] Communications media can embody computer-readable instructions, data structures, program modules or other structured or unstructured data in a data signal such as a modulated data signal, e.g., a carrier wave or other transport mechanism, and includes any information delivery or transport media. The term “modulated data signal” or signals refers to a signal that has one or more of its characteristics set or changed in such a manner as to encode information in one or more signals. By way of example, and not limitation, communication media include

wired media, such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media.

[0092] With reference to **FIG. 10**, implementing various aspects described herein with regards to the end-user device can include a computer 1000, the computer 1000 including a processing unit 1004, a system memory 1006 and a system bus 1008. The system bus 1008 couples system components including, but not limited to, the system memory 1006 to the processing unit 1004. The processing unit 1004 can be any of various commercially available processors. Dual microprocessors and other multi-processor architectures can also be employed as the processing unit 1004.

[0093] The system bus 1008 can be any of several types of bus structure that can further interconnect to a memory bus (with or without a memory controller), a peripheral bus, and a local bus using any of a variety of commercially available bus architectures. The system memory 1006 includes read-only memory (ROM) 1027 and random access memory (RAM) 1012. A basic input/output system (BIOS) is stored in a non-volatile memory 1027 such as ROM, EPROM, EEPROM, which BIOS contains the basic routines that help to transfer information between elements within the computer 1000, such as during start-up. The RAM 1012 can also include a high-speed RAM such as static RAM for caching data.

[0094] The computer 1000 further includes an internal hard disk drive (HDD) 1014 (e.g., EIDE, SATA), which internal hard disk drive 1014 can also be configured for external use in a suitable chassis (not shown), a magnetic floppy disk drive (FDD) 1016, (e.g., to read from or write to a removable diskette 1018) and an optical disk drive 1020, (e.g., reading a CD-ROM disk 1022 or, to read from or write to other high capacity optical media such as the DVD). The hard disk drive 1014, magnetic disk drive 1016 and optical disk drive 1020 can be connected to the system bus 1008 by a hard disk drive interface 1024, a magnetic disk drive interface 1026 and an optical drive interface 1028, respectively. The interface 1024 for external drive implementations includes at least one or both of Universal Serial Bus (USB) and IEEE 1394 interface technologies. Other external drive connection technologies are within contemplation of the subject embodiments.

[0095] The drives and their associated computer-readable media provide nonvolatile storage of data, data structures, computer-executable instructions, and so forth. For the computer 1000 the drives and media accommodate the storage of any data in a suitable digital format. Although the description of computer-readable media above refers to a HDD, a removable magnetic diskette, and a removable optical

media such as a CD or DVD, it should be appreciated by those skilled in the art that other types of media which are readable by a computer 1000, such as zip drives, magnetic cassettes, flash memory cards, cartridges, and the like, can also be used in the example operating environment, and further, that any such media can contain computer-executable instructions for performing the methods of the disclosed embodiments.

[0096] A number of program modules can be stored in the drives and RAM 1012, including an operating system 1030, one or more application programs 1032, other program modules 1034 and program data 1036. All or portions of the operating system, applications, modules, and/or data can also be cached in the RAM 1012. It is to be appreciated that the various embodiments can be implemented with various commercially available operating systems or combinations of operating systems.

[0097] A user can enter commands and information into the computer 1000 through one or more wired/wireless input devices, e.g., a keyboard 1038 and a pointing device, such as a mouse 1040. Other input devices (not shown) may include a microphone, an IR remote control, a joystick, a game pad, a stylus pen, touch screen, or the like. These and other input devices are often connected to the processing unit 1004 through an input device interface 1042 that is coupled to the system bus 1008, but can be connected by other interfaces, such as a parallel port, an IEEE 1394 serial port, a game port, a USB port, an IR interface, etc.

[0098] A monitor 1044 or other type of display device is also connected to the system bus 1008 through an interface, such as a video adapter 1046. In addition to the monitor 1044, a computer 1000 typically includes other peripheral output devices (not shown), such as speakers, printers, etc.

[0099] The computer 1000 can operate in a networked environment using logical connections by wired and/or wireless communications to one or more remote computers, such as a remote computer(s) 1048. The remote computer(s) 1048 can be a workstation, a server computer, a router, a personal computer, portable computer, microprocessor-based entertainment device, a peer device or other common network node, and typically includes many or all of the elements described relative to the computer, although, for purposes of brevity, only a memory/storage device 1050 is illustrated. The logical connections depicted include wired/wireless connectivity to a local area network (LAN) 1052 and/or larger networks, e.g., a wide area network (WAN) 1054. Such LAN and WAN networking environments are commonplace in offices and companies, and facilitate enterprise-wide computer networks, such as

intranets, all of which may connect to a global communications network, e.g., the Internet.

[00100] When used in a LAN networking environment, the computer 1000 is connected to the local network 1052 through a wired and/or wireless communication network interface or adapter 1056. The adapter 1056 may facilitate wired or wireless communication to the LAN 1052, which may also include a wireless access point disposed thereon for communicating with the wireless adapter 1056.

[00101] When used in a WAN networking environment, the computer 1000 can include a modem 1058, or is connected to a communications server on the WAN 1054, or has other means for establishing communications over the WAN 1054, such as by way of the Internet. The modem 1058, which can be internal or external and a wired or wireless device, is connected to the system bus 1008 through the input device interface 1042. In a networked environment, program modules depicted relative to the computer, or portions thereof, can be stored in the remote memory/storage device 1050. It will be appreciated that the network connections shown are exemplary and other means of establishing a communications link between the computers can be used.

[00102] The computer is operable to communicate with any wireless devices or entities operatively disposed in wireless communication, e.g., a printer, scanner, desktop and/or portable computer, portable data assistant, communications satellite, any piece of equipment or location associated with a wirelessly detectable tag (e.g., a kiosk, news stand, restroom), and telephone. This includes at least Wi-Fi and Bluetooth™ wireless technologies. Thus, the communication can be a predefined structure as with a conventional network or simply an ad hoc communication between at least two devices.

[00103] Wi-Fi, or Wireless Fidelity, allows connection to the Internet from a couch at home, a bed in a hotel room, or a conference room at work, without wires. Wi-Fi is a wireless technology similar to that used in a cell phone that enables such devices, e.g., computers, to send and receive data indoors and out; anywhere within the range of a base station. Wi-Fi networks use radio technologies called IEEE802.11 (a, b, g, n, etc.) to provide secure, reliable, fast wireless connectivity. A Wi-Fi network can be used to connect computers to each other, to the Internet, and to wired networks (which use IEEE802.3 or Ethernet). Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands, at an 11 Mbps (802.11b) or 54 Mbps (802.11a) data rate, for example, or with products that contain both bands (dual band), so the

networks can provide real-world performance similar to the basic “10BaseT” wired Ethernet networks used in many offices.

[00104] As used in this application, the terms “system,” “component,” “interface,” and the like are generally intended to refer to a computer-related entity or an entity related to an operational machine with one or more specific functionalities. The entities disclosed herein can be either hardware, a combination of hardware and software, software, or software in execution. For example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a server and the server can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers. These components also can execute from various computer readable storage media having various data structures stored thereon. The components may communicate via local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network such as the Internet with other systems *via* the signal). As another example, a component can be an apparatus with specific functionality provided by mechanical parts operated by electric or electronic circuitry that is operated by software or firmware application(s) executed by a processor, wherein the processor can be internal or external to the apparatus and executes at least a part of the software or firmware application. As yet another example, a component can be an apparatus that provides specific functionality through electronic components without mechanical parts, the electronic components can comprise a processor therein to execute software or firmware that confers at least in part the functionality of the electronic components. An interface can comprise input/output (I/O) components as well as associated processor, application, and/or API components.

[00105] Furthermore, the disclosed subject matter may be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof to control a computer to implement the disclosed subject matter. The term “article of manufacture” as used herein is intended to encompass a computer program accessible from any computer-readable device, computer-readable carrier, or computer-readable media. For example, computer-readable media can include, but

are not limited to, a magnetic storage device, e.g., hard disk; floppy disk; magnetic strip(s); an optical disk (e.g., compact disk (CD), a digital video disc (DVD), a Blu-ray Disc™ (BD)); a smart card; a flash memory device (e.g., card, stick, key drive); and/or a virtual device that emulates a storage device and/or any of the above computer-readable media.

[00106] As it employed in the subject specification, the term “processor” can refer to substantially any computing processing unit or device comprising, but not limited to comprising, single-core processors; single-processors with software multithread execution capability; multi-core processors; multi-core processors with software multithread execution capability; multi-core processors with hardware multithread technology; parallel platforms; and parallel platforms with distributed shared memory. Additionally, a processor can refer to an integrated circuit, an application specific integrated circuit (ASIC), a digital signal processor (DSP), a field programmable gate array (FPGA), a programmable logic controller (PLC), a complex programmable logic device (CPLD), a discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. Processors can exploit nano-scale architectures such as, but not limited to, molecular and quantum-dot based transistors, switches and gates, in order to optimize space usage or enhance performance of user equipment. A processor also can be implemented as a combination of computing processing units.

[00107] In the subject specification, terms such as “store,” “data store,” “data storage,” “database,” “repository,” “queue”, and substantially any other information storage component relevant to operation and functionality of a component, refer to “memory components,” or entities embodied in a “memory” or components comprising the memory. It will be appreciated that the memory components described herein can be either volatile memory or nonvolatile memory, or can comprise both volatile and nonvolatile memory. In addition, memory components or memory elements can be removable or stationary. Moreover, memory can be internal or external to a device or component, or removable or stationary. Memory can comprise various types of media that are readable by a computer, such as hard-disc drives, zip drives, magnetic cassettes, flash memory cards or other types of memory cards, cartridges, or the like.

[00108] By way of illustration, and not limitation, nonvolatile memory can comprise read only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable ROM (EEPROM), or flash

memory. Volatile memory can comprise random access memory (RAM), which acts as external cache memory. By way of illustration and not limitation, RAM is available in many forms such as synchronous RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDR SDRAM), enhanced SDRAM (ESDRAM), Synchlink DRAM (SLDRAM), and direct Rambus RAM (DRRAM). Additionally, the disclosed memory components of systems or methods herein are intended to comprise, without being limited to comprising, these and any other suitable types of memory.

[00109] In particular and in regard to the various functions performed by the above described components, devices, circuits, systems and the like, the terms (including a reference to a “means”) used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (*e.g.*, a functional equivalent), even though not structurally equivalent to the disclosed structure, which performs the function in the herein illustrated example aspects of the embodiments. In this regard, it will also be recognized that the embodiments comprise a system as well as a computer-readable medium having computer-executable instructions for performing the acts and/or events of the various methods.

[00110] Computing devices typically comprise a variety of media, which can comprise computer-readable storage media and/or communications media, which two terms are used herein differently from one another as follows. Computer-readable storage media can be any available storage media that can be accessed by the computer and comprises both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer-readable storage media can be implemented in connection with any method or technology for storage of information such as computer-readable instructions, program modules, structured data, or unstructured data.

[00111] Computer-readable storage media can include, but are not limited to, random access memory (RAM), read only memory (ROM), electrically erasable programmable read only memory (EEPROM), flash memory or other memory technology, solid state drive (SSD) or other solid-state storage technology, compact disk read only memory (CD ROM), digital versatile disk (DVD), Blu-ray disc or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices or other tangible and/or non-transitory media which can be used to store desired information.

[00112] In this regard, the terms “tangible” or “non-transitory” herein as applied to storage, memory or computer-readable media, are to be understood to exclude only propagating transitory signals per se as modifiers and do not relinquish rights to all standard storage, memory or computer-readable media that are not only propagating transitory signals per se. Computer-readable storage media can be accessed by one or more local or remote computing devices, e.g., via access requests, queries or other data retrieval protocols, for a variety of operations with respect to the information stored by the medium.

[00113] On the other hand, communications media typically embody computer-readable instructions, data structures, program modules or other structured or unstructured data in a data signal such as a modulated data signal, e.g., a carrier wave or other transport mechanism, and comprises any information delivery or transport media. The term “modulated data signal” or signals refers to a signal that has one or more of its characteristics set or changed in such a manner as to encode information in one or more signals. By way of example, and not limitation, communications media comprise wired media, such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media

[00114] Further, terms like “user equipment,” “user device,” “mobile device,” “mobile,” station,” “access terminal,” “terminal,” “handset,” and similar terminology, generally refer to a wireless device utilized by a subscriber or user of a wireless communication network or service to receive or convey data, control, voice, video, sound, gaming, or substantially any data-stream or signaling-stream. The foregoing terms are utilized interchangeably in the subject specification and related drawings. Likewise, the terms “access point,” “node B,” “base station,” “evolved Node B,” “cell,” “cell site,” and the like, can be utilized interchangeably in the subject application, and refer to a wireless network component or appliance that serves and receives data, control, voice, video, sound, gaming, or substantially any data-stream or signaling-stream from a set of subscriber stations. Data and signaling streams can be packetized or frame-based flows. It is noted that in the subject specification and drawings, context or explicit distinction provides differentiation with respect to access points or base stations that serve and receive data from a mobile device in an outdoor environment, and access points or base stations that operate in a confined, primarily indoor environment overlaid in an outdoor coverage area. Data and signaling streams can be packetized or frame-based flows.

[00115] Furthermore, the terms “user,” “subscriber,” “customer,” “consumer,” and the like are employed interchangeably throughout the subject specification, unless context warrants particular distinction(s) among the terms. It should be appreciated that such terms can refer to human entities, associated devices, or automated components supported through artificial intelligence (e.g., a capacity to make inference based on complex mathematical formalisms) which can provide simulated vision, sound recognition and so forth. In addition, the terms “wireless network” and “network” are used interchangeable in the subject application, when context wherein the term is utilized warrants distinction for clarity purposes such distinction is made explicit.

[00116] Moreover, the word “exemplary” is used herein to mean serving as an example, instance, or illustration. Any aspect or design described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other aspects or designs. Rather, use of the word exemplary is intended to present concepts in a concrete fashion. As used in this application, the term “or” is intended to mean an inclusive “or” rather than an exclusive “or”. That is, unless specified otherwise, or clear from context, “X employs A or B” is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then “X employs A or B” is satisfied under any of the foregoing instances. In addition, the articles “a” and “an” as used in this application and the appended claims should generally be construed to mean “one or more” unless specified otherwise or clear from context to be directed to a singular form.

[00117] In addition, while a particular feature may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application. Furthermore, to the extent that the terms “includes” and “including” and variants thereof are used in either the detailed description or the claims, these terms are intended to be inclusive in a manner similar to the term “comprising.”

[00118] The above descriptions of various embodiments of the subject disclosure and corresponding figures and what is described in the Abstract, are described herein for illustrative purposes, and are not intended to be exhaustive or to limit the disclosed embodiments to the precise forms disclosed. It is to be understood that one of ordinary skill in the art may recognize that other embodiments having modifications, permutations, combinations, and additions can be implemented for

performing the same, similar, alternative, or substitute functions of the disclosed subject matter, and are therefore considered within the scope of this disclosure.

Therefore, the disclosed subject matter should not be limited to any single embodiment described herein, but rather should be construed in breadth and scope in accordance with the claims below.

CLAIMS

What is claimed is:

1. A transmitter device, comprising:
a processor; and
a memory that stores executable instructions that, when executed by the processor, facilitate performance of operations, comprising:
receiving channel state information from a user equipment device
wherein the channel state information comprises a rank indicator that indicates a first group of layers available for a downlink transmission;
based on the channel state information, determining first downlink control information associated with a first data channel to the user equipment device, wherein the first downlink control information is associated with a second group of layers selected from the first group of layers;
based on the channel state information, determining second downlink control information associated with a second data channel to the user equipment device, wherein the second downlink control information is associated with a layer of the first group of layers, wherein the layer corresponds to a layer indicator in the channel state information; and
transmitting the first downlink control information via a first downlink control channel and the second downlink control information via a second downlink control channel to the user equipment device.
2. The transmitter device of claim 1, wherein the second group of layers comprises the layer.
3. The transmitter device of claim 2, wherein the first group of layers matches the second group of layers.
4. The transmitter device of claim 1, wherein the second group of layers does not comprise the layer.
5. The transmitter device of claim 1, wherein the layer indicator indicates the layer with a highest signal to noise ratio of the group of layers.

6. The transmitter device of claim 5, wherein the second downlink control information comprises information identifying the layer for the second data channel.
7. The transmitter device of claim 1, wherein the operations further comprise:
transmitting first data via the first data channel and second data via the second data channel to the user equipment device.
8. The transmitter device of claim 7, wherein the operations further comprise:
mixing the first data and the second data after a resource element mapper component of a coding structure maps resource elements and before an inverse fourier transform component of the coding structure applies an inverse fourier transform.
9. The transmitter device of claim 1, wherein the first downlink control information comprises a first modulation and coding scheme for the first data channel and the second downlink control information comprises a second modulation and coding scheme for the second data channel.
10. The transmitter device of claim 9, wherein the first modulation and coding scheme has a higher data rate than the second modulation coding scheme.
11. The transmitter device of claim 1, wherein a same resource element is associated with the first data channel and the second data channel.

12. A method, comprising:
 - receiving, by a base station device comprising a processor, channel state information comprising a channel quality indicator that indicates a channel quality of a channel, and a rank indicator that indicates a group of layers available for a downlink transmission;
 - based on the channel quality indicator,
 - determining, by the base station device, first downlink control information to facilitate a first data channel to a user equipment device, wherein the first data channel is associated with the group of layers, and
 - determining, by the base station device, second downlink control information to facilitate a second data channel to the user equipment device, wherein the second data channel is associated with a layer of the group of layers, wherein the layer corresponds to a layer indicator in the channel state information; and
 - transmitting, by the base station device, the first downlink control information via a first downlink control channel and the second downlink control information via a second downlink control channel to the user equipment device.
13. The method of claim 12, wherein the layer indicator indicates the layer with a highest signal to noise ratio of the group of layers.
14. The method of claim 12, wherein the second downlink control information comprises information identifying the layer for the second data channel.
15. The method of claim 12, wherein the first downlink control information comprises a first modulation and coding scheme for the first data channel and the second downlink control information comprises a second modulation and coding scheme for the second data channel, and wherein the first modulation and coding scheme has a higher data rate than the second modulation coding scheme.
16. The method of claim 12, wherein a same resource element is associated with the first data channel and the second data channel.

17. The method of claim 12, further comprising:
mixing, by the base station device, first data associated with the first data channel and second data associated with the second data channel after a resource element mapper component of a coding structure has performed element mapping operations and before an inverse fourier transform component of the coding structure has performed an inverse fourier transform.
18. A machine-readable storage medium, comprising executable instructions that, when executed by a processor of a device, facilitate performance of operations, comprising:
receiving channel state information from a user equipment device, wherein the channel state information comprises a rank indicator that indicates a first group of layers available for a downlink transmission;
determining first downlink control information associated with a first data channel to the user equipment device, wherein the first downlink control information is based on the channel state information and is associated with a second group of layers selected from the first group of layers;
determining second downlink control information associated with a second data channel to the user equipment device, wherein the second downlink control information is based on the channel state information and is associated with a layer of the first group of layers, wherein the layer corresponds to a layer indicator in the channel state information; and
transmitting the first downlink control information via a first downlink control channel and the second downlink control information via a second downlink control channel to the user equipment device.
19. The machine-readable storage medium of claim 18, wherein the first downlink control information comprises a first modulation and coding scheme for the first data channel and the second downlink control information comprises a second modulation and coding scheme for the second data channel.
20. The machine-readable storage medium of claim 19, wherein the first modulation and coding scheme has a higher data rate than the second modulation coding scheme.

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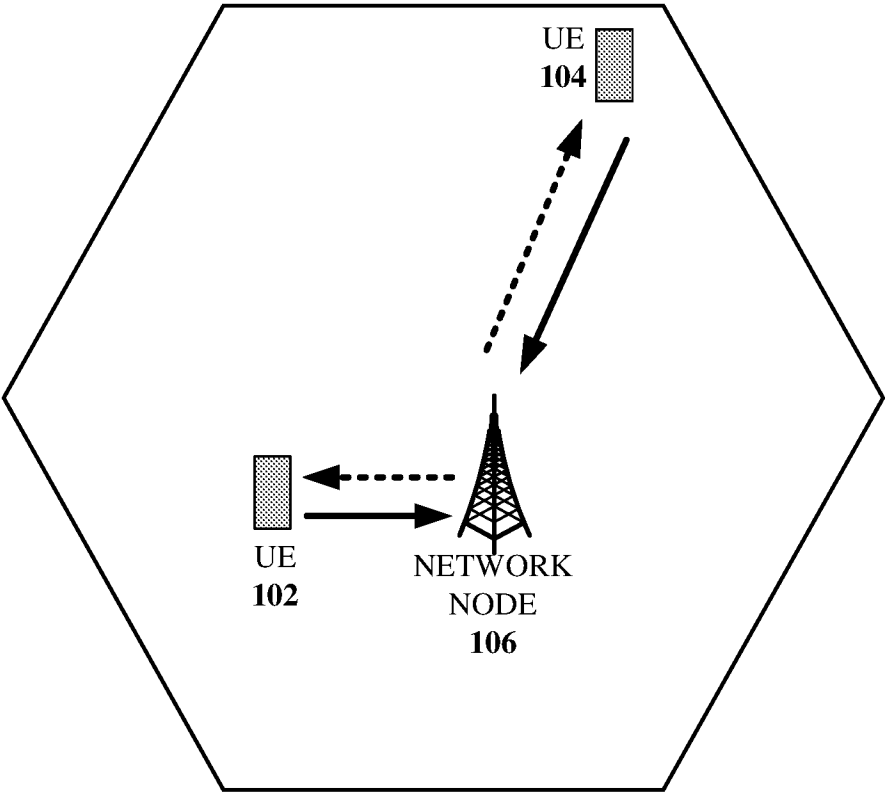


FIG. 1

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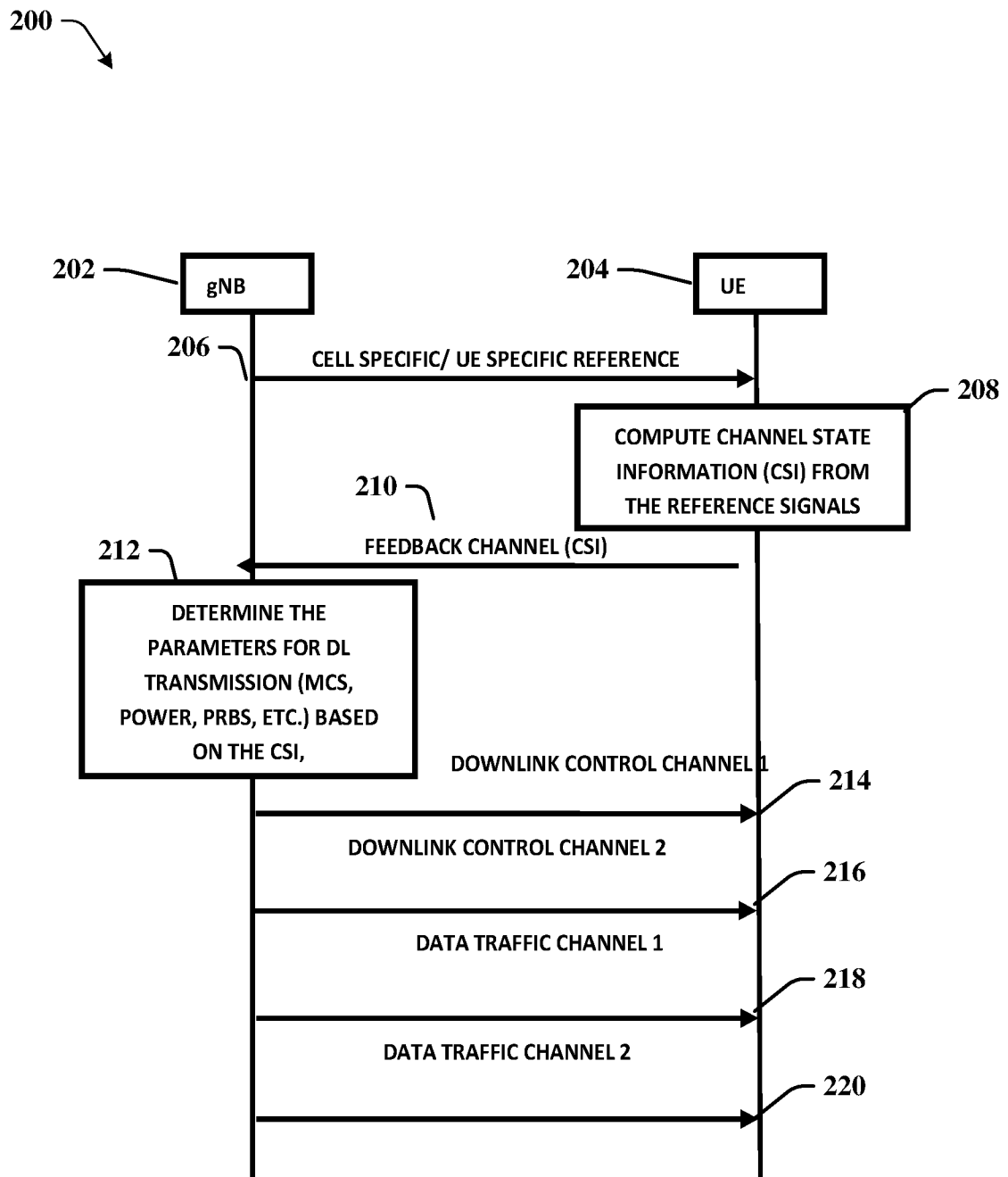
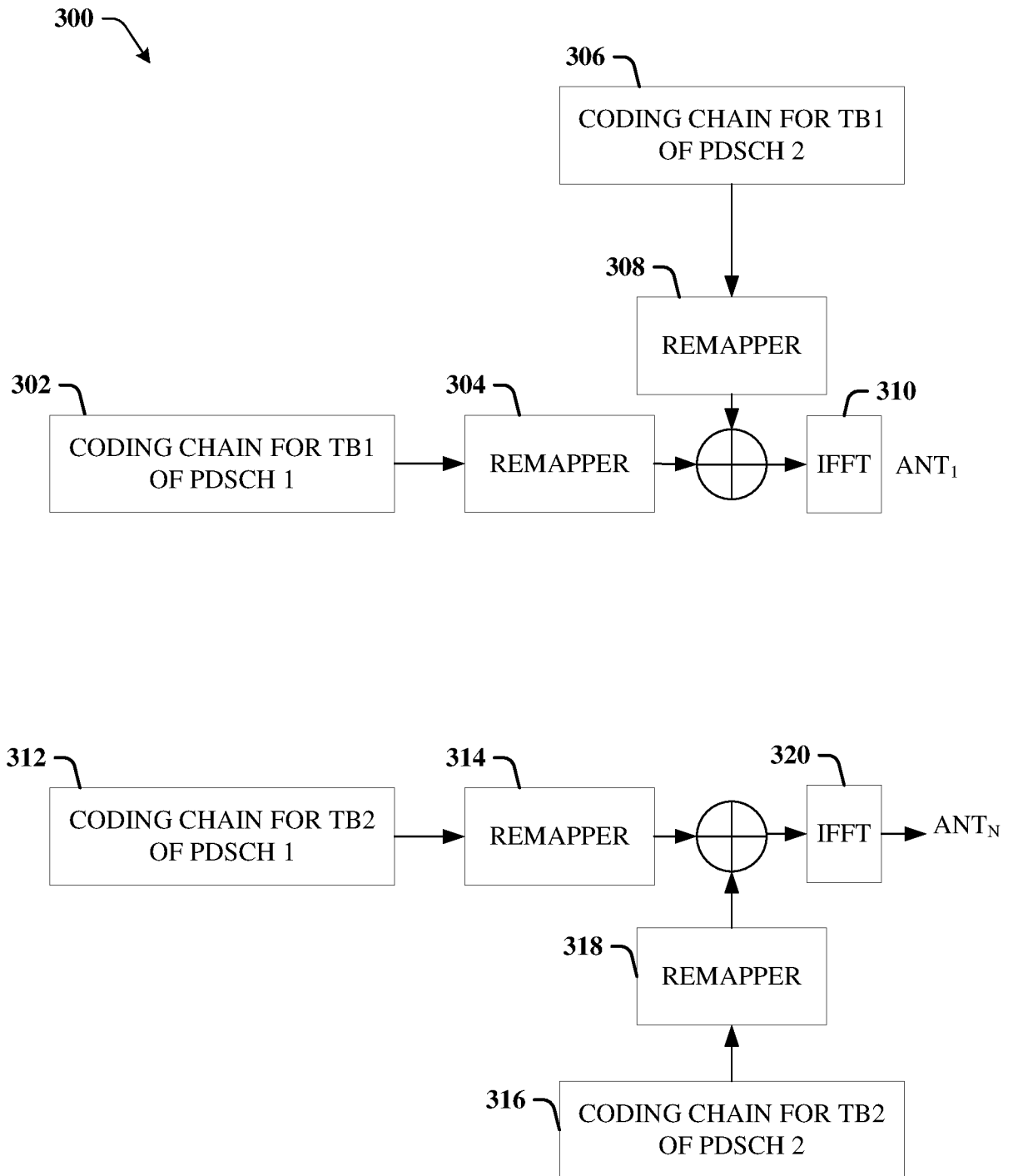


FIG. 2

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**FIG. 3**

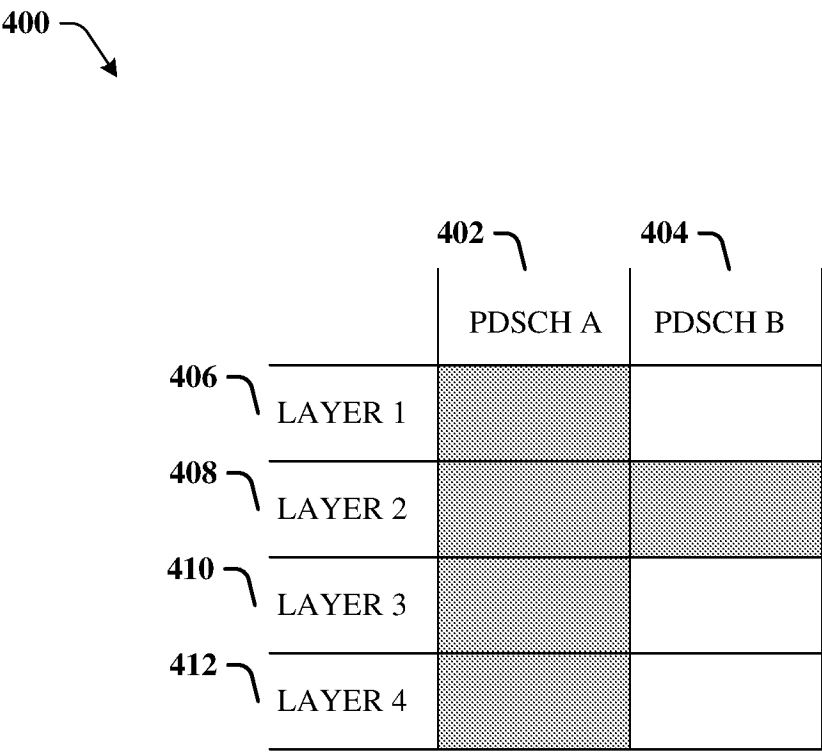


FIG. 4

500 ↘

	502 PDSCH A	504 PDSCH B
506 LAYER 1		
508 LAYER 2		
510 LAYER 3		
512 LAYER 4		

FIG. 5

600

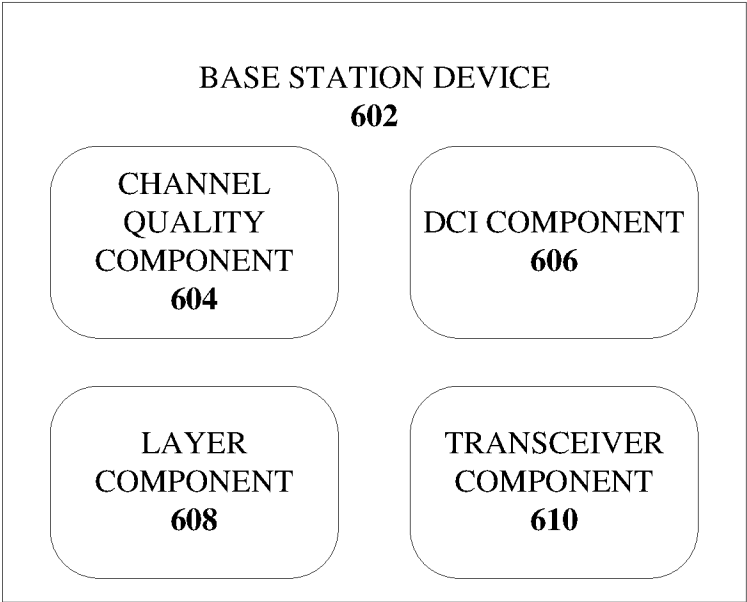
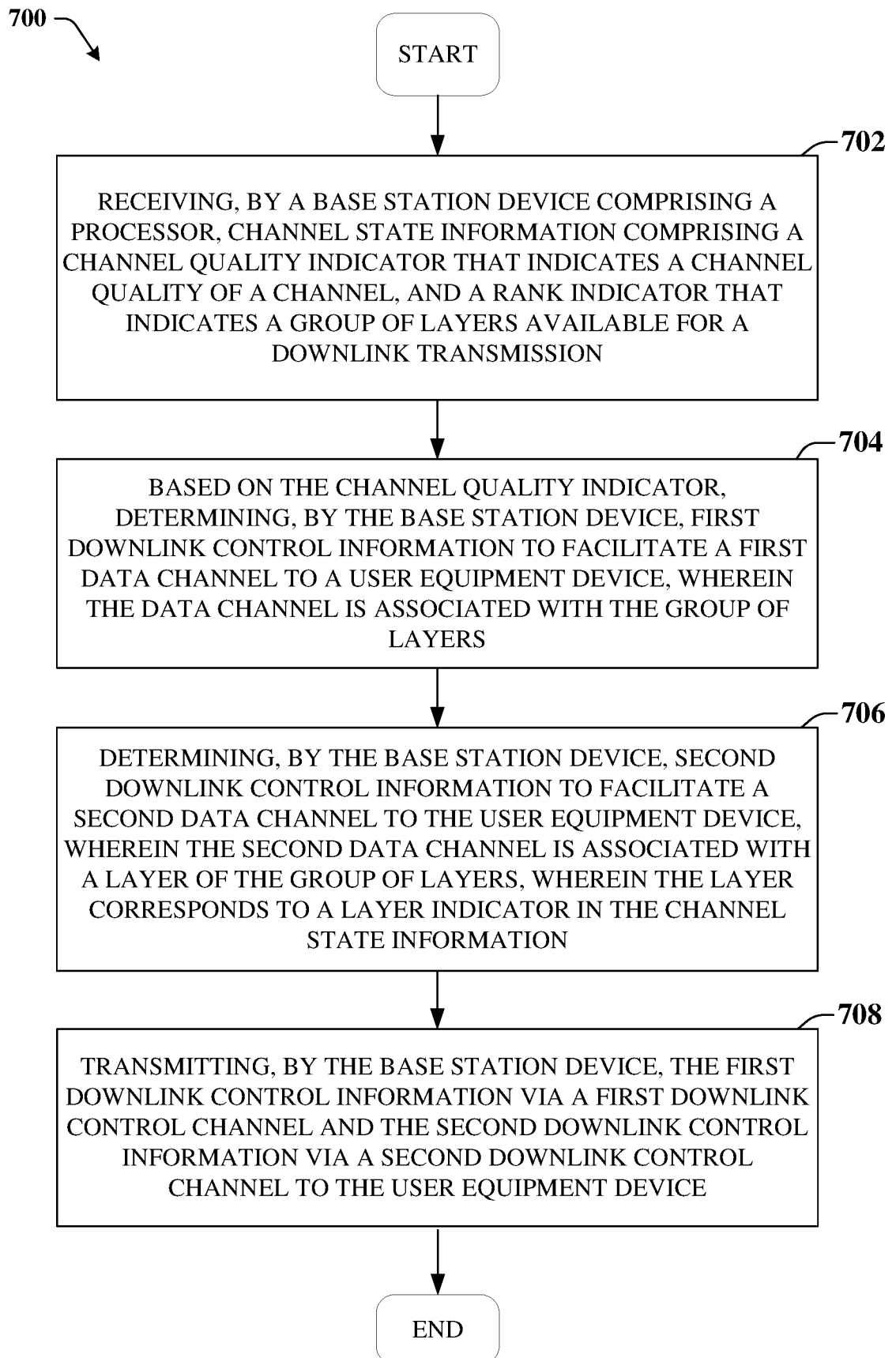
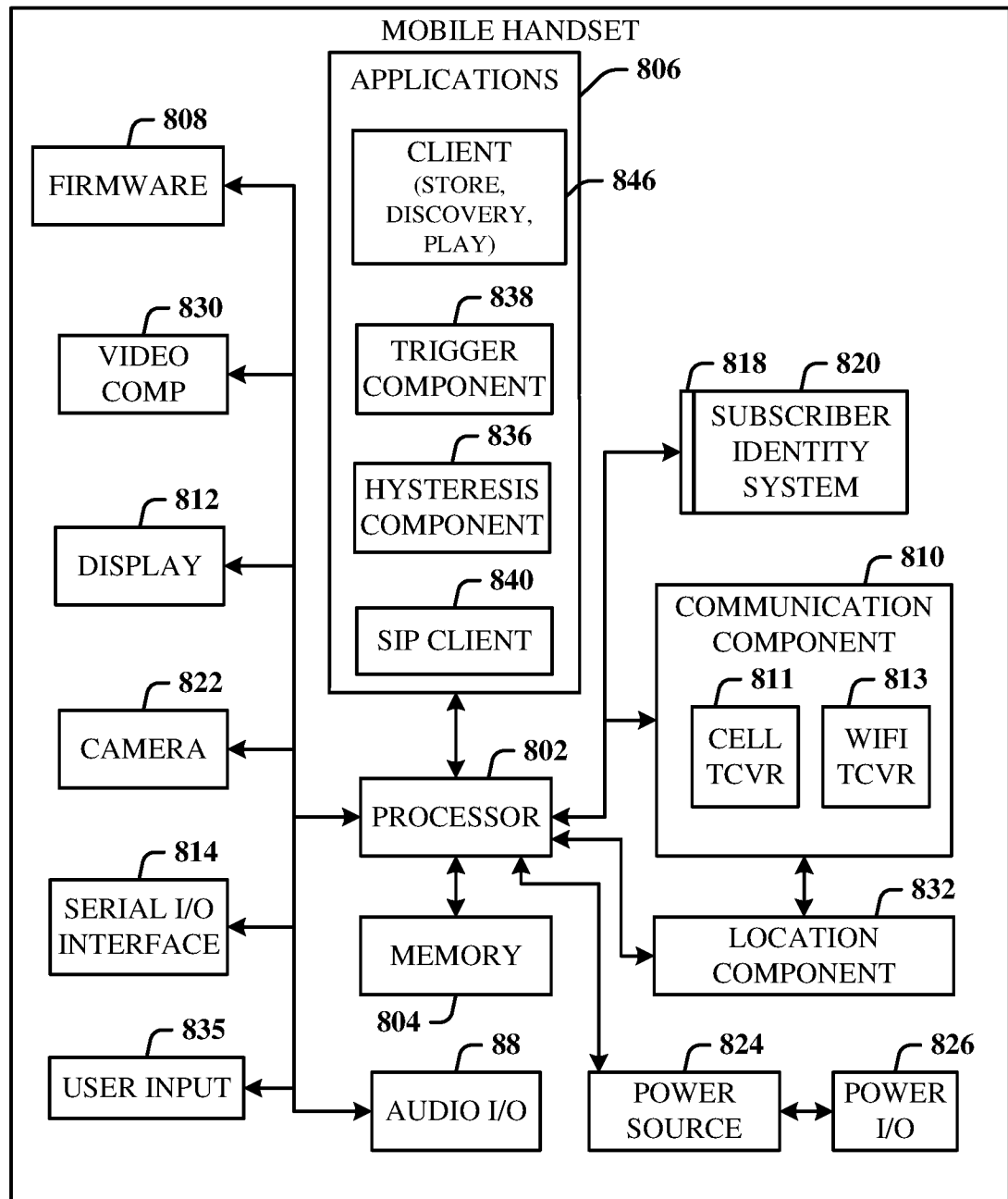


FIG. 6

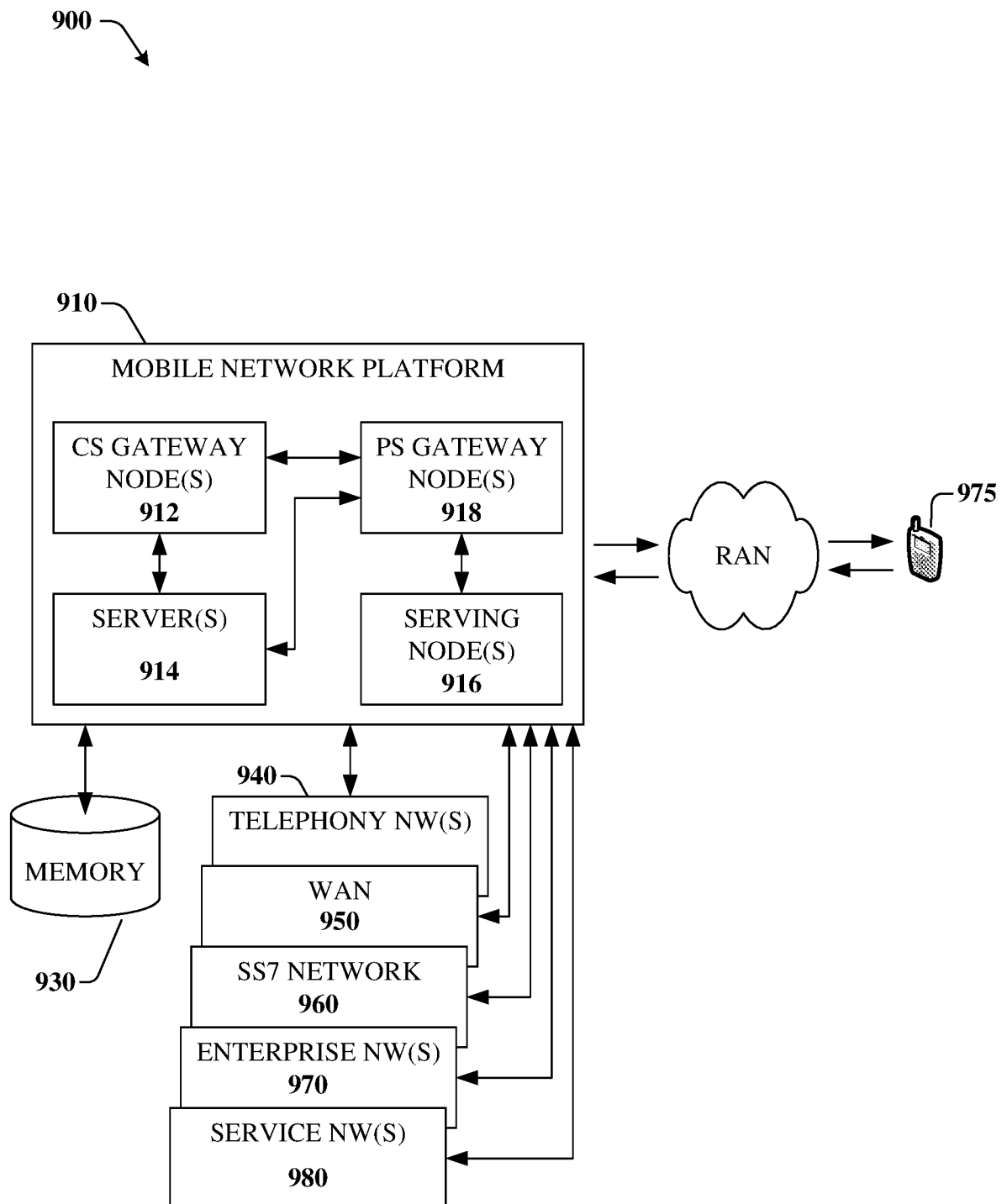
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**FIG. 7**

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**FIG. 8**

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**FIG. 9**

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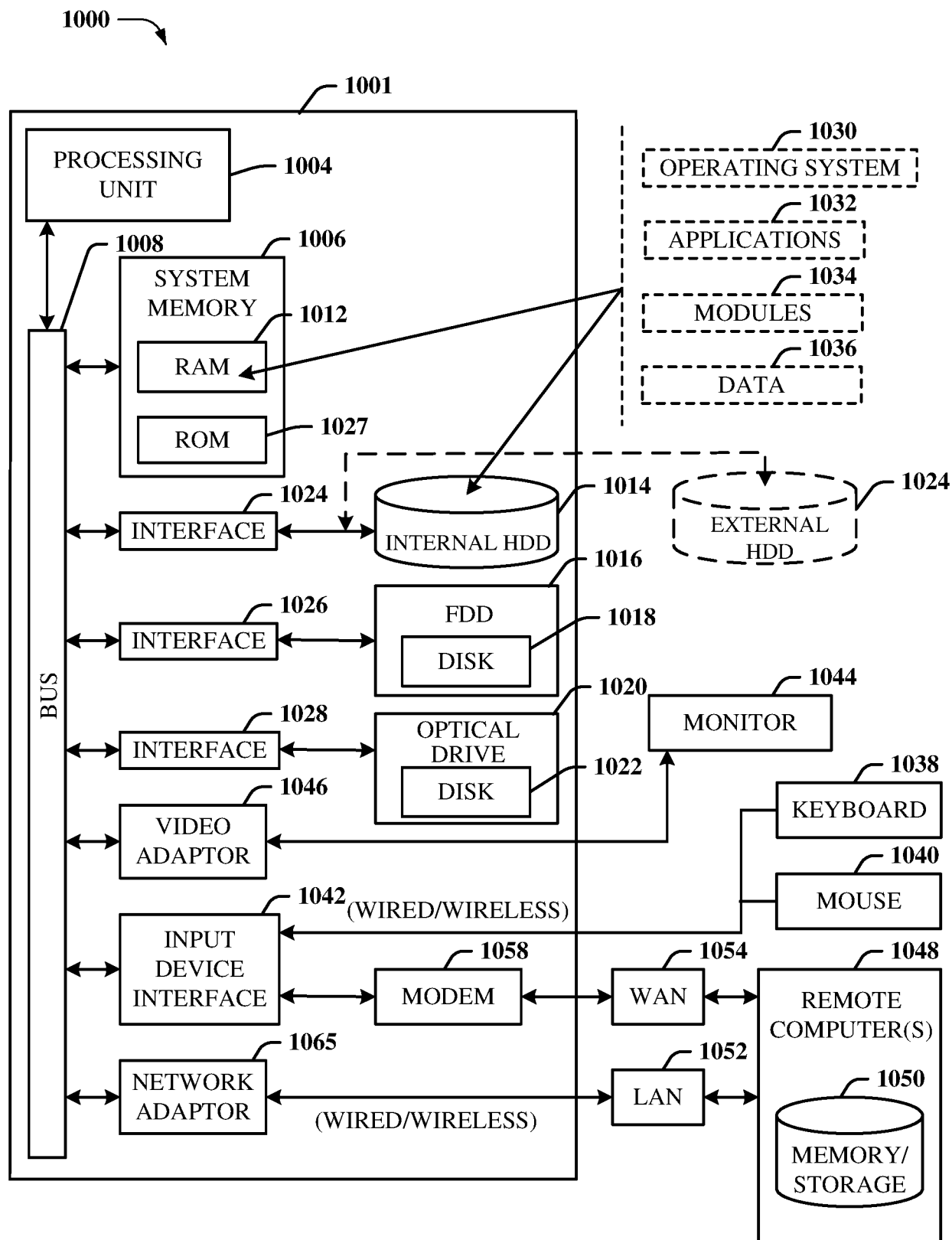


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/030714

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/0456 H04B7/06
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2016/119807 A1 (LUO T; MALLADI D; MALLADI D P; RUO T; SEON J; SU H; SUN J; WEI Y; XU H) 28 April 2016 (2016-04-28) figures 1B,12 paragraphs [0038], [0039], [0042], [0063], [0067], [0059], [0060] ----- -/--	1-20



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

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"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

12 July 2019

Date of mailing of the international search report

19/07/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Oana, Andrei

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/030714

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	NOKIA ET AL: "On the number of codewords in NR", 3GPP DRAFT; R1-1705952, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Spokane, WA, USA; 20170403 - 20170407 2 April 2017 (2017-04-02), XP051244061, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2017-04-02] page 4, paragraphs 1,2 page 3; figures 2,3	1-20
Y	----- US 2016/212458 A1 (KWON SUN-HYOUNG [KR] ET AL) 21 July 2016 (2016-07-21) paragraphs [0011], [0075] - [0078]; figures 1,3	8,17
A	----- US 2017/290046 A1 (SUN JING [US] ET AL) 5 October 2017 (2017-10-05) paragraphs [0007], [0088], [0148]; figures 2,5,6 -----	1-20

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Information on patent family members

International application No

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