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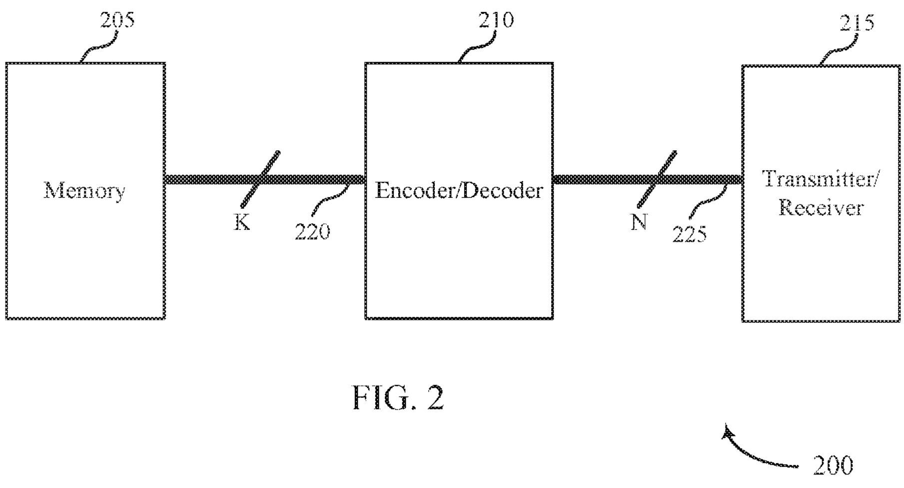

FIG. 2

(57) Abstract: Methods, systems, and devices for wireless communication are described. To encode a vector of bits using a polar code, an encoder may allocate information bits of the vector to polarized bit-channels associated with a channel (e.g., a set of unpolarized bit-channels) used for a transmission. In some cases, the polarized bit-channels may be partitioned into groups associated with different reliability metrics. The information bits may be allocated to the polarized bit-channels based on the reliability metrics of the different polarized bit-channels and the overall capacity of a transmission. That is, the bit locations of a transmission may depend on the reliability metrics of different polarized bit-channels and the overall capacity of the transmission. To facilitate puncturing, the overall capacity of the transmission may be adjusted and the unpolarized bit-channels may be partitioned into polarized bit-channels based on the adjusted capacity.

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MUTUAL-INFORMATION BASED RECURSIVE POLAR CODE CONSTRUCTION

BACKGROUND

[0001] The following relates generally to wireless communication and more specifically to mutual-information based recursive polar code construction.

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

[0003] Code blocks may be encoded by a transmitting device (*e.g.*, a base station or UE) using an encoding algorithm. Error correcting codes may be used to introduce redundancy in a code block so that transmission errors may be detected and corrected. Some examples of encoding algorithms with error correcting codes include convolutional codes (CCs), low-density parity-check (LDPC) codes, and polar codes. Some coding techniques, such as polar coding, use reliability metrics during encoding and decoding such that information bits may be loaded on channel instances (of the encoder or decoder) that are associated with favorable (*e.g.*, high) reliability metrics. Selection of channel instances used for information bits may present challenges when implemented in a system where a flexible bit rate for processing bits for a transmission is desired.

SUMMARY

[0004] In some cases, a codeword encoded using a polar code may be punctured. For example, to achieve a given code rate with an encoder having lengths determined by a power function (*e.g.*, 2^N), more bits may be generated from encoding than are transmitted for the given code rate. A punctured bit may be a bit for which no information is transmitted (*e.g.*, the bit is skipped), or a bit that is used for another purpose (*e.g.*, transmission of a reference signal, *etc.*). Puncturing may include, for example, shortening puncturing (or known bit puncturing), in which a set of most significant bits (MSBs) or later-generated bits of a codeword are punctured, and block puncturing (or unknown bit puncturing), in which a set of least significant bits (LSBs) or earlier-generated bits of a codeword are punctured. The present disclosure describes techniques for encoding and decoding a codeword using a polar code when one or more bits are punctured.

[0005] A method for wireless communication is described. The method may include receiving a codeword over a wireless channel, the codeword being encoded using a polar code, identifying a set of punctured bit locations in the received codeword, identifying a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, and decoding the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0006] An apparatus for wireless communication is described. The apparatus may include means for receiving a codeword over a wireless channel, the codeword being encoded using a polar code, means for identifying a set of punctured bit locations in the received codeword, means for identifying a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, and means for decoding the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0007] Another apparatus for wireless communication is described. The apparatus may include a processor, memory in electronic communication with the processor, and instructions stored in the memory. The instructions may be operable to cause the processor to receive a codeword over a wireless channel, the codeword being encoded using a polar code, identify a set of punctured bit locations in the received codeword, identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, and decode the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0008] A non-transitory computer readable medium for wireless communication is described. The non-transitory computer-readable medium may include instructions operable to cause a processor to receive a codeword over a wireless channel, the codeword being encoded using a polar code, identify a set of punctured bit locations in the received codeword, identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, and decode the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0009] In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the target mutual information may be determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations may be set to zero. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the non-shortening based puncturing comprises block puncturing.

[0010] In some examples of the method, apparatus, and non-transitory computer-readable medium described above, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions may be determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and a number of the punctured bit locations may be added to the number of the information bits for assigning to the bit-channel partitions for the first recursive partitioning.

[0011] In some examples of the method, apparatus, and non-transitory computer-readable medium described above, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations may be set to unity. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the mutual information transfer function may be based on a binary erasure channel (BEC) function and a correction term.

[0012] A method for wireless communication is described. The method may include receiving a codeword that is encoded using a polar code, identifying a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term, and processing the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0013] An apparatus for wireless communication is described. The apparatus may include means for receiving a codeword that is encoded using a polar code, means for identifying a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term, and means for processing the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0014] Another apparatus for wireless communication is described. The apparatus may include a processor, memory in electronic communication with the processor, and instructions stored in the memory. The instructions may be operable to cause the processor to receive a codeword that is encoded using a polar code, identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term, and process the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0015] A non-transitory computer readable medium for wireless communication is described. The non-transitory computer-readable medium may include instructions operable to cause a processor to receive a codeword that is encoded using a polar code, identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term, and process the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0016] In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the correction term may be based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the correction term comprises an offset factor applied to the bit-channel capacity. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the correction term comprises a scaling factor applied to the offset bit-channel capacity. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

[0017] A method for wireless communication is described. The method may include identifying a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code, identifying a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, encoding the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword, and transmitting the codeword over a wireless channel, wherein the transmitting comprises puncturing the codeword at the set of punctured bit locations.

[0018] An apparatus for wireless communication is described. The apparatus may include means for identifying a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code, means for identifying a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, means for encoding the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword, and means for transmitting the codeword over a wireless channel, wherein the transmitting comprises puncturing the codeword at the set of punctured bit locations.

[0019] Another apparatus for wireless communication is described. The apparatus may include a processor, memory in electronic communication with the processor, and instructions stored in the memory. The instructions may be operable to cause the processor to identify a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code, identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, encode the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword, and transmit the codeword over a wireless channel, wherein the transmitting comprises puncturing the codeword at the set of punctured bit locations.

[0020] A non-transitory computer readable medium for wireless communication is described. The non-transitory computer-readable medium may include instructions operable to cause a processor to identify a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code, identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, encode the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword, and transmit the codeword over a wireless channel, wherein the transmitting comprises puncturing the codeword at the set of punctured bit locations.

[0021] In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the target mutual information may be determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the non-shortening based puncturing comprises block puncturing.

[0022] In some examples of the method, apparatus, and non-transitory computer-readable medium described above, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations may be set to zero. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions may be determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

[0023] In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and a number of the punctured bit locations may be added to the number of information bits for assigning to the bit-channel partitions for the first recursive partitioning. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations may be set to unity.

[0024] In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the mutual information transfer function may be based on a BEC function and a correction term.

[0025] A method for wireless communication is described. The method may include identifying an information bit vector for encoding using a polar code, identifying a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term, encoding the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword, and transmitting the codeword over a wireless channel.

[0026] An apparatus for wireless communication is described. The apparatus may include means for identifying an information bit vector for encoding using a polar code, means for identifying a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term, means for encoding the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword, and means for transmitting the codeword over a wireless channel.

[0027] Another apparatus for wireless communication is described. The apparatus may include a processor, memory in electronic communication with the processor, and instructions stored in the memory. The instructions may be operable to cause the processor to identify an information bit vector for encoding using a polar code, identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term, encode the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword, and transmit the codeword over a wireless channel.

[0028] A non-transitory computer readable medium for wireless communication is described. The non-transitory computer-readable medium may include instructions operable to cause a processor to identify an information bit vector for encoding using a polar code, identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term, encode the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword, and transmit the codeword over a wireless channel.

[0029] In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the correction term may be based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the correction term comprises an offset factor applied to the bit-channel capacity. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the correction term comprises a scaling factor applied to the offset bit-channel capacity. In some examples of the method, apparatus, and non-transitory computer-readable medium described above, the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. 1 illustrates an example of a wireless communications system that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure;

[0031] FIG. 2 illustrates an example of a device that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure;

[0032] FIGs. 3-8 illustrate examples of a polar coding scheme that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure;

[0033] FIG. 9 illustrates an example of a channel polarization mutual information transfer function in accordance with various aspects of the present disclosure;

[0034] FIG. 10 illustrates an example of a channel polarization mutual information transfer function comparison and correction in accordance with various aspects of the present disclosure;

[0035] FIGs. 11 through 13 show block diagrams of a device that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure;

[0036] FIG. 14 illustrates a block diagram of a system including a user equipment (UE) that supports mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure;

[0037] FIG. 15 illustrates a block diagram of a system including a base station that supports mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure;

[0038] FIGs. 16 through 19 illustrate methods for a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure.

DETAILED DESCRIPTION

[0039] Techniques are described for enhanced performance of polar codes where puncturing is employed. A base station may encode a set of bits for a transmission to a UE using a polar code. The number of bits generated by a polar code encoder may be determined based on a power function (*e.g.*, 2^N). Thus, in order to achieve a given code rate or codeword size for a transmission, more bits may be generated by the polar code than are transmitted for the given code rate or codeword size. In such cases, the base station may puncture the encoded bits to satisfy the given code rate. That is, the base station may rate match the output codeword of the polar code encoder to a number of desired bits for the given code rate by not transmitting some of the encoded bits. Because the polar code construction may not account for the punctured bits, the gains associated with using the polar code may be compromised, which may result in reduced throughput in a wireless communications system.

[0040] Some wireless communications systems may support efficient techniques for accommodating puncturing in a polar coding scheme. An encoder may identify a target mutual information for a transmission, and the encoder may polarize bit-channels based on the target mutual information. The resulting polarized bit-channels may then be partitioned into groups, each associated with a specific capacity (or mutual information) that corresponds to the reliability of the bit-channels in the group. The polarization of the bit-channels and the partitioning of the bit-channels into different groups may be done recursively until the block size of a group of polarized bit-channels is below a certain threshold or the error due to dividing an integer number of bit locations is above a certain threshold. The information bits may then be distributed to the polarized bit-channels based on the allocations (e.g., distributed within each block according to polarization weight or a predetermined bit-channel ranking within each block).

[0041] However, if a set of bits is punctured for the transmission, the capacity (or target mutual information) of the unpolarized bit-channels may be different (e.g., some unpolarized bit-channels may have zero capacity because they are not transmitted in the punctured codeword). As described herein, an encoder may employ a polar coding scheme that accounts for differences in capacity of the unpolarized bit-channels based on the number of bits punctured for a transmission. Specifically, initial target mutual information and recursive partitioning may be adjusted for the puncturing. For example, as the polarized bit-channels are recursively partitioned into groups, the effect of capacity differences due to punctured bits is propagated to each set of partitioned bit-channels. Thus, the number of information bits allocated to each partitioned bit-channel group accounts for the punctured bit-channels. As such, the adjusted initial capacity (or number of un-punctured bits) may be distributed to the different groups of polarized bit-channels appropriately, and, the information bits of the transmission may be allocated to the most reliable polarized bit-channels.

[0042] Aspects of the disclosure introduced above are described below in the context of a wireless communications system. Examples of processes and signaling exchanges that support a mutual-information based recursive polar code construction are then described. Aspects of the disclosure are further illustrated by and described with reference to apparatus diagrams, system diagrams, and flowcharts that relate to a mutual-information based recursive polar code construction.

[0043] **FIG. 1** illustrates an example of a wireless communications system 100 that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure. The wireless communications system 100 includes base stations 105, UEs 115, and a core network 130. In some examples, the wireless communications system 100 may be a Long Term Evolution (LTE), LTE-Advanced (LTE-A) network, or a New Radio (NR) network. In some cases, wireless communications system 100 may support enhanced broadband communications, ultra-reliable (*i.e.*, mission critical) communications, low latency communications, and communications with low-cost and low-complexity devices.

[0044] Base stations 105 may wirelessly communicate with UEs 115 via one or more base station antennas. Each base station 105 may provide communication coverage for a respective geographic coverage area 110. Communication links 125 shown in wireless communications system 100 may include uplink transmissions from a UE 115 to a base station 105, or downlink transmissions from a base station 105 to a UE 115. Control information and data may be multiplexed on an uplink channel or downlink according to various techniques. Control information and data may be multiplexed on a downlink channel, for example, using time division multiplexing (TDM) techniques, frequency division multiplexing (FDM) techniques, or hybrid TDM-FDM techniques. In some examples, the control information transmitted during a transmission time interval (TTI) of a downlink channel may be distributed between different control regions in a cascaded manner (*e.g.*, between a common control region and one or more UE-specific control regions).

[0045] UEs 115 may be dispersed throughout the wireless communications system 100, and each UE 115 may be stationary or mobile. A UE 115 may also be referred to as a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client, or some other suitable terminology. A UE 115 may be a cellular phone, a personal digital assistant (PDA), a wireless modem, a wireless communication device, a handheld device, a tablet computer, a laptop computer, a cordless phone, a personal electronic device, a handheld device, a personal computer, a wireless local loop (WLL) station, an Internet of Things (IoT) device, an Internet of Everything (IoE) device, a machine type communication (MTC) device, an appliance, an automobile, or the like.

[0046] Base stations 105 may communicate with the core network 130 and with one another. For example, base stations 105 may interface with the core network 130 through backhaul links 132 (*e.g.*, S1, *etc.*). Base stations 105 may communicate with one another over backhaul links 134 (*e.g.*, X2, *etc.*) either directly or indirectly (*e.g.*, through core network 130). Base stations 105 may perform radio configuration and scheduling for communication with UEs 115, or may operate under the control of a base station controller (not shown). In some examples, base stations 105 may be macro cells, small cells, hot spots, or the like. Base stations 105 may also be referred to as evolved NodeBs (eNBs) 105.

[0047] A base station 105 may be connected by an S1 interface to the core network 130. The core network may be an evolved packet core (EPC), which may include at least one mobility management entity (MME), at least one serving gateway (S-GW), and at least one Packet Data Network (PDN) gateway (P-GW). The MME may be the control node that processes the signaling between the UE 115 and the EPC. All user Internet Protocol (IP) packets may be transferred through the S-GW, which itself may be connected to the P-GW. The P-GW may provide IP address allocation as well as other functions. The P-GW may be connected to the network operators IP services. The operators IP services may include the Internet, the Intranet, an IP Multimedia Subsystem (IMS), and a Packet-Switched (PS) Streaming Service.

[0048] The core network 130 may provide user authentication, access authorization, tracking, Internet Protocol (IP) connectivity, and other access, routing, or mobility functions. At least some of the network devices, such as base station 105 may include subcomponents such as an access network entity, which may be an example of an access node controller (ANC). Each access network entity may communicate with a number of UEs 115 through a number of other access network transmission entities, each of which may be an example of a smart radio head, or a transmission/reception point (TRP). In some configurations, various functions of each access network entity or base station 105 may be distributed across various network devices (*e.g.*, radio heads and access network controllers) or consolidated into a single network device (*e.g.*, a base station 105).

[0049] In some cases, a base station 105 may encode a set of bits for a transmission to a UE 115 using a polar code. The number of bits generated by a polar code encoder may be determined based on a power function (*e.g.*, 2^N). Thus, in order to achieve a given code rate or codeword size for a transmission, more bits may be generated by the polar code than are transmitted for the given code rate or codeword size. In such cases, the base station 105 may puncture the encoded bits to satisfy the given code rate. That is, the base station 105 may rate match the output codeword of the polar code encoder to a number of desired bits for the given code rate by not transmitting some of the encoded bits. Because the polar code may not account for the punctured bits, the gains associated with using the polar code may be compromised, which may result in reduced throughput in a wireless communicaitons system.

[0050] Wireless communications system 100 may support efficient techniques for accommodating puncturing in a polar coding scheme. An encoder may identify a target mutual information for a transmission, and the encoder may polarize bit-channels based on the target mutual information. At each stage of polarization, a capacity of each bit-channel is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function. The resulting polarized bit-channels may then be partitioned into groups, each associated with a specific capacity (or mutual information) that corresponds to the aggregate reliability of the bit-channels in the group. The polarization of the bit-channels and the partitioning of the bit-channels into different groups may be done recursively until the number of bit locations allocated to a group of polarized bit-channels is below a certain threshold. The information bits may then be distributed to different polarized bit-channels based on the reliability metrics of the polarized bit-channels.

[0051] However, if a set of bits is punctured for the transmission, the initial capacity (or target mutual information) used to partition the unpolarized bit-channels into polarized bit-channels may be different. As described herein, an encoder may employ a polar coding scheme that adjusts the initial target mutual information based on the number of bits punctured for a transmission. Thus, the polarized bit-channels may be partitioned into groups associated with different reliability metrics (or different mutual information) based on the number of un-punctured bits. As such, the adjusted initial capacity (or number of un-punctured bits) may be distributed to the different groups of polarized bit-channels appropriately, and, the information bits of the transmission may be allocated to the most reliable polarized bit-channels.

[0052] **FIG. 2** illustrates an example of a device 200 that supports mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure. Device 200 may include memory 205, encoder/decoder 210, and transmitter/receiver 215. Bus 220 may connect memory 205 and encoder/decoder 210, and bus 225 may connect encoder/decoder 210 and transmitter/receiver 215. In some instances, device 200 may have data stored in memory 205 to be transmitted to another device, such as, a UE 115 or a base station 105. To initiate data transmission, device 200 may retrieve the data, including information bits, from memory 205 for the transmission. The information bits included in memory 205 may be passed on to encoder/decoder 210 via bus 220. The number of information bits may be represented as a value k, as shown.

[0053] Encoder/decoder 210 may encode the k information bits and output a codeword having a length N, where $k<N$. Parity bits may be used in some forms of outer codes to provide redundancy to protect information bits, and frozen bits may be denoted by a given value (0, 1, *etc.*) known to both the encoder and the decoder (*i.e.*, the encoder encoding information bits at a transmitter, and the decoder decoding the codeword received at a receiver). From a transmitting device perspective, device 200 may encode information bits to produce a codeword, and the codeword may be transmitted via transmitter 215. For a receiving device perspective, device 200 may receive encoded data (*e.g.*, a codeword) via receiver 215 and may decode the encoded data using decoder 210 to obtain the information bits.

[0054] As mentioned above, device 200 may generate a codeword of length N and dimensionality k (corresponding to the number of information bits) using a polar code. A polar code is an example of a linear block error correcting code and is the first coding technique to provably achieve channel capacity. That is, polar codes may be used to increase the probability of a successful transmission. During encoding, a set of unpolarized bit-channels may be transformed into polarized bit-channels (*e.g.*, channel instances or sub-channels) that may each be associated with a reliability metric. A reliability metric of a polarized bit-channel may approximate the ability of the polarized bit-channel to successfully convey an information bit to a receiver. Each polarized bit-channel may then be loaded with an information bit or non-information bit for a transmission based on the reliability metrics of different polarized bit-channels.

[0055] In some cases, reliability metrics may be determined based on a recursive partitioning of bit locations (*e.g.*, channel instances or sub-channels) of the polar code. In a first polarization stage, a set of unpolarized bit-channels may be polarized, and the resulting polarized bit-channels may each be associated with a reliability metric determined based on the reliability metric (or mutual information) of the unpolarized bit-channels. The polarized bit-channels may then be partitioned into sectors or groups based on the determined reliability metrics of the different polarized bit-channels. For example, the bit-channels corresponding to the single parity check operation may be partitioned into a first, lower reliability group, while the bit-channels corresponding to a repetition operation may be partitioned into a second, higher reliability group. The polarization process may continue recursively until each partition reaches a given size.

[0056] A transmitting device may identify a number of information bits for a transmission (*e.g.*, of an information bit vector), and the transmitting device may allocate or distribute the information bits to different groups of polarized bit-channels during the recursive partitioning based on a capacity of the different groups. Since the capacity of the different groups may be based on the reliability metric of different polarized bit-channels, subsets of the information bits may be distributed or allocated to different groups of polarized channels based on the reliability metrics associated with the different groups of polarized channels. The information bits may then be assigned to specific polarized bit-channels within a group based on a polarization metric (*e.g.*, polarization weight, density evolution, *etc.*). Assigning information bits within each group may be based on a predetermined ranking of bit-channels within the groups. As such, the information bits may be loaded on the polarized bit-channels associated with the highest reliability metrics, and the remaining bits (*e.g.*, parity bits and frozen bits) may be loaded on the remaining polarized bit-channels.

[0057] In some cases, however, the capacity of the unpolarized bit-channels may not be the same (*e.g.*, due to puncturing). In such cases, if a polar code does not account for punctured bits, the information bits may not be allocated or distributed to the most favorable bit locations (*i.e.*, bit location associated with the highest reliability). Accordingly, a wireless device may experience reduced throughput. Device 200 may support efficient techniques for facilitating puncturing in a polar coding scheme. Specifically, the recursive partitioning of bit-channels into polarized bit-channels may be based on the overall capacity for a transmission adjusted based on the number of bits punctured. The capacity of different sectors and groups of polarized bit-channels may thus be altered according to the adjusted polarized bit capacity, and a device may be able to allocate or distribute information bits to the most favorable bit locations.

[0058] **FIG. 3** illustrates an example of a polar coding scheme 300. In some cases, a transmitting device (*e.g.*, a base station or a UE) may identify information for a transmission to a receiving device over a channel 'W'. In some examples, the polar coding scheme 300 may be used to generate eight (8) coded bits for the transmission (*e.g.*, four (4) information bits 310 (*i.e.*, K=4) and four (4) parity and frozen bits). As shown in polar coding scheme 300, an encoding process would proceed from left to right, while polarization may be understood as occurring in polarization stages proceeding from right to left.

[0059] To ensure that the information bits transmitted by the transmitting device can be decoded by the receiving device, the transmitting device may transmit the information bits on channel instances (or sub-channels) of the channel 'W' associated with the highest reliability. In some cases, the transmitting device may identify a target mutual information (or code rate) for a transmission, and the transmitting device may use this information to encode the information bits for the transmission. In the present example, the target mutual information (or code rate) may be calculated as the number of information bits divided by the capacity of a group of bit-channels at a specific encoding stage (*e.g.*, encoding stage 315-a). As can be seen in equation 1 below, the capacity of each bit-channel at the first polarization stage 315-a corresponds to the overall capacity of the transmission.

$$Target\ Mutual\ Information = Code\ rate = \frac{K}{2^m} \quad (1)$$

Where m=log2(N) if N is the code length without puncturing. Based on the target mutual information (or code rate), the transmitting device may partition the unpolarized bit-channels 305 into groups of polarized bit-channels 320.

[0060] Specifically, the transmitting device may determine the mutual information or capacity of the polarized bit-channels based on mapping the target mutual information to a channel polarization mutual information transfer function, such as a function corresponding to the channel polarization mutual information transfer chart 350. Furthermore, the transmitting device may allocate or distribute information bits to the different polarized bit-channels based on the mutual information or capacity of the polarized bit-channels. As illustrated, the number of polarized bit-channels 320-a in each partitioned group for each polarization stage is the same. As shown in the channel polarization mutual information transfer chart, the mutual information or capacity of the polarized bit-channels 320-b may be greater than or equal to the mutual information or capacity of the polarized bit-channels 320-a, and the sum of the capacity of the polarized bit-channels 320-a and 320-b may be equal to the sum of the capacity of the un-polarized bit-channels 305.

$$Capacity(W+) \geq Capacity(W-) \quad (2)$$

$$Capacity(W+) + Capacity(W-) = 2 * Capacity(W) \quad (3)$$

[0061] Thus, the transmitting device may allocate or distribute more information bits to polarized bit-channels 320-b than to polarized bit-channels 320-a. The transmitting device may identify the distribution of the information bits between the polarized bit-channels 320 based on the following equations:

$$K0 + K1 = K \quad (4)$$

$$\frac{K0}{K1} = \frac{Cap(W-)}{Cap(W+)} \quad (5)$$

where K0 corresponds to the number of information bits (or bit locations) allocated or distributed to polarized bit-channels 320-a, and K1 corresponds to the number of information bits (or bit locations) allocated or distributed to polarized bit-channels 320-b.

[0062] In the example introduced above where K=4 and m=3, each of the unpolarized bit-channels 305 may have a capacity of 0.5 which, based on the channel polarization mutual information transfer chart 350, gives a mutual information for the polarized bit-channels 320-b of approximately 0.75 and a mutual information of the polarized bit-channels 320-a of approximately 0.25. Since mutual information corresponds to the capacity of the polarized bit-channels 320, the transmitting device may allocate or distribute three (3) bits to polarized bit-channels 320-b (*i.e.*, K1 = 3) and one (1) bit to polarized bit-channels 320-a (*i.e.*, K0 = 1).

Thus, the resulting mutual information of the group of polarized bit-channels 320-a corresponds to the following equation:

$$Mutual\ Information = \frac{K0}{2^{m-1}} = \tag{6}$$

Similarly, the resulting mutual information of the group of polarized bit-channels 320-b corresponds to the following equation:

$$Mutual\ Information = \frac{K1}{2^{m-1}} = \tag{7}$$

[0063] As illustrated, the transmitting device may then recursively partition the polarized bit-channels into groups of further polarized bit-channels based on the capacity of different partitions to identify the bit-channels with the highest reliabilities. The transmitting device may distribute or allocate the information bits to these further polarized bit-channels (*i.e.*, assign bit locations) based on the mutual information (or reliability) of the polarized bit-channels. As an example, polarized bit-channels 320-a may be further polarized into polarized bit-channels 335. The transmitting device may identify the mutual information of polarized bit-channels 320-a and use this information to partition these bit-channels into further polarized bit-channels 335. As discussed above, in the present example, the mutual information of polarized bit-channels 320-a may be 0.25 while the mutual information of polarized bit-channels 320-b may be 075.

[0064] Based on the mutual information, the transmitting device may partition the polarized bit-channels 320-a into groups of polarized bit-channels 335 using the same techniques described above. The example provided is simplified for ease of illustration and the techniques described herein may generally be applied to cases where the codeword length 'N' is above a specific threshold (*e.g.*, 32, 64, *etc.*) These techniques may be repeated recursively until the block size of a group of polarized bit-channels is below a certain threshold. An encoder may then assign a number of information bits to each group based on the reliability of the polarized bit-channels within a group.

[0065] For example, if the size of a block is less than or equal to the threshold, then a sequence may be used to determine the distribution of the allocated information bits within the group. The sequence may be derived by applying a polarization weight or by using density evolution techniques (*e.g.*, with a pre-calculated sequence). Accordingly, the bit locations of the information bits may be chosen to ensure that a receiving device can repeat the process used to determine the information bit locations. A receiving device may receive the transmission and may use similar techniques to identify the bit locations of the transmission by partitioning unpolarized bit-channels into polarized bit-channels recursively.

[0066] In some cases, however, the number of bits generated by the polar code may exceed the number of bits to be transmitted. For example, the transmitting device may puncture some bits of the encoded bits prior to transmitting the bits to a receiving device. A punctured bit may be a bit for which no information is transmitted (*e.g.*, the bit is skipped), or a bit that is used for another purpose (*e.g.*, transmission of a reference signal, *etc.*). Puncturing may include, for example, shortening puncturing (or known bit puncturing), in which a set of most significant bits (MSBs) or later-generated bits of a codeword are punctured, and block puncturing (or unknown bit puncturing), in which a set of least significant bits (LSBs) or earlier-generated bits of a codeword are punctured. To facilitate puncturing, the transmitting device may adjust the polar coding scheme based on the number of bits punctured for a transmission.

[0067] **FIG. 4** illustrates an example of a polar coding scheme 400 that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure. In some cases, a transmitting device (*e.g.*, a base station or a UE) may identify information for a transmission to a receiving device over a channel 'W'. In some examples, the polar coding scheme 400 may be used to generate eight (8) coded bits for the transmission (*e.g.*, four (4) information bits 410 (*i.e.*, K=4) and four (4) parity and frozen bits). The transmitting device may identify that a portion of bits (*e.g.*, bit 435) may be punctured for the transmission (*e.g.*, unknown bit puncturing), and the transmitting device may adjust polar coding scheme 400 based on the number of punctured bits.

[0068] To increase robustness of transmission for the information bits, the transmitting device may transmit the information bits on channel instances (or sub-channels) corresponding to the channels associated with the highest reliability. In some cases, the transmitting device may identify a target mutual information (or code rate) for a transmission, and the transmitting device may use this information to encode the information bits for the transmission. The target mutual information (or code rate) for the transmission may be adjusted to account for the puncturing. Specifically, in the present example, the mutual information of the punctured bit 435 may be set to zero (0), and the target mutual information (or code rate) may be calculated as the number of information bits divided by the capacity of a group at a corresponding encoding stage of a transmission (*e.g.*, encoding stage 415-a). As can be seen in equation 8 below, the capacity of the unpolarized bit-channels at a first encoding stage 415-a corresponds to the difference between the overall capacity of the transmission and the number of punctured bits denoted as M (*i.e.*, the number of un-punctured bits).

$$Target\ Mutual\ Information = Code\ rate = \frac{K}{2^m - M} \quad (8)$$

Based on the target mutual information (or code rate), the transmitting device may partition the unpolarized bit-channels 405 into groups of polarized bit-channels 420.

[0069] Specifically, the transmitting device may determine the mutual information or capacity of the polarized bit-channels based on mapping the target mutual information to a channel polarization mutual information transfer function, such as a function corresponding to the channel polarization mutual information transfer chart 450. Furthermore, the transmitting device may allocate or distribute information bits to the different polarized bit-channels based on the mutual information or capacity of the polarized bit-channels. As illustrated in the channel polarization mutual information transfer chart, the mutual information or capacity of each of the polarized bit-channels 420-b is greater than or equal to the capacity of corresponding ones of the polarized bit-channels 420-a, and the sum of the capacity of the polarized bit-channels may be equal to the sum of the capacity of the un-polarized bit-channels. The capacity of non-shortening based punctured bits may be set to zero.

$$Capacity(W+) > Capacity(W-) \quad (9)$$

$$C(W10) + C(W12) + C(W14) + C(W16) + C(W11) + C(W13) + C(W15) + C(W17) = 0 + C(W01) + C(W02) + C(W03) + C(W04) + C(W05) + C(W06) + C(W07) \quad (10)$$

[0070] Thus, the transmitting device may allocate or distribute information bits to polarized bit-channels 420-b and polarized bit-channels 420-a in proportion to their capacities. The transmitting device may identify the distribution of the information bits between the polarized bit-channels 420 based on the following equations:

$$K0 + K1 = K \quad (11)$$

$$\frac{K0}{K1} = \frac{C(W10) + C(W12) + C(W14) + C(W16)}{C(W11) + C(W13) + C(W15) + C(W17)} \quad (12)$$

Mutual information transfer chart 450 shows the capacity for the *W*+ and *W*- bit-channels where the capacity of the input bit-channels may be different. For a given set of two (2) capacity (or mutual information) values input on single parity check and partition input bit-channels, the capacity for mutual information transfer chart 450 will be the larger of the two values, and an alpha value may correspond to a ratio between the two values. Thus, the capacity of one input bit-channel may be a normalized common capacity and the capacity of another input bit-channel may be the normalized capacity scaled by the alpha value.

[0071] These techniques may be repeated recursively until the block size of a group of polarized bit-channels is below a certain threshold (*e.g.*, 32, 64, or 128 bit-channels, *etc.*). For example, if the size of a nested polar code is less than or equal to the threshold, then a reliability ranking calculation (e.g., polarization weight) or pre-calculated ranking may be used to determine the distribution of the allocated information bits (*i.e.*, the bit locations) within a group. The pre-calculated ranking may be derived by applying a polarization weight or by using density evolution techniques. Accordingly, the bit locations of the information bits may be chosen in a manner that can be repeated by a receiving device. A receiving device may receive the transmission and may perform similar techniques to identify the bit locations of the transmission by partitioning unpolarized bit-channels into polarized bit-channels recursively.

[0072] **FIG. 5** illustrates an example of a polar coding scheme 500 that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure. In some cases, a transmitting device (*e.g.*, a base station or a UE) may identify information for a transmission to a receiving device over a channel 'W'. In some examples, the polar coding scheme 500 may be used to generate eight (8) coded bits for the transmission (*e.g.*, four (4) information bits 510 (*i.e.*, K=4) and four (4) parity and frozen bits). The transmitting device may identify that a portion of bits (*e.g.*, bit 535) may be punctured for the transmission (*e.g.*, known bit puncturing), and the transmitting device may adjust polar coding scheme 500 based on the number of punctured bits.

[0073] To increase robustness of transmission for the information bits transmitted by the transmitting device can be decoded by the receiving device, the transmitting device may transmit the information bits on channel instances (or sub-channels) corresponding to the channels associated with the highest reliability. In some cases, the transmitting device may identify a target mutual information (or code rate) for a transmission, and the transmitting device may use this information to encode the information bits for the transmission. The target mutual information (or code rate) for the transmission may be adjusted to account for the puncturing. Specifically, in the present example, the mutual information of the punctured bit 525 may be set to one, and the target mutual information (or code rate) may be calculated as the number of information bits divided by the capacity of a group of polarized bits at a corresponding encoding stage of a transmission (*e.g.*, encoding stage 515-a). As can be seen in equation 13 below, the capacity of the unpolarized bit-channels at a first encoding stage 515-a corresponds to the difference between the overall capacity of the transmission and the number of punctured bits denoted as M (*i.e.*, the number of un-punctured bits).

$$Target\ Mutual\ Information = Code\ rate = \frac{K}{2^m - M} \quad (13)$$

Based on the target mutual information (or code rate), the transmitting device may partition the unpolarized bit-channels 505 into groups of polarized bit-channels 520.

[0074] Specifically, the transmitting device may determine the mutual information or capacity of the polarized bit-channels based on mapping the target mutual information to a channel polarization mutual information transfer function, such as a function corresponding to the channel polarization mutual information transfer chart 550. Furthermore, the transmitting device may allocate or distribute information bits to the different polarized bit-channels based on the mutual information or capacity of the polarized bit-channels. As illustrated in the channel polarization mutual information transfer chart, the mutual information or capacity of each of the polarized bit-channels 520-b is greater than or equal to the capacity of corresponding ones of the polarized bit-channels 520-a, and the sum of the capacity of the polarized bit-channels may be equal to the sum of the capacity of the un-polarized bit-channels. The capacity of shortening based punctured bits may be set to unity (a capacity value of 1).

$$Capacity(W+) > Capacity(W-) \quad (14)$$

$$C(W10) + C(W12) + C(W14) + C(W16) + C(W11) + C(W13) + C(W15) + C(W17) = C(W00) + C(W01) + C(W02) + C(W03) + C(W04) + C(W05) + C(W06) + 1 \quad (15)$$

[0075] Thus, the transmitting device may allocate or distribute information bits to polarized bit-channels 520-b and polarized bit-channels 520-a in proportion to their capacities. The transmitting device may identify the distribution of the information bits between the polarized bit-channels 520 based on the following equations:

$$K0 + K1 = K + M \quad (16)$$

$$\frac{K0}{K1} = \frac{C(W10) + C(W12) + C(W14) + C(W16)}{C(W11) + C(W13) + C(W15) + C(W17)} \quad (17)$$

[0076] For a given set of two (2) capacity (or mutual information) values input on a single parity check and partition input bit-channels, the normalized capacity will be the larger of the two values, and an alpha value may correspond to a ratio between the two values. Thus, the capacity of one bit-channel may be a normalized capacity and the capacity of another bit-channel may be the normalized capacity scaled by the alpha value.

[0077] These techniques may be repeated recursively until the block size of a group of polarized bit-channels is below a certain threshold. For example, if the size of a nested polar code is less than or equal to the threshold, then a reliability ranking calculation (e.g., polarization weight) or pre-calculated ranking may be used to determine the distribution of the allocated information bits (*i.e.,* the bit locations) within a group. The pre-calculated ranking may be derived by applying a polarization weight or by using density evolution techniques. Accordingly, the bit locations of the information bits may be chosen in a manner that can be repeated by a receiving device. A receiving device may receive the transmission and may perform similar techniques to identify the bit locations of the transmission by partitioning unpolarized bit-channels into polarized bit-channels recursively.

[0078] **FIG. 6** illustrates an example of a polar coding scheme 600 that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure. An encoder at a transmitting device may receive an input vector (U) with a set of bits (*e.g.,* U0, U1, U2, U3, U4, U5, U6, and U7), including information bits, frozen bits, and/or parity bits. The set of bits may be encoded in a codeword

Z using a polar code encoding algorithm implemented by the encoder. The polar code encoding algorithm may be implemented by a plurality of operations, including, for example, exclusive OR (XOR) operations 605 performed where the upper ends of vertical arrow segments intersect horizontal arrow segments, and repetition operations 610 performed where the lower ends of vertical arrow segments intersect horizontal arrow segments. Each XOR operation 605 and repetition operation 610 may generate an output, and the XOR operations 605 and repetition operations 610 may be performed on a number of interconnected bit-channels to generate the codeword Z.

[0079] The codeword Z includes a set of bits (*e.g.*, Z0, Z1, Z2, Z3, Z4, Z5, Z6, and Z7) that may be transmitted over a physical channel. Codeword Y includes bits Y0, Y1, Y2, Y3, Y4, Y5, Y6, and Y7, which may be in a bit-reversed order compared to the bits of the codeword Z. The transmitter may transmit codeword Z (non-bit-reversed) or codeword Y (bit-reversed). In some cases, the codewords Y or Z may be punctured in accordance with a non-shortening puncturing scheme before the bits are transmitted. Unknown bit puncturing is one form of non-shortening puncturing, and involves refraining from transmitting a set of least significant bits (LSBs) of the codeword Z (*e.g.*, LSBs Z0, Z1, and Z2). The set of LSBs that are punctured are bits of the codeword Z that are dependent on the computation of other bits of the codeword Z. As illustrated, the puncture of a contiguous set of three (3) LSBs of codeword Z results in a puncture of a non-contiguous set of bits in codeword Y. Block puncturing may refer to puncturing of a contiguous set of bit locations in codeword Z. Polar coding scheme 700 may implement similar techniques to those described with reference to FIG. 4 to accommodate puncturing in the encoding process.

[0080] **FIG. 7** illustrates an example of a polar coding scheme 700 that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure. An encoder at a transmitting device may receive an input vector (U) with a set of bits (*e.g.*, U0, U1, U2, U3, U4, U5, U6, and U7) including information bits, frozen bits, and/or parity bits. The set of bits may be encoded in a codeword Z using a polar code encoding algorithm implemented by the encoder. The polar code encoding algorithm may be implemented by a plurality of operations, including, for example, XOR operations 705 performed where the upper ends of vertical arrow segments intersect horizontal arrow segments, and repetition operations 710 performed where the lower ends of vertical arrow segments intersect horizontal arrow segments. Each XOR operation 705 and repetition operation 710 may generate an output, and the XOR operations 705 and repetition operations 710 may be performed on a number of interconnected bit-channels to generate the codeword Z.

[0081] The codeword Z includes a set of bits (*e.g.*, Z0, Z1, Z2, Z3, Z4, Z5, Z6, and Z7) that may be transmitted over a physical channel. Codeword Y includes bits Y0, Y1, Y2, Y3, Y4, Y5, Y6, and Y7, which may be in a bit-reversed order compared to the bits of the codeword Z. The transmitter may transmit codeword Z (non-bit-reversed) or codeword Y (bit-reversed). In some cases, the codewords Y or Z may be punctured in accordance with a shortening puncturing scheme before the bits are transmitted. In the present example, shortening (or known bit puncturing) may include the puncturing of a set of MSBs of the codeword Z and zeroing of corresponding locations in U with the same indices. In some examples, zeroing may be equivalent to any known bit value (*e.g.*, a logic 0 or a logic 1). As illustrated, the puncturing of a contiguous set of three (3) MSBs of codeword Z results in the puncturing of a non-contiguous set of bits in codeword Y. This type of puncturing may be referred to as natural order shortening. Polar coding scheme 700 may implement similar techniques to those described with reference to FIG. 5 to accommodate puncturing in the encoding process.

[0082] **FIG. 8** illustrates an example of a polar coding scheme 800 that supports a mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure. An encoder at a transmitting device may receive an input vector (U) with a set of bits (*e.g.*, U0, U1, U2, U3, U4, U5, U6, and U7) including information bits, frozen bits, and/or parity bits. The set of bits may be encoded in a codeword Z using a polar code encoding algorithm implemented by the encoder. The polar code encoding algorithm may be implemented by a plurality of operations, including, for example, XOR operations 805 performed where the upper ends of vertical arrow segments intersect horizontal arrow segments, and repetition operations 810 performed where the lower ends of vertical arrow segments intersect horizontal arrow segments. Each XOR operation 805 and repetition operation 810 may generate an output, and the XOR operations 805 and repetition operations 810 may be performed on a number of interconnected bit-channels to generate the codeword Z.

[0083] The codeword Z includes a set of bits (*e.g.*, Z0, Z1, Z2, Z3, Z4, Z5, Z6, and Z7) that may be transmitted over a physical channel. Codeword Y includes bits Y0, Y1, Y2, Y3, Y4, Y5, Y6, and Y7, which may be in a bit-reversed order compared to the bits of the codeword Z. The transmitter may transmit codeword Z (non-bit-reversed) or codeword Y (bit-reversed). In some cases, the codewords Y or Z may be punctured in accordance with a shortening puncturing scheme before the bits are transmitted. In the present example, shortening (or known bit puncturing) may include the puncturing of a set of MSBs of the codeword Y and zeroing of corresponding locations in U with the indices that are bit-reversed compared to the bit locations zeroed in codeword Y. In some examples, zeroing may be equivalent to any known bit value (*e.g.*, a logic 0 or a logic 1). As illustrated, the puncturing of a contiguous set of three (3) MSBs of codeword Y results in the puncturing of a non-contiguous set of bits in codeword Z. This type of puncturing may be referred to as bit-reversed order shortening. Polar coding scheme 800 may implement similar techniques to those described with reference to FIG. 5 to accommodate puncturing in the encoding process.

[0084] **FIG. 9** illustrates an example of a channel polarization mutual information transfer function that supports mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure. The mutual information transfer function may be used to derive channel polarization mutual information transfer chart with uneven input mutual information 900-a. As described with reference to FIGs. 3-5, the channel polarization mutual information transfer function may be used to determine the mutual information of polarized bit-channels (*e.g.*, polarized bit-channels W+ and W-) based on the mutual information of a bit-channel 'W.' Similarly, the channel polarization mutual information transfer function may be used to recursively determine the mutual information of polarized bit-channels. In some cases, however, the computational complexity associated with a mutual information transfer function (*e.g.*, such as those described with reference to FIGs. 4 and 5) may be high, which may be detrimental to implementations at a UE. Thus, less computationally complex mutual information transfer functions may be desirable.

[0085] Mutual information transfer function may be less computationally complex than other mutual information transfer functions (*e.g.*, such as those described with reference to FIGs. 4 and 5). Mutual information transfer function may be derived based on a BEC, whereas other mutual information transfer functions may be derived based on an additive white Gaussian noise (AWGN) channel. Computation 900-b is associated with mutual information transfer chart 900-a and shows the relationship between the BEC capacity of input bit-channels and the BEC capacity of output polarized bit-channels. Computation 900-b illustrates the simplicity of the computation used to derive the capacity of polarized bit-channels as compared to computations associated with other mutual information transfer functions. In some cases, however, the mutual information transfer function described in the present example may not align with other mutual information transfer functions derived based on an AWGN channel.

[0086] **FIG. 10** illustrates an example of a channel polarization mutual information transfer function comparison and correction 1000 that supports mutual-information based recursive polar code construction in accordance with various aspects of the present disclosure. As illustrated in mutual information transfer chart 1000-a, the mutual information transfer chart derived based on a BEC does not align with the mutual information transfer chart derived based on a AWGN channel. Accordingly, an encoder may apply a correction term to the mutual information transfer function derived based on the BEC to align the functions. Specifically, the output capacity of the mutual information transfer function derived based on the BEC

$$Output\ Capacity = (\alpha + 1)C - \alpha C^2 \tag{18}$$

may be adjusted by a correction term to align the graphs to give

$$Output\ Capacity = (\alpha + 1)C - \alpha C^2 - \delta \tag{19}$$

where

$$\delta = (F1e^{F2} * abs(C + F3) + F4e^{F5}) * \alpha \tag{20}$$

corresponds to an example of the correction term, and C corresponds to a capacity of a bit-channel or mutual information associated with a bit-channel. In some examples, the factors in the equation above may be defined as follows: F1=-4, F2=-2, F3=-0.5, F4=2, and F5=-2.

[0087] **FIG. 11** shows a block diagram 1100 of a wireless device 1105 that supports mutual-information based recursive polar code construction in accordance with aspects of the present disclosure. Wireless device 1105 may be an example of aspects of a UE 115 or base station 105 as described with reference to FIG. 1. Wireless device 1105 may include receiver 1110, communications manager 1115, and transmitter 1120. wireless device 1105 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0088] Receiver 1110 may receive signaling via an antenna. In some examples, the signaling may be encoded in one or more codewords using a polar code. The receiver may process the signaling (e.g., downconversion, filtering, analog-to-digital conversion, baseband processing) and may pass the processed signaling on to other components of the wireless device. The receiver 1110 may be an example of aspects of the transceiver 1435 described with reference to FIG. 14. The receiver 1110 may utilize a single antenna or a set of antennas.

[0089] Communications manager 1115 may be an example of aspects of the communications manager 1415 described with reference to FIG. 14. Communications manager 1115 and/or at least some of its various sub-components may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions of the communications manager 1115 and/or at least some of its various sub-components may be executed by a general-purpose processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), an field-programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described in the present disclosure.

[0090] The communications manager 1115 and/or at least some of its various sub-components may be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations by one or more physical devices. In some examples, communications manager 1115 and/or at least some of its various sub-components may be a separate and distinct component in accordance with various aspects of the present disclosure. In other examples, communications manager 1115 and/or at least some of its various sub-components may be combined with one or more other hardware components, including but not limited to an I/O component, a transceiver, a network server, another computing device, one or more other components described in the present disclosure, or a combination thereof in accordance with various aspects of the present disclosure.

[0091] Communications manager 1115 may identify a set of punctured bit locations in the received codeword, identify a set of bit locations of the polar code used for information bits for the encoding, where the set of bit locations is determined based on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and where a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, and decode the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0092] The communications manager 1115 may also identify a set of bit locations of the polar code used for information bits for the encoding, where the set of bit locations is determined based on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and where the mutual information transfer function is based on a BEC function and a correction term and process the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

[0093] The communications manager 1115 may also identify a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code, identify a set of bit locations of the polar code to be used for information bits of the information bit vector, where the set of bit locations is determined based on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and where a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword, and encode the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword.

[0094] The communications manager 1115 may also identify an information bit vector for encoding using a polar code, identify a set of bit locations of the polar code to be used for information bits of the information bit vector, where the set of bit locations is determined based on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and where the mutual information transfer function is based on a BEC function and a correction term, and encode the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword.

[0095] Transmitter 1120 may transmit signals generated by other components of the device. In some examples, the transmitter 1120 may be collocated with a receiver 1110 in a transceiver module. For example, the transmitter 1120 may be an example of aspects of the transceiver 1435 described with reference to FIG. 14. The transmitter 1120 may utilize a single antenna or a set of antennas. Transmitter 1120 may transmit the codeword over a wireless channel, where, in some cases, the transmitting includes puncturing the codeword at the set of punctured bit locations.

[0096] **FIG. 12** shows a block diagram 1200 of a wireless device 1205 that supports mutual-information based recursive polar code construction in accordance with aspects of the present disclosure. Wireless device 1205 may be an example of aspects of a wireless device 1105 or a UE 115 or base station 105 as described with reference to FIGs. 1 and 11. wireless device 1205 may include receiver 1210, communications manager 1215, and transmitter 1220. wireless device 1205 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0097] Receiver 1210 may receive signaling via an antenna. In some examples, the signaling may be encoded in one or more codewords using a polar code. The receiver may process the signaling (e.g., downconversion, filtering, analog-to-digital conversion, baseband processing) and may pass the processed signaling on to other components of the wireless device. The receiver 1210 may be an example of aspects of the transceiver 1435 described with reference to FIG. 14. The receiver 1210 may utilize a single antenna or a set of antennas.

[0098] Communications manager 1215 may be an example of aspects of the communications manager 1415 described with reference to FIG. 14. Communications manager 1215 may include punctured bit location identifier 1225, information bit location identifier 1230, decoder 1235, encoder 1240, and information bit vector identifier 1245.

[0099] In some cases, punctured bit location identifier 1225 may identify a set of punctured bit locations in a received codeword, and, in other cases, punctured bit location identifier 1225 may identify a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code.

[0100] Information bit location identifier 1230 may identify a set of bit locations of the polar code used for (or to be used for) information bits for the encoding, where the set of bit locations is determined based on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and where a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword. In some cases, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

[0101] In some cases, information bit location identifier 1230 may identify a set of bit locations of the polar code to be used for (or used for) information bits of an information bit vector, where the set of bit locations is determined based on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions. In some cases, a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword. In some cases, the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

[0102] In some cases, the mutual information transfer function is based on a BEC function and a correction term. In some cases, the correction term includes an offset applied to the scaled and offset bit-channel capacity. In some cases, the mutual information transfer function is based on a BEC function and a correction term. In some cases, the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor. In some cases, the correction term includes an offset factor applied to the bit-channel capacity. In some cases, the correction term includes a scaling factor applied to the offset bit-channel capacity. In some cases, the correction term includes an offset applied to the scaled and offset bit-channel capacity.

[0103] Decoder 1235 may decode the received codeword according to the polar code to obtain an information bit vector at the set of bit locations and process the received codeword according to the polar code to obtain an information bit vector at the set of bit locations. Encoder 1240 may encode the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword and encode the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword. Information bit vector identifier 1245 may identify an information bit vector for encoding using a polar code.

[0104] Transmitter 1220 may transmit signals generated by other components of the device. In some examples, the transmitter 1220 may be collocated with a receiver 1210 in a transceiver module. For example, the transmitter 1220 may be an example of aspects of the transceiver 1435 described with reference to FIG. 14. The transmitter 1220 may utilize a single antenna or a set of antennas.

[0105] **FIG. 13** shows a block diagram 1300 of a communications manager 1315 that supports mutual-information based recursive polar code construction in accordance with aspects of the present disclosure. The communications manager 1315 may be an example of aspects of a communications manager 1115, a communications manager 1215, or a communications manager 1415 described with reference to FIGs. 11, 12, and 14. The communications manager 1315 may include punctured bit location identifier 1320, information bit location identifier 1325, decoder 1330, encoder 1335, information bit vector identifier 1340, unknown bit puncturing manager 1345, and known bit puncturing manager 1350. Each of these modules may communicate, directly or indirectly, with one another (e.g., via one or more buses).

[0106] In some cases, punctured bit location identifier 1320 may identify a set of punctured bit locations in the received codeword, and, in other cases, punctured bit location identifier 1320 may identify a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code.

[0107] Information bit location identifier 1330 may identify a set of bit locations of the polar code used for (or to be used for) information bits for the encoding, where the set of bit locations is determined based on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and where a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword. In some cases, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

[0108] In some cases, information bit location identifier 1330 may identify a set of bit locations of the polar code to be used for (or used for) information bits of an information bit vector, where the set of bit locations is determined based on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions. In some cases, a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword. In some cases, the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

[0109] In some cases, the mutual information transfer function is based on a BEC function and a correction term. In some cases, the correction term includes an offset applied to the scaled and offset bit-channel capacity. In some cases, the mutual information transfer function is based on a BEC function and a correction term. In some cases, the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor. In some cases, the correction term includes an offset factor applied to the bit-channel capacity. In some cases, the correction term includes a scaling factor applied to the offset bit-channel capacity. In some cases, the correction term includes an offset applied to the scaled and offset bit-channel capacity.

[0110] Decoder 1330 may decode the received codeword according to the polar code to obtain an information bit vector at the set of bit locations and process the received codeword according to the polar code to obtain an information bit vector at the set of bit locations. Encoder 1335 may encode the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword and encode the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword. Information bit vector identifier 1340 may identify an information bit vector for encoding using a polar code.

[0111] Unknown bit puncturing manager 1345 may identify a set of bits punctured (or to be punctured) in a transmission. In some cases, the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword. In some cases, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to zero. In some cases, the non-shortening based puncturing includes block puncturing.

[0112] Known bit puncturing manager 1350 may identify a set of bits punctured (or to be punctured) in a transmission. In some cases, the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and a number of the punctured bit locations is added to the number of the information bits for assigning to the bit-channel partitions for the first recursive partitioning. In some cases, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to unity. In some cases, the identifying the set of bit locations includes shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations.

[0113] **FIG. 14** shows a diagram of a system 1400 including a device 1405 that supports mutual-information based recursive polar code construction in accordance with aspects of the present disclosure. Device 1405 may be an example of or include the components of wireless device 1105, wireless device 1205, or a UE 115 as described above, e.g., with reference to FIGs. 1, 11 and 12. Device 1405 may include components for bi-directional voice and data communications including components for transmitting and receiving communications, including UE communications manager 1415, processor 1420, memory 1425, software 1430, transceiver 1435, antenna 1440, and I/O controller 1445. These components may be in electronic communication via one or more busses (e.g., bus 1410). Device 1405 may communicate wirelessly with one or more base stations 105.

[0114] Processor 1420 may include an intelligent hardware device, (e.g., a general-purpose processor, a DSP, a central processing unit (CPU), a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some cases, processor 1420 may be configured to operate a memory array using a memory controller. In other cases, a memory controller may be integrated into processor 1420. Processor 1420 may be configured to execute computer-readable instructions stored in a memory to perform various functions (e.g., functions or tasks supporting mutual-information based recursive polar code construction).

[0115] Memory 1425 may include random access memory (RAM) and read only memory (ROM). The memory 1425 may store computer-readable, computer-executable software 1430 including instructions that, when executed, cause the processor to perform various functions described herein. In some cases, the memory 1425 may contain, among other things, a basic input/output system (BIOS) which may control basic hardware and/or software operation such as the interaction with peripheral components or devices.

[0116] Software 1430 may include code to implement aspects of the present disclosure, including code to support mutual-information based recursive polar code construction. Software 1430 may be stored in a non-transitory computer-readable medium such as system memory or other memory. In some cases, the software 1430 may not be directly executable by the processor but may cause a computer (e.g., when compiled and executed) to perform functions described herein.

[0117] Transceiver 1435 may communicate bi-directionally, via one or more antennas, wired, or wireless links as described above. For example, the transceiver 1435 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 1435 may also include a modem to modulate the packets and provide the modulated packets to the antennas for transmission, and to demodulate packets received from the antennas.

[0118] In some cases, the wireless device may include a single antenna 1440. However, in some cases the device may have more than one antenna 1440, which may be capable of concurrently transmitting or receiving multiple wireless transmissions.

[0119] I/O controller 1445 may manage input and output signals for device 1405. I/O controller 1445 may also manage peripherals not integrated into device 1405. In some cases, I/O controller 1445 may represent a physical connection or port to an external peripheral. In some cases, I/O controller 1445 may utilize an operating system such as iOS®, ANDROID®, MS-DOS®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In other cases, I/O controller 1445 may represent or interact with a modem, a keyboard, a mouse, a touchscreen, or a similar device. In some cases, I/O controller 1445 may be implemented as part of a processor. In some cases, a user may interact with device 1405 via I/O controller 1445 or via hardware components controlled by I/O controller 1445.

[0120] **FIG. 15** shows a diagram of a system 1500 including a device 1505 that supports mutual-information based recursive polar code construction in accordance with aspects of the present disclosure. Device 1505 may be an example of or include the components of wireless device 1205, wireless device 1305, or a base station 105 as described above, e.g., with reference to FIGs. 1, 12 and 13. Device 1505 may include components for bi-directional voice and data communications including components for transmitting and receiving communications, including base station communications manager 1515, processor 1520, memory 1525, software 1530, transceiver 1535, antenna 1540, network communications manager 1545, and inter-station communications manager 1550. These components may be in electronic communication via one or more busses (e.g., bus 1510). Device 1505 may communicate wirelessly with one or more UEs 115.

[0121] Processor 1520 may include an intelligent hardware device, (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some cases, processor 1520 may be configured to operate a memory array using a memory controller. In other cases, a memory controller may be integrated into processor 1520. Processor 1520 may be configured to execute computer-readable instructions stored in a memory to perform various functions (e.g., functions or tasks supporting mutual-information based recursive polar code construction).

[0122] Memory 1525 may include RAM and ROM. The memory 1525 may store computer-readable, computer-executable software 1530 including instructions that, when executed, cause the processor to perform various functions described herein. In some cases, the memory 1525 may contain, among other things, a BIOS which may control basic hardware and/or software operation such as the interaction with peripheral components or devices.

[0123] Software 1530 may include code to implement aspects of the present disclosure, including code to support mutual-information based recursive polar code construction. Software 1530 may be stored in a non-transitory computer-readable medium such as system memory or other memory. In some cases, the software 1530 may not be directly executable by the processor but may cause a computer (e.g., when compiled and executed) to perform functions described herein.

[0124] Transceiver 1535 may communicate bi-directionally, via one or more antennas, wired, or wireless links as described above. For example, the transceiver 1535 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 1535 may also include a modem to modulate the packets and provide the modulated packets to the antennas for transmission, and to demodulate packets received from the antennas.

[0125] In some cases, the wireless device may include a single antenna 1540. However, in some cases the device may have more than one antenna 1540, which may be capable of concurrently transmitting or receiving multiple wireless transmissions.

[0126] Network communications manager 1545 may manage communications with the core network (e.g., via one or more wired backhaul links). For example, the network communications manager 1545 may manage the transfer of data communications for client devices, such as one or more UEs 115.

[0127] Inter-station communications manager 1550 may manage communications with other base station 105, and may include a controller or scheduler for controlling communications with UEs 115 in cooperation with other base stations 105. For example, the inter-station communications manager 1550 may coordinate scheduling for transmissions to UEs 115 for various interference mitigation techniques such as beamforming or joint transmission. In some examples, inter-station communications manager 1550 may provide an X2 interface within an Long Term Evolution (LTE)/LTE-A wireless communication network technology to provide communication between base stations 105.

[0128] **FIG. 16** shows a flowchart illustrating a method 1600 for mutual-information based recursive polar code construction in accordance with aspects of the present disclosure. The operations of method 1600 may be implemented by a UE 115 or base station 105 or its components as described herein. For example, the operations of method 1600 may be performed by a communications manager as described with reference to FIGs. 11 through 13. In some examples, a UE 115 or base station 105 may execute a set of codes to control the functional elements of the device to perform the functions described below. Additionally or alternatively, the UE 115 or base station 105 may perform aspects of the functions described below using special-purpose hardware.

[0129] At block 1605 the UE 115 or base station 105 may receive a codeword over a wireless channel, the codeword being encoded using a polar code. The operations of block 1605 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1605 may be performed by a receiver as described with reference to FIGs. 11 through 13.

[0130] At block 1610 the UE 115 or base station 105 may identify a set of punctured bit locations in the received codeword. The operations of block 1610 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1610 may be performed by a punctured bit location identifier as described with reference to FIGs. 11 through 13.

[0131] At block 1615 the UE 115 or base station 105 may identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword. The operations of block 1615 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1615 may be performed by an information bit location identifier as described with reference to FIGs. 11 through 13.

[0132] At block 1620 the UE 115 or base station 105 may decode the received codeword according to the polar code to obtain an information bit vector at the set of bit locations. The operations of block 1620 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1620 may be performed by a decoder as described with reference to FIGs. 11 through 13.

[0133] **FIG. 17** shows a flowchart illustrating a method 1700 for mutual-information based recursive polar code construction in accordance with aspects of the present disclosure. The operations of method 1700 may be implemented by a UE 115 or base station 105 or its components as described herein. For example, the operations of method 1700 may be performed by a communications manager as described with reference to FIGs. 11 through 13.

In some examples, a UE 115 or base station 105 may execute a set of codes to control the functional elements of the device to perform the functions described below. Additionally or alternatively, the UE 115 or base station 105 may perform aspects of the functions described below using special-purpose hardware.

[0134] At block 1705 the UE 115 or base station 105 may receive a codeword that is encoded using a polar code. The operations of block 1705 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1705 may be performed by a receiver as described with reference to FIGs. 11 through 13.

[0135] At block 1710 the UE 115 or base station 105 may identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term. The operations of block 1710 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1710 may be performed by an information bit location identifier as described with reference to FIGs. 11 through 13.

[0136] At block 1715 the UE 115 or base station 105 may process the received codeword according to the polar code to obtain an information bit vector at the set of bit locations. The operations of block 1715 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1715 may be performed by a decoder as described with reference to FIGs. 11 through 13.

[0137] **FIG. 18** shows a flowchart illustrating a method 1800 for mutual-information based recursive polar code construction in accordance with aspects of the present disclosure. The operations of method 1800 may be implemented by a UE 115 or base station 105 or its components as described herein. For example, the operations of method 1800 may be performed by a communications manager as described with reference to FIGs. 11 through 13. In some examples, a UE 115 or base station 105 may execute a set of codes to control the functional elements of the device to perform the functions described below. Additionally or alternatively, the UE 115 or base station 105 may perform aspects of the functions described below using special-purpose hardware.

[0138] At block 1805 the UE 115 or base station 105 may identify a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code. The operations of block 1805 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1805 may be performed by a punctured bit location identifier as described with reference to FIGs. 11 through 13.

[0139] At block 1810 the UE 115 or base station 105 may identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword. The operations of block 1810 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1810 may be performed by an information bit location identifier as described with reference to FIGs. 11 through 13.

[0140] At block 1815 the UE 115 or base station 105 may encode the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword. The operations of block 1815 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1815 may be performed by a encoder as described with reference to FIGs. 11 through 13.

[0141] At block 1820 the UE 115 or base station 105 may transmit the codeword over a wireless channel, wherein the transmitting comprises puncturing the codeword at the set of punctured bit locations. The operations of block 1820 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1820 may be performed by a transmitter as described with reference to FIGs. 11 through 13.

[0142] **FIG. 19** shows a flowchart illustrating a method 1900 for mutual-information based recursive polar code construction in accordance with aspects of the present disclosure. The operations of method 1900 may be implemented by a UE 115 or base station 105 or its components as described herein. For example, the operations of method 1900 may be performed by a communications manager as described with reference to FIGs. 11 through 13. In some examples, a UE 115 or base station 105 may execute a set of codes to control the functional elements of the device to perform the functions described below. Additionally or alternatively, the UE 115 or base station 105 may perform aspects of the functions described below using special-purpose hardware.

[0143] At block 1905 the UE 115 or base station 105 may identify an information bit vector for encoding using a polar code. The operations of block 1905 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1905 may be performed by an information bit vector identifier as described with reference to FIGs. 11 through 13.

[0144] At block 1910 the UE 115 or base station 105 may identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a BEC function and a correction term. The operations of block 1910 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1910 may be performed by an information bit location identifier as described with reference to FIGs. 11 through 13.

[0145] At block 1915 the UE 115 or base station 105 may encode the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword. The operations of block 1915 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1915 may be performed by a encoder as described with reference to FIGs. 11 through 13.

[0146] At block 1920 the UE 115 or base station 105 may transmit the codeword over a wireless channel. The operations of block 1920 may be performed according to the methods described with reference to FIGs. 1 through 10. In certain examples, aspects of the operations of block 1920 may be performed by a transmitter as described with reference to FIGs. 11 through 13.

[0147] It should be noted that the methods described above describe possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Furthermore, aspects from two or more of the methods may be combined.

[0148] Techniques described herein may be used for various wireless communications systems such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), and other systems. The terms "system" and "network" are often used interchangeably. A code division multiple access (CDMA) system may implement a radio technology such as CDMA2000, Universal Terrestrial Radio Access (UTRA), etc. CDMA2000 covers IS-2000, IS-95, and IS-856 standards. IS-2000 Releases may be commonly referred to as CDMA2000 1X, 1X, etc. IS-856 (TIA-856) is commonly referred to as CDMA2000 1xEV-DO, High Rate Packet Data (HRPD), etc. UTRA includes Wideband CDMA (WCDMA) and other variants of CDMA. A time division multiple access (TDMA) system may implement a radio technology such as Global System for Mobile Communications (GSM).

[0149] An orthogonal frequency division multiple access (OFDMA) system may implement a radio technology such as Ultra Mobile Broadband (UMB), Evolved UTRA (E-UTRA), Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, etc. UTRA and E-UTRA are part of Universal Mobile Telecommunications system (UMTS). 3GPP Long Term Evolution (LTE) and LTE-Advanced (LTE-A) are releases of Universal Mobile Telecommunications System (UMTS) that use E-UTRA. UTRA, E-UTRA, UMTS, LTE, LTE-A, NR, and Global System for Mobile communications (GSM) are described in documents from the organization named "3rd Generation Partnership Project" (3GPP). CDMA2000 and UMB are described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). The techniques described herein may be used for the systems and radio technologies mentioned above as well as other systems and radio technologies. While aspects an LTE or an NR system may be described for purposes of example, and LTE or NR terminology may be used in much of the description, the techniques described herein are applicable beyond LTE or NR applications.

[0150] In LTE/LTE-A networks, including such networks described herein, the term evolved node B (eNB) may be generally used to describe the base stations. The wireless communications system or systems described herein may include a heterogeneous LTE/LTE-A or NR network in which different types of evolved node B (eNBs) provide coverage for various geographical regions. For example, each eNB, gNB or base station may provide communication coverage for a macro cell, a small cell, or other types of cell. The term "cell" may be used to describe a base station, a carrier or component carrier associated with a base station, or a coverage area (e.g., sector, etc.) of a carrier or base station, depending on context.

[0151] Base stations may include or may be referred to by those skilled in the art as a base transceiver station, a radio base station, an access point, a radio transceiver, a NodeB, eNodeB (eNB), next generation NodeB (gNB), Home NodeB, a Home eNodeB, or some other suitable terminology. The geographic coverage area for a base station may be divided into sectors making up only a portion of the coverage area. The wireless communications system or systems described herein may include base stations of different types (e.g., macro or small cell base stations). The UEs described herein may be able to communicate with various types of base stations and network equipment including macro eNBs, small cell eNBs, gNBs, relay base stations, and the like. There may be overlapping geographic coverage areas for different technologies.

[0152] A macro cell generally covers a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by UEs with service subscriptions with the network provider. A small cell is a lower-powered base station, as compared with a macro cell, that may operate in the same or different (e.g., licensed, unlicensed, etc.) frequency bands as macro cells. Small cells may include pico cells, femto cells, and micro cells according to various examples. A pico cell, for example, may cover a small geographic area and may allow unrestricted access by UEs with service subscriptions with the network provider. A femto cell may also cover a small geographic area (e.g., a home) and may provide restricted access by UEs having an association with the femto cell (e.g., UEs in a closed subscriber group (CSG), UEs for users in the home, and the like). An eNB for a macro cell may be referred to as a macro eNB. An eNB for a small cell may be referred to as a small cell eNB, a pico eNB, a femto eNB, or a home eNB. An eNB may support one or multiple (e.g., two, three, four, and the like) cells (e.g., component carriers).

[0153] The wireless communications system or systems described herein may support synchronous or asynchronous operation. For synchronous operation, the base stations may have similar frame timing, and transmissions from different base stations may be approximately aligned in time. For asynchronous operation, the base stations may have different frame timing, and transmissions from different base stations may not be aligned in time. The techniques described herein may be used for either synchronous or asynchronous operations.

[0154] The downlink transmissions described herein may also be called forward link transmissions while the uplink transmissions may also be called reverse link transmissions. Each communication link described herein—including, for example, wireless communications system 100 and 200 of FIGs. 1 and 2—may include one or more carriers, where each carrier may be a signal made up of multiple sub-carriers (e.g., waveform signals of different frequencies).

[0155] The description set forth herein, in connection with the appended drawings, describes example configurations and does not represent all the examples that may be implemented or that are within the scope of the claims. The term "exemplary" used herein means "serving as an example, instance, or illustration," and not "preferred" or "advantageous over other examples." The detailed description includes specific details for the purpose of providing an understanding of the described techniques. These techniques, however, may be practiced without these specific details. In some instances, well-known structures and devices are shown in block diagram form in order to avoid obscuring the concepts of the described examples.

[0156] In the appended figures, similar components or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If just the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

[0157] Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0158] The various illustrative blocks and modules described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration).

[0159] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described above can be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations. Also, as used herein, including in the claims, "or" as used in a list of items (for example, a list of items prefaced by a phrase such as "at least one of" or "one or more of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an exemplary step that is described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on."

[0160] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that can be accessed by a general purpose or special purpose computer. By way of example, and not limitation, non-transitory computer-readable media may comprise RAM, ROM, electrically erasable programmable read only memory (EEPROM), compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that can be used to carry or store desired program code means in the form of instructions or data structures and that can be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, include CD, laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above are also included within the scope of computer-readable media.

[0161] The description herein is provided to enable a person skilled in the art to make or use the disclosure. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein, but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A method for wireless communication, comprising:

receiving a codeword over a wireless channel, the codeword being encoded using a polar code;

identifying a set of punctured bit locations in the received codeword;

identifying a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword; and

decoding the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

2. The method of claim 1, wherein the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

3. The method of claim 2, wherein the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword.

4. The method of claim 3, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to zero.

5. The method of claim 3, wherein the non-shortening based puncturing comprises block puncturing.

6. The method of claim 1, wherein, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

7. The method of claim 1, wherein the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and wherein a number of the punctured bit locations is added to the number of the information bits for assigning to the bit-channel partitions for the first recursive partitioning.

8. The method of claim 7, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to unity.

9. The method of claim 7, wherein the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations.

10. The method of claim 1, wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term.

11. A method for wireless communication, comprising:

receiving a codeword that is encoded using a polar code;

identifying a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term; and

processing the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

12. The method of claim 11, wherein the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor.

13. The method of claim 12, wherein the correction term comprises an offset factor applied to the bit-channel capacity.

14. The method of claim 13, wherein the correction term comprises a scaling factor applied to the offset bit-channel capacity.

15. The method of claim 14, wherein the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

16. A method for wireless communication, comprising:

identifying a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code;

identifying a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword;

encoding the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword; and

transmitting the codeword over a wireless channel, wherein the transmitting comprises puncturing the codeword at the set of punctured bit locations.

17. The method of claim 16, wherein the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

18. The method of claim 17, wherein the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword.

19. The method of claim 18, wherein the non-shortening based puncturing comprises block puncturing.

20. The method of claim 17, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to zero.

21. The method of claim 16, wherein, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

22. The method of claim 16, wherein the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and wherein a number of the punctured bit locations is added to the number of information bits for assigning to the bit-channel partitions for the first recursive partitioning.

23. The method of claim 22, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to unity.

24. The method of claim 22, wherein the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations.

25. The method of claim 16, wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term.

26. A method for wireless communication, comprising:

identifying an information bit vector for encoding using a polar code;

identifying a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term;

encoding the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword; and

transmitting the codeword over a wireless channel.

27. The method of claim 26, wherein the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor.

28. The method of claim 27, wherein the correction term comprises an offset factor applied to the bit-channel capacity.

29. The method of claim 28, wherein the correction term comprises a scaling factor applied to the offset bit-channel capacity.

30. The method of claim 29, wherein the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

31. An apparatus for wireless communication, comprising:

means for receiving a codeword over a wireless channel, the codeword being encoded using a polar code;

means for identifying a set of punctured bit locations in the received codeword;

means for identifying a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword; and

means for decoding the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

32. The apparatus of claim 31, wherein the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

33. The apparatus of claim 32, wherein the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword.

34. The apparatus of claim 33, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to zero.

35. The apparatus of claim 33, wherein the non-shortening based puncturing comprises block puncturing.

36. The apparatus of claim 31, wherein, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

37. The apparatus of claim 31, wherein the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and wherein a number of the punctured bit locations is added to the number of the information bits for assigning to the bit-channel partitions for the first recursive partitioning.

38. The apparatus of claim 37, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to unity.

39. The apparatus of claim 37, wherein the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations.

40. The apparatus of claim 31, wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term.

41. An apparatus for wireless communication, comprising:

means for receiving a codeword that is encoded using a polar code;

means for identifying a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term; and means for processing the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

42. The apparatus of claim 41, wherein the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor.

43. The apparatus of claim 42, wherein the correction term comprises an offset factor applied to the bit-channel capacity.

44. The apparatus of claim 43, wherein the correction term comprises a scaling factor applied to the offset bit-channel capacity.

45. The apparatus of claim 44, wherein the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

46. An apparatus for wireless communication, comprising:

means for identifying a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code;

means for identifying a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword;

means for encoding the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword; and

means for transmitting the codeword over a wireless channel, wherein the transmitting comprises puncturing the codeword at the set of punctured bit locations.

47. The apparatus of claim 46, wherein the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

48. The apparatus of claim 47, wherein the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword.

49. The apparatus of claim 48, wherein the non-shortening based puncturing comprises block puncturing.

50. The apparatus of claim 47, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to zero.

51. The apparatus of claim 46, wherein, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

52. The apparatus of claim 46, wherein the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and wherein a number of the punctured bit locations is added to the number of information bits for assigning to the bit-channel partitions for the first recursive partitioning.

53. The apparatus of claim 52, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to unity.

54. The apparatus of claim 52, wherein the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations.

55. The apparatus of claim 46, wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term.

56. An apparatus for wireless communication, comprising:

means for identifying an information bit vector for encoding using a polar code;

means for identifying a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term;

means for encoding the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword; and

means for transmitting the codeword over a wireless channel.

57. The apparatus of claim 56, wherein the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor.

58. The apparatus of claim 57, wherein the correction term comprises an offset factor applied to the bit-channel capacity.

59. The apparatus of claim 58, wherein the correction term comprises a scaling factor applied to the offset bit-channel capacity.

60. The apparatus of claim 59, wherein the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

61. An apparatus for wireless communication, in a system comprising:

a processor;

memory in electronic communication with the processor; and

instructions stored in the memory and operable, when executed by the processor, to cause the apparatus to:

receive a codeword over a wireless channel, the codeword being encoded using a polar code;

identify a set of punctured bit locations in the received codeword;

identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword; and

decode the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

62. The apparatus of claim 61, wherein the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

63. The apparatus of claim 62, wherein the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword.

64. The apparatus of claim 63, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to zero.

65. The apparatus of claim 63, wherein the non-shortening based puncturing comprises block puncturing.

66. The apparatus of claim 61, wherein, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

67. The apparatus of claim 61, wherein the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and wherein a number of the punctured bit locations is added to the number of the information bits for assigning to the bit-channel partitions for the first recursive partitioning.

68. The apparatus of claim 67, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to unity.

69. The apparatus of claim 67, wherein the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations.

70. The apparatus of claim 61, wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term.

71. An apparatus for wireless communication, in a system comprising:

a processor;

memory in electronic communication with the processor; and

instructions stored in the memory and operable, when executed by the processor, to cause the apparatus to:

receive a codeword that is encoded using a polar code;

identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term; and

process the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

72. The apparatus of claim 71, wherein the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor.

73. The apparatus of claim 72, wherein the correction term comprises an offset factor applied to the bit-channel capacity.

74. The apparatus of claim 73, wherein the correction term comprises a scaling factor applied to the offset bit-channel capacity.

75. The apparatus of claim 74, wherein the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

76. An apparatus for wireless communication, in a system comprising:

a processor;

memory in electronic communication with the processor; and

instructions stored in the memory and operable, when executed by the processor, to cause the apparatus to:

identify a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code;

identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword;

encode the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword; and

transmit the codeword over a wireless channel, wherein the transmitting comprises puncturing the codeword at the set of punctured bit locations.

77. The apparatus of claim 76, wherein the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

78. The apparatus of claim 77, wherein the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword.

79. The apparatus of claim 78, wherein the non-shortening based puncturing comprises block puncturing.

80. The apparatus of claim 77, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to zero.

81. The apparatus of claim 76, wherein, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

82. The apparatus of claim 76, wherein the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and wherein a number of the punctured bit locations is added to the number of information bits for assigning to the bit-channel partitions for the first recursive partitioning.

83. The apparatus of claim 82, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to unity.

84. The apparatus of claim 82, wherein the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations.

85. The apparatus of claim 76, wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term.

86. An apparatus for wireless communication, in a system comprising:

a processor;

memory in electronic communication with the processor; and

instructions stored in the memory and operable, when executed by the processor, to cause the apparatus to:

identify an information bit vector for encoding using a polar code;

identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term;

encode the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword; and

transmit the codeword over a wireless channel.

87. The apparatus of claim 86, wherein the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor.

88. The apparatus of claim 87, wherein the correction term comprises an offset factor applied to the bit-channel capacity.

89. The apparatus of claim 88, wherein the correction term comprises a scaling factor applied to the offset bit-channel capacity.

90. The apparatus of claim 89, wherein the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

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

receive a codeword over a wireless channel, the codeword being encoded using a polar code;

identify a set of punctured bit locations in the received codeword;

identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword; and

decode the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

92. The non-transitory computer-readable medium of claim 91, wherein the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

93. The non-transitory computer-readable medium of claim 92, wherein the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword.

94. The non-transitory computer-readable medium of claim 93, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to zero.

95. The non-transitory computer-readable medium of claim 93, wherein the non-shortening based puncturing comprises block puncturing.

96. The non-transitory computer-readable medium of claim 91, wherein, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

97. The non-transitory computer-readable medium of claim 91, wherein the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and wherein a number of the punctured bit locations is added to the number of the information bits for assigning to the bit-channel partitions for the first recursive partitioning.

98. The non-transitory computer-readable medium of claim 97, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to unity.

99. The non-transitory computer-readable medium of claim 97, wherein the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations.

100. The non-transitory computer-readable medium of claim 91, wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term.

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

receive a codeword that is encoded using a polar code;

identify a set of bit locations of the polar code used for information bits for the encoding, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of the information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term; and

process the received codeword according to the polar code to obtain an information bit vector at the set of bit locations.

102. The non-transitory computer-readable medium of claim 101, wherein the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor.

103. The non-transitory computer-readable medium of claim 102, wherein the correction term comprises an offset factor applied to the bit-channel capacity.

104. The non-transitory computer-readable medium of claim 103, wherein the correction term comprises a scaling factor applied to the offset bit-channel capacity.

105. The non-transitory computer-readable medium of claim 104, wherein the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

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

identify a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code;

identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein a target mutual information for a first polarization stage is determined as a function of the number of the information bits and a number of un-punctured bit locations in the received codeword;

encode the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword; and

transmit the codeword over a wireless channel, wherein the transmitting comprises puncturing the codeword at the set of punctured bit locations.

107. The non-transitory computer-readable medium of claim 106, wherein the target mutual information is determined as the number of the information bits divided by the number of un-punctured bit locations in the received codeword.

108. The non-transitory computer-readable medium of claim 107, wherein the set of punctured bit locations correspond to non-shortening based puncturing of the received codeword.

109. The non-transitory computer-readable medium of claim 108, wherein the non-shortening based puncturing comprises block puncturing.

110. The non-transitory computer-readable medium of claim 107, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to zero.

111. The non-transitory computer-readable medium of claim 106, wherein, for the each stage of polarization, a capacity of each bit-channel of each of the bit-channel partitions is determined based on bit-channel capacities of input bit-channels from the previous stage of polarization and the mutual information transfer function.

112. The non-transitory computer-readable medium of claim 106, wherein the set of punctured bit locations correspond to shortening-based puncturing of the received codeword, and wherein a number of the punctured bit locations is added to the number of information bits for assigning to the bit-channel partitions for the first recursive partitioning.

113. The non-transitory computer-readable medium of claim 112, wherein, for the first polarization stage, a capacity of each corresponding bit-channel of the set of punctured bit locations is set to unity.

114. The non-transitory computer-readable medium of claim 112, wherein the identifying the set of bit locations comprises shortening a preliminary set of bit locations determined as a result of the recursively partitioning of the bit-channels by the number of the punctured bit locations.

115. The non-transitory computer-readable medium of claim 106, wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term.

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

identify an information bit vector for encoding using a polar code;

identify a set of bit locations of the polar code to be used for information bits of the information bit vector, wherein the set of bit locations is determined based at least in part on recursively partitioning bit-channels of the polar code for each stage of polarization and assigning portions of a number of information bits of each partition of each stage of polarization to bit-channel partitions based on a mutual information transfer function of respective aggregate capacities of the bit-channel partitions, and wherein the mutual information transfer function is based on a binary erasure channel (BEC) function and a correction term;

encode the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword; and

transmit the codeword over a wireless channel.

117. The non-transitory computer-readable medium of claim 116, wherein the correction term is based on a function of a bit-channel capacity of the each stage of polarization and a capacity imbalance factor.

118. The non-transitory computer-readable medium of claim 117, wherein the correction term comprises an offset factor applied to the bit-channel capacity.

119. The non-transitory computer-readable medium of claim 118, wherein the correction term comprises a scaling factor applied to the offset bit-channel capacity.

120. The non-transitory computer-readable medium of claim 119, wherein the correction term comprises an offset applied to the scaled and offset bit-channel capacity.

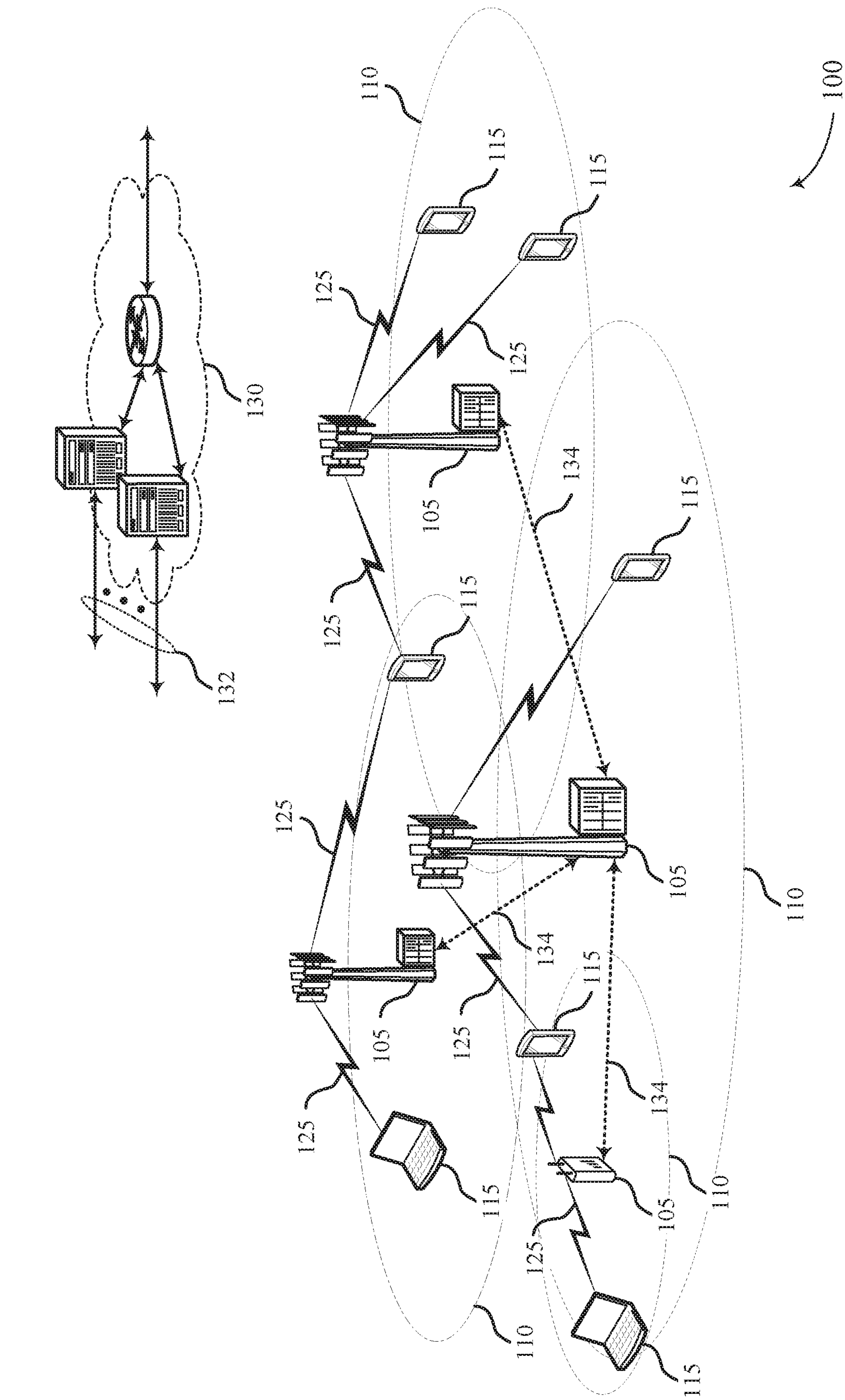


FIG. 1

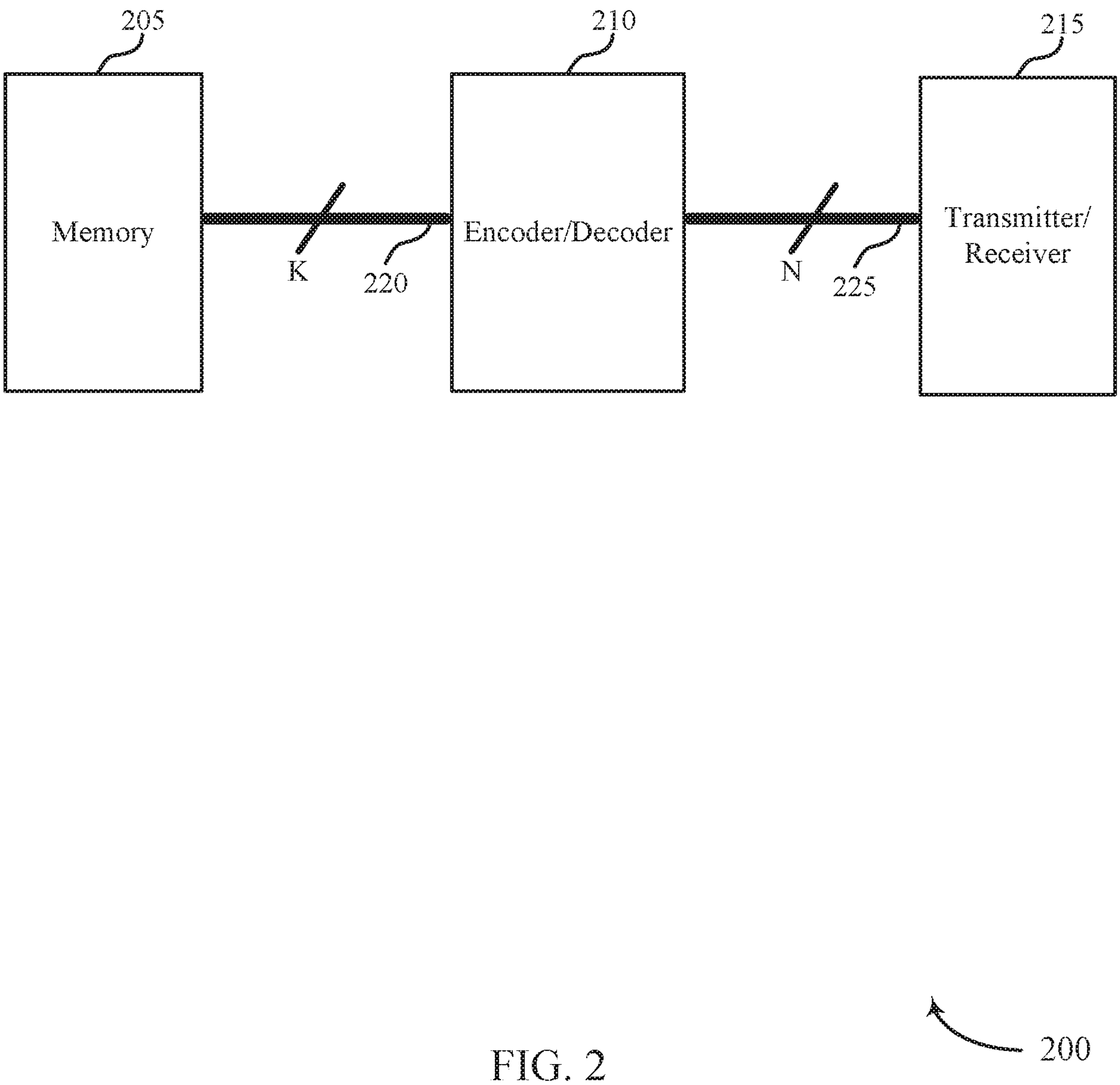

205
210
215
Memory
Encoder/Decoder
Transmitter/
Receiver
K
220
N
225
200

FIG. 2

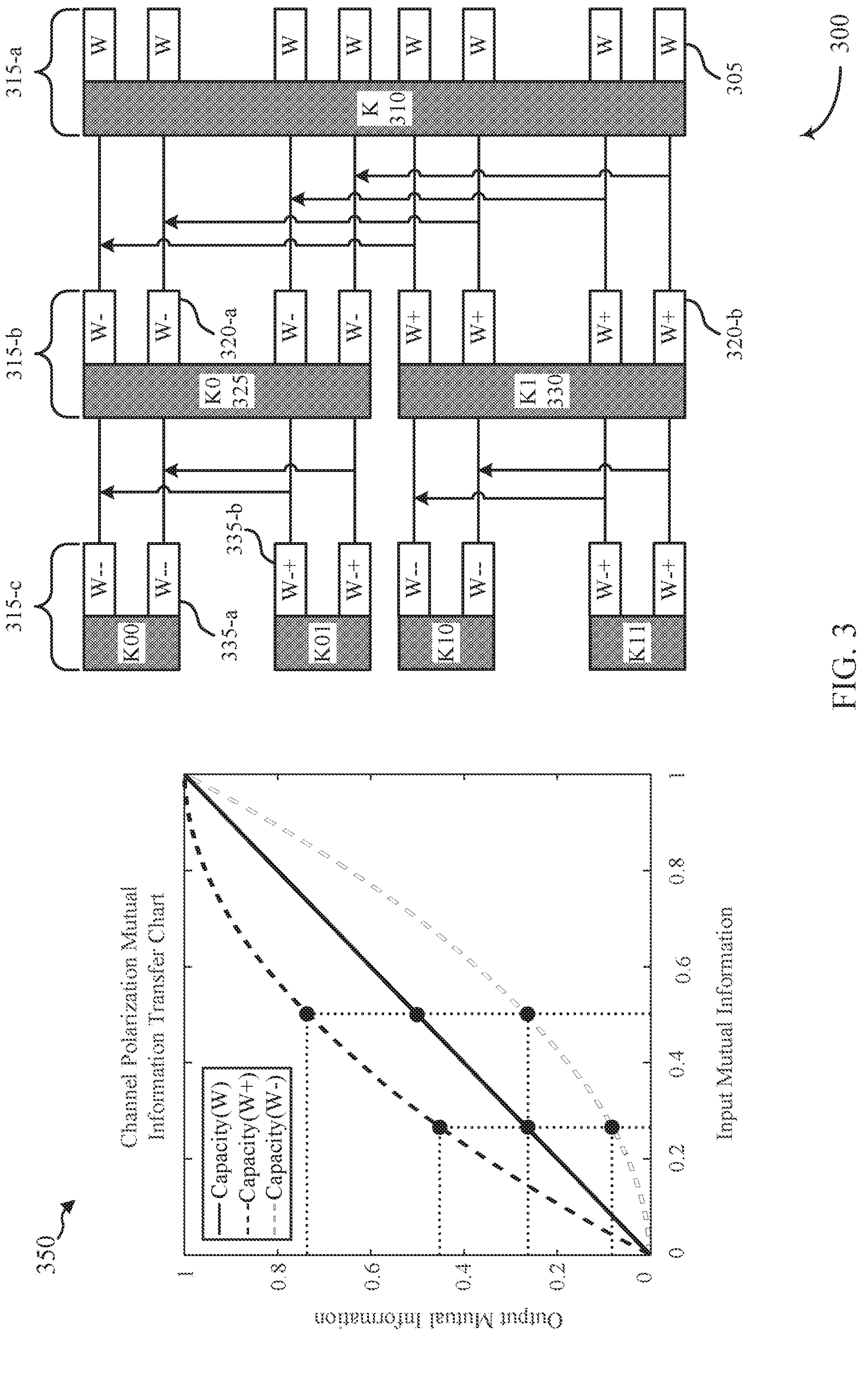
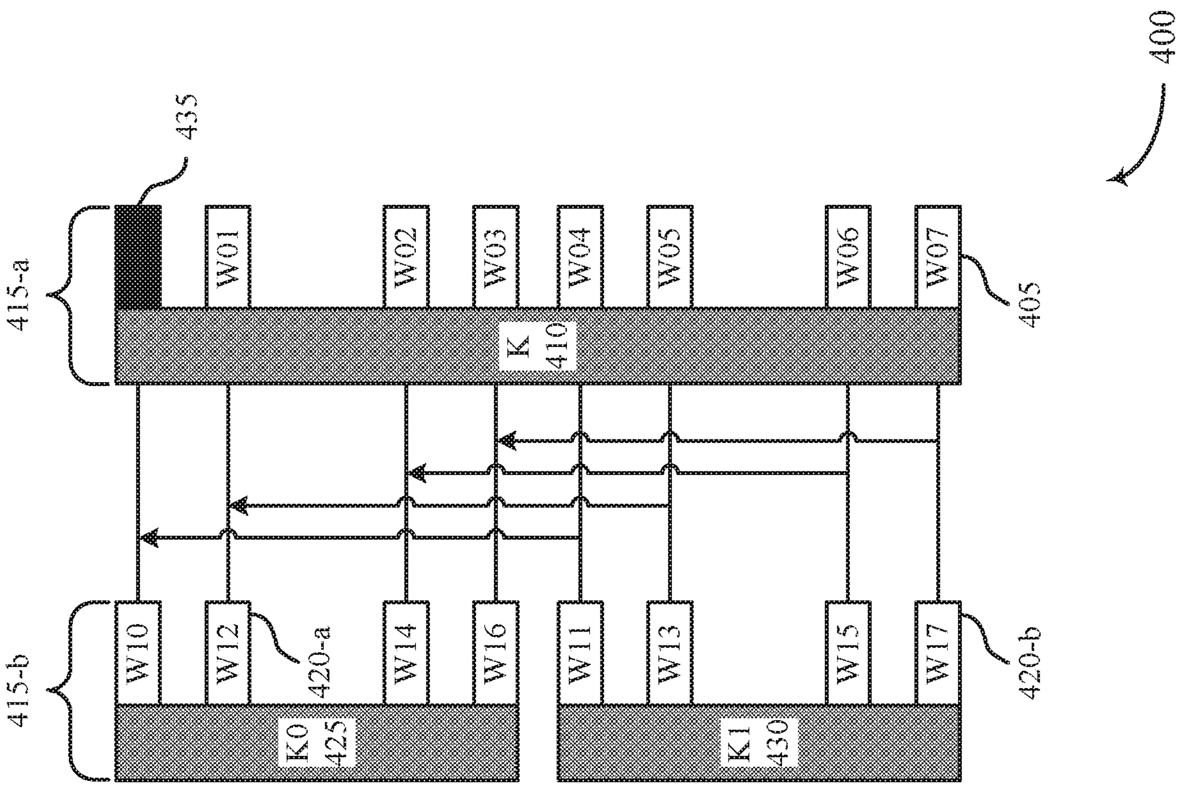

300
305
W
K
310
315-a
315-b
315-c
W-
W+
K0
325
K1
330
320-a
320-b
W--
W-+
K00
K01
K10
K11
335-a
335-b
350
Channel Polarization Mutual Information Transfer Chart
Capacity(W)
Capacity(W+)
Capacity(W-)
Input Mutual Information
Output Mutual Information
0
0.2
0.4
0.6
0.8
1

FIG. 3


400
435
415-a
W01
W02
W03
W04
W05
W06
W07
405
K
410
415-b
W10
W12
420-a
W14
W16
W11
W13
W15
W17
420-b
K0
425
K1
430

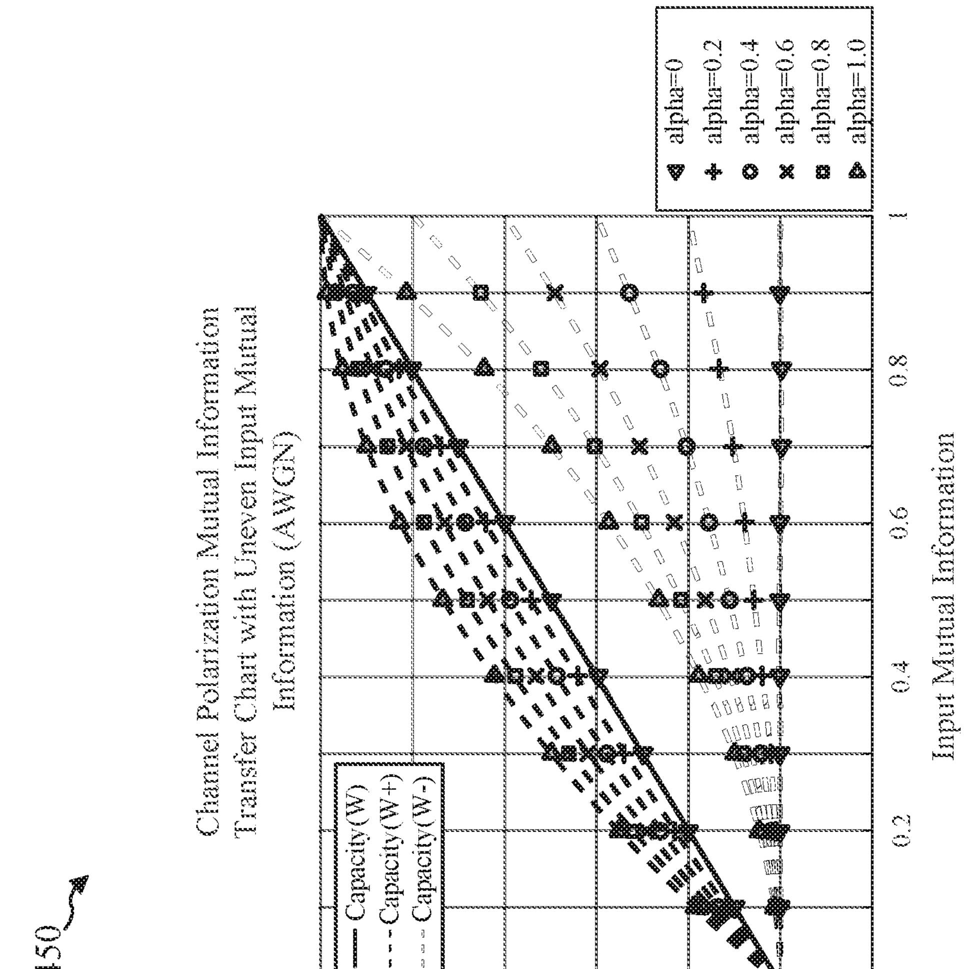

450
Channel Polarization Mutual Information Transfer Chart with Uneven Input Mutual Information (AWGN)
Capacity(W)
Capacity(W+)
Capacity(W-)
alpha=0
alpha=0.2
alpha=0.4
alpha=0.6
alpha=0.8
alpha=1.0
Output Mutual Information
Input Mutual Information
-0.2
0
0.2
0.4
0.6
0.8
1

FIG. 4

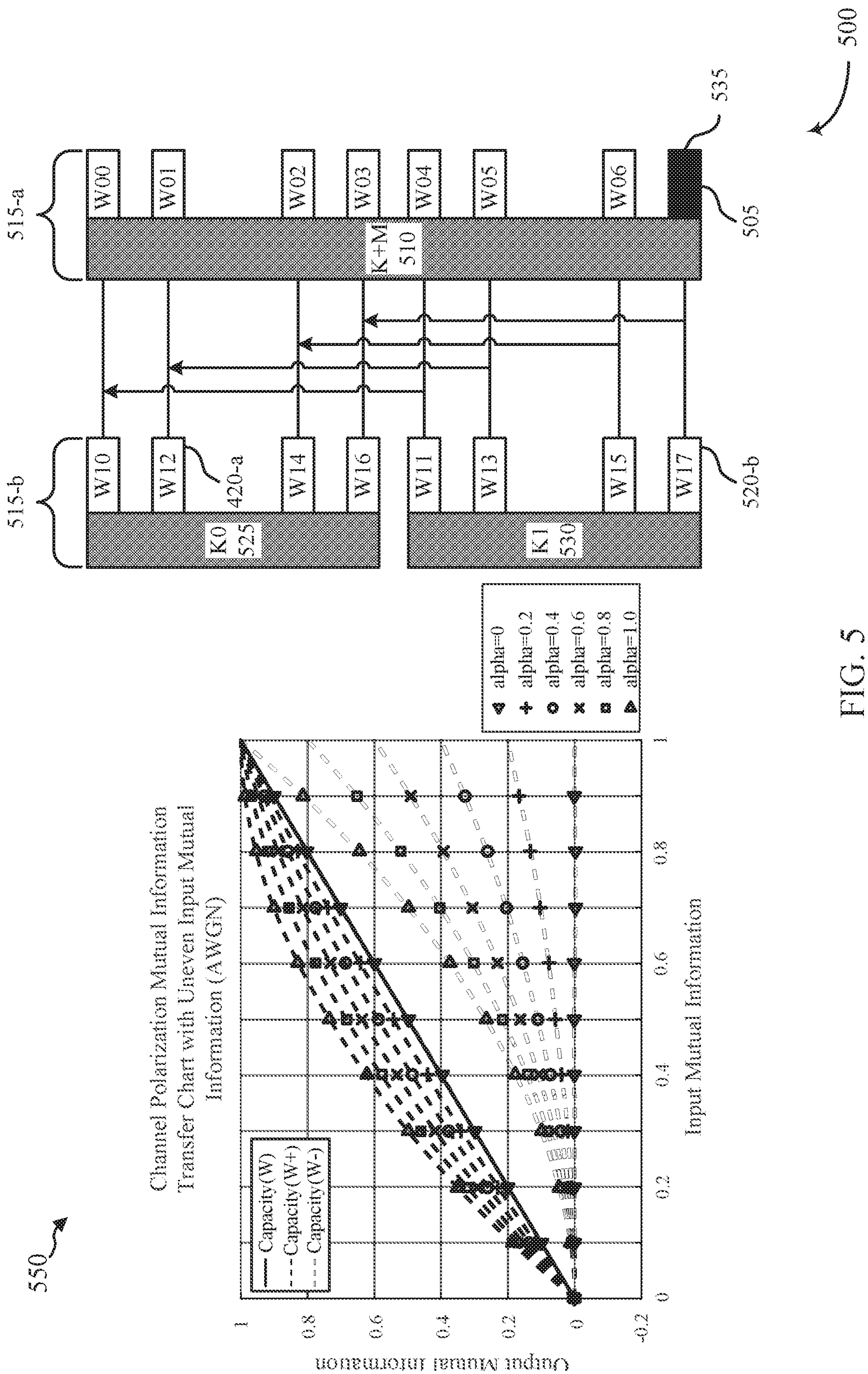

500
515-a
W00
W01
W02
W03
W04
W05
W06
535
505
K+M
510
515-b
W10
W12
420-a
W14
W16
W11
W13
W15
W17
520-b
K0
525
K1
530
550
Channel Polarization Mutual Information Transfer Chart with Uneven Input Mutual Information (AWGN)
Capacity(W)
Capacity(W+)
Capacity(W-)
alpha=0
alpha=0.2
alpha=0.4
alpha=0.6
alpha=0.8
alpha=1.0
Output Mutual Information
Input Mutual Information
1
0.8
0.6
0.4
0.2
0
-0.2

FIG. 5

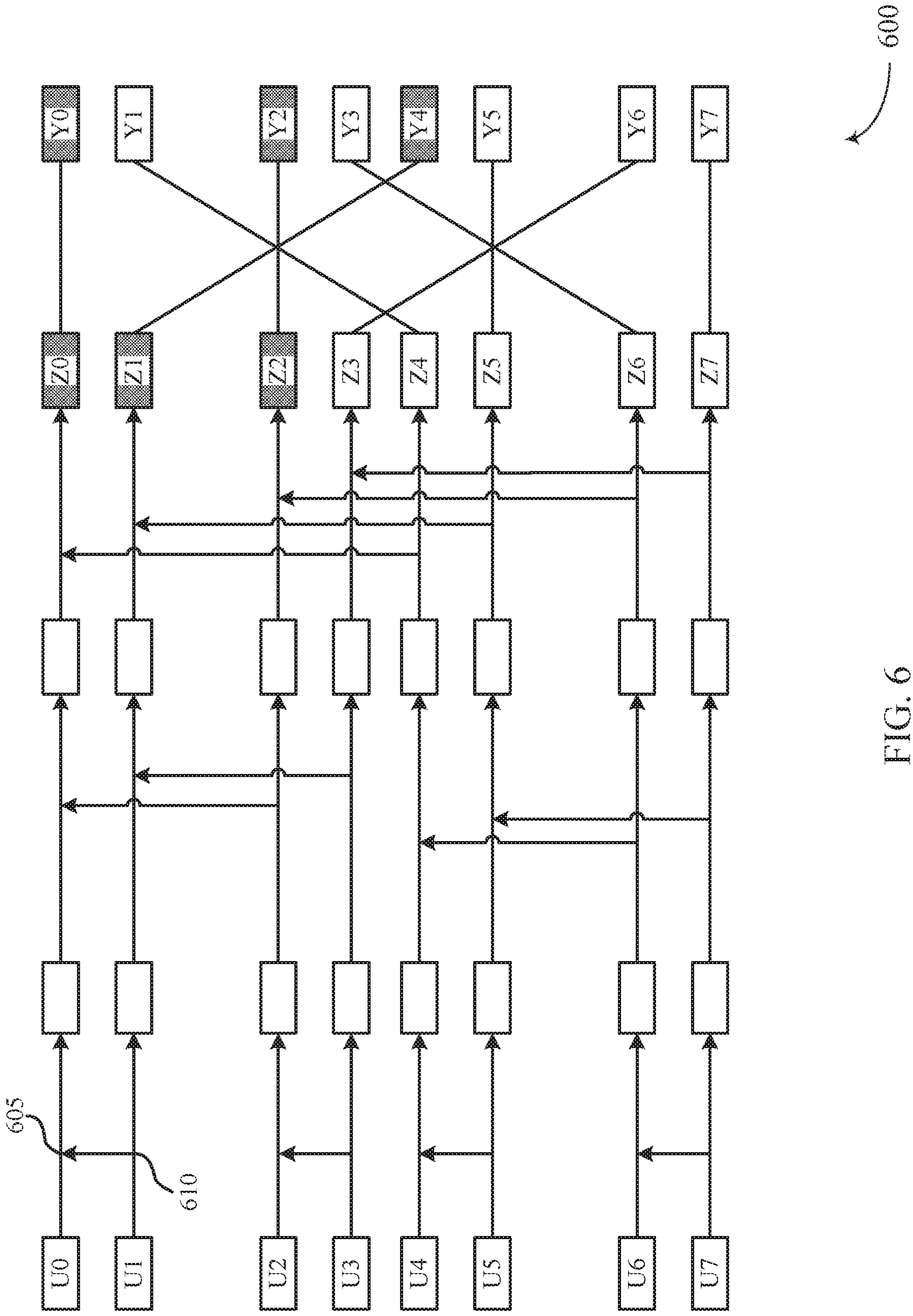

600
Y0
Y1
Y2
Y3
Y4
Y5
Y6
Y7
Z0
Z1
Z2
Z3
Z4
Z5
Z6
Z7
605
610
U0
U1
U2
U3
U4
U5
U6
U7

FIG. 6

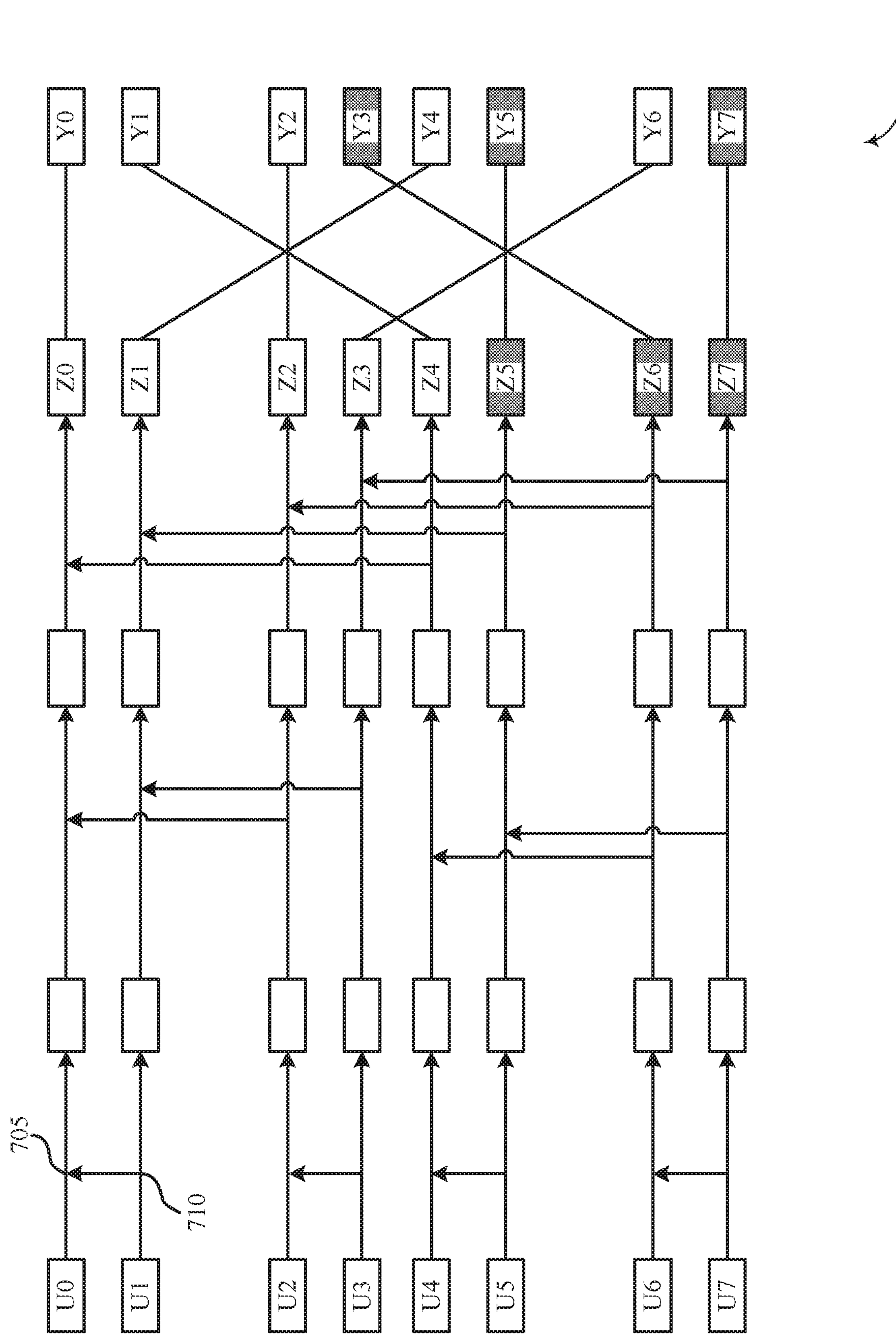

700
Y0
Y1
Y2
Y3
Y4
Y5
Y6
Y7
Z0
Z1
Z2
Z3
Z4
Z5
Z6
Z7
705
710
U0
U1
U2
U3
U4
U5
U6
U7

FIG. 7

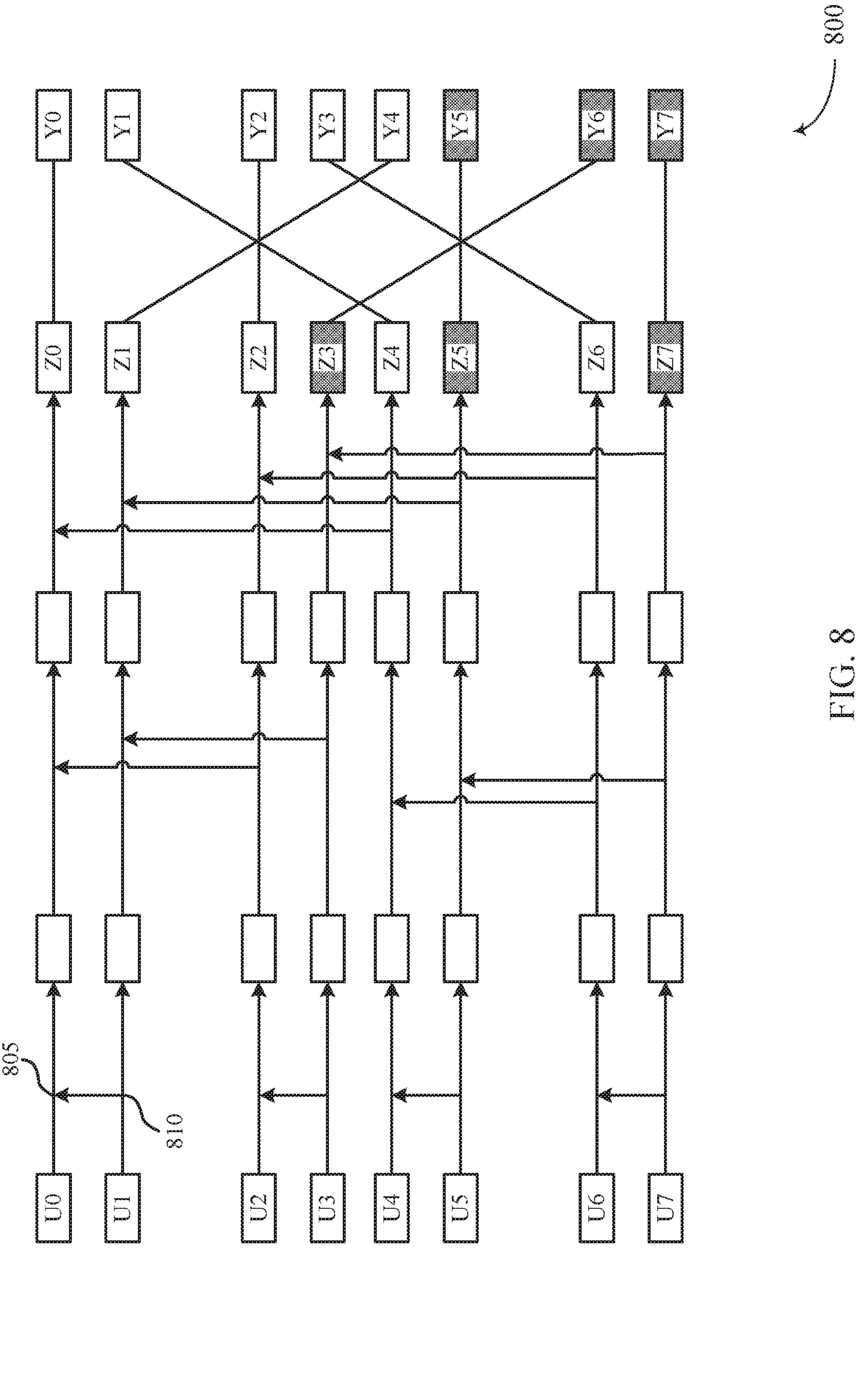
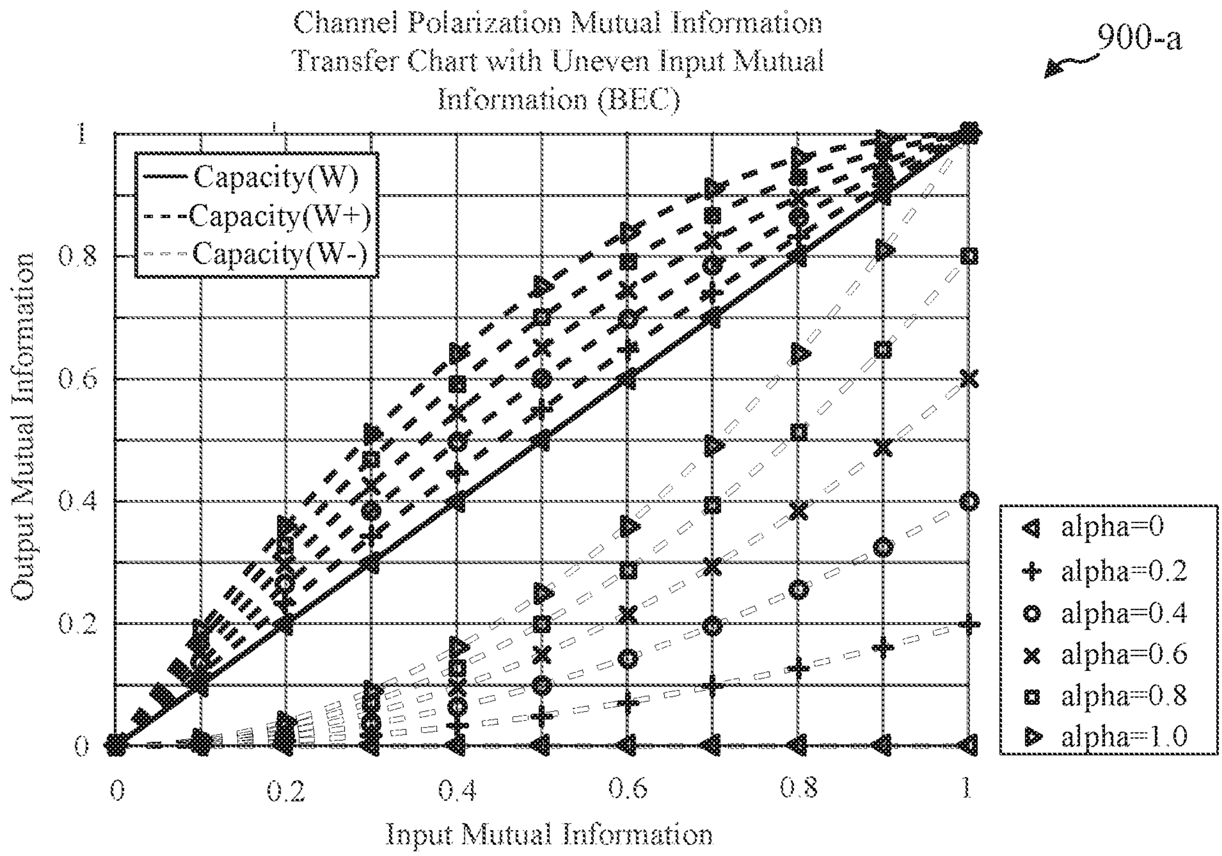

800
Y0
Y1
Y2
Y3
Y4
Y5
Y6
Y7
Z0
Z1
Z2
Z3
Z4
Z5
Z6
Z7
805
810
U0
U1
U2
U3
U4
U5
U6
U7

FIG. 8

900-a



900-b

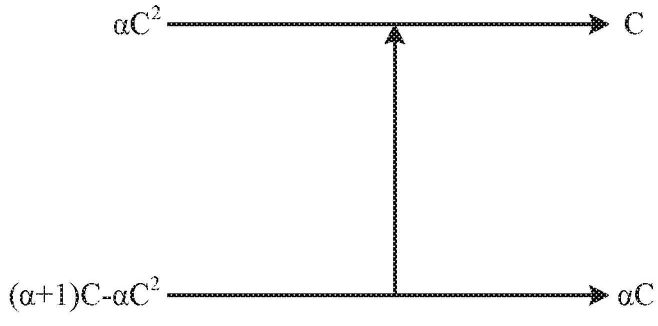
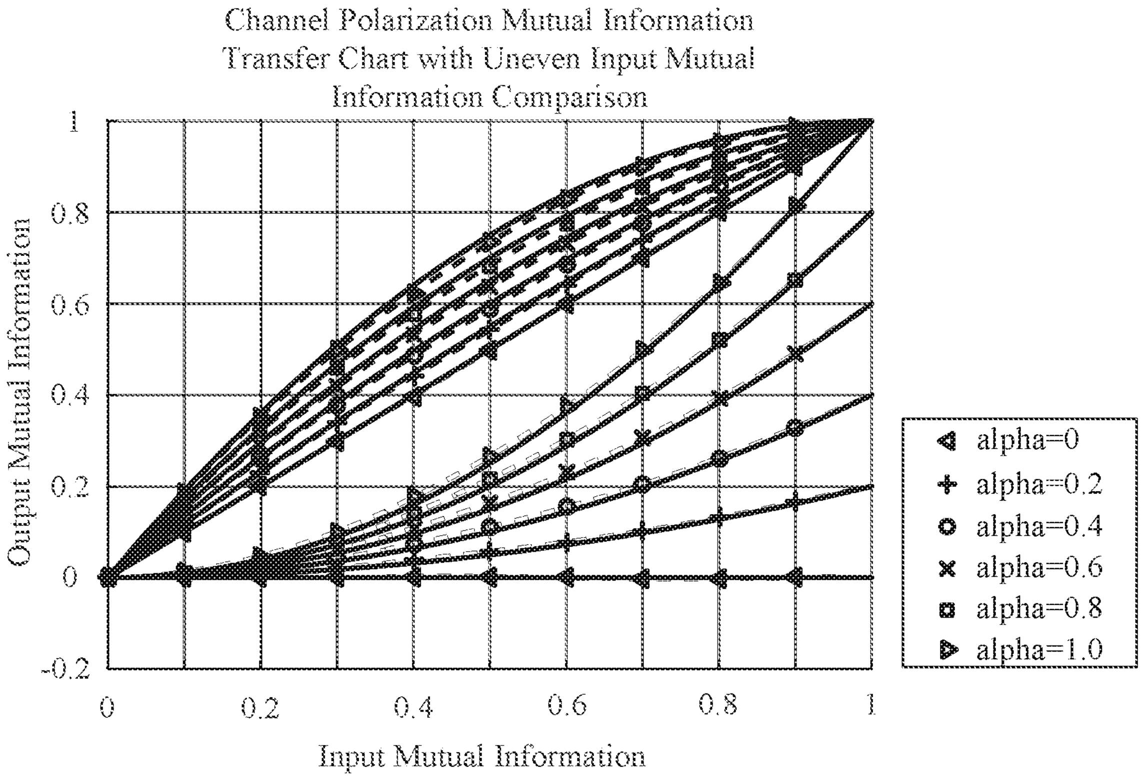
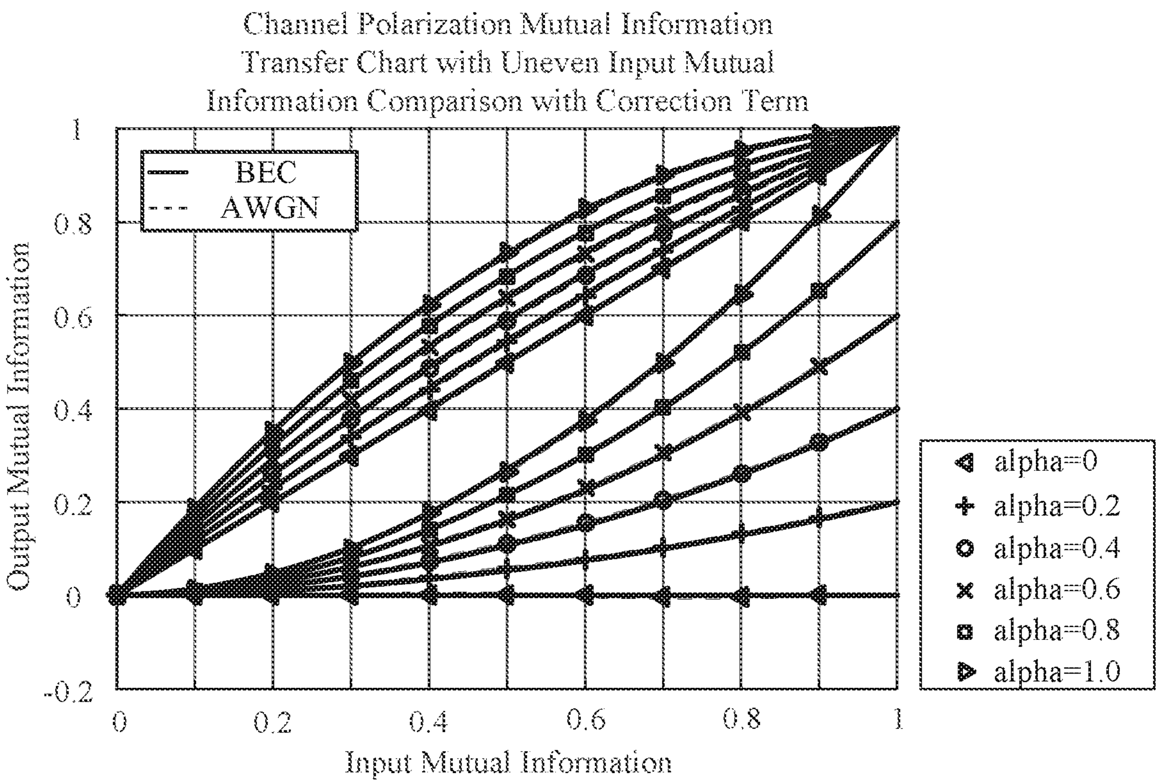


FIG. 9



1000-a

FIG. 10A



1000-b

FIG. 10B

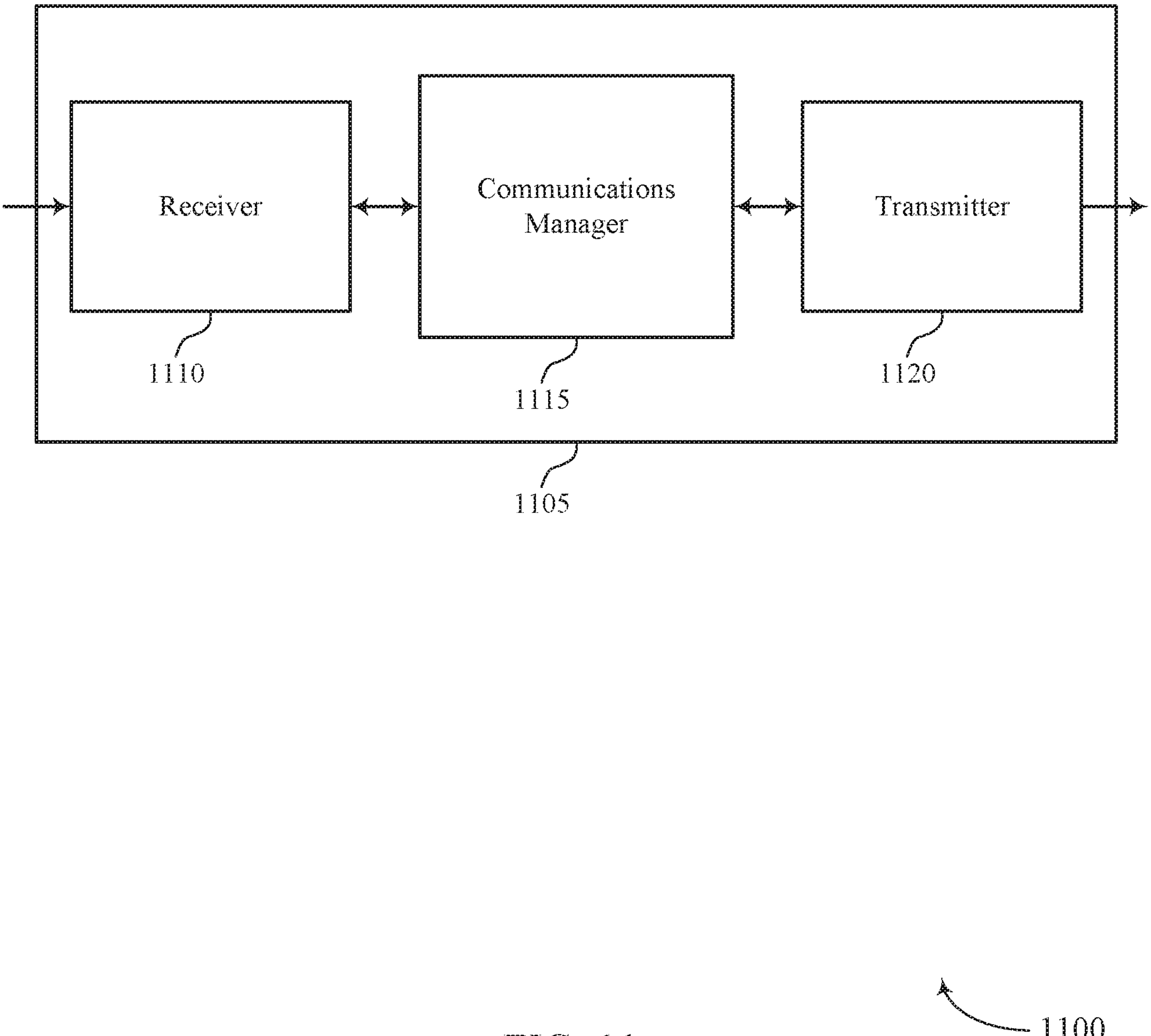

Receiver
Communications Manager
Transmitter
1110
1115
1120
1105
1100

FIG. 11

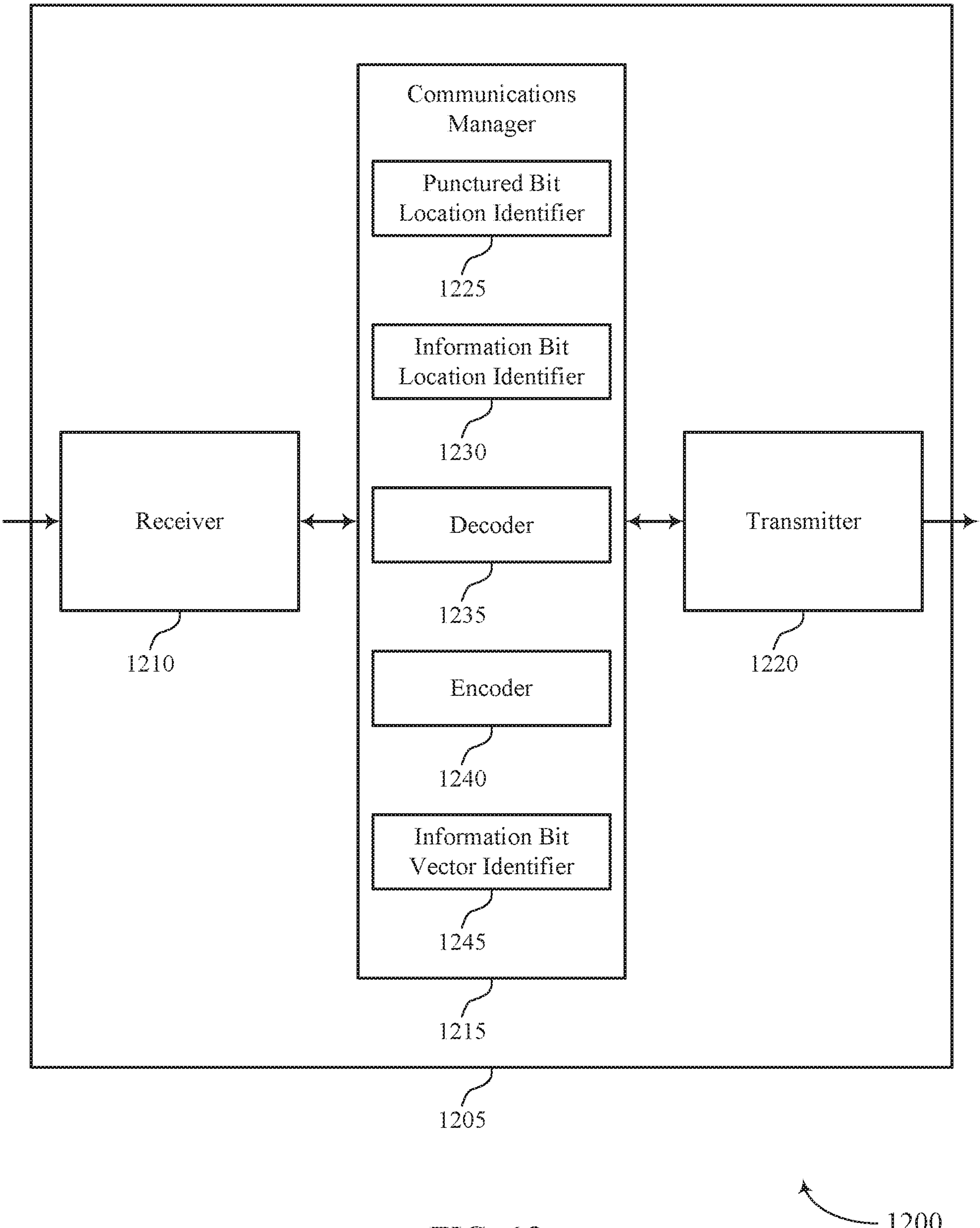

Communications Manager
Punctured Bit Location Identifier
1225
Information Bit Location Identifier
1230
Receiver
Decoder
Transmitter
1235
1210
1220
Encoder
1240
Information Bit Vector Identifier
1245
1215
1205
1200

FIG. 12

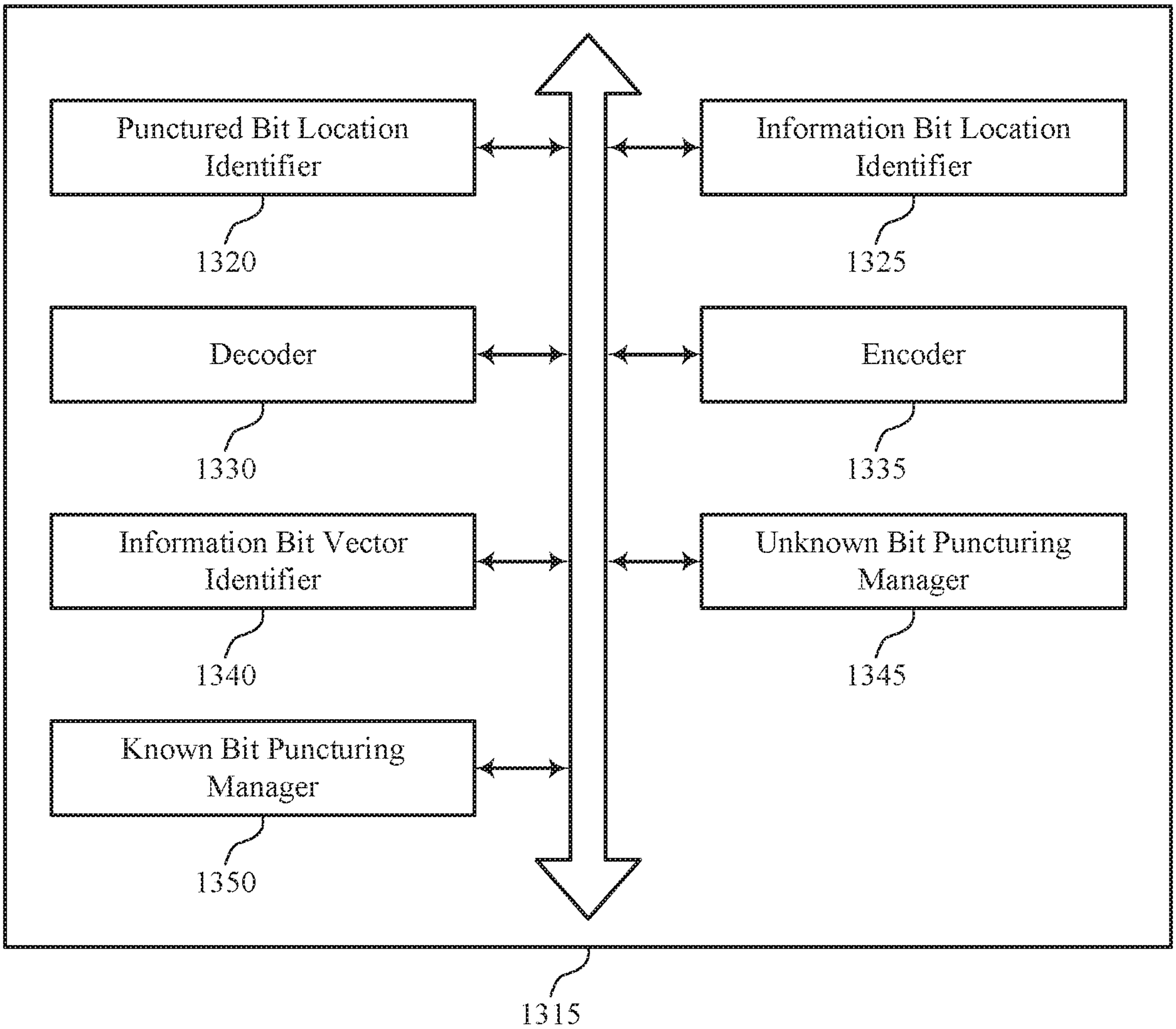

Punctured Bit Location Identifier
1320
Information Bit Location Identifier
1325
Decoder
1330
Encoder
1335
Information Bit Vector Identifier
1340
Unknown Bit Puncturing Manager
1345
Known Bit Puncturing Manager
1350
1315
1300

FIG. 13

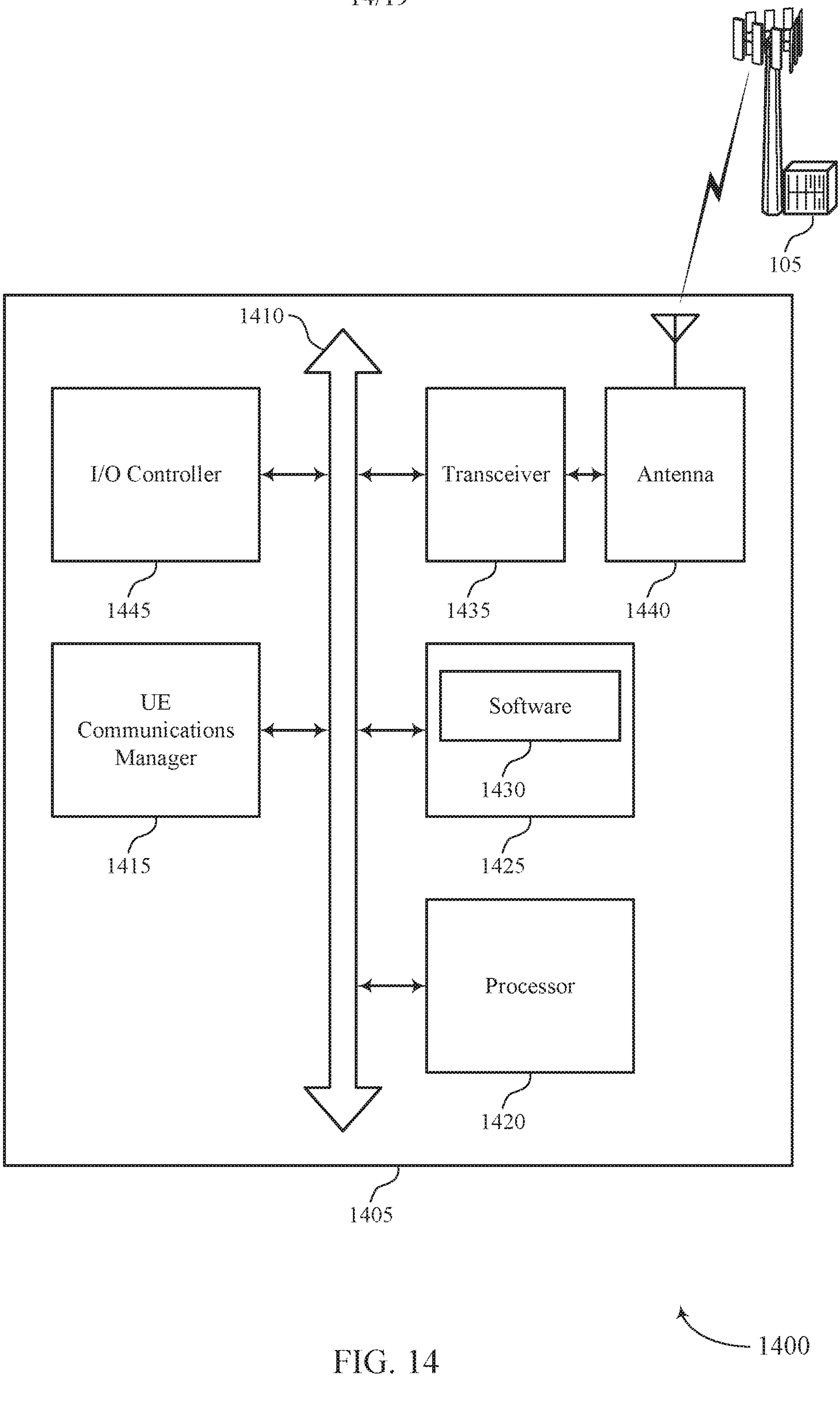

105
1410
1405
I/O Controller
1445
Transceiver
1435
Antenna
1440
UE
Communications
Manager
1415
Software
1430
1425
Processor
1420
1400

FIG. 14

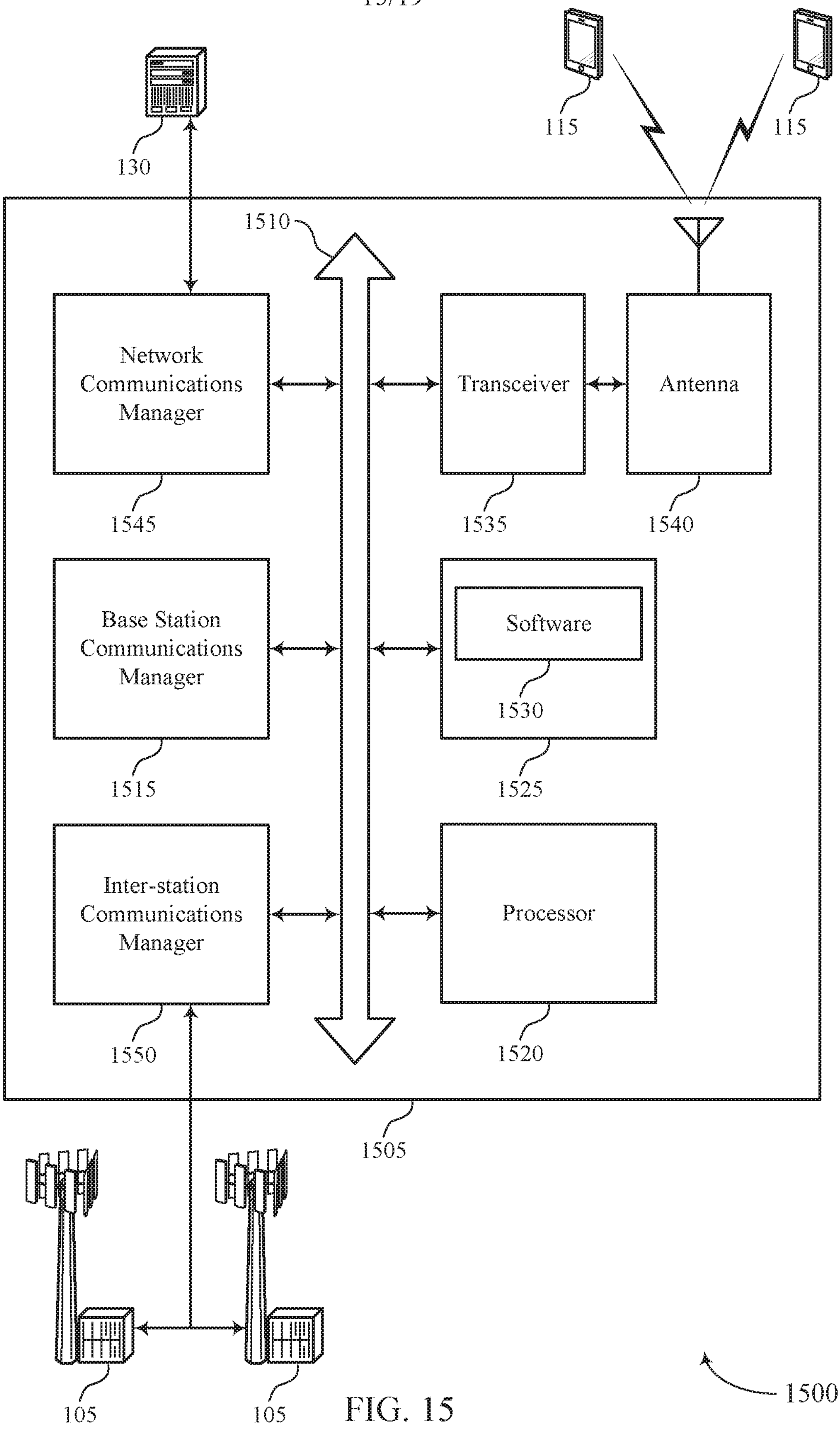

115
115
130
1510
Network Communications Manager
Transceiver
Antenna
1545
1535
1540
Base Station Communications Manager
Software
1530
1515
1525
Inter-station Communications Manager
Processor
1550
1520
1505
105
105
1500

FIG. 15

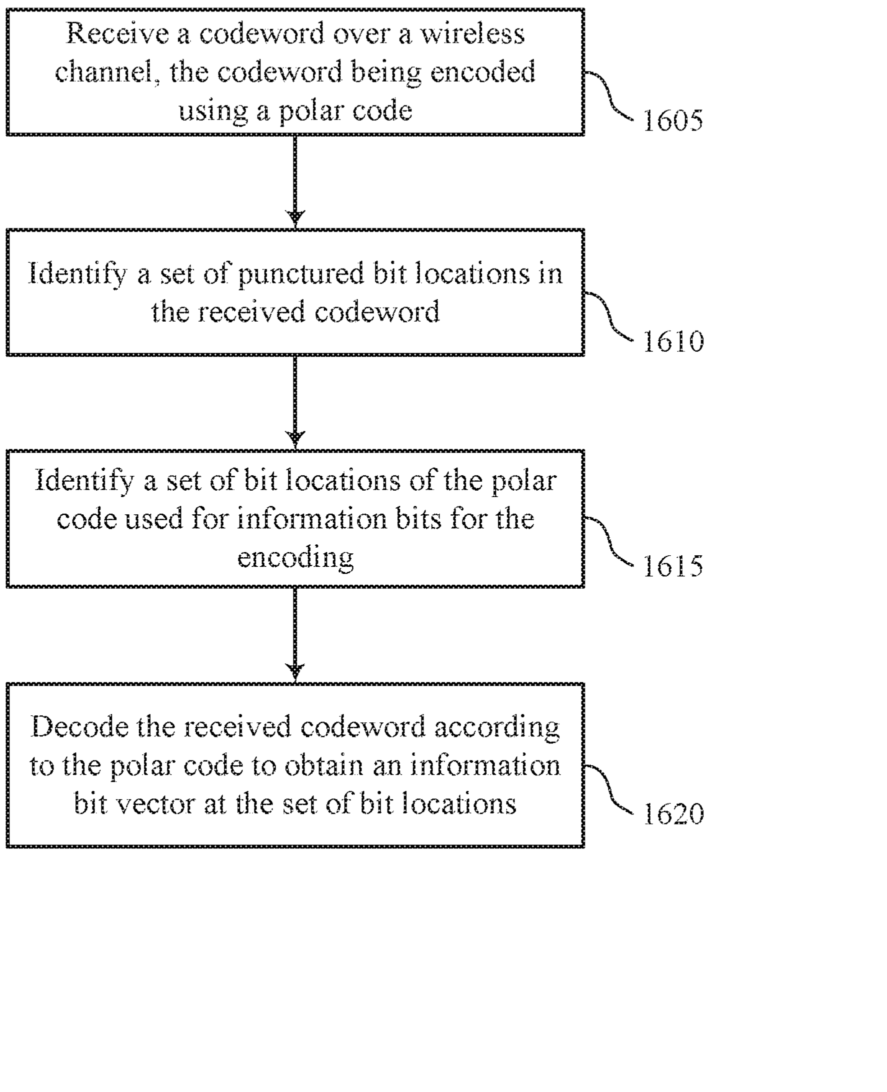

Receive a codeword over a wireless channel, the codeword being encoded using a polar code
1605
Identify a set of punctured bit locations in the received codeword
1610
Identify a set of bit locations of the polar code used for information bits for the encoding
1615
Decode the received codeword according to the polar code to obtain an information bit vector at the set of bit locations
1620
1600

FIG. 16

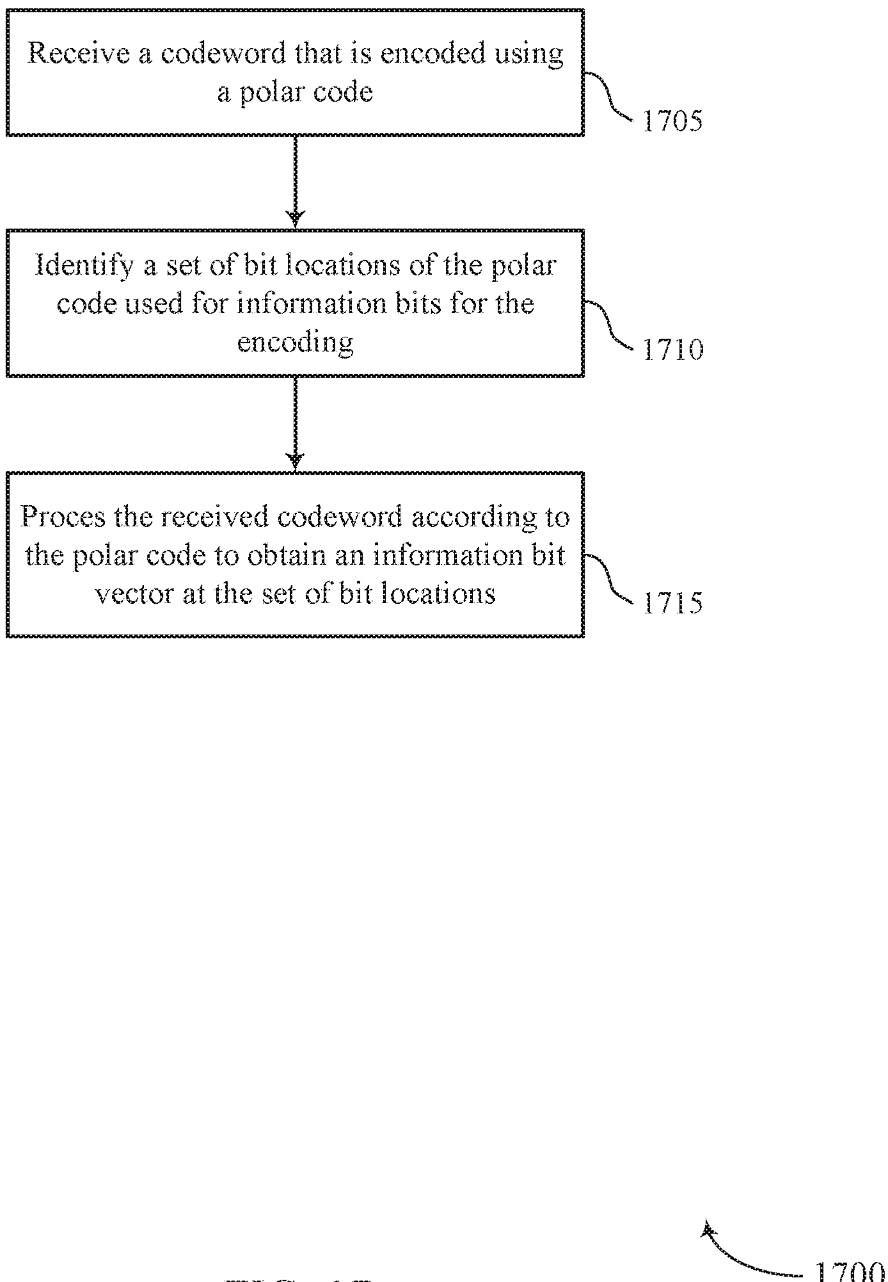

Receive a codeword that is encoded using a polar code
1705
Identify a set of bit locations of the polar code used for information bits for the encoding
1710
Proces the received codeword according to the polar code to obtain an information bit vector at the set of bit locations
1715
1700

FIG. 17

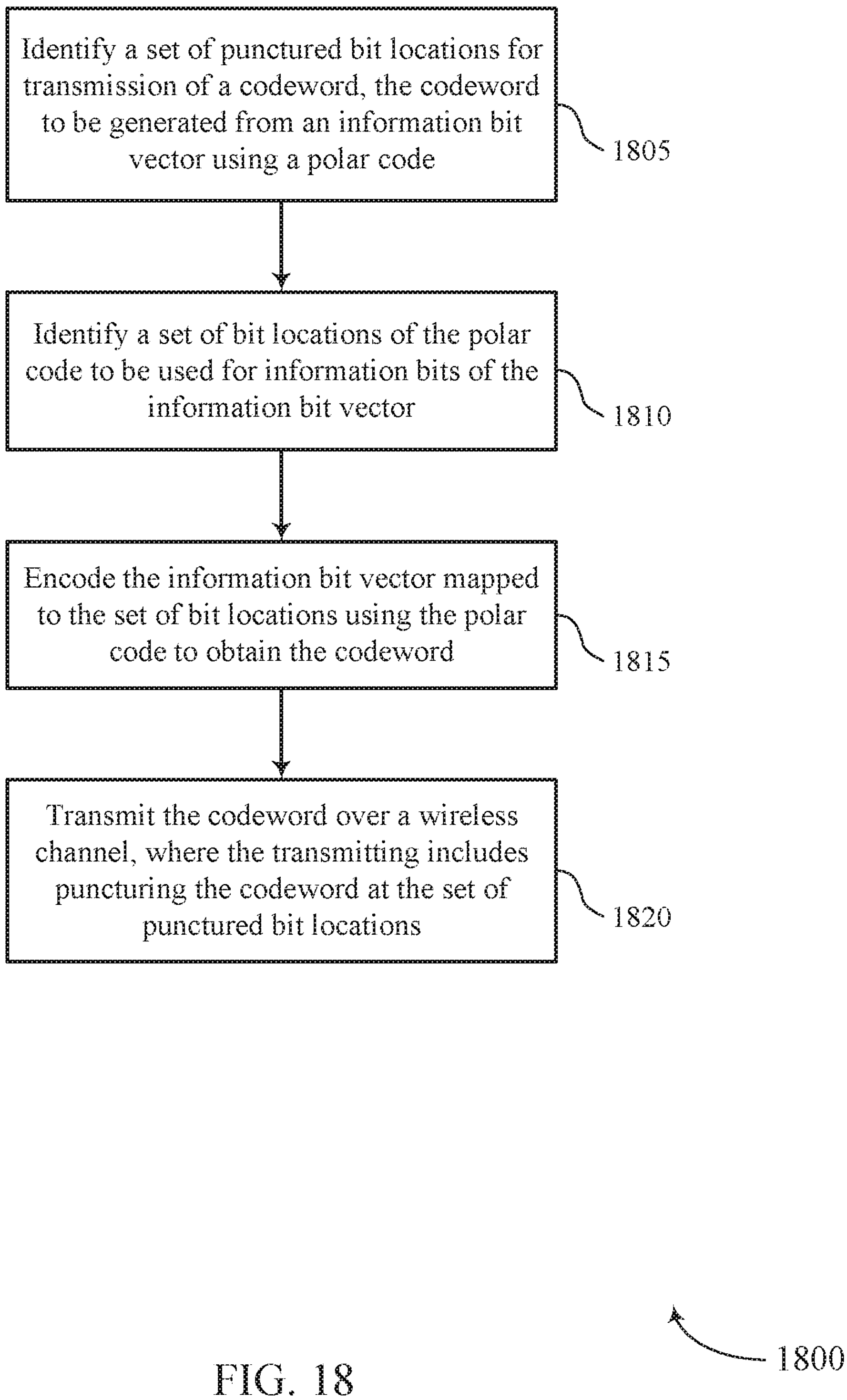

Identify a set of punctured bit locations for transmission of a codeword, the codeword to be generated from an information bit vector using a polar code
1805
Identify a set of bit locations of the polar code to be used for information bits of the information bit vector
1810
Encode the information bit vector mapped to the set of bit locations using the polar code to obtain the codeword
1815
Transmit the codeword over a wireless channel, where the transmitting includes puncturing the codeword at the set of punctured bit locations
1820
1800

FIG. 18

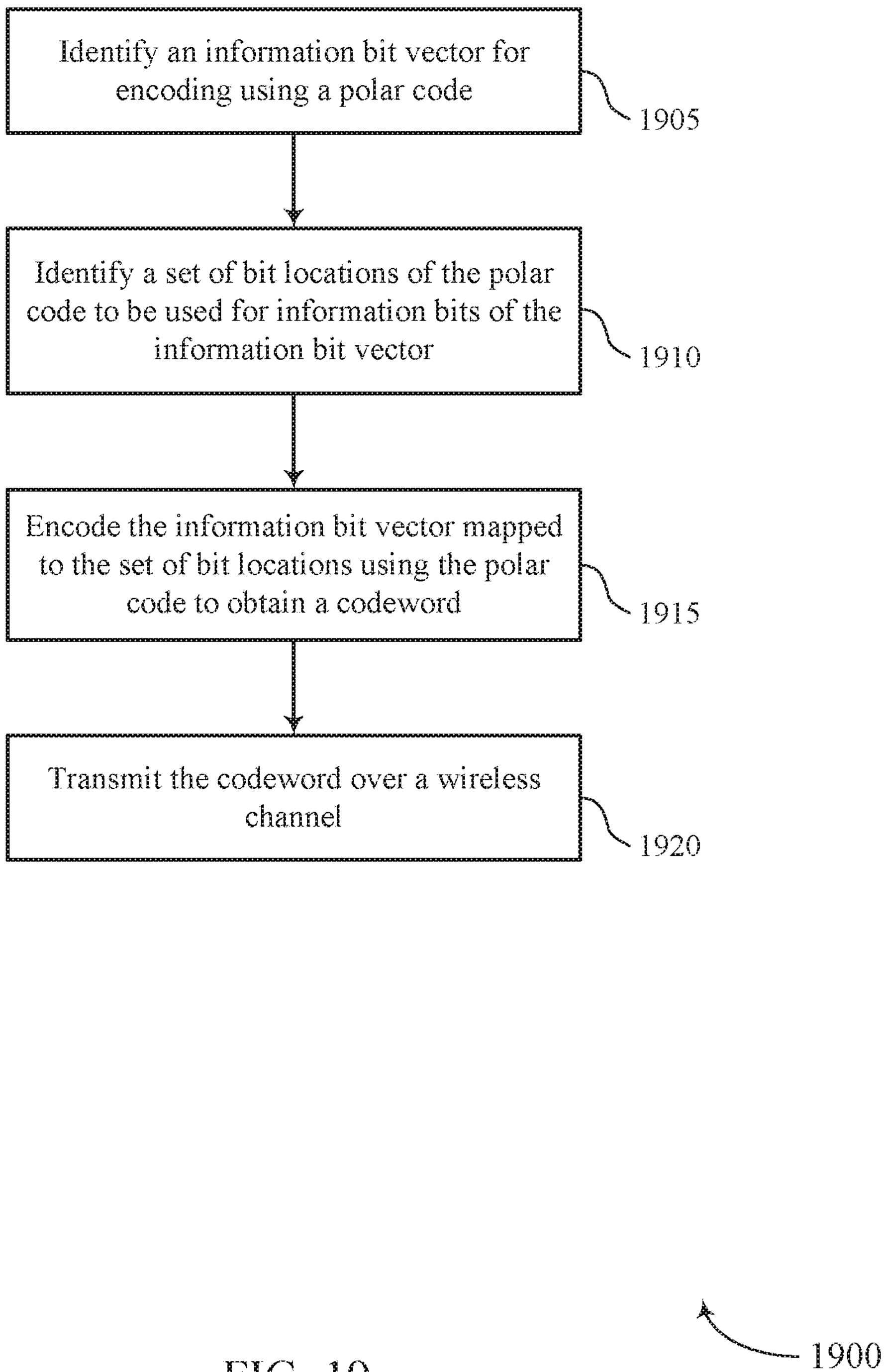

Identify an information bit vector for encoding using a polar code
1905
Identify a set of bit locations of the polar code to be used for information bits of the information bit vector
1910
Encode the information bit vector mapped to the set of bit locations using the polar code to obtain a codeword
1915
Transmit the codeword over a wireless channel
1920
1900

FIG. 19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/074381

A. CLASSIFICATION OF SUBJECT MATTER

H03M 13/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H03M; H04L

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

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

CNABS;CNTXT;CNKI;VEN;WOTXT;EPTXT;USTXT:punctur+, polar code, recursiv+, partition+, stage

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014108748 A1 (SAMSUNG ELECTRONICS CO.， LTD.ET AL.) 17 April 2014 (2014-04-17) description，paragraphs [0009]-[0025]，[0086]-[0172]	1-120
A	US 2015333769 A1 (SAMSUNG ELECTRONICS CO.， LTD.ET AL.) 19 November 2015 (2015-11-19) the whole document	1-120
A	CN 105493424 A (HUAWEI TECHNOLOGIES CO.， LTD.) 13 April 2016 (2016-04-13) the whole document	1-120

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 November 2017	**14 November 2017**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/074381

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		EP 3079287 A1	12 October 2016
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