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NONBINARY POLAR CODING WITH PARTIALLY FROZEN SYMBOLS

Abstract

Various aspects of the present disclosure generally relate to wireless communication. In some aspects, a receiver device may receive encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The receiver device may decode the information bits from the encoded symbols. Numerous other aspects are described.

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Background/Summary

FIELD OF THE DISCLOSURE

[0001] Aspects of the present disclosure generally relate to wireless communication and specifically relate to techniques, apparatuses, and methods for nonbinary polar coding with partially frozen symbols.

BACKGROUND

[0002] Wireless communication systems are widely deployed to provide various services that may include carrying voice, text, messaging, video, data, and/or other traffic. The services may include unicast, multicast, and/or broadcast services, among other examples. Typical wireless communication systems may employ multiple-access radio access technologies (RATs) capable of supporting communication with multiple users by sharing available system resources (for example, time domain resources, frequency domain resources, spatial domain resources, and/or device transmit power, among other examples). Examples of such multiple-access RATs include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency division multiple access (SC-FDMA) systems, and time division synchronous code division multiple access (TD-SCDMA) systems.

[0003] The above multiple-access RATs have been adopted in various telecommunication standards to provide common protocols that enable different wireless communication devices to communicate on a municipal, national, regional, or global level. An example telecommunication standard is New Radio (NR). NR, which may also be referred to as 5G, is part of a continuous mobile broadband evolution promulgated by the Third Generation Partnership Project (3GPP). NR (and other mobile broadband evolutions beyond NR) may be designed to better support Internet of things (IoT) and reduced capability device deployments, industrial connectivity, millimeter wave (mmWave) expansion, licensed and unlicensed spectrum access, non-terrestrial network (NTN) deployment, sidelink and other device-to-device direct communication technologies (for example, cellular vehicle-to-everything (CV2X) communication), massive multiple-input multiple-output (MIMO), disaggregated network architectures and network topology expansions, multiple-subscriber implementations, high-precision positioning, and/or radio frequency (RF) sensing, among other examples. As the demand for mobile broadband access continues to increase, further improvements in NR may be implemented, and other radio access technologies such as 6G may be introduced, to further advance mobile broadband evolution.

SUMMARY

[0004] Some aspects described herein relate to an apparatus for wireless communication at a receiver device. The apparatus may include one or more memories and one or more processors coupled to the one or more memories. The one or more processors may be configured, individually or in any combination, to receive encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The one or more processors may be configured, individually or in any combination, to decode the information bits from the encoded symbols.

[0005] Some aspects described herein relate to an apparatus for wireless communication at a transmitter device. The apparatus may include one or more memories and one or more processors coupled to the one or more memories. The one or more processors may be configured, individually or in any combination, to encode information bits using nonbinary polar coding to generate

encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate the information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The one or more processors may be configured, individually or in any combination, to transmit the encoded symbols.

[0006] Some aspects described herein relate to a method of wireless communication performed by a receiver device. The method may include receiving encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The method may include decoding the information bits from the encoded symbols.

[0007] Some aspects described herein relate to a method of wireless communication performed by a transmitter device. The method may include encoding information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate the information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The method may include transmitting the encoded symbols.

[0008] Some aspects described herein relate to a non-transitory computer-readable medium that stores a set of instructions for wireless communication by a receiver device. The set of instructions, when executed by one or more processors of the receiver device, may cause the receiver device to receive encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The set of instructions, when executed by one or more processors of the receiver device, may cause the receiver device to decode the information bits from the encoded symbols.

[0009] Some aspects described herein relate to a non-transitory computer-readable medium that stores a set of instructions for wireless communication by a transmitter device. The set of instructions, when executed by one or more processors of the transmitter device, may cause the transmitter device to encode information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate the information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The set of instructions, when executed by one or more processors of the transmitter device, may cause the transmitter device to transmit the encoded symbols.

[0010] Some aspects described herein relate to an apparatus for wireless communication. The apparatus may include means for receiving encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The apparatus may include means for decoding the information bits from the encoded symbols.

[0011] Some aspects described herein relate to an apparatus for wireless communication. The apparatus may include means for encoding information bits using nonbinary polar coding to

generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate the information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The apparatus may include means for transmitting the encoded symbols.
[0012] Aspects of the present disclosure may generally be implemented by or as a method, apparatus, system, computer program product, non-transitory computer-readable medium, user equipment, base station, network node, network entity, wireless communication device, and/or processing system as substantially described with reference to, and as illustrated by, the specification and accompanying drawings.
[0013] The foregoing paragraphs of this section have broadly summarized some aspects of the present disclosure. These and additional aspects and associated advantages will be described hereinafter. The disclosed aspects may be used as a basis for modifying or designing other aspects for carrying out the same or similar purposes of the present disclosure. Such equivalent aspects do not depart from the scope of the appended claims. Characteristics of the aspects disclosed herein, both their organization and method of operation, together with associated advantages, will be better understood from the following description when considered in connection with the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0014] The appended drawings illustrate some aspects of the present disclosure, but are not limiting of the scope of the present disclosure because the description may enable other aspects. Each of the drawings is provided for purposes of illustration and description, and not as a definition of the limits of the claims. The same or similar reference numbers in different drawings may identify the same or similar elements.
[0015] FIG. **1** is a diagram illustrating an example of a wireless communication network in accordance with the present disclosure.
[0016] FIG. **2** is a diagram illustrating an example network node in communication with an example user equipment (UE) in a wireless network in accordance with the present disclosure.
[0017] FIG. **3** is a diagram illustrating an example disaggregated base station architecture in accordance with the present disclosure.
[0018] FIG. **4** is a diagram illustrating an example of nonbinary polar coding, in accordance with the present disclosure.
[0019] FIG. **5** is a diagram of an example associated with nonbinary polar coding with partially frozen symbols, in accordance with the present disclosure.
[0020] FIG. **6** is a diagram illustrating an example process performed, for example, at a transmitter device or an apparatus of a transmitter device, in accordance with the present disclosure.
[0021] FIG. **7** is a diagram illustrating an example process performed, for example, at a receiver device or an apparatus of a receiver device, in accordance with the present disclosure.
[0022] FIG. **8** is a diagram of an example apparatus for wireless communication, in accordance with the present disclosure.
[0023] FIG. **9** is a diagram of an example apparatus for wireless communication, in accordance with the present disclosure.
DETAILED DESCRIPTION
[0024] Various aspects of the present disclosure are described hereinafter with reference to the accompanying drawings. However, aspects of the present disclosure may be embodied in many different forms and is not to be construed as limited to any specific aspect illustrated by or

described with reference to an accompanying drawing or otherwise presented in this disclosure. Rather, these aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. One skilled in the art may appreciate that the scope of the disclosure is intended to cover any aspect of the disclosure disclosed herein, whether implemented independently of or in combination with any other aspect of the disclosure. For example, an apparatus may be implemented or a method may be practiced using various combinations or quantities of the aspects set forth herein. In addition, the scope of the disclosure is intended to cover an apparatus having, or a method that is practiced using, other structures and/or functionalities in addition to or other than the structures and/or functionalities with which various aspects of the disclosure set forth herein may be practiced. Any aspect of the disclosure disclosed herein may be embodied by one or more elements of a claim.

[0025] Several aspects of telecommunication systems will now be presented with reference to various methods, operations, apparatuses, and techniques. These methods, operations, apparatuses, and techniques will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, modules, components, circuits, steps, processes, or algorithms (collectively referred to as “elements”). These elements may be implemented using hardware, software, or a combination of hardware and software. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0026] Polar codes are error-correcting codes that are used in communication signals. Wireless communications may be encoded using polar coding to improve resilience to non-ideal channel conditions. Polar coding has a built-in channel polarization structure that splits (or “polarizes”) polar code subchannels into reliable subchannels and unreliable subchannels. The reliable subchannels may carry information bits and the unreliable channels may carry “frozen” or “fixed” bits (e.g., “0” bits).

[0027] Polar coding schemes may use binary polar coding or nonbinary polar coding. In binary polar coding, each encoded symbol can indicate a single bit of data (e.g., the symbol alphabet is binary, whereby each symbol has two possible values). In nonbinary polar coding, each encoded symbol can indicate multiple bits of data (e.g., the symbol alphabet has a larger field, whereby each symbol has more than two possible values). Generally, nonbinary polar coding uses information symbols (e.g., symbols that carry information bits) and frozen symbols (e.g., symbols with a predetermined value and that do not carry information bits). While nonbinary polar codes are associated with lower latency and improved polarization properties relative to binary polar codes, for small block lengths (e.g., for finite lengths), nonbinary polar codes may result in many imperfectly polarized symbol channels (e.g., not-fully polarized symbol channels), thereby affecting information rate and spectrum efficiency.

[0028] Various aspects relate generally to utilizing imperfectly polarized symbol channels. Some aspects more specifically relate to nonbinary polar coding with information symbols, partially frozen symbols, and frozen symbols. In some aspects, the information symbols and the partially frozen symbols can carry data bits. For example, the information symbols may be used for indicating any of the symbol values in a set of values, and the partially frozen symbols may be used for indicating only symbol values of a proper subset of the set of values. In some aspects, positions of the information symbols and the partially frozen symbols in a codeword may be identifiable in accordance with a universal reliability sequence.

[0029] Particular aspects of the subject matter described in this disclosure can be implemented to realize one or more of the following potential advantages. In some examples, by using information symbols and partially frozen symbols to indicate information bits, the described techniques better utilize frequency resources, improve information rate, and improve spectrum efficiency. Furthermore, controlling partially frozen symbols to a subset of values that are available to information symbols can simplify decoding by reducing a candidate space associated with processing partially frozen symbols. In addition, using a universal reliability sequence for identification of positions of information symbols and partially frozen symbols simplifies decoding and reduces signaling that would otherwise be needed to signal a reliability sequence to a user equipment (UE), thereby conserving network resources.

[0030] Multiple-access radio access technologies (RATs) have been adopted in various telecommunication standards to provide common protocols that enable wireless communication devices to communicate on a municipal, enterprise, national, regional, or global level. For example, 5G New Radio (NR) is part of a continuous mobile broadband evolution promulgated by the Third Generation Partnership Project (3GPP). 5G NR supports various technologies and use cases including enhanced mobile broadband (cMBB), ultra-reliable low-latency communication (URLLC), massive machine-type communication (mMTC), millimeter wave (mmWave) technology, beamforming, network slicing, edge computing, Internet of Things (IoT) connectivity and management, and network function virtualization (NFV).

[0031] As the demand for broadband access increases and as technologies supported by wireless communication networks evolve, further technological improvements may be adopted in or implemented for 5G NR or future RATs, such as 6G, to further advance the evolution of wireless communication for a wide variety of existing and new use cases and applications. Such technological improvements may be associated with new frequency band expansion, licensed and unlicensed spectrum access, overlapping spectrum use, small cell deployments, non-terrestrial network (NTN) deployments, disaggregated network architectures and network topology expansion, device aggregation, advanced duplex communication, sidelink and other device-to-device direct communication, IoT (including passive or ambient IoT) networks, reduced capability (RedCap) UE functionality, industrial connectivity, multiple-subscriber implementations, high-precision positioning, radio frequency (RF) sensing, and/or artificial intelligence or machine learning (AI/ML), among other examples. These technological improvements may support use cases such as wireless backhauls, wireless data centers, extended reality (XR) and metaverse applications, meta services for supporting vehicle connectivity, holographic and mixed reality communication, autonomous and collaborative robots, vehicle platooning and cooperative maneuvering, sensing networks, gesture monitoring, human-brain interfacing, digital twin applications, asset management, and universal coverage applications using non-terrestrial and/or aerial platforms, among other examples. The methods, operations, apparatuses, and techniques described herein may enable one or more of the foregoing technologies and/or support one or more of the foregoing use cases.

[0032] FIG. **1** is a diagram illustrating an example of a wireless communication network **100** in accordance with the present disclosure. The wireless communication network **100** may be or may include elements of a 5G (or NR) network or a 6G network, among other examples. The wireless communication network **100** may include multiple network nodes **110**, shown as a network node (NN) **110***a*, a network node **110***b*, a network node **110***c*, and a network node **110***d*. The network nodes **110** may support communications with multiple UEs **120**, shown as a UE **120***a*, a UE **120***b*, a UE **120***c*, a UE **120***d*, and a UE **120***c*.

[0033] The network nodes **110** and the UEs **120** of the wireless communication network **100** may communicate using the electromagnetic spectrum, which may be subdivided by frequency or wavelength into various classes, bands, carriers, and/or channels. For example, devices of the wireless communication network **100** may communicate using one or more operating bands. In some aspects, multiple wireless networks **100** may be deployed in a given geographic area. Each wireless communication network **100** may support a particular RAT (which may also be referred to as an air interface) and may operate on one or more carrier frequencies in one or more frequency ranges. Examples of RATs include a 4G RAT, a 5G/NR RAT, and/or a 6G RAT, among other examples. In some examples, when multiple RATs are deployed in a given geographic area, each RAT in the geographic area may operate on different frequencies to avoid interference with one another.

[0034] Various operating bands have been defined as frequency range designations FR1(410 MHz through 7.125 GHZ), FR2 (24.25 GHz through 52.6 GHZ), FR3 (7.125 GHZ through 24.25 GHZ), FR4a or FR4-1 (52.6 GHz through 71 GHz), FR4 (52.6 GHZ through 114.25 GHZ), and FR5 (114.25 GHz through 300 GHz). Although a portion of FR1 is greater than 6 GHZ, FR1 is often referred to (interchangeably) as a “Sub-6 GHz” band in some documents and articles. Similarly, FR2 is often referred to (interchangeably) as a “millimeter wave” band in some documents and articles, despite being different than the extremely high frequency (EHF) band (30 GHz through 300 GHz), which is identified by the International Telecommunications Union (ITU) as a “millimeter wave” band. The frequencies between FR1 and FR2 are often referred to as mid-band frequencies, which include FR3. Frequency bands falling within FR3 may inherit FR1 characteristics or FR2 characteristics, and thus may effectively extend features of FR1 or FR2 into mid-band frequencies. Thus, “sub-6 GHZ,” if used herein, may broadly refer to frequencies that are less than 6 GHZ, that are within FR1, and/or that are included in mid-band frequencies. Similarly, the term “millimeter wave,” if used herein, may broadly refer to frequencies that are included in mid-band frequencies, that are within FR2, FR4, FR4-a or FR4-1, or FR5, and/or that are within the EHF band. Higher frequency bands may extend 5G NR operation, 6G operation, and/or other RATs beyond 52.6 GHz. For example, each of FR4a, FR4-1, FR4, and FR5 falls within the EHF band. In some examples, the wireless communication network 100 may implement dynamic spectrum sharing (DSS), in which multiple RATs (for example, 4G/LTE and 5G/NR) are implemented with dynamic bandwidth allocation (for example, based on user demand) in a single frequency band. It is contemplated that the frequencies included in these operating bands (for example, FR1, FR2, FR3, FR4, FR4-a, FR4-1, and/or FR5) may be modified, and techniques described herein may be applicable to those modified frequency ranges.

[0035] A network node **110** may include one or more devices, components, or systems that enable communication between a UE **120** and one or more devices, components, or systems of the wireless communication network **100**. A network node **110** may be, may include, or may also be referred to as an NR network node, a 5G network node, a 6G network node, a Node B, an eNB, a gNB, an access point (AP), a transmission reception point (TRP), a mobility element, a core, a network entity, a network element, a network equipment, and/or another type of device, component, or system included in a radio access network (RAN).

[0036] A network node **110** may be implemented as a single physical node (for example, a single physical structure) or may be implemented as two or more physical nodes (for example, two or more distinct physical structures). For example, a network node **110** may be a device or system that implements part of a radio protocol stack, a device or system that implements a full radio protocol stack (such as a full gNB protocol stack), or a collection of devices or systems that collectively implement the full radio protocol stack. For example, and as shown, a network node **110** may be an aggregated network node (having an aggregated architecture), meaning that the network node **110** may implement a full radio protocol stack that is physically and logically integrated within a single node (for example, a single physical structure) in the wireless communication network **100**. For example, an aggregated network node **110** may consist of a single standalone base station or a single TRP that uses a full radio protocol stack to enable or facilitate communication between a UE **120** and a core network of the wireless communication network **100**.

[0037] Alternatively, and as also shown, a network node **110** may be a disaggregated network node (sometimes referred to as a disaggregated base station), meaning that the network node **110** may implement a radio protocol stack that is physically distributed and/or logically distributed among two or more nodes in the same geographic location or in different geographic locations. For example, a disaggregated network node may have a disaggregated architecture. In some deployments, disaggregated network nodes **110** may be used in an integrated access and backhaul (IAB) network, in an open radio access network (O-RAN) (such as a network configuration in compliance with the O-RAN Alliance), or in a virtualized radio access network (vRAN), also known as a cloud radio access network (C-RAN), to facilitate scaling by separating base station functionality into multiple units that can be individually deployed.

[0038] The network nodes **110** of the wireless communication network **100** may include one or more central units (CUs), one or more distributed units (DUs), and/or one or more radio units (RUS). A CU may host one or more higher layer control functions, such as radio resource control (RRC) functions, packet data convergence protocol (PDCP) functions, and/or service data adaptation protocol (SDAP) functions, among other examples. A DU may host one or more of a radio link control (RLC) layer, a medium access control (MAC) layer, and/or one or more higher physical (PHY) layers depending, at least in part, on a functional split, such as a functional split defined by the 3GPP. In some examples, a DU also may host one or more lower PHY layer functions, such as a fast Fourier transform (FFT), an inverse FFT (iFFT), beamforming, physical random access channel (PRACH) extraction and filtering, and/or scheduling of resources for one or more UEs **120**, among other examples. An RU may host RF processing functions or lower PHY layer functions, such as an FFT, an iFFT, beamforming, or PRACH extraction and filtering, among other examples, according to a functional split, such as a lower layer functional split. In such an architecture, each RU can be operated to handle over the air (OTA) communication with one or more UEs **120**.

[0039] In some aspects, a single network node **110** may include a combination of one or more CUs, one or more DUs, and/or one or more RUs. Additionally or alternatively, a network node **110** may include one or more Near-Real Time (Near-RT) RAN Intelligent Controllers (RICs) and/or one or more Non-Real Time (Non-RT) RICs. In some examples, a CU, a DU, and/or an RU may be implemented as a virtual unit, such as a virtual central unit (VCU), a virtual distributed unit (VDU), or a virtual radio unit (VRU), among other examples. A virtual unit may be implemented as a virtual network function, such as associated with a cloud deployment.

[0040] Some network nodes **110** (for example, a base station, an RU, or a TRP) may provide communication coverage for a particular geographic area. In the 3GPP, the term "cell" can refer to a coverage area of a network node **110** or to a network node **110** itself, depending on the context in which the term is used. A network node **110** may support one or multiple (for example, three) cells. In some examples, a network node **110** may provide communication coverage for a macro cell, a pico cell, a femto cell, or another type of cell. A macro cell may cover a relatively large geographic area (for example, several kilometers in radius) and may allow unrestricted access by UEs **120** with service subscriptions. A pico cell may cover a relatively small geographic area and may allow unrestricted access by UEs **120** with service subscriptions. A femto cell may cover a relatively small geographic area (for example, a home) and may allow restricted access by UEs **120** having association with the femto cell (for example, UEs **120** in a closed subscriber group (CSG)). A network node **110** for a macro cell may be referred to as a macro network node. A network node **110** for a pico cell may be referred to as a pico network node. A network node **110** for a femto cell may be referred to as a femto network node or an in-home network node. In some examples, a cell may not necessarily be stationary. For example, the geographic area of the cell may move according to the location of an associated mobile network node **110** (for example, a train, a satellite base station, an unmanned aerial vehicle, or an NTN network node).

[0041] The wireless communication network **100** may be a heterogeneous network that includes network nodes **110** of different types, such as macro network nodes, pico network nodes, femto network nodes, relay network nodes, aggregated network nodes, and/or disaggregated network nodes, among other examples. In the example shown in FIG. **1**, the network node **110***a* may be a macro network node for a macro cell **130***a*, the network node **110***b* may be a pico network node for a pico cell **130***b*, and the network node **110***c* may be a femto network node for a femto cell **130***c*. Various different types of network nodes **110** may generally transmit at different power levels, serve different coverage areas, and/or have different impacts on interference in the wireless communication network **100** than other types of network nodes **110**. For example, macro network nodes may have a high transmit power level (for example, 5 to 40 watts), whereas pico network nodes, femto network nodes, and relay network nodes may have lower transmit power levels (for example, 0.1 to 2 watts).

[0042] In some examples, a network node **110** may be, may include, or may operate as an RU, a TRP, or a base station that communicates with one or more UEs **120** via a radio access link (which may be referred to as a "Uu" link). The radio access link may include a downlink and an uplink. "Downlink" (or "DL") refers to a communication direction from a network node **110** to a UE **120**, and "uplink" (or "UL") refers to a communication direction from a UE **120** to a network node **110**. Downlink channels may include one or more control channels and one or more data channels. A downlink control channel may be used to transmit downlink control information (DCI) (for example, scheduling information, reference signals, and/or configuration information) from a network node **110** to a UE **120**. A downlink data channel may be used to transmit downlink data (for example, user data associated with a UE **120**) from a network node **110** to a UE **120**. Downlink control channels may include one or more physical downlink control channels (PDCCHs), and downlink data channels may include one or more physical downlink shared channels (PDSCHs). Uplink channels may similarly include one or more control channels and one or more data channels. An uplink control channel may be used to transmit uplink control information (UCI) (for example, reference signals and/or feedback corresponding to one or more downlink transmissions) from a UE **120** to a network node **110**. An uplink data channel may be used to transmit uplink data (for example, user data associated with a UE **120**) from a UE **120** to a network node **110**. Uplink control channels may include one or more physical uplink control channels (PUCCHs), and uplink data channels may include one or more physical uplink shared channels (PUSCHs). The downlink and the uplink may each include a set of resources on which the network node **110** and the UE **120** may communicate.

[0043] Downlink and uplink resources may include time domain resources (frames, subframes, slots, and/or symbols), frequency domain resources (frequency bands, component carriers, subcarriers, resource blocks, and/or resource elements), and/or spatial domain resources (particular transmit directions and/or beam parameters). Frequency domain resources of some bands may be subdivided into bandwidth parts (BWPs). A BWP may be a continuous block of frequency domain resources (for example, a continuous block of resource blocks) that are allocated for one or more UEs **120**. A UE **120** may be configured with both an uplink BWP and a downlink BWP (where the uplink BWP and the downlink BWP may be the same BWP or different BWPs). A BWP may be dynamically configured (for example, by a network node **110** transmitting a DCI configuration to the one or more UEs **120**) and/or reconfigured, which means that a BWP can be adjusted in real-time (or near-real-time) based on changing network conditions in the wireless communication network **100** and/or based on the specific requirements of the one or more UEs **120**. This enables more efficient use of the available frequency domain resources in the wireless communication network **100** because fewer frequency domain resources may be allocated to a BWP for a UE **120** (which may reduce the quantity of frequency domain resources that a UE **120** is required to monitor), leaving more frequency domain resources to be spread across multiple UEs **120**. Thus, BWPs may also assist in the implementation of lower-capability UEs **120** by facilitating the configuration of smaller bandwidths for communication by such UEs **120**.

[0044] As described above, in some aspects, the wireless communication network **100** may be, may include, or may be included in, an IAB network. In an IAB network, at least one network node **110** is an anchor network node that communicates with a core network. An anchor network node **110** may also be referred to as an IAB donor (or "IAB-donor"). The anchor network node **110** may connect to the core network via a wired backhaul link. For example, an Ng interface of the anchor network node **110** may terminate at the core network. Additionally or alternatively, an anchor network node **110** may connect to one or more devices of the core network that provide a core access and mobility management function (AMF). An IAB network also generally includes multiple non-anchor network nodes **110**, which may also be referred to as relay network nodes or simply as IAB nodes (or "IAB-nodes"). Each non-anchor network node **110** may communicate directly with the anchor network node **110** via a wireless backhaul link to access the core network, or may communicate indirectly with the anchor network node **110** via one or more other non-anchor network nodes **110** and associated wireless backhaul links that form a backhaul path to the core network. Some anchor network node **110** or other non-anchor network node **110** may also communicate directly with one or more UEs **120** via wireless access links that carry access traffic. In some examples, network resources for wireless communication (such as time resources, frequency resources, and/or spatial resources) may be shared between access links and backhaul links.

[0045] In some examples, any network node **110** that relays communications may be referred to as a relay network node, a relay station, or simply as a relay. A relay may receive a transmission of a communication from an upstream station (for example, another network node **110** or a UE **120**) and transmit the communication to a downstream station (for example, a UE **120** or another network node **110**). In this case, the wireless communication network **100** may include or be referred to as a "multi-hop network." In the example shown in FIG. **1**, the network node **110***d* (for example, a relay network node) may communicate with the network node **110***a* (for example, a macro network node) and the UE **120***d* in order to facilitate communication between the network node **110***a* and the UE **120***d*. Additionally or alternatively, a UE **120** may be or may operate as a relay station that can relay transmissions to or from other UEs **120**. A UE **120** that relays communications may be referred to as a UE relay or a relay UE, among other examples.

[0046] The UEs **120** may be physically dispersed throughout the wireless communication network **100**, and each UE **120** may be stationary or mobile. A UE **120** may be, may include, or may be included in an access terminal, another terminal, a mobile station, or a subscriber unit. A UE **120** may be, include, or be coupled with a cellular phone (for example, a smart phone), a personal digital assistant (PDA), a wireless modem, a wireless communication device, a handheld device, a laptop computer, a cordless phone, a wireless local loop (WLL) station, a tablet, a camera, a gaming device, a netbook, a smartbook, an ultrabook, a medical device, a biometric device, a wearable device (for example, a smart watch, smart clothing, smart glasses, a smart wristband, and/or smart jewelry, such as a smart ring or a smart bracelet), an entertainment device (for example, a music device, a video device, and/or a satellite radio), an XR device, a vehicular component or sensor, a smart meter or sensor, industrial manufacturing equipment, a Global Navigation Satellite System (GNSS) device (such as a Global Positioning System device or another type of positioning device), a UE function of a network node, and/or any other suitable device or function that may communicate via a wireless medium.

[0047] A UE **120** and/or a network node **110** may include one or more chips, system-on-chips (SoCs), chipsets, packages, or devices that individually or collectively constitute or comprise a processing system. The processing system includes processor (or "processing") circuitry in the form of one or multiple processors, microprocessors, processing units (such as central processing units (CPUs), graphics processing units (GPUs), neural processing units (NPUs) and/or digital signal processors (DSPs)), processing blocks, application-specific integrated circuits (ASIC), programmable logic devices (PLDs) (such as field programmable gate arrays (FPGAs)), or other discrete gate or transistor logic or circuitry (all of which may be generally referred to herein individually as "processors" or collectively as "the processor" or "the processor circuitry"). One or more of the processors may be individually or collectively configurable or configured to perform various functions or operations described herein. A group of processors collectively configurable or configured to perform a set of functions may include a first processor configurable or configured to perform a first function of the set and a second processor configurable or configured to perform a second function of the set, or may include the group of processors all being configured or configurable to perform the set of functions.

[0048] The processing system may further include memory circuitry in the form of one or more memory devices, memory blocks, memory elements or other discrete gate or transistor logic or circuitry, each of which may include tangible storage media such as random-access memory (RAM) or read-only memory (ROM), or combinations thereof (all of which may be generally referred to herein individually as “memories” or collectively as “the memory” or “the memory circuitry”). One or more of the memories may be coupled (for example, operatively coupled, communicatively coupled, electronically coupled, or electrically coupled) with one or more of the processors and may individually or collectively store processor-executable code (such as software) that, when executed by one or more of the processors, may configure one or more of the processors to perform various functions or operations described herein. Additionally or alternatively, in some examples, one or more of the processors may be preconfigured to perform various functions or operations described herein without requiring configuration by software. The processing system may further include or be coupled with one or more modems (such as a Wi-Fi (for example, IEEE compliant) modem or a cellular (for example, 3GPP 4G LTE, 5G, or 6G compliant) modem). In some implementations, one or more processors of the processing system include or implement one or more of the modems. The processing system may further include or be coupled with multiple radios (collectively “the radio”), multiple RF chains, or multiple transceivers, each of which may in turn be coupled with one or more of multiple antennas. In some implementations, one or more processors of the processing system include or implement one or more of the radios, RF chains or transceivers. The UE **120** may include or may be included in a housing that houses components associated with the UE **120** including the processing system.

[0049] Some UEs **120** may be considered machine-type communication (MTC) UEs, evolved or enhanced machine-type communication (eMTC), UEs, further enhanced eMTC (feMTC) UEs, or enhanced feMTC (efeMTC) UEs, or further evolutions thereof, all of which may be simply referred to as “MTC UEs”. An MTC UE may be, may include, or may be included in or coupled with a robot, an uncrewed aerial vehicle, a remote device, a sensor, a meter, a monitor, and/or a location tag. Some UEs **120** may be considered IoT devices and/or may be implemented as NB-IoT (narrowband IoT) devices. An IoT UE or NB-IoT device may be, may include, or may be included in or coupled with an industrial machine, an appliance, a refrigerator, a doorbell camera device, a home automation device, and/or a light fixture, among other examples. Some UEs **120** may be considered Customer Premises Equipment, which may include telecommunications devices that are installed at a customer location (such as a home or office) to enable access to a service provider's network (such as included in or in communication with the wireless communication network **100**).

[0050] Some UEs **120** may be classified according to different categories in association with different complexities and/or different capabilities. UEs **120** in a first category may facilitate massive IoT in the wireless communication network **100**, and may offer low complexity and/or cost relative to UEs **120** in a second category. UEs **120** in a second category may include mission-critical IoT devices, legacy UEs, baseline UEs, high-tier UEs, advanced UEs, full-capability UEs, and/or premium UEs that are capable of URLLC, enhanced mobile broadband (cMBB), and/or precise positioning in the wireless communication network **100**, among other examples. A third category of UEs **120** may have mid-tier complexity and/or capability (for example, a capability between UEs **120** of the first category and UEs **120** of the second capability). A UE **120** of the third category may be referred to as a reduced capacity UE (“RedCap UE”), a mid-tier UE, an NR-Light UE, and/or an NR-Lite UE, among other examples. RedCap UEs may bridge a gap between the capability and complexity of NB-IoT devices and/or eMTC UEs, and mission-critical IoT devices and/or premium UEs. RedCap UEs may include, for example, wearable devices, IoT devices, industrial sensors, and/or cameras that are associated with a limited bandwidth, power capacity, and/or transmission range, among other examples. RedCap UEs may support healthcare environments, building automation, electrical distribution, process automation, transport and logistics, and/or smart city deployments, among other examples.

[0051] In some examples, two or more UEs **120** (for example, shown as UE **120***a* and UE **120***c*) may communicate directly with one another using sidelink communications (for example, without communicating by way of a network node **110** as an intermediary). As an example, the UE **120***a* may directly transmit data, control information, or other signaling as a sidelink communication to the UE **120***c*. This is in contrast to, for example, the UE **120***a* first transmitting data in an UL communication to a network node **110**, which then transmits the data to the UE **120***e* in a DL communication. In various examples, the UEs **120** may transmit and receive sidelink communications using peer-to-peer (P2P) communication protocols, device-to-device (D2D) communication protocols, vehicle-to-everything (V2X) communication protocols (which may include vehicle-to-vehicle (V2V) protocols, vehicle-to-infrastructure (V2I) protocols, and/or vehicle-to-pedestrian (V2P) protocols), and/or mesh network communication protocols. In some deployments and configurations, a network node **110** may schedule and/or allocate resources for sidelink communications between UEs **120** in the wireless communication network **100**. In some other deployments and configurations, a UE **120** (instead of a network node **110**) may perform, or collaborate or negotiate with one or more other UEs to perform, scheduling operations, resource selection operations, and/or other operations for sidelink communications.

[0052] In various examples, some of the network nodes **110** and the UEs **120** of the wireless communication network **100** may be configured for full-duplex operation in addition to half-duplex operation. A network node **110** or a UE **120** operating in a half-duplex mode may perform only one of transmission or reception during particular time resources, such as during particular slots, symbols, or other time periods. Half-duplex operation may involve time-division duplexing (TDD), in which DL transmissions of the network node **110** and UL transmissions of the UE **120** do not occur in the same time resources (that is, the transmissions do not overlap in time). In contrast, a network node **110** or a UE **120** operating in a full-duplex mode can transmit and receive communications concurrently (for example, in the same time resources). By operating in a full-duplex mode, network nodes **110** and/or UEs **120** may generally increase the capacity of the network and the radio access link. In some examples, full-duplex operation may involve frequency-division duplexing (FDD), in which DL transmissions of the network node **110** are performed in a first frequency band or on a first component carrier and transmissions of the UE **120** are performed in a second frequency band or on a second component carrier different than the first frequency band or the first component carrier, respectively. In some examples, full-duplex operation may be enabled for a UE **120** but not for a network node **110**. For example, a UE **120** may simultaneously transmit an UL transmission to a first network node **110** and receive a DL transmission from a second network node **110** in the same time resources. In some other examples, full-duplex operation may be enabled for a network node **110** but not for a UE **120**. For example, a network node **110** may simultaneously transmit a DL transmission to a first UE **120** and receive an UL transmission from a second UE **120** in the same time resources. In some other examples, full-duplex operation may be enabled for both a network node **110** and a UE **120**.

[0053] In some examples, the UEs **120** and the network nodes **110** may perform MIMO communication. "MIMO" generally refers to transmitting or receiving multiple signals (such as multiple layers or multiple data streams) simultaneously over the same time and frequency resources. MIMO techniques generally exploit multipath propagation. MIMO may be implemented using various spatial processing or spatial multiplexing operations. In some examples, MIMO may support simultaneous transmission to multiple receivers, referred to as multi-user MIMO (MU-MIMO). Some RATs may employ advanced MIMO techniques, such as mTRP operation (including redundant transmission or reception on multiple TRPs), reciprocity in the time domain or the frequency domain, single-frequency-network (SFN) transmission, or non-coherent joint transmission (NC-JT).

[0054] In some aspects, a UE **120** may include a communication manager **140**. As described in more detail elsewhere herein, the communication manager **140** may encode information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate the information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and transmit the encoded symbols. As described in more detail elsewhere herein, the communication manager **140** may receive encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and decode the information bits from the encoded symbols. Additionally, or alternatively, the communication manager **140** may perform one or more other operations described herein.

[0055] In some aspects, a network node **110** may include a communication manager **150**. As described in more detail elsewhere herein, the communication manager **150** may encode information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate the information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and transmit the encoded symbols. As described in more detail elsewhere herein, the communication manager **150** may receive encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and decode the information bits from the encoded symbols. Additionally, or alternatively, the communication manager **150** may perform one or more other operations described herein.

[0056] As indicated above, FIG. **1** is provided as an example. Other examples may differ from what is described with regard to FIG. **1**.

[0057] FIG. **2** is a diagram illustrating an example network node **110** in communication with an example UE **120** in a wireless network in accordance with the present disclosure.

[0058] As shown in FIG. **2**, the network node **110** may include a data source **212**, a transmit processor **214**, a transmit (TX) MIMO processor **216**, a set of modems **232** (shown as **232***a* through **232***t*, where t≥1), a set of antennas **234** (shown as **234***a* through **234***v*, where v≥1), a MIMO detector **236**, a receive processor **238**, a data sink **239**, a controller/processor **240**, a memory **242**, a communication unit **244**, a scheduler **246**, and/or a communication manager **150**, among other examples. In some configurations, one or a combination of the antenna(s) **234**, the modem(s) **232**, the MIMO detector **236**, the receive processor **238**, the transmit processor **214**, and/or the TX MIMO processor **216** may be included in a transceiver of the network node **110**. The transceiver may be under control of and used by one or more processors, such as the controller/processor **240**, and in some aspects in conjunction with processor-readable code stored in the memory **242**, to perform aspects of the methods, processes, and/or operations described herein. In some aspects, the network node **110** may include one or more interfaces, communication components, and/or other components that facilitate communication with the UE **120** or another network node.

[0059] The terms “processor,” “controller,” or “controller/processor” may refer to one or more controllers and/or one or more processors. For example, reference to “a/the processor,” “a/the controller/processor,” or the like (in the singular) should be understood to refer to any one or more of the processors described in connection with FIG. **2**, such as a single processor or a combination of multiple different processors. Reference to “one or more processors” should be understood to refer to any one or more of the processors described in connection with FIG. **2**. For example, one or more processors of the network node **110** may include transmit processor **214**, TX MIMO processor **216**, MIMO detector **236**, receive processor **238**, and/or controller/processor **240**. Similarly, one or more processors of the UE **120** may include MIMO detector **256**, receive processor **258**, transmit processor **264**, TX MIMO processor **266**, and/or controller/processor **280**.

[0060] In some aspects, a single processor may perform all of the operations described as being performed by the one or more processors. In some aspects, a first set of (one or more) processors of the one or more processors may perform a first operation described as being performed by the one or more processors, and a second set of (one or more) processors of the one or more processors may perform a second operation described as being performed by the one or more processors. The first set of processors and the second set of processors may be the same set of processors or may be different sets of processors. Reference to “one or more memories” should be understood to refer to any one or more memories of a corresponding device, such as the memory described in connection with FIG. **2**. For example, operation described as being performed by one or more memories can be performed by the same subset of the one or more memories or different subsets of the one or more memories.

[0061] For downlink communication from the network node **110** to the UE **120**, the transmit processor **214** may receive data (“downlink data”) intended for the UE **120** (or a set of UEs that includes the UE **120**) from the data source **212** (such as a data pipeline or a data queue). In some examples, the transmit processor **214** may select one or more MCSs for the UE **120** in accordance with one or more channel quality indicators (CQIs) received from the UE **120**. The network node **110** may process the data (for example, including encoding the data) for transmission to the UE **120** on a downlink in accordance with the MCS(s) selected for the UE **120** to generate data symbols. The transmit processor **214** may process system information (for example, semi-static resource partitioning information (SRPI)) and/or control information (for example, CQI requests, grants, and/or upper layer signaling) and provide overhead symbols and/or control symbols. The transmit processor **214** may generate reference symbols for reference signals (for example, a cell-specific reference signal (CRS), a demodulation reference signal (DMRS), or a channel state information (CSI) reference signal (CSI-RS)) and/or synchronization signals (for example, a primary synchronization signal (PSS) or a secondary synchronization signals (SSS)).

[0062] The TX MIMO processor **216** may perform spatial processing (for example, precoding) on the data symbols, the control symbols, the overhead symbols, and/or the reference symbols, if applicable, and may provide a set of output symbol streams (for example, T output symbol streams) to the set of modems **232**. For example, each output symbol stream may be provided to a respective modulator component (shown as MOD) of a modem **232**. Each modem **232** may use the respective modulator component to process (for example, to modulate) a respective output symbol stream (for example, for orthogonal frequency division multiplexing (OFDM)) to obtain an output sample stream. Each modem **232** may further use the respective modulator component to process (for example, convert to analog, amplify, filter, and/or upconvert) the output sample stream to obtain a time domain downlink signal. The modems **232***a* through **232***t* may together transmit a set of downlink signals (for example, T downlink signals) via the corresponding set of antennas **234**.

[0063] A downlink signal may include a DCI communication, a MAC control element (MAC-CE) communication, an RRC communication, a downlink reference signal, or another type of downlink communication. Downlink signals may be transmitted on a PDCCH, a PDSCH, and/or on another downlink channel. A downlink signal may carry one or more transport blocks (TBs) of data. A TB may be a unit of data that is transmitted over an air interface in the wireless communication network **100**. A data stream (for example, from the data source **212**) may be encoded into multiple TBs for transmission over the air interface. The quantity of TBs used to carry the data associated with a particular data stream may be associated with a TB size common to the multiple TBs. The

TB size may be based on or otherwise associated with radio channel conditions of the air interface, the MCS used for encoding the data, the downlink resources allocated for transmitting the data, and/or another parameter. In general, the larger the TB size, the greater the amount of data that can be transmitted in a single transmission, which reduces signaling overhead. However, larger TB sizes may be more prone to transmission and/or reception errors than smaller TB sizes, but such errors may be mitigated by more robust error correction techniques.
[0064] For uplink communication from the UE **120** to the network node **110**, uplink signals from the UE **120** may be received by an antenna **234**, may be processed by a modem **232** (for example, a demodulator component, shown as DEMOD, of a modem **232**), may be detected by the MIMO detector **236** (for example, a receive (Rx) MIMO processor) if applicable, and/or may be further processed by the receive processor **238** to obtain decoded data and/or control information. The receive processor **238** may provide the decoded data to a data sink **239** (which may be a data pipeline, a data queue, and/or another type of data sink) and provide the decoded control information to a processor, such as the controller/processor **240**.
[0065] The network node **110** may use the scheduler **246** to schedule one or more UEs **120** for downlink or uplink communications. In some aspects, the scheduler **246** may use DCI to dynamically schedule DL transmissions to the UE **120** and/or UL transmissions from the UE **120**. In some examples, the scheduler **246** may allocate recurring time domain resources and/or frequency domain resources that the UE **120** may use to transmit and/or receive communications using an RRC configuration (for example, a semi-static configuration), for example, to perform semi-persistent scheduling (SPS) or to configure a configured grant (CG) for the UE **120**.
[0066] One or more of the transmit processor **214**, the TX MIMO processor **216**, the modem **232**, the antenna **234**, the MIMO detector **236**, the receive processor **238**, and/or the controller/processor **240** may be included in an RF chain of the network node **110**. An RF chain may include one or more filters, mixers, oscillators, amplifiers, analog-to-digital converters (ADCs), and/or other devices that convert between an analog signal (such as for transmission or reception via an air interface) and a digital signal (such as for processing by one or more processors of the network node **110**). In some aspects, the RF chain may be or may be included in a transceiver of the network node **110**.
[0067] In some examples, the network node **110** may use the communication unit **244** to communicate with a core network and/or with other network nodes. The communication unit **244** may support wired and/or wireless communication protocols and/or connections, such as Ethernet, optical fiber, common public radio interface (CPRI), and/or a wired or wireless backhaul, among other examples. The network node **110** may use the communication unit **244** to transmit and/or receive data associated with the UE **120** or to perform network control signaling, among other examples. The communication unit **244** may include a transceiver and/or an interface, such as a network interface.
[0068] The UE **120** may include a set of antennas **252** (shown as antennas **252***a* through **252***r*, where r≥1), a set of modems **254** (shown as modems **254***a* through **254***u*, where u≥1), a MIMO detector **256**, a receive processor **258**, a data sink **260**, a data source **262**, a transmit processor **264**, a TX MIMO processor **266**, a controller/processor **280**, a memory **282**, and/or a communication manager **140**, among other examples. One or more of the components of the UE **120** may be included in a housing **284**. In some aspects, one or a combination of the antenna(s) **252**, the modem(s) **254**, the MIMO detector **256**, the receive processor **258**, the transmit processor **264**, or the TX MIMO processor **266** may be included in a transceiver that is included in the UE **120**. The transceiver may be under control of and used by one or more processors, such as the controller/processor **280**, and in some aspects in conjunction with processor-readable code stored in the memory **282**, to perform aspects of the methods, processes, or operations described herein. In some aspects, the UE **120** may include another interface, another communication component, and/or another component that facilitates communication with the network node **110** and/or another

UE **120**.

[0069] For downlink communication from the network node **110** to the UE **120**, the set of antennas **252** may receive the downlink communications or signals from the network node **110** and may provide a set of received downlink signals (for example, R received signals) to the set of modems **254**. For example, each received signal may be provided to a respective demodulator component (shown as DEMOD) of a modem **254**. Each modem **254** may use the respective demodulator component to condition (for example, filter, amplify, downconvert, and/or digitize) a received signal to obtain input samples. Each modem **254** may use the respective demodulator component to further demodulate or process the input samples (for example, for OFDM) to obtain received symbols. The MIMO detector **256** may obtain received symbols from the set of modems **254**, may perform MIMO detection on the received symbols if applicable, and may provide detected symbols. The receive processor **258** may process (for example, decode) the detected symbols, may provide decoded data for the UE **120** to the data sink **260** (which may include a data pipeline, a data queue, and/or an application executed on the UE **120**), and may provide decoded control information and system information to the controller/processor **280**.

[0070] For uplink communication from the UE **120** to the network node **110**, the transmit processor **264** may receive and process data ("uplink data") from a data source **262** (such as a data pipeline, a data queue, and/or an application executed on the UE **120**) and control information from the controller/processor **280**. The control information may include one or more parameters, feedback, one or more signal measurements, and/or other types of control information. In some aspects, the receive processor **258** and/or the controller/processor **280** may determine, for a received signal (such as received from the network node **110** or another UE), one or more parameters relating to transmission of the uplink communication. The one or more parameters may include a reference signal received power (RSRP) parameter, a received signal strength indicator (RSSI) parameter, a reference signal received quality (RSRQ) parameter, a CQI parameter, or a transmit power control (TPC) parameter, among other examples. The control information may include an indication of the RSRP parameter, the RSSI parameter, the RSRQ parameter, the CQI parameter, the TPC parameter, and/or another parameter. The control information may facilitate parameter selection and/or scheduling for the UE **120** by the network node **110**.

[0071] The transmit processor **264** may generate reference symbols for one or more reference signals, such as an uplink DMRS, an uplink sounding reference signal (SRS), and/or another type of reference signal. The symbols from the transmit processor **264** may be precoded by the TX MIMO processor **266**, if applicable, and further processed by the set of modems **254** (for example, for DFT-s-OFDM or CP-OFDM). The TX MIMO processor **266** may perform spatial processing (for example, precoding) on the data symbols, the control symbols, the overhead symbols, and/or the reference symbols, if applicable, and may provide a set of output symbol streams (for example, U output symbol streams) to the set of modems **254**. For example, each output symbol stream may be provided to a respective modulator component (shown as MOD) of a modem **254**. Each modem **254** may use the respective modulator component to process (for example, to modulate) a respective output symbol stream (for example, for OFDM) to obtain an output sample stream. Each modem **254** may further use the respective modulator component to process (for example, convert to analog, amplify, filter, and/or upconvert) the output sample stream to obtain an uplink signal.

[0072] The modems **254***a* through **254***u* may transmit a set of uplink signals (for example, R uplink signals or U uplink symbols) via the corresponding set of antennas **252**. An uplink signal may include a UCI communication, a MAC-CE communication, an RRC communication, or another type of uplink communication. Uplink signals may be transmitted on a PUSCH, a PUCCH, and/or another type of uplink channel. An uplink signal may carry one or more TBs of data. Sidelink data and control transmissions (that is, transmissions directly between two or more UEs **120**) may generally use similar techniques as were described for uplink data and control transmission, and may use sidelink-specific channels such as a physical sidelink shared channel (PSSCH), a physical sidelink control channel (PSCCH), and/or a physical sidelink feedback channel (PSFCH).

[0073] One or more antennas of the set of antennas **252** or the set of antennas **234** may include, or may be included within, one or more antenna panels, one or more antenna groups, one or more sets of antenna elements, or one or more antenna arrays, among other examples. An antenna panel, an antenna group, a set of antenna elements, or an antenna array may include one or more antenna elements (within a single housing or multiple housings), a set of coplanar antenna elements, a set of non-coplanar antenna elements, or one or more antenna elements coupled with one or more transmission or reception components, such as one or more components of FIG. **2**. As used herein, "antenna" can refer to one or more antennas, one or more antenna panels, one or more antenna groups, one or more sets of antenna elements, or one or more antenna arrays. "Antenna panel" can refer to a group of antennas (such as antenna elements) arranged in an array or panel, which may facilitate beamforming by manipulating parameters of the group of antennas. "Antenna module" may refer to circuitry including one or more antennas, which may also include one or more other components (such as filters, amplifiers, or processors) associated with integrating the antenna module into a wireless communication device.

[0074] In some examples, each of the antenna elements of an antenna **234** or an antenna **252** may include one or more sub-elements for radiating or receiving radio frequency signals. For example, a single antenna element may include a first sub-element cross-polarized with a second sub-element that can be used to independently transmit cross-polarized signals. The antenna elements may include patch antennas, dipole antennas, and/or other types of antennas arranged in a linear pattern, a two-dimensional pattern, or another pattern. A spacing between antenna elements may be such that signals with a desired wavelength transmitted separately by the antenna elements may interact or interfere constructively and destructively along various directions (such as to form a desired beam). For example, given an expected range of wavelengths or frequencies, the spacing may provide a quarter wavelength, a half wavelength, or another fraction of a wavelength of spacing between neighboring antenna elements to allow for the desired constructive and destructive interference patterns of signals transmitted by the separate antenna elements within that expected range.

[0075] The amplitudes and/or phases of signals transmitted via antenna elements and/or sub-elements may be modulated and shifted relative to each other (such as by manipulating phase shift, phase offset, and/or amplitude) to generate one or more beams, which is referred to as beamforming. The term "beam" may refer to a directional transmission of a wireless signal toward a receiving device or otherwise in a desired direction. "Beam" may also generally refer to a direction associated with such a directional signal transmission, a set of directional resources associated with the signal transmission (for example, an angle of arrival, a horizontal direction, and/or a vertical direction), and/or a set of parameters that indicate one or more aspects of a directional signal, a direction associated with the signal, and/or a set of directional resources associated with the signal. In some implementations, antenna elements may be individually selected or deselected for directional transmission of a signal (or signals) by controlling amplitudes of one or more corresponding amplifiers and/or phases of the signal(s) to form one or more beams. The shape of a beam (such as the amplitude, width, and/or presence of side lobes) and/or the direction of a beam (such as an angle of the beam relative to a surface of an antenna array) can be dynamically controlled by modifying the phase shifts, phase offsets, and/or amplitudes of the multiple signals relative to each other.

[0076] Different UEs **120** or network nodes **110** may include different numbers of antenna elements. For example, a UE **120** may include a single antenna element, two antenna elements, four antenna elements, eight antenna elements, or a different number of antenna elements. As another example, a network node **110** may include eight antenna elements, **24** antenna elements, **64** antenna elements, **128** antenna elements, or a different number of antenna elements. Generally, a larger number of antenna elements may provide increased control over parameters for beam generation relative to a smaller number of antenna elements, whereas a smaller number of antenna elements may be less complex to implement and may use less power than a larger number of antenna elements. Multiple antenna elements may support multiple-layer transmission, in which a first layer of a communication (which may include a first data stream) and a second layer of a communication (which may include a second data stream) are transmitted using the same time and frequency resources with spatial multiplexing.

[0077] While blocks in FIG. **2** are illustrated as distinct components, the functions described above with respect to the blocks may be implemented in a single hardware, software, or combination component or in various combinations of components. For example, the functions described with respect to the transmit processor **264**, the receive processor **258**, and/or the TX MIMO processor **266** may be performed by or under the control of the controller/processor **280**.

[0078] FIG. **3** is a diagram illustrating an example disaggregated base station architecture **300** in accordance with the present disclosure. One or more components of the example disaggregated base station architecture **300** may be, may include, or may be included in one or more network nodes (such one or more network nodes **110**). The disaggregated base station architecture **300** may include a CU **310** that can communicate directly with a core network **320** via a backhaul link, or that can communicate indirectly with the core network **320** via one or more disaggregated control units, such as a Non-RT RIC **350** associated with a Service Management and Orchestration (SMO) Framework **360** and/or a Near-RT RIC **370** (for example, via an E2 link). The CU **310** may communicate with one or more DUs **330** via respective midhaul links, such as via F1 interfaces. Each of the DUs **330** may communicate with one or more RUs **340** via respective fronthaul links. Each of the RUs **340** may communicate with one or more UEs **120** via respective RF access links. In some deployments, a UE **120** may be simultaneously served by multiple RUs **340**.

[0079] Each of the components of the disaggregated base station architecture **300**, including the CUS **310**, the DUs **330**, the RUs **340**, the Near-RT RICs **370**, the Non-RT RICs **350**, and the SMO Framework **360**, may include one or more interfaces or may be coupled with one or more interfaces for receiving or transmitting signals, such as data or information, via a wired or wireless transmission medium.

[0080] In some aspects, the CU **310** may be logically split into one or more CU user plane (CU-UP) units and one or more CU control plane (CU-CP) units. A CU-UP unit may communicate bidirectionally with a CU-CP unit via an interface, such as the E1 interface when implemented in an O-RAN configuration. The CU **310** may be deployed to communicate with one or more DUs **330**, as necessary, for network control and signaling. Each DU **330** may correspond to a logical unit that includes one or more base station functions to control the operation of one or more RUs **340**. For example, a DU **330** may host various layers, such as an RLC layer, a MAC layer, or one or more PHY layers, such as one or more high PHY layers or one or more low PHY layers. Each layer (which also may be referred to as a module) may be implemented with an interface for communicating signals with other layers (and modules) hosted by the DU **330**, or for communicating signals with the control functions hosted by the CU **310**. Each RU **340** may implement lower layer functionality. In some aspects, real-time and non-real-time aspects of control and user plane communication with the RU(s) **340** may be controlled by the corresponding DU **330**.

[0081] The SMO Framework **360** may support RAN deployment and provisioning of non-virtualized and virtualized network elements. For non-virtualized network elements, the SMO Framework **360** may support the deployment of dedicated physical resources for RAN coverage requirements, which may be managed via an operations and maintenance interface, such as an O1 interface. For virtualized network elements, the SMO Framework **360** may interact with a cloud computing platform (such as an open cloud (O-Cloud) platform **390**) to perform network element life cycle management (such as to instantiate virtualized network elements) via a cloud computing platform interface, such as an O2 interface. A virtualized network element may include, but is not limited to, a CU **310**, a DU **330**, an RU **340**, a non-RT RIC **350**, and/or a Near-RT RIC **370**. In some aspects, the SMO Framework **360** may communicate with a hardware aspect of a 4G RAN, a 5G NR RAN, and/or a 6G RAN, such as an open eNB (O-eNB) **380**, via an O1 interface. Additionally or alternatively, the SMO Framework **360** may communicate directly with each of one or more RUs **340** via a respective O1 interface. In some deployments, this configuration can enable each DU **330** and the CU **310** to be implemented in a cloud-based RAN architecture, such as a vRAN architecture.

[0082] The Non-RT RIC **350** may include or may implement a logical function that enables non-real-time control and optimization of RAN elements and resources, AI/ML workflows including model training and updates, and/or policy-based guidance of applications and/or features in the Near-RT RIC **370**. The Non-RT RIC **350** may be coupled to or may communicate with (such as via an A1 interface) the Near-RT RIC **370**. The Near-RT RIC **370** may include or may implement a logical function that enables near-real-time control and optimization of RAN elements and resources via data collection and actions via an interface (such as via an E2 interface) connecting one or more CUs **310**, one or more DUs **330**, and/or an O-eNB with the Near-RT RIC **370**.

[0083] In some aspects, to generate AI/ML models to be deployed in the Near-RT RIC **370**, the Non-RT RIC **350** may receive parameters or external enrichment information from external servers. Such information may be utilized by the Near-RT RIC **370** and may be received at the SMO Framework **360** or the Non-RT RIC **350** from non-network data sources or from network functions. In some examples, the Non-RT RIC **350** or the Near-RT RIC **370** may tune RAN behavior or performance. For example, the Non-RT RIC **350** may monitor long-term trends and patterns for performance and may employ AI/ML models to perform corrective actions via the SMO Framework **360** (such as reconfiguration via an O1 interface) or via creation of RAN management policies (such as A1 interface policies).

[0084] The network node **110**, the controller/processor **240** of the network node **110**, the UE **120**, the controller/processor **280** of the UE **120**, the CU **310**, the DU **330**, the RU **340**, or any other component(s) of FIG. **1**, **2**, or **3** may implement one or more techniques or perform one or more operations associated with nonbinary polar coding with partially frozen symbols, as described in more detail elsewhere herein. For example, the controller/processor **240** of the network node **110**, the controller/processor **280** of the UE **120**, any other component(s) of FIG. **2**, the CU **310**, the DU **330**, or the RU **340** may perform or direct operations of, for example, process **600** of FIG. **6**, process **700** of FIG. **7**, or other processes as described herein (alone or in conjunction with one or more other processors). In some aspects, the transmitter device described herein is the network node **110** or the UE **120**, is included in the network node **110** or the UE **120**, or includes one or more components of the network node **110** or the UE **120** shown in FIG. **2**. In some aspects, the receiver device described herein is the network node **110** or the UE **120**, is included in the network node **110** or the UE **120**, or includes one or more components of the network node **110** or the UE **120** shown in FIG. **2**. The memory **242** may store data and program codes for the network node **110**, the network node **110**, the CU **310**, the DU **330**, or the RU **340**. The memory **282** may store data and program codes for the UE **120**. In some examples, the memory **242** or the memory **282** may include a non-transitory computer-readable medium storing a set of instructions (for example, code or program code) for wireless communication. The memory **242** may include one or more memories, such as a single memory or multiple different memories (of the same type or of different types). The memory **282** may include one or more memories, such as a single memory or multiple different memories (of the same type or of different types). For example, the set of instructions, when executed (for example, directly, or after compiling, converting, or interpreting) by one or more processors of the network node **110**, the UE **120**, the CU **310**, the DU **330**, or the RU **340**, may cause the one or more processors to perform process **600** of FIG. **6**, process **700** of FIG. **7**, or other processes as described herein. In some examples, executing instructions may include running the instructions, converting the instructions, compiling the instructions, and/or interpreting the instructions, among other examples.

[0085] In some aspects, a transmitter device (e.g., a UE **120** or a network node **110**) includes means for encoding information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate the information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and/or means for transmitting the encoded symbols. In some aspects, the means for the transmitter device to perform operations described herein may include, for example, one or more of communication manager **150**, transmit processor **214**, TX MIMO processor **216**, modem **232**, antenna **234**, MIMO detector **236**, receive processor **238**, controller/processor **240**, memory **242**, or scheduler **246**. In some aspects, the means for the transmitter device to perform operations described herein may include, for example, one or more of communication manager **140**, antenna **252**, modem **254**, MIMO detector **256**, receive processor **258**, transmit processor **264**, TX MIMO processor **266**, controller/processor **280**, or memory **282**.

[0086] In some aspects, a receiver device (e.g., a UE **120** or a network node **110**) includes means for receiving encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and/or means for decoding the information bits from the encoded symbols. In some aspects, the means for the receiver device to perform operations described herein may include, for example, one or more of communication manager **150**, transmit processor **214**, TX MIMO processor **216**, modem **232**, antenna **234**, MIMO detector **236**, receive processor **238**, controller/processor **240**, memory **242**, or scheduler **246**. In some aspects, the means for the receiver device to perform operations described herein may include, for example, one or more of communication manager **140**, antenna **252**, modem **254**, MIMO detector **256**, receive processor **258**, transmit processor **264**, TX MIMO processor **266**, controller/processor **280**, or memory **282**.

[0087] As indicated above, FIG. **3** is provided as an example. Other examples may differ from what is described with regard to FIG. **3**.

[0088] FIG. **4** is a diagram illustrating an example **400** of nonbinary (e.g., quaternary or “4-ary”) polar coding, in accordance with the present disclosure.

[0089] Wireless communications may be encoded using polar coding to improve resilience to non-ideal channel conditions. Polar encoding may involve constructing a codeword c having a length N. In some examples, encoding with an (N=2.sup.m, K) code defined over a Galois Field (GF) with four elements (GF(4)), the codeword

[00001] $$c = u\begin{pmatrix} 1 & 0 \\ & 1 \end{pmatrix}^{\text{.Math. } m},$$

where u.sub.i, c.sub.i∈GF(4) and γ is an element of GF(4) not equal to 0 or 1. A symbol u.sub.i may carry information (e.g., a two-bit payload) or may be frozen (e.g., having a fixed value, such as u.sub.i=0).

[0090] The matrix

[00002] $$\begin{pmatrix} 1 & 0 \\ & 1 \end{pmatrix}^{\text{.Math. } m},$$

for γ≠1, may polarize 2.sup.m copies of a channel W into subchannels W.sup.(i), which may be almost noisy (e.g., I(W.sup.(i)).fwdarw.0) or almost noiseless (e.g., I(W.sup.(i)).fwdarw.2). As an example, subchannels W.sup.(i) may be polarized into highly reliable (e.g., low noise) subchannels W.sup.(i) and highly unreliable (e.g., noisy) subchannels W.sup.(i). For example, the capacities of the subchannels W.sup.(i), I(W.sup.(i)), may approach two for highly reliable subchannels W.sup.(i) and 0 for highly unreliable subchannels W.sup.(i). If γ=1, subchannels W.sup.(i) may be present where the capacities I(W.sup.(i)) approach one (e.g., I(W.sup.(i)).fwdarw.1).

[0091] Polar coding provides for a set of information symbols i.sub.0, . . . i.sub.K−1 to be mapped to reliable symbol positions and for unreliable symbols to be replaced with frozen symbols. For example, the information symbols i.sub.0, . . . i.sub.K−1 may correspond to the K largest capacities I(W.sup.(i)). For example, a transmitter may transmit the information symbols i.sub.0, . . . i.sub.K−1 through the subchannels W.sup.(i) that have the K largest capacities I(W.sup.(i)).

[0092] Example **400** demonstrates polar encoding by coupling a plurality of subchannels W.sup.(i) over multiple phases **410-430**. Phase **410** involves coupling neighboring subchannels W.sup.(i). Phase **420** involves coupling subchannels W.sup.(i) separated by one subchannel W.sup.(i). Phase **430** involves coupling subchannels W.sup.(i) separated by three subchannels W.sup.(i). Polar decoding may involve performing example **400** in reverse (e.g., phase **430**, followed by phase **420**, followed by phase **410**).

[0093] Nonbinary polar coding may use a general nonbinary kernel

[00003]$G = \begin{pmatrix} 1 & 0 \\ & 1 \end{pmatrix}$,

where γ∈{1, α, α.sup.2}, and a is the primitive element of GF(2.sup.2). Thus, the elements of GF(2.sup.2) may include {0, 1, α, α.sup.2=α+1}, which may be considered as the elements {00, 01, 10, 11} of a two-dimensional vector space over GF(2). The summation of the elements may be defined coordinate-wise (e.g., where each coordinate is a single bit), and for multiplication of the elements, the following properties may be used: 0.Math.x=0, 1.Math.x=x, and α.sup.3=1. As described herein, for encoding in nonbinary polar coding, a recursive structure

[00004]$\begin{pmatrix} 1 & 0 \\ & 1 \end{pmatrix}^{\text{.Math. } m}$

is used. With respect to decoding in nonbinary polar coding, given a received symbol y, the decoder needs to know the sufficient statistic for p(c|y). With a nonbinary alphabet, a single log likelihood ratio (LLR) value is not sufficient for the decoder. Instead, the decoder can use a logarithmic probability mass function (LPMF):

[00005]$s = \left[\log\left(\frac{p(c=0 \text{ .Math. } y)}{p(c=0 \text{ .Math. } y)}\right) \log\left(\frac{p(c=1 \text{ .Math. } y)}{p(c=0 \text{ .Math. } y)}\right) \log\left(\frac{p(c=2 \text{ .Math. } y)}{p(c=0 \text{ .Math. } y)}\right) \log\left(\frac{p(c=3 \text{ .Math. } y)}{p(c=0 \text{ .Math. } y)}\right)\right]$

For list decoding of nonbinary polar codes, using a max-sum approximation applying a function f(a, b):

[00006]$(\mathbb{R}^4, \mathbb{R}^4) \text{ .fwdarw. } \mathbb{R}^4, s_i = \max_{j,k: i=j+k} (a_j + b_k)$,

and using an exact computation applying a function g(a, b, c):(custom-character.sup.4, custom-character.sup.4, GF(2.sup.2)).fwdarw.custom-character.sup.4, s.sub.i=α.sub.c+γi+b.sub.i. Thus, a maximum-likelihood decision corresponds to

[00007]$c^* = \operatorname{argmax}_j s_j$.

Accordingly, a path continuation with c has a penalty equal to s.sub.c*−s.sub.cc. The decoding logic described herein may be the same for both frozen symbols and information symbols.

[0094] Nonbinary polar codes may provide faster polarization than binary codes, but for small block lengths (e.g., for finite lengths), nonbinary polar codes result in many imperfectly polarized symbol channels (e.g., there are not many fully polarized symbol subchannels). For example, nonbinary polar codes may provide lower latency and improved polarization properties relative to binary polar codes. However, the many imperfectly polarized symbol channels resulting from nonbinary polar coding may affect information rate and spectrum efficiency.

[0095] Various aspects relate generally to utilizing imperfectly polarized symbol channels. Some aspects more specifically relate to nonbinary polar coding with information symbols, partially frozen symbols, and frozen symbols. In some aspects, the information symbols and the partially frozen symbols can carry data bits. For example, the information symbols may be used for indicating any of the symbol values in a set of values, and the partially frozen symbols may be used for indicating only symbol values of a proper subset of the set of values. In some aspects, positions of the information symbols and the partially frozen symbols in a codeword may be identifiable in accordance with a universal reliability sequence.

[0096] Particular aspects of the subject matter described in this disclosure can be implemented to realize one or more of the following potential advantages. In some examples, by using information symbols and partially frozen symbols to indicate information bits, the described techniques better utilize frequency resources, improve information rate, and improve spectrum efficiency. Furthermore, controlling partially frozen symbols to a subset of values that are available to information symbols can simplify decoding by reducing a candidate space associated with processing partially frozen symbols. In addition, using a universal reliability sequence for identification of positions of information symbols and partially frozen symbols simplifies decoding and reduces signaling that would otherwise be needed to signal a reliability sequence to a UE, thereby conserving network resources.

[0097] As indicated above, FIG. **4** is provided as an example. Other examples may differ from what is described with respect to FIG. **4**.

[0098] FIG. **5** is a diagram of an example **500** associated with nonbinary polar coding with partially frozen symbols, in accordance with the present disclosure. As shown in FIG. **5**, a transmitter device and a receiver device may communicate. The transmitter device may be or may be included in a network node (e.g., network node **110**, a CU, a DU, and/or an RU) or a UE (e.g., UE **120**). Similarly, the receiver device may be or may be included in a network node or a UE. In some aspects, the transmitter device and the receiver device may be part of a wireless network (e.g., wireless network **100**). The transmitter device and the receiver device may have established a wireless connection prior to operations shown in FIG. **5**. Although the transmitter device is described herein as transmitting communications to the receiver device, the transmitter device may additionally or alternatively receive communications from the receiver device. Furthermore, although the receiver device is described herein as receiving communications from the transmitter device, the receiver device may additionally or alternatively transmit communications to the transmitter device.

[0099] As shown by reference number **505**, the transmitter device (e.g., a network node) may transmit, and the receiver device (e.g., a UE) may receive, configuration information. In some aspects, the receiver device may receive the configuration information via one or more of system information (e.g., a master information block (MIB) and/or a system information block (SIB), among other examples), RRC signaling, one or more MAC-CEs, and/or DCI, among other examples.

[0100] In some aspects, the configuration information may indicate one or more candidate configurations and/or communication parameters. In some aspects, the one or more candidate configurations and/or communication parameters may be selected, activated, and/or deactivated by a subsequent indication. For example, the subsequent indication may select a candidate configuration and/or communication parameter from the one or more candidate configurations and/or communication parameters. In some aspects, the subsequent indication (e.g., an indication described herein) may include a dynamic indication, such as one or more MAC-CEs and/or one or more DCI messages, among other examples.

[0101] In some aspects, the configuration information may indicate an MCS that is to be used. In some aspects, the configuration information may indicate that the receiver device is to use nonbinary polar coding for one or more communication types, channels, and/or signals. Additionally, or alternatively, the configuration information may indicate that the receiver device is to use partially frozen symbols for encoding and/or decoding. The receiver device may configure itself based at least in part on the configuration information. In some aspects, the receiver device may be configured to perform one or more operations described herein based at least in part on the configuration information. In some aspects, the receiver device (e.g., a network node) may transmit, and the transmitter device (e.g., a UE) may receive, the configuration information.

[0102] As shown by reference number **510**, the receiver device (e.g., a UE) may transmit, and the transmitter device (e.g., a network node) may receive, a capabilities report. The capabilities report may indicate whether the receiver device supports a feature and/or one or more parameters related to the feature. For example, the capability report may indicate a capability and/or parameter for nonbinary polar coding. As another example, the capabilities report may indicate a capability and/or parameter for use of partially frozen symbols. One or more operations described herein may be based on capability information of the capabilities report. For example, the receiver device may perform a communication in accordance with the capability information, or may receive configuration information that is in accordance with the capability information. In some aspects, the transmitter device (e.g., a UE) may transmit, and the receiver device (e.g., a network node) may receive, the capabilities report.

[0103] In some aspects, the configuration information described in connection with reference number **505** and/or the capabilities report may include information transmitted via multiple communications. Additionally, or alternatively, the transmitter device (e.g., a network node) may transmit the configuration information, or a communication including at least a portion of the configuration information, before and/or after the receiver device (e.g., a UE) transmits the capabilities report. For example, the transmitter device may transmit a first portion of the configuration information before the capabilities report, the receiver device may transmit at least a portion of the capabilities report, and the transmitter device may transmit a second portion of the configuration information after receiving the capabilities report.

[0104] As shown by reference number **515**, the transmitter device (e.g., a network node or a UE) may encode information bits using nonbinary polar coding (e.g., using a nonbinary polar code) to generate encoded symbols. The information bits may relate to DCI, UCI, hybrid automatic repeat request (HARQ) feedback, or a broadcast channel, among other examples. The encoded symbols may be part of a codeword for transmission over a communication channel. The encoding of the information bits may use a quaternary polar code. In some aspects, the nonbinary polar coding may use a set of values, such as GF(4), as an alphabet. For example, the set of values may have four values (e.g., 0, 1, α, α.sup.2).

[0105] The encoded symbols may include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols. In some aspects, a quantity of partially frozen symbols in the set of partially frozen symbols may be according to a code rate (e.g., of the codeword). The information symbols may indicate values in the set of values (e.g., the information symbols may take all possible GF(4) values). For example, an information symbol may have four possible values. As an example, an information symbol may carry two bits of data (e.g., two bits of the information bits). The frozen symbols may indicate a value (e.g., 0) that has been made known to the receiver device (e.g., the decoder). For example, the frozen symbols carry no data.

[0106] The partially frozen symbols may indicate values in a proper subset of the set of values (e.g., the partially frozen symbols may take a proper subset of the GF(4) values). For example, a partially frozen symbol may have two possible values or three possible values (e.g., the subset of the set of values has two values or three values, whereas the set of values has four values). As an example, a partially frozen symbol may carry less than two bits of data (e.g., less than two bits of the information bits). A partially frozen symbol that has two possible values may carry log.sub.22=1 data bit. A partially frozen symbol that has three possible values may carry log.sub.23 data bits. Accordingly, the partially frozen symbols may be hybrid symbols that carry both data and frozen bits for nonbinary polar codes. For example, the partial freezing may be at a symbol level (e.g., a symbol may have one frozen value and three non-frozen values).

[0107] As shown by reference number **520**, the transmitter device may transmit, and the receiver device (e.g., a network node or a UE) may receive, the encoded symbols (e.g., over a communication channel). For example, the receiver device may receive the encoded symbols that have been encoded using nonbinary polar coding. In some aspects, the transmitter device may transmit a codeword formed from the encoded symbols, and the receiver device may receive the codeword.

[0108] As shown by reference number **525**, the receiver device may decode the information bits from the encoded symbols. In some aspects, the receiver device may identify a quantity of partially frozen symbols in the set of partially frozen symbols according to a code rate (e.g., of the codeword). For example, an optimal symbol type allocation may be sensitive to changes in code rate and/or an operating signal-to-noise ratio (SNR).

[0109] Moreover, positions of the information symbols and of the partially frozen symbols in the encoded symbols may be in accordance with a reliability sequence. For example, the receiver device may identify the positions of the information symbols and the partially frozen symbols using the reliability sequence. The reliability sequence may be a universal reliability sequence (e.g., a universal symbol reliability sequence). The universal reliability sequence may be a predetermined (e.g., static) sequence. For example, the universal reliability sequence may be provisioned (e.g., preconfigured) for the receiver device (e.g., a UE) without the use of signaling from the transmitter device (e.g., a network node). The universal reliability sequence may be as defined or similarly as defined for 5G NR in 3GPP Technical Specification 38.212.

[0110] In some aspects, the receiver device may process (e.g., on a per-symbol basis) the encoded symbols in a quaternary successive cancellation (SC) or successive cancellation list (SCL) decoder. For example, to decode the encoded symbols, the receiver device may process the encoded symbols using an SC or SCL methodology. As an example, with respect to an information symbol u.sub.i, for each path u.sub.i.sup.(l)=(u.sub.0.sup.(l), . . . u.sub.i−1.sup.(l)) with a metric μ.sup.(l) and a corresponding LPMF s.sup.(l)=(s.sub.0.sup.(l), s.sub.1.sup.(l), s.sub.2.sup.(l), s.sub.3.sup.(l)), the receiver device, for each α∈GF(4), may generate candidates (u.sub.i.sup.(l), α)=(u.sub.0.sup.(l), . . . u.sub.i−1.sup.(l), α) with metrics

[00008] $\,^{(l)}_{a} = \,^{(l)} + \max_{j} s_j^{(l)} - s_a^{(l)}$.

Continuing with the example, the receiver device may sort all of the candidates according to their respective metrics and select (e.g., keep) L paths (out of 4L) with the smallest values μ.sub.α.sup.(l). As another example, with respect to a partially frozen symbol u.sub.i that can carry one bit of data and can take two values (0, ρ), in a similar manner as described for the information symbols, the receiver device may generate only two candidates (u.sub.i.sup.(o), 0) and (u.sub.i.sup.(l), ρ) (e.g., reducing the quantity of values that a symbol can take from four values to two values reduces the quantity of candidates that are generated), and the receiver device may select L paths out of 2L. By reducing the quantity of candidates for sorting in connection with partially frozen symbols, computing resources (e.g., memory resources and/or processor resources) of the receiver device can be conserved.

[0111] As an example of this decoding, assuming an all-zero payload and that u.sub.i has a computed LPMF s=[0 −2 1.5 −3.5] (i.e., the correct value of u.sub.i=0 corresponds to s.sub.0=0), if u.sub.i is an information symbol, then the decoder (e.g., the SC decoder) would select

[00009] $u_i = \arg \max_{i \in \{0,1,2,3\}} \text{or} s_i = 2,$

which results in a decoding error. However, if u.sub.i is a partially frozen symbol that can take the values (0, 3), then the decoder would select

[00010] $u_i = \arg \max_{i \in \{0,3\}} \text{or} s_i = 0,$

which results in a correct decoding. Thus, limiting the possible values of partially frozen symbols improves decoding efficiency.

[0112] As an example of utilizing the reliability sequence (e.g., an information symbol reliability

sequence) to identify partially frozen symbols that can take two values, the receiver device, for each quantity of information bits 2K, may select a quantity 2x of partially frozen symbols (e.g., which entails unfreezing x additional symbol channels, and therefore the value of x should be carefully selected). Continuing with the example, the receiver device may select K+x best symbol channels according to the reliability sequence (e.g., where the best symbol channels are associated with the highest reliability values of the reliability sequence). The receiver device may identify K−x of the K+x best symbol channels as information that carry two bits of data. The receiver device may identify the 2.x remaining of the K+x best symbol channels as partially frozen that carry one bit of data. Accordingly, for each of the 2.x remaining partially frozen symbols, the receiver device may select an acceptable value ρ∈{1,2,3} that corresponds to a non-zero bit value.
[0113] As described herein, partially frozen symbols may take three values (0, α, β), where three data bits (e.g., 2.sup.3=8 possible values) are mapped to two symbols (e.g., 3.sup.2=9 possible values). The mapping may be performed using a defined function f: {0,1}.sup.3.fwdarw.(GF(4)).sup.2. After decoding, the receiver device may apply f.sup.−1 to recover the data bits. Here, there may be one combination of partial symbol values that does not correspond to a valid bit string.
[0114] In connection with decoding the encoded symbols using an SC or SCL methodology, and with respect to a partially frozen symbol u.sub.i that can take three values (0, α, β), in a similar manner as described for the information symbols, the receiver device may generate (e.g., may consider) three candidates (u.sub.i.sup.(l), 0), (u.sub.i.sup.(l), α), (u.sub.i.sup.(l), β), and the receiver device may select L paths out of 3L. For example, the receiver device may decode the encoded symbols by processing partially frozen symbols on a per-symbol basis. At an end of the decoding, the receiver device may discard all paths that do not correspond to a valid information bit value. Alternatively, the receiver device (e.g., the decoder) may keep track of partially frozen symbol pairs during decoding. Here, for the first symbol in a symbol pair, the receiver device may consider three candidates, as described above, and for the second symbol in the symbol pair, the receiver device may consider all three candidates or only two candidates depending on a value of the first symbol (e.g., to avoid selecting an a priori invalid pair). For example, the receiver device may decode the encoded symbols by processing partially frozen symbols in symbol pairs, thereby improving a performance of the decoding.
[0115] As an example of utilizing the reliability sequence (e.g., an information symbol
[0116] reliability sequence) to identify partially frozen symbols that can take three values, the receiver device, for each quantity of information bits 2K, may select a quantity 4x of partially frozen symbols. Continuing with the example, the receiver device may select K+x best symbol channels according to the reliability sequence. The receiver device may identify K−3x of the K+x best symbol channels as information that carry two bits of data. The receiver device may identify the 4x remaining of the K+x best symbol channels as partially frozen, which can be split into symbols pairs. Each pair of partially frozen symbols may carry three bits of data. Accordingly, for each pair of partially frozen symbols, the defined function f: {0,1}.sup.3.fwdarw.(GF(4)).sup.2 maps bit triplet values to symbol pair values.
[0117] By using partially frozen symbols, as described herein, imperfectly polarized symbol channels are utilized more efficiently. Accordingly, the partially frozen symbols efficiently utilize frequency resources, improve information rate, and improve spectrum efficiency.
[0118] As indicated above, FIG. **5** is provided as an example. Other examples may differ from what is described with respect to FIG. **5**.
[0119] FIG. **6** is a diagram illustrating an example process **600** performed, for example, at a transmitter device or an apparatus of a transmitter device, in accordance with the present disclosure. Example process **600** is an example where the apparatus or the transmitter device (e.g., a UE **120** or a network node **110**) performs operations associated with nonbinary polar coding with partially frozen symbols.

[0120] As shown in FIG. **6**, in some aspects, process **600** may include encoding information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate the information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values (block **610**). For example, the transmitter device (e.g., using communication manager **806**, depicted in FIG. **8**) may encode information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, as described above. In some aspects, the set of information symbols and the set of partially frozen symbols indicate the information bits. In some aspects, the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values.
[0121] As further shown in FIG. **6**, in some aspects, process **600** may include transmitting the encoded symbols (block **620**). For example, the transmitter device (e.g., using transmission component **804** and/or communication manager **806**, depicted in FIG. **8**) may transmit the encoded symbols, as described above.
[0122] Process **600** may include additional aspects, such as any single aspect or any combination of aspects described below and/or in connection with one or more other processes described elsewhere herein.
[0123] In a first aspect, each information symbol, of the set of information symbols, indicates two bits of data.
[0124] In a second aspect, alone or in combination with the first aspect, each partially frozen symbol, of the set of partially frozen symbols, indicates less than two bits of data.
[0125] In a third aspect, alone or in combination with one or more of the first and second aspects, an information symbol, of the set of information symbols, has four possible values, and a partially frozen symbol, of the set of partially frozen symbols, has two possible values or three possible values.
[0126] In a fourth aspect, alone or in combination with one or more of the first through third aspects, a quantity of partially frozen symbols in the set of partially frozen symbols is according to a code rate.
[0127] In a fifth aspect, alone or in combination with one or more of the first through fourth aspects, positions of information symbols, of the set of information symbols, and of partially frozen symbols, of the set of partially frozen symbols, in the encoded symbols are in accordance with a reliability sequence.
[0128] In a sixth aspect, alone or in combination with one or more of the first through fifth aspects, process **600** includes communicating configuration information indicating that partially frozen symbols are to be used.
[0129] In a seventh aspect, alone or in combination with one or more of the first through sixth aspects, process **600** includes communicating a capabilities report indicating a capability to use partially frozen symbols.
[0130] Although FIG. **6** shows example blocks of process **600**, in some aspects, process **600** may include additional blocks, fewer blocks, different blocks, or differently arranged blocks than those depicted in FIG. **6**. Additionally, or alternatively, two or more of the blocks of process **600** may be performed in parallel.
[0131] FIG. **7** is a diagram illustrating an example process **700** performed, for example, at a receiver device or an apparatus of a receiver device, in accordance with the present disclosure. Example process **700** is an example where the apparatus or the receiver device (e.g., a UE **120** or a network node **110**) performs operations associated with nonbinary polar coding with partially frozen symbols.

[0132] As shown in FIG. **7**, in some aspects, process **700** may include receiving encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, where the set of information symbols and the set of partially frozen symbols indicate information bits, and where the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values (block **710**). For example, the receiver device (e.g., using reception component **902** and/or communication manager **906**, depicted in FIG. **9**) may receive encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, as described above. In some aspects, the set of information symbols and the set of partially frozen symbols indicate information bits. In some aspects, the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values.
[0133] As further shown in FIG. **7**, in some aspects, process **700** may include decoding the information bits from the encoded symbols (block **720**). For example, the receiver device (e.g., using communication manager **906**, depicted in FIG. **9**) may decode the information bits from the encoded symbols, as described above.
[0134] Process **700** may include additional aspects, such as any single aspect or any combination of aspects described below and/or in connection with one or more other processes described elsewhere herein.
[0135] In a first aspect, each information symbol, of the set of information symbols, indicates two bits of data.
[0136] In a second aspect, alone or in combination with the first aspect, each partially frozen symbol, of the set of partially frozen symbols, indicates less than two bits of data.
[0137] In a third aspect, alone or in combination with one or more of the first and second aspects, an information symbol, of the set of information symbols, has four possible values, and a partially frozen symbol, of the set of partially frozen symbols, has two possible values or three possible values.
[0138] In a fourth aspect, alone or in combination with one or more of the first through third aspects, a quantity of partially frozen symbols in the set of partially frozen symbols is according to a code rate.
[0139] In a fifth aspect, alone or in combination with one or more of the first through fourth aspects, positions of information symbols, of the set of information symbols, and of partially frozen symbols, of the set of partially frozen symbols, in the encoded symbols are in accordance with a reliability sequence.
[0140] In a sixth aspect, alone or in combination with one or more of the first through fifth aspects, decoding the information bits from the encoded symbols comprises decoding the information bits from the encoded symbols by processing partially frozen symbols, of the set of partially frozen symbols, on a per-symbol basis.
[0141] In a seventh aspect, alone or in combination with one or more of the first through fifth aspects, decoding the information bits from the encoded symbols comprises decoding the information bits from the encoded symbols by processing partially frozen symbols, of the set of partially frozen symbols, in symbol pairs.
[0142] In an eighth aspect, alone or in combination with one or more of the first through seventh aspects, process **700** includes communicating configuration information indicating that partially frozen symbols are to be used.
[0143] In a ninth aspect, alone or in combination with one or more of the first through eighth aspects, process **700** includes communicating a capabilities report indicating a capability to use partially frozen symbols.
[0144] Although FIG. **7** shows example blocks of process **700**, in some aspects, process **700** may include additional blocks, fewer blocks, different blocks, or differently arranged blocks than those

depicted in FIG. **7**. Additionally, or alternatively, two or more of the blocks of process **700** may be performed in parallel.

[0145] FIG. **8** is a diagram of an example apparatus **800** for wireless communication, in accordance with the present disclosure. The apparatus **800** may be a transmitter device (e.g., a UE **120** or a network node **110**), or a transmitter device may include the apparatus **800**. In some aspects, the apparatus **800** includes a reception component **802**, a transmission component **804**, and/or a communication manager **806**, which may be in communication with one another (for example, via one or more buses and/or one or more other components). In some aspects, the communication manager **806** is the communication manager **140** or the communication manager **150** described in connection with FIG. **1**. As shown, the apparatus **800** may communicate with another apparatus **808**, such as a UE or a network node (such as a CU, a DU, an RU, or a base station), using the reception component **802** and the transmission component **804**.

[0146] In some aspects, the apparatus **800** may be configured to perform one or more operations described herein in connection with FIG. **5**. Additionally, or alternatively, the apparatus **800** may be configured to perform one or more processes described herein, such as process **600** of FIG. **6**, process **700** of FIG. **7**, or a combination thereof. In some aspects, the apparatus **800** and/or one or more components shown in FIG. **8** may include one or more components of the transmitter device described in connection with FIG. **2**. Additionally, or alternatively, one or more components shown in FIG. **8** may be implemented within one or more components described in connection with FIG. **2**. Additionally, or alternatively, one or more components of the set of components may be implemented at least in part as software stored in one or more memories. For example, a component (or a portion of a component) may be implemented as instructions or code stored in a non-transitory computer-readable medium and executable by one or more controllers or one or more processors to perform the functions or operations of the component.

[0147] The reception component **802** may receive communications, such as reference signals, control information, data communications, or a combination thereof, from the apparatus **808**. The reception component **802** may provide received communications to one or more other components of the apparatus **800**. In some aspects, the reception component **802** may perform signal processing on the received communications (such as filtering, amplification, demodulation, analog-to-digital conversion, demultiplexing, deinterleaving, de-mapping, equalization, interference cancellation, or decoding, among other examples), and may provide the processed signals to the one or more other components of the apparatus **800**. In some aspects, the reception component **802** may include one or more antennas, one or more modems, one or more demodulators, one or more MIMO detectors, one or more receive processors, one or more controllers/processors, one or more memories, or a combination thereof, of the transmitter device described in connection with FIG. **2**.

[0148] The transmission component **804** may transmit communications, such as reference signals, control information, data communications, or a combination thereof, to the apparatus **808**. In some aspects, one or more other components of the apparatus **800** may generate communications and may provide the generated communications to the transmission component **804** for transmission to the apparatus **808**. In some aspects, the transmission component **804** may perform signal processing on the generated communications (such as filtering, amplification, modulation, digital-to-analog conversion, multiplexing, interleaving, mapping, or encoding, among other examples), and may transmit the processed signals to the apparatus **808**. In some aspects, the transmission component **804** may include one or more antennas, one or more modems, one or more modulators, one or more transmit MIMO processors, one or more transmit processors, one or more controllers/processors, one or more memories, or a combination thereof, of the transmitter device described in connection with FIG. **2**. In some aspects, the transmission component **804** may be co-located with the reception component **802** in one or more transceivers.

[0149] The communication manager **806** may support operations of the reception component **802** and/or the transmission component **804**. For example, the communication manager **806** may receive information associated with configuring reception of communications by the reception component **802** and/or transmission of communications by the transmission component **804**. Additionally, or alternatively, the communication manager **806** may generate and/or provide control information to the reception component **802** and/or the transmission component **804** to control reception and/or transmission of communications.

[0150] The communication manager **806** may encode information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols. In some aspects, the set of information symbols and the set of partially frozen symbols indicate the information bits. In some aspects, the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The transmission component **804** may transmit the encoded symbols.

[0151] The number and arrangement of components shown in FIG. **8** are provided as an example. In practice, there may be additional components, fewer components, different components, or differently arranged components than those shown in FIG. **8**. Furthermore, two or more components shown in FIG. **8** may be implemented within a single component, or a single component shown in FIG. **8** may be implemented as multiple, distributed components. Additionally, or alternatively, a set of (one or more) components shown in FIG. **8** may perform one or more functions described as being performed by another set of components shown in FIG. **8**.

[0152] FIG. **9** is a diagram of an example apparatus **900** for wireless communication, in accordance with the present disclosure. The apparatus **900** may be a receiver device (e.g., a UE **120** or a network node **110**), or a receiver device may include the apparatus **900**. In some aspects, the apparatus **900** includes a reception component **902**, a transmission component **904**, and/or a communication manager **906**, which may be in communication with one another (for example, via one or more buses and/or one or more other components). In some aspects, the communication manager **906** is the communication manager **140** or the communication manager **150** described in connection with FIG. **1**. As shown, the apparatus **900** may communicate with another apparatus **908**, such as a UE or a network node (such as a CU, a DU, an RU, or a base station), using the reception component **902** and the transmission component **904**.

[0153] In some aspects, the apparatus **900** may be configured to perform one or more operations described herein in connection with FIG. **5**. Additionally, or alternatively, the apparatus **900** may be configured to perform one or more processes described herein, such as process **600** of FIG. **6**, process **700** of FIG. **7**, or a combination thereof. In some aspects, the apparatus **900** and/or one or more components shown in FIG. **9** may include one or more components of the receiver device described in connection with FIG. **2**. Additionally, or alternatively, one or more components shown in FIG. **9** may be implemented within one or more components described in connection with FIG. **2**. Additionally, or alternatively, one or more components of the set of components may be implemented at least in part as software stored in one or more memories. For example, a component (or a portion of a component) may be implemented as instructions or code stored in a non-transitory computer-readable medium and executable by one or more controllers or one or more processors to perform the functions or operations of the component.

[0154] The reception component **902** may receive communications, such as reference signals, control information, data communications, or a combination thereof, from the apparatus **908**. The reception component **902** may provide received communications to one or more other components of the apparatus **900**. In some aspects, the reception component **902** may perform signal processing on the received communications (such as filtering, amplification, demodulation, analog-to-digital conversion, demultiplexing, deinterleaving, de-mapping, equalization, interference cancellation, or decoding, among other examples), and may provide the processed signals to the one or more other components of the apparatus **900**. In some aspects, the reception component **902** may include one or more antennas, one or more modems, one or more demodulators, one or more MIMO detectors, one or more receive processors, one or more controllers/processors, one or more memories, or a combination thereof, of the receiver device described in connection with FIG. **2**.

[0155] The transmission component **904** may transmit communications, such as reference signals, control information, data communications, or a combination thereof, to the apparatus **908**. In some aspects, one or more other components of the apparatus **900** may generate communications and may provide the generated communications to the transmission component **904** for transmission to the apparatus **908**. In some aspects, the transmission component **904** may perform signal processing on the generated communications (such as filtering, amplification, modulation, digital-to-analog conversion, multiplexing, interleaving, mapping, or encoding, among other examples), and may transmit the processed signals to the apparatus **908**. In some aspects, the transmission component **904** may include one or more antennas, one or more modems, one or more modulators, one or more transmit MIMO processors, one or more transmit processors, one or more controllers/processors, one or more memories, or a combination thereof, of the receiver device described in connection with FIG. **2**. In some aspects, the transmission component **904** may be co-located with the reception component **902** in one or more transceivers.

[0156] The communication manager **906** may support operations of the reception component **902** and/or the transmission component **904**. For example, the communication manager **906** may receive information associated with configuring reception of communications by the reception component **902** and/or transmission of communications by the transmission component **904**. Additionally, or alternatively, the communication manager **906** may generate and/or provide control information to the reception component **902** and/or the transmission component **904** to control reception and/or transmission of communications.

[0157] The reception component **902** may receive encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols. In some aspects, the set of information symbols and the set of partially frozen symbols indicate information bits. In some aspects, the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values. The communication manager **906** may decode the information bits from the encoded symbols.

[0158] The number and arrangement of components shown in FIG. **9** are provided as an example. In practice, there may be additional components, fewer components, different components, or differently arranged components than those shown in FIG. **9**. Furthermore, two or more components shown in FIG. **9** may be implemented within a single component, or a single component shown in FIG. **9** may be implemented as multiple, distributed components. Additionally, or alternatively, a set of (one or more) components shown in FIG. **9** may perform one or more functions described as being performed by another set of components shown in FIG. **9**.

[0159] The following provides an overview of some Aspects of the present disclosure:

[0160] Aspect 1: A method of wireless communication performed by a transmitter device, comprising: encoding information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, wherein the set of information symbols and the set of partially frozen symbols indicate the information bits, and wherein the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and transmitting the encoded symbols.

[0161] Aspect 2: The method of Aspect 1, wherein each information symbol, of the set of information symbols, indicates two bits of data.

[0162] Aspect 3: The method of any of Aspects 1-2, wherein each partially frozen symbol, of the set of partially frozen symbols, indicates less than two bits of data.

[0163] Aspect 4: The method of any of Aspects 1-3, wherein an information symbol, of the set of information symbols, has four possible values, and a partially frozen symbol, of the set of partially frozen symbols, has two possible values or three possible values.

[0164] Aspect 5: The method of any of Aspects 1-4, wherein a quantity of partially frozen symbols in the set of partially frozen symbols is according to a code rate.

[0165] Aspect 6: The method of any of Aspects 1-5, wherein positions of information symbols, of the set of information symbols, and of partially frozen symbols, of the set of partially frozen symbols, in the encoded symbols are in accordance with a reliability sequence.

[0166] Aspect 7: The method of any of Aspects 1-6, further comprising: communicating configuration information indicating that partially frozen symbols are to be used.

[0167] Aspect 8: The method of any of Aspects 1-7, further comprising: communicating a capabilities report indicating a capability to use partially frozen symbols.

[0168] Aspect 9: A method of wireless communication performed by a receiver device, comprising: receiving encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, wherein the set of information symbols and the set of partially frozen symbols indicate information bits, and wherein the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and decoding the information bits from the encoded symbols.

[0169] Aspect 10: The method of Aspect 9, wherein each information symbol, of the set of information symbols, indicates two bits of data.

[0170] Aspect 11: The method of any of Aspects 9-10, wherein each partially frozen symbol, of the set of partially frozen symbols, indicates less than two bits of data.

[0171] Aspect 12: The method of any of Aspects 9-11, wherein an information symbol, of the set of information symbols, has four possible values, and a partially frozen symbol, of the set of partially frozen symbols, has two possible values or three possible values.

[0172] Aspect 13: The method of any of Aspects 9-12, wherein a quantity of partially frozen symbols in the set of partially frozen symbols is according to a code rate.

[0173] Aspect 14: The method of any of Aspects 9-13, wherein positions of information symbols, of the set of information symbols, and of partially frozen symbols, of the set of partially frozen symbols, in the encoded symbols are in accordance with a reliability sequence.

[0174] Aspect 15: The method of any of Aspects 9-14, wherein decoding the information bits from the encoded symbols comprises: decoding the information bits from the encoded symbols by processing partially frozen symbols, of the set of partially frozen symbols, on a per-symbol basis.

[0175] Aspect 16: The method of any of Aspects 9-14, wherein decoding the information bits from the encoded symbols comprises: decoding the information bits from the encoded symbols by processing partially frozen symbols, of the set of partially frozen symbols, in symbol pairs.

[0176] Aspect 17: The method of any of Aspects 9-16, further comprising: communicating configuration information indicating that partially frozen symbols are to be used.

[0177] Aspect 18: The method of any of Aspects 9-17, further comprising: communicating a capabilities report indicating a capability to use partially frozen symbols.

[0178] Aspect 19: An apparatus for wireless communication at a device, the apparatus comprising one or more processors; one or more memories coupled with the one or more processors; and instructions stored in the one or more memories and executable by the one or more processors to cause the apparatus to perform the method of one or more of Aspects 1-18.

[0179] Aspect 20: An apparatus for wireless communication at a device, the apparatus comprising one or more memories and one or more processors coupled to the one or more memories, the one or more processors configured to cause the device to perform the method of one or more of Aspects 1-18.

[0180] Aspect 21: An apparatus for wireless communication, the apparatus comprising at least one means for performing the method of one or more of Aspects 1-18.

[0181] Aspect 22: A non-transitory computer-readable medium storing code for wireless communication, the code comprising instructions executable by one or more processors to perform the method of one or more of Aspects 1-18.

[0182] Aspect 23: A non-transitory computer-readable medium storing a set of instructions for wireless communication, the set of instructions comprising one or more instructions that, when executed by one or more processors of a device, cause the device to perform the method of one or more of Aspects 1-18.

[0183] Aspect 24: A device for wireless communication, the device comprising a processing system that includes one or more processors and one or more memories coupled with the one or more processors, the processing system configured to cause the device to perform the method of one or more of Aspects 1-18.

[0184] Aspect 25: An apparatus for wireless communication at a device, the apparatus comprising one or more memories and one or more processors coupled to the one or more memories, the one or more processors individually or collectively configured to cause the device to perform the method of one or more of Aspects 1-18.

[0185] The foregoing disclosure provides illustration and description but is not intended to be exhaustive or to limit the aspects to the precise forms disclosed. Modifications and variations may be made in light of the above disclosure or may be acquired from practice of the aspects.

[0186] As used herein, the term “component” is intended to be broadly construed as hardware or a combination of hardware and at least one of software or firmware. “Software” shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, or functions, among other examples, whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise. As used herein, a “processor” is implemented in hardware or a combination of hardware and software. It will be apparent that systems or methods described herein may be implemented in different forms of hardware or a combination of hardware and software. The actual specialized control hardware or software code used to implement these systems or methods is not limiting of the aspects. Thus, the operation and behavior of the systems or methods are described herein without reference to specific software code, because those skilled in the art will understand that software and hardware can be designed to implement the systems or methods based, at least in part, on the description herein. A component being configured to perform a function means that the component has a capability to perform the function, and does not require the function to be actually performed by the component, unless noted otherwise.

[0187] As used herein, “satisfying a threshold” may, depending on the context, refer to a value being greater than the threshold, greater than or equal to the threshold, less than the threshold, less than or equal to the threshold, equal to the threshold, or not equal to the threshold, among other examples.

[0188] As used herein, a phrase referring to “at least one of” a list of items refers to any combination of those items, including single members. As an example, “at least one of: a, b, or c” is intended to cover a, b, c, a+b, a+c, b+c, and a+b+c, as well as any combination with multiples of the same element (for example, a+a, a+a+a, a+a+b, a+a+c, a+b+b, a+c+c, b+b, b+b+b, b+b+c, c+c, and c+c+c, or any other ordering of a, b, and c).

[0189] No element, act, or instruction used herein should be construed as critical or essential unless explicitly described as such. Also, as used herein, the articles “a” and “an” are intended to include one or more items and may be used interchangeably with “one or more.” Further, as used herein, the article “the” is intended to include one or more items referenced in connection with the article “the” and may be used interchangeably with “the one or more.” Furthermore, as used herein, the terms “set” and “group” are intended to include one or more items and may be used interchangeably with “one or more.” Where only one item is intended, the phrase “only one” or similar language is used. Also, as used herein, the terms “has,” “have,” “having,” and similar terms

are intended to be open-ended terms that do not limit an element that they modify (for example, an element “having” A may also have B). Further, the phrase “based on” is intended to mean “based on or otherwise in association with” unless explicitly stated otherwise. Also, as used herein, the term “or” is intended to be inclusive when used in a series and may be used interchangeably with “and/or,” unless explicitly stated otherwise (for example, if used in combination with “either” or “only one of”). It should be understood that “one or more” is equivalent to “at least one.”
[0190] Even though particular combinations of features are recited in the claims or disclosed in the specification, these combinations are not intended to limit the disclosure of various aspects. Many of these features may be combined in ways not specifically recited in the claims or disclosed in the specification. The disclosure of various aspects includes each dependent claim in combination with every other claim in the claim set.

Claims

1. An apparatus for wireless communication at a receiver device, comprising: one or more memories; and one or more processors, coupled to the one or more memories, which are configured, individually or in any combination, to: receive encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, wherein the set of information symbols and the set of partially frozen symbols indicate information bits, and wherein the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and decode the information bits from the encoded symbols.
2. The apparatus of claim 1, wherein each information symbol, of the set of information symbols, indicates two bits of data.
3. The apparatus of claim 1, wherein each partially frozen symbol, of the set of partially frozen symbols, indicates less than two bits of data.
4. The apparatus of claim 1, wherein an information symbol, of the set of information symbols, has four possible values, and a partially frozen symbol, of the set of partially frozen symbols, has two possible values or three possible values.
5. The apparatus of claim 1, wherein a quantity of partially frozen symbols in the set of partially frozen symbols is according to a code rate.
6. The apparatus of claim 1, wherein positions of information symbols, of the set of information symbols, and of partially frozen symbols, of the set of partially frozen symbols, in the encoded symbols are in accordance with a reliability sequence.
7. The apparatus of claim 1, wherein the one or more processors, to cause the receiver device to decode the information bits from the encoded symbols, are configured to: decode the information bits from the encoded symbols by processing partially frozen symbols, of the set of partially frozen symbols, on a per-symbol basis.
8. The apparatus of claim 1, wherein the one or more processors, to cause the receiver device to decode the information bits from the encoded symbols, are configured to: decode the information bits from the encoded symbols by processing partially frozen symbols, of the set of partially frozen symbols, in symbol pairs.
9. The apparatus of claim 1, wherein the one or more processors are further configured to: communicate configuration information indicating that partially frozen symbols are to be used.
10. The apparatus of claim 1, wherein the one or more processors are further configured to: communicate a capabilities report indicating a capability to use partially frozen symbols.
11. An apparatus for wireless communication at a transmitter device, comprising: one or more memories; and one or more processors, coupled to the one or more memories, which are configured, individually or in any combination, to: encode information bits using nonbinary polar coding to generate encoded symbols that include a set of information symbols, a set of partially

frozen symbols, and a set of frozen symbols, wherein the set of information symbols and the set of partially frozen symbols indicate the information bits, and wherein the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and transmit the encoded symbols.

12. The apparatus of claim 11, wherein each information symbol, of the set of information symbols, indicates two bits of data.

13. The apparatus of claim 11, wherein each partially frozen symbol, of the set of partially frozen symbols, indicates less than two bits of data.

14. The apparatus of claim 11, wherein an information symbol, of the set of information symbols, has four possible values, and a partially frozen symbol, of the set of partially frozen symbols, has two possible values or three possible values.

15. The apparatus of claim 11, wherein a quantity of partially frozen symbols in the set of partially frozen symbols is according to a code rate.

16. The apparatus of claim 11, wherein positions of information symbols, of the set of information symbols, and of partially frozen symbols, of the set of partially frozen symbols, in the encoded symbols are in accordance with a reliability sequence.

17. The apparatus of claim 11, wherein the one or more processors are further configured to: communicate configuration information indicating that partially frozen symbols are to be used.

18. The apparatus of claim 11, wherein the one or more processors are further configured to: communicate a capabilities report indicating a capability to use partially frozen symbols.

19. A method of wireless communication performed by a receiver device, comprising: receiving encoded symbols, encoded using nonbinary polar coding, that include a set of information symbols, a set of partially frozen symbols, and a set of frozen symbols, wherein the set of information symbols and the set of partially frozen symbols indicate information bits, and wherein the set of information symbols indicate values in a set of values, and the set of partially frozen symbols indicate values in a proper subset of the set of values; and decoding the information bits from the encoded symbols.

20. The method of claim 19, wherein each partially frozen symbol, of the set of partially frozen symbols, indicates less than two bits of data.