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United States Patent	12395388
Kind Code	B2
Date of Patent	August 19, 2025
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Interference randomization in orthogonal cover codes

Abstract

Certain aspects of the present disclosure provide techniques for selecting a first orthogonal cover code (OCC) codeword from an OCC matrix for a transmission occurring during a first transmission time interval based on a first pseudo-random codeword allocator function, such as a first pseudo-random permutation matrix, corresponding to the first transmission time interval; and sending the transmission during the first transmission time interval using the first OCC codeword.

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Appl. No.: **18/205457**

Filed: **June 02, 2023**

Prior Publication Data

Publication Classification

Int. Cl.: **H04L27/26** (20060101); **H04J13/16** (20110101)

U.S. Cl.:

CPC **H04L27/26035** (20210101); **H04J13/16** (20130101);

Field of Classification Search

CPC: H04L (27/26035)

USPC: 375/260

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Background/Summary

FIELD OF THE DISCLOSURE
(1) Aspects of the present disclosure relate to wireless communications, and more particularly, to techniques for cover coding data with orthogonal cover codes (OCC) using an interference randomization scheme.
DESCRIPTION OF RELATED ART
(2) Wireless communications systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, broadcasts, or other similar types of services. These wireless communications systems may employ multiple-access technologies capable of supporting communications with multiple users by sharing available wireless communications system resources with those users
(3) Although wireless communications systems have made great technological advancements over many years, challenges still exist. For example, complex and dynamic environments can still attenuate or block signals between wireless transmitters and wireless receivers. Accordingly, there is a continuous desire to improve the technical performance of wireless communications systems,

including, for example: improving speed and data carrying capacity of communications, improving efficiency of the use of shared communications mediums, reducing power used by transmitters and receivers while performing communications, improving reliability of wireless communications, avoiding redundant transmissions and/or receptions and related processing, improving the coverage area of wireless communications, increasing the number and types of devices that can access wireless communications systems, increasing the ability for different types of devices to intercommunicate, increasing the number and type of wireless communications mediums available for use, and the like. Consequently, there exists a need for further improvements in wireless communications systems to overcome the aforementioned technical challenges and others.

SUMMARY

(4) One aspect provides a method for wireless communication by a user equipment (UE). The method includes selecting a first orthogonal cover code (OCC) codeword from an OCC matrix for a transmission occurring during a first transmission time interval based on a first pseudo-random codeword allocator function corresponding to the first transmission time interval; and sending the transmission during the first transmission time interval using the first OCC codeword.

(5) Another aspect provides a method for wireless communication by a network entity. The method includes obtaining a transmission encoded with an OCC codeword during a first transmission time interval within a predefined transmission timeframe, the transmission from a first user equipment; selecting, from a plurality of pseudo-random codeword allocator functions, a pseudo-random codeword allocator function corresponding to the first transmission time interval; selecting the OCC codeword from an OCC matrix corresponding to the first user equipment and based on the selected pseudo-random codeword allocator function; and decoding the transmission with the selected OCC codeword corresponding to the first user equipment.

(6) Other aspects provide: one or more apparatuses operable, configured, or otherwise adapted to perform any portion of any method described herein (e.g., such that performance may be by only one apparatus or in a distributed fashion across multiple apparatuses); one or more non-transitory, computer-readable media comprising instructions that, when executed by one or more processors of one or more apparatuses, cause the one or more apparatuses to perform any portion of any method described herein (e.g., such that instructions may be included in only one computer-readable medium or in a distributed fashion across multiple computer-readable media, such that instructions may be executed by only one processor or by multiple processors in a distributed fashion, such that each apparatus of the one or more apparatuses may include one processor or multiple processors, and/or such that performance may be by only one apparatus or in a distributed fashion across multiple apparatuses); one or more computer program products embodied on one or more computer-readable storage media comprising code for performing any portion of any method described herein (e.g., such that code may be stored in only one computer-readable medium or across computer-readable media in a distributed fashion); and/or one or more apparatuses comprising one or more means for performing any portion of any method described herein (e.g., such that performance would be by only one apparatus or by multiple apparatuses in a distributed fashion). By way of example, an apparatus may comprise a processing system, a device with a processing system, or processing systems cooperating over one or more networks.

(7) The following description and the appended figures set forth certain features for purposes of illustration.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) The appended figures depict certain features of the various aspects described herein and are not to be considered limiting of the scope of this disclosure.

(2) FIG. **1** depicts an example wireless communications network.

(3) FIG. **2** depicts an example disaggregated base station architecture.

(4) FIG. **3** depicts aspects of an example base station and an example user equipment (UE).

(5) FIGS. **4**A, **4**B, **4**C, and **4**D depict various example aspects of data structures for a wireless communications network.

(6) FIG. **5** depicts an illustrative example of cover coding data with OCC codewords using an interference randomization scheme.

(7) FIG. **6** depicts a method for wireless communications.

(8) FIG. **7** depicts another method for wireless communications.

(9) FIG. **8** depicts aspects of an example communications device.

(10) FIG. **9** depicts aspects of an example communications device.

DETAILED DESCRIPTION

(11) Aspects of the present disclosure provide apparatuses, methods, processing systems, and computer-readable mediums for cover coding data with orthogonal cover codes (OCC) using an interference randomization scheme.

(12) As wireless communication systems grow, an increasing number of wireless apparatuses (e.g., user equipments (UEs)) communicate with a predefined set of time-frequency resources. Multiple access schemes, such as multiplexing multiple UEs, can increase the number of UEs within the same amount of time-frequency resources. However, multiplexing multiple UEs may create interference between signals from the multiple UEs at base stations. Furthermore, the aforementioned interference can arise from UE to UE communication, for example, through sidelink. Orthogonal cover codes (OCCs) can mitigate the interference. For example, during a transmission timeframe, T, a UE is assigned a fixed OCC so that data from the UE is cover coded across repetitions in an orthogonal manner.

(13) While OCCs can mitigate the interference caused by multiplexing multiple UEs, phase impairments, such as carrier frequency offset (CFO), may impact OCC performance, for example, as described herein below. CFO occurs, for example, when a local oscillator signal in a receiver UE does not synchronize with the carrier single contained in the received signal. Thus, the received signal is shifted in frequency. Accordingly, when CFOs of two or more UEs being multiplexed are far apart, the interference caused by these UEs can be significant and result in wireless communication performance loss. Additionally, for instances where fixed OCC are utilized, the loss persists throughout the entire transmission time leading to transmissions from two or more UEs being un-decodable.

(14) For purposes of explanation of the performance loss associated with CFO, and without limitation, consider a scenario in which a wireless communication system includes 4 user equipments (UE1, UE2, UE3, and UE4) using a discrete Fourier transform (DFT) matrix as the basis for OCC, where each codeword, (e.g., row of the DFT matrix), is separated by 400 Hz. Additionally, for example, the CFO on UE1 and UE2 are +200 Hz and −200 HZ, respectively and UE3 and UE4 have comparatively small CFO. Furthermore, the codeword of UE1 is separated from the codeword of UE2 by 400 Hz, for example, as being defined by consecutive rows of the DFT matrix. In such an instance, the CFO on UE1 and UE2 results in the transmission of both UEs appearing as the same OCC codeword at the network received (e.g., a base station) during the entire transmission timeframe, T. Accordingly, the transmissions from the two UEs, UE1 and UE2, are un-decodable at the network receiver because the CFO on UE1 and UE2 of +200 Hz and −200 HZ, respectively cancels out the 400 Hz separation introduced by the OCC codeword. That is, the transmission from the two UEs, UE1 and UE2, have the same or at least indistinguishable frequencies.

(15) To overcome the aforementioned technical problem, aspects described herein are directed to cover coding data with OCCs using an interference randomization scheme rather than utilizing fixed OCC for an entire transmission timeframe, T. The interference randomization scheme has the

beneficial technical effect of averaging out interference cause by phase impairments due to CFO, which leads to performance gains in wireless communications. For example, performance gains can be realized with respect to better decoding performance which increases data throughput, reduction in retransmissions, less power used, enabling higher coding rates, better network efficiency, and/or the like. That is, implementation of randomized assignment of codewords to UEs in the wireless communication system during the transmission timeframe, T, enables the interference to be shared among all UEs and furthermore averaged out over the transmission timeframe, T. For example, in some transmission time intervals, t, of the transmission timeframe T, UE1 and UE3 will have consecutive codewords and UE2 and UE4 will have consecutive codewords, which aids in averaging out the interference across the entire transmission timeframe, T. With reference to the above described example, in cases where UE1 and UE3 have consecutive codewords and where UE2 and UE4 have consecutive codewords, the transmissions are more resilient to interference due to CFO.

(16) For example, in one aspect, a first UE, selects a first OCC codeword from an OCC matrix for a transmission occurring during a first transmission time interval based on a first pseudo-random codeword allocator function corresponding to the first transmission time interval. For purposes of explanation of the interference randomization scheme, the pseudo-random codeword allocator function is described herein as a pseudo-random permutation matrix. However, it is understood that the pseudo-random codeword allocator function is as an expression, a matrix, a logical operation, or the like that is configured to indicate to a UE which codeword from the OCC matrix is to be selected for a corresponding transmission time interval (e.g., e.g., t, t+1, t+2, . . .) of the predefined transmission timeframe, T.

(17) Next, the first UE sends the transmission during the first transmission time interval using the first OCC codeword. In aspects, the first UE being multiplexed in the wireless communication system is associated with a row, for example, the first row, of the first pseudo-random permutation matrix. Likewise, a second UE being multiplexed in the wireless communication system is associated with a different row, for example, the second row, of the first pseudo-random permutation matrix. The first pseudo-random permutation matrix indicates to each UE being multiplexed as to which row of the OCC matrix is to be selected for use as the first OCC codeword for the transmission occurring during the first transmission time interval of a plurality of transmission time intervals within a predefined transmission time.

(18) During a second transmission time interval within the predefined transmission time, the first UE selects a second OCC codeword from the OCC matrix for a transmission occurring during a second transmission time interval based on a second pseudo-random permutation matrix corresponding to the second transmission time interval. Next, the second UE sends the transmission during the second transmission time interval using the second OCC codeword. In aspects, the first UE being multiplexed in the wireless communication system is associated with a row, for example, the first row, of the second pseudo-random permutation matrix. Likewise, a second UE being multiplexed in the wireless communication system is associated with a different row, for example, the second row, of the second pseudo-random permutation matrix. The second pseudo-random permutation matrix indicates to each UE being multiplexed as to which row of the OCC matrix is to be selected for use as the second OCC codeword for the transmission occurring during the second transmission time interval of a plurality of transmission time intervals within a predefined transmission time.

(19) It is noted that the aforementioned interference randomization scheme of using a plurality of pseudo-random permutation matrices each corresponding to one of a plurality of transmission time intervals for selecting the OCC codeword enables randomization of assigned OCC codewords to UEs and/or network entities (e.g., base stations) through the transmission timeframe.

(20) Thus, a beneficial technical effect of this interference randomization scheme is an increase in capacity of multiplexing UEs using OCC codewords within the predefined time-frequency

resources and averaging out interference caused by phase impairments due to CFO that impacts OCC performance.

(21) Aspects described herein may thus be used to reduce impairments due to phase impairments in multiple access schemes using OCC thereby improving reliability in the communication with multiplexed UEs. Thus, aspects described herein provide a technical solution to the interference problem discussed above.

(22) Introduction to Wireless Communications Networks

(23) The techniques and methods described herein may be used for various wireless communications networks. While aspects may be described herein using terminology commonly associated with 3G, 4G, 5G, 6G and other generations of wireless technologies, aspects of the present disclosure may likewise be applicable to other communications systems and standards not explicitly mentioned herein.

(24) FIG. **1** depicts an example of a wireless communications network **100**, in which aspects described herein may be implemented.

(25) Generally, wireless communications network **100** includes various network entities (alternatively, network elements or network nodes). A network entity is generally a communications device and/or a communications function performed by a communications device (e.g., a user equipment (UE), a base station (BS), a component of a BS, a server, etc.). As such communications devices are part of wireless communications network **100**, and facilitate wireless communications, such communications devices may be referred to as wireless communications devices. For example, various functions of a network as well as various devices associated with and interacting with a network may be considered network entities. Further, wireless communications network **100** includes terrestrial aspects, such as ground-based network entities (e.g., BSs **102**), and non-terrestrial aspects, such as satellite **140** and aircraft **145**, which may include network entities on-board (e.g., one or more BSs) capable of communicating with other network elements (e.g., terrestrial BSs) and UEs.

(26) In the depicted example, wireless communications network **100** includes BSs **102**, UEs **104**, and one or more core networks, such as an Evolved Packet Core (EPC) **160** and 5G Core (5GC) network **190**, which interoperate to provide communications services over various communications links, including wired and wireless links.

(27) FIG. **1** depicts various example UEs **104**, which may more generally include: a cellular phone, smart phone, session initiation protocol (SIP) phone, laptop, personal digital assistant (PDA), satellite radio, global positioning system, multimedia device, video device, digital audio player, camera, game console, tablet, smart device, wearable device, vehicle, electric meter, gas pump, large or small kitchen appliance, healthcare device, implant, sensor/actuator, display, internet of things (IoT) devices, always on (AON) devices, edge processing devices, or other similar devices. UEs **104** may also be referred to more generally as a mobile device, a wireless device, a station, a mobile station, a subscriber station, a mobile subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a remote device, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, and others.

(28) BSs **102** wirelessly communicate with (e.g., transmit signals to or receive signals from) UEs **104** via communications links **120**. The communications links **120** between BSs **102** and UEs **104** may include uplink (UL) (also referred to as reverse link) transmissions from a UE **104** to a BS **102** and/or downlink (DL) (also referred to as forward link) transmissions from a BS **102** to a UE **104**. The communications links **120** may use multiple-input and multiple-output (MIMO) antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity in various aspects.

(29) BSs **102** may generally include: a NodeB, enhanced NodeB (eNB), next generation enhanced NodeB (ng-eNB), next generation NodeB (gNB or gNodeB), access point, base transceiver station, radio base station, radio transceiver, transceiver function, transmission reception point, and/or

others. Each of BSs **102** may provide communications coverage for a respective coverage area **110**, which may sometimes be referred to as a cell, and which may overlap in some cases (e.g., small cell **102′** may have a coverage area **110′** that overlaps the coverage area **110** of a macro cell). A BS may, for example, provide communications coverage for a macro cell (covering relatively large geographic area), a pico cell (covering relatively smaller geographic area, such as a sports stadium), a femto cell (relatively smaller geographic area (e.g., a home)), and/or other types of cells.

(30) While BSs **102** are depicted in various aspects as unitary communications devices, BSs **102** may be implemented in various configurations. For example, one or more components of a base station may be disaggregated, including a central unit (CU), one or more distributed units (DUs), one or more radio units (RUS), a Near-Real Time (Near-RT) RAN Intelligent Controller (RIC), or a Non-Real Time (Non-RT) RIC, to name a few examples. In another example, various aspects of a base station may be virtualized. More generally, a base station (e.g., BS **102**) may include components that are located at a single physical location or components located at various physical locations. In examples in which a base station includes components that are located at various physical locations, the various components may each perform functions such that, collectively, the various components achieve functionality that is similar to a base station that is located at a single physical location. In some aspects, a base station including components that are located at various physical locations may be referred to as a disaggregated radio access network architecture, such as an Open RAN (O-RAN) or Virtualized RAN (VRAN) architecture. FIG. **2** depicts and describes an example disaggregated base station architecture.

(31) Different BSs **102** within wireless communications network **100** may also be configured to support different radio access technologies, such as 3G, 4G, and/or 5G. For example, BSs **102** configured for 4G LTE (collectively referred to as Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (E-UTRAN)) may interface with the EPC **160** through first backhaul links **132** (e.g., an S1 interface). BSs **102** configured for 5G (e.g., 5G NR or Next Generation RAN (NG-RAN)) may interface with 5GC **190** through second backhaul links **184**. BSs **102** may communicate directly or indirectly (e.g., through the EPC **160** or 5GC **190**) with each other over third backhaul links **134** (e.g., X2 interface), which may be wired or wireless.

(32) Wireless communications network **100** may subdivide the electromagnetic spectrum into various classes, bands, channels, or other features. In some aspects, the subdivision is provided based on wavelength and frequency, where frequency may also be referred to as a carrier, a subcarrier, a frequency channel, a tone, or a subband. For example, 3GPP currently defines Frequency Range 1 (FR1) as including 410 MHz-7125 MHz, which is often referred to (interchangeably) as "Sub-6 GHz". Similarly, 3GPP currently defines Frequency Range 2 (FR2) as including 24,250 MHz-52,600 MHz, which is sometimes referred to (interchangeably) as a "millimeter wave" ("mmW" or "mmWave"). A base station configured to communicate using mmWave/near mmWave radio frequency bands (e.g., a mmWave base station such as BS **180**) may utilize beamforming (e.g., **182**) with a UE (e.g., **104**) to improve path loss and range.

(33) The communications links **120** between BSs **102** and, for example, UEs **104**, may be through one or more carriers, which may have different bandwidths (e.g., 5, 10, 15, 20, 100, 400, and/or other MHz), and which may be aggregated in various aspects. Carriers may or may not be adjacent to each other. Allocation of carriers may be asymmetric with respect to DL and UL (e.g., more or fewer carriers may be allocated for DL than for UL).

(34) Communications using higher frequency bands may have higher path loss and a shorter range compared to lower frequency communications. Accordingly, certain base stations (e.g., **180** in FIG. **1**) may utilize beamforming **182** with a UE **104** to improve path loss and range. For example, BS **180** and the UE **104** may each include a plurality of antennas, such as antenna elements, antenna panels, and/or antenna arrays to facilitate the beamforming. In some cases, BS **180** may transmit a beamformed signal to UE **104** in one or more transmit directions **182′**. UE **104** may receive the

beamformed signal from the BS **180** in one or more receive directions **182″**. UE **104** may also transmit a beamformed signal to the BS **180** in one or more transmit directions **182″**. BS **180** may also receive the beamformed signal from UE **104** in one or more receive directions **182′**. BS **180** and UE **104** may then perform beam training to determine the best receive and transmit directions for each of BS **180** and UE **104**. Notably, the transmit and receive directions for BS **180** may or may not be the same. Similarly, the transmit and receive directions for UE **104** may or may not be the same.

(35) Wireless communications network **100** further includes a Wi-Fi AP **150** in communication with Wi-Fi stations (STAs) **152** via communications links **154** in, for example, a 2.4 GHz and/or 5 GHz unlicensed frequency spectrum.

(36) Certain UEs **104** may communicate with each other using device-to-device (D2D) communications link **158**. D2D communications link **158** may use one or more sidelink channels, such as a physical sidelink broadcast channel (PSBCH), a physical sidelink discovery channel (PSDCH), a physical sidelink shared channel (PSSCH), a physical sidelink control channel (PSCCH), and/or a physical sidelink feedback channel (PSFCH).

(37) EPC **160** may include various functional components, including: a Mobility Management Entity (MME) **162**, other MMEs **164**, a Serving Gateway **166**, a Multimedia Broadcast Multicast Service (MBMS) Gateway **168**, a Broadcast Multicast Service Center (BM-SC) **170**, and/or a Packet Data Network (PDN) Gateway **172**, such as in the depicted example. MME **162** may be in communication with a Home Subscriber Server (HSS) **174**. MME **162** is the control node that processes the signaling between the UEs **104** and the EPC **160**. Generally, MME **162** provides bearer and connection management.

(38) Generally, user Internet protocol (IP) packets are transferred through Serving Gateway **166**, which itself is connected to PDN Gateway **172**. PDN Gateway **172** provides UE IP address allocation as well as other functions. PDN Gateway **172** and the BM-SC **170** are connected to IP Services **176**, which may include, for example, the Internet, an intranet, an IP Multimedia Subsystem (IMS), a Packet Switched (PS) streaming service, and/or other IP services.

(39) BM-SC **170** may provide functions for MBMS user service provisioning and delivery. BM-SC **170** may serve as an entry point for content provider MBMS transmission, may be used to authorize and initiate MBMS Bearer Services within a public land mobile network (PLMN), and/or may be used to schedule MBMS transmissions. MBMS Gateway **168** may be used to distribute MBMS traffic to the BSs **102** belonging to a Multicast Broadcast Single Frequency Network (MBSFN) area broadcasting a particular service, and/or may be responsible for session management (start/stop) and for collecting eMBMS related charging information.

(40) 5GC **190** may include various functional components, including: an Access and Mobility Management Function (AMF) **192**, other AMFs **193**, a Session Management Function (SMF) **194**, and a User Plane Function (UPF) **195**. AMF **192** may be in communication with Unified Data Management (UDM) **196**.

(41) AMF **192** is a control node that processes signaling between UEs **104** and 5GC **190**. AMF **192** provides, for example, quality of service (QOS) flow and session management.

(42) Internet protocol (IP) packets are transferred through UPF **195**, which is connected to the IP Services **197**, and which provides UE IP address allocation as well as other functions for 5GC **190**. IP Services **197** may include, for example, the Internet, an intranet, an IMS, a PS streaming service, and/or other IP services.

(43) In various aspects, a network entity or network node can be implemented as an aggregated base station, as a disaggregated base station, a component of a base station, an integrated access and backhaul (IAB) node, a relay node, a sidelink node, to name a few examples.

(44) FIG. **2** depicts an example disaggregated base station **200** architecture. The disaggregated base station **200** architecture may include one or more central units (CUs) **210** that can communicate directly with a core network **220** via a backhaul link, or indirectly with the core network **220**

through one or more disaggregated base station units (such as a Near-Real Time (Near-RT) RAN Intelligent Controller (RIC) **225** via an E2 link, or a Non-Real Time (Non-RT) RIC **215** associated with a Service Management and Orchestration (SMO) Framework **205**, or both). A CU **210** may communicate with one or more distributed units (DUs) **230** via respective midhaul links, such as an F1 interface. The DUs **230** may communicate with one or more radio units (RUS) **240** via respective fronthaul links. The RUs **240** may communicate with respective UEs **104** via one or more radio frequency (RF) access links. In some implementations, the UE **104** may be simultaneously served by multiple RUs **240**.

(45) Each of the units, e.g., the CUS **210**, the DUs **230**, the RUs **240**, as well as the Near-RT RICs **225**, the Non-RT RICs **215** and the SMO Framework **205**, may include one or more interfaces or be coupled to one or more interfaces configured to receive or transmit signals, data, or information (collectively, signals) via a wired or wireless transmission medium. Each of the units, or an associated processor or controller providing instructions to the communications interfaces of the units, can be configured to communicate with one or more of the other units via the transmission medium. For example, the units can include a wired interface configured to receive or transmit signals over a wired transmission medium to one or more of the other units. Additionally or alternatively, the units can include a wireless interface, which may include a receiver, a transmitter or transceiver (such as a radio frequency (RF) transceiver), configured to receive or transmit signals, or both, over a wireless transmission medium to one or more of the other units.

(46) In some aspects, the CU **210** may host one or more higher layer control functions. Such control functions can include radio resource control (RRC), packet data convergence protocol (PDCP), service data adaptation protocol (SDAP), or the like. Each control function can be implemented with an interface configured to communicate signals with other control functions hosted by the CU **210**. The CU **210** may be configured to handle user plane functionality (e.g., Central Unit-User Plane (CU-UP)), control plane functionality (e.g., Central Unit-Control Plane (CU-CP)), or a combination thereof. In some implementations, the CU **210** can be logically split into one or more CU-UP units and one or more CU-CP units. The CU-UP unit can communicate bidirectionally with the CU-CP unit via an interface, such as the E1 interface when implemented in an O-RAN configuration. The CU **210** can be implemented to communicate with the DU **230**, as necessary, for network control and signaling.

(47) The DU **230** may correspond to a logical unit that includes one or more base station functions to control the operation of one or more RUs **240**. In some aspects, the DU **230** may host one or more of a radio link control (RLC) layer, a medium access control (MAC) layer, and one or more high physical (PHY) layers (such as modules for forward error correction (FEC) encoding and decoding, scrambling, modulation and demodulation, or the like) depending, at least in part, on a functional split, such as those defined by the 3.sup.rd Generation Partnership Project (3GPP). In some aspects, the DU **230** may further host one or more low PHY layers. Each layer (or module) can be implemented with an interface configured to communicate signals with other layers (and modules) hosted by the DU **230**, or with the control functions hosted by the CU **210**.

(48) Lower-layer functionality can be implemented by one or more RUs **240**. In some deployments, an RU **240**, controlled by a DU **230**, may correspond to a logical node that hosts RF processing functions, or low-PHY layer functions (such as performing fast Fourier transform (FFT), inverse FFT (IFFT), digital beamforming, physical random access channel (PRACH) extraction and filtering, or the like), or both, based at least in part on the functional split, such as a lower layer functional split. In such an architecture, the RU(s) **240** can be implemented to handle over the air (OTA) communications with one or more UEs **104**. In some implementations, real-time and non-real-time aspects of control and user plane communications with the RU(s) **240** can be controlled by the corresponding DU **230**. In some scenarios, this configuration can enable the DU(s) **230** and the CU **210** to be implemented in a cloud-based RAN architecture, such as a vRAN architecture.

(49) The SMO Framework **205** may be configured to support RAN deployment and provisioning of

non-virtualized and virtualized network elements. For non-virtualized network elements, the SMO Framework **205** may be configured to 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 **205** may be configured to interact with a cloud computing platform (such as an open cloud (O-Cloud) **290**) 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). Such virtualized network elements can include, but are not limited to, CUs **210**, DUs **230**, RUS **240** and Near-RT RICs **225**. In some implementations, the SMO Framework **205** can communicate with a hardware aspect of a 4G RAN, such as an open eNB (O-eNB) **211**, via an O1 interface. Additionally, in some implementations, the SMO Framework **205** can communicate directly with one or more RUs **240** via an O1 interface. The SMO Framework **205** also may include a Non-RT RIC **215** configured to support functionality of the SMO Framework **205**.

(50) The Non-RT RIC **215** may be configured to include a logical function that enables non-real-time control and optimization of RAN elements and resources, Artificial Intelligence/Machine Learning (AI/ML) workflows including model training and updates, or policy-based guidance of applications/features in the Near-RT RIC **225**. The Non-RT RIC **215** may be coupled to or communicate with (such as via an A1 interface) the Near-RT RIC **225**. The Near-RT RIC **225** may be configured to include a logical function that enables near-real-time control and optimization of RAN elements and resources via data collection and actions over an interface (such as via an E2 interface) connecting one or more CUs **210**, one or more DUs **230**, or both, as well as an O-eNB, with the Near-RT RIC **225**.

(51) In some implementations, to generate AI/ML models to be deployed in the Near-RT RIC **225**, the Non-RT RIC **215** may receive parameters or external enrichment information from external servers. Such information may be utilized by the Near-RT RIC **225** and may be received at the SMO Framework **205** or the Non-RT RIC **215** from non-network data sources or from network functions. In some examples, the Non-RT RIC **215** or the Near-RT RIC **225** may be configured to tune RAN behavior or performance. For example, the Non-RT RIC **215** may monitor long-term trends and patterns for performance and employ AI/ML models to perform corrective actions through the SMO Framework **205** (such as reconfiguration via **01**) or via creation of RAN management policies (such as A1 policies).

(52) FIG. **3** depicts aspects of an example BS **102** and a UE **104**.

(53) Generally, BS **102** includes various processors (e.g., **320**, **330**, **338**, and **340**), antennas **334***a-t* (collectively **334**), transceivers **332***a-t* (collectively **332**), which include modulators and demodulators, and other aspects, which enable wireless transmission of data (e.g., data source **312**) and wireless reception of data (e.g., data sink **339**). For example, BS **102** may send and receive data between BS **102** and UE **104**. BS **102** includes controller/processor **340**, which may be configured to implement various functions described herein related to wireless communications.

(54) Generally, UE **104** includes various processors (e.g., **358**, **364**, **366**, and **380**), antennas **352***a-r* (collectively **352**), transceivers **354***a-r* (collectively **354**), which include modulators and demodulators, and other aspects, which enable wireless transmission of data (e.g., retrieved from data source **362**) and wireless reception of data (e.g., provided to data sink **360**). UE **104** includes controller/processor **380**, which may be configured to implement various functions described herein related to wireless communications.

(55) In regards to an example downlink transmission, BS **102** includes a transmit processor **320** that may receive data from a data source **312** and control information from a controller/processor **340**. The control information may be for the physical broadcast channel (PBCH), physical control format indicator channel (PCFICH), physical hybrid automatic repeat request (HARQ) indicator channel (PHICH), physical downlink control channel (PDCCH), group common PDCCH (GC PDCCH), and/or others. The data may be for the physical downlink shared channel (PDSCH), in

some examples.

(56) Transmit processor **320** may process (e.g., encode and symbol map) the data and control information to obtain data symbols and control symbols, respectively. Transmit processor **320** may also generate reference symbols, such as for the primary synchronization signal (PSS), secondary synchronization signal (SSS), PBCH demodulation reference signal (DMRS), and channel state information reference signal (CSI-RS).

(57) Transmit (TX) multiple-input multiple-output (MIMO) processor **330** may perform spatial processing (e.g., precoding) on the data symbols, the control symbols, and/or the reference symbols, if applicable, and may provide output symbol streams to the modulators (MODs) in transceivers **332***a*-**332***t*. Each modulator in transceivers **332***a*-**332***t* may process a respective output symbol stream to obtain an output sample stream. Each modulator may further process (e.g., convert to analog, amplify, filter, and upconvert) the output sample stream to obtain a downlink signal. Downlink signals from the modulators in transceivers **332***a*-**332***t* may be transmitted via the antennas **334***a*-**334***t*, respectively.

(58) In order to receive the downlink transmission, UE **104** includes antennas **352***a*-**352***r* that may receive the downlink signals from the BS **102** and may provide received signals to the demodulators (DEMODs) in transceivers **354***a*-**354***r*, respectively. Each demodulator in transceivers **354***a*-**354***r* may condition (e.g., filter, amplify, downconvert, and digitize) a respective received signal to obtain input samples. Each demodulator may further process the input samples to obtain received symbols.

(59) RX MIMO detector **356** may obtain received symbols from all the demodulators in transceivers **354***a*-**354***r*, perform MIMO detection on the received symbols if applicable, and provide detected symbols. Receive processor **358** may process (e.g., demodulate, deinterleave, and decode) the detected symbols, provide decoded data for the UE **104** to a data sink **360**, and provide decoded control information to a controller/processor **380**.

(60) In regards to an example uplink transmission, UE **104** further includes a transmit processor **364** that may receive and process data (e.g., for the PUSCH) from a data source **362** and control information (e.g., for the physical uplink control channel (PUCCH)) from the controller/processor **380**. Transmit processor **364** may also generate reference symbols for a reference signal (e.g., for the sounding reference signal (SRS)). The symbols from the transmit processor **364** may be precoded by a TX MIMO processor **366** if applicable, further processed by the modulators in transceivers **354***a*-**354***r* (e.g., for SC-FDM), and transmitted to BS **102**.

(61) At BS **102**, the uplink signals from UE **104** may be received by antennas **334***a-t*, processed by the demodulators in transceivers **332***a*-**332***t*, detected by a RX MIMO detector **336** if applicable, and further processed by a receive processor **338** to obtain decoded data and control information sent by UE **104**. Receive processor **338** may provide the decoded data to a data sink **339** and the decoded control information to the controller/processor **340**.

(62) Memories **342** and **382** may store data and program codes for BS **102** and UE **104**, respectively.

(63) Scheduler **344** may schedule UEs for data transmission on the downlink and/or uplink.

(64) In various aspects, BS **102** may be described as transmitting and receiving various types of data associated with the methods described herein. In these contexts, "transmitting" may refer to various mechanisms of outputting data, such as outputting data from data source **312**, scheduler **344**, memory **342**, transmit processor **320**, controller/processor **340**, TX MIMO processor **330**, transceivers **332***a-t*, antenna **334***a-t*, and/or other aspects described herein. Similarly, "receiving" may refer to various mechanisms of obtaining data, such as obtaining data from antennas **334***a-t*, transceivers **332***a-t*, RX MIMO detector **336**, controller/processor **340**, receive processor **338**, scheduler **344**, memory **342**, and/or other aspects described herein.

(65) In various aspects, UE **104** may likewise be described as transmitting and receiving various types of data associated with the methods described herein. In these contexts, "transmitting" may

refer to various mechanisms of outputting data, such as outputting data from data source **362**, memory **382**, transmit processor **364**, controller/processor **380**, TX MIMO processor **366**, transceivers **354***a-t*, antenna **352***a-t*, and/or other aspects described herein. Similarly, "receiving" may refer to various mechanisms of obtaining data, such as obtaining data from antennas **352***a-t*, transceivers **354***a-t*, RX MIMO detector **356**, controller/processor **380**, receive processor **358**, memory **382**, and/or other aspects described herein.

(66) In some aspects, a processor may be configured to perform various operations, such as those associated with the methods described herein, and transmit (output) to or receive (obtain) data from another interface that is configured to transmit or receive, respectively, the data.

(67) FIGS. **4**A, **4**B, **4**C, and **4**D depict aspects of data structures for a wireless communications network, such as wireless communications network **100** of FIG. **1**.

(68) In particular, FIG. **4**A is a diagram **400** illustrating an example of a first subframe within a 5G (e.g., 5G NR) frame structure, FIG. **4**B is a diagram **430** illustrating an example of DL channels within a 5G subframe, FIG. **4**C is a diagram **450** illustrating an example of a second subframe within a 5G frame structure, and FIG. **4**D is a diagram **480** illustrating an example of UL channels within a 5G subframe.

(69) Wireless communications systems may utilize orthogonal frequency division multiplexing (OFDM) with a cyclic prefix (CP) on the uplink and downlink. Such systems may also support half-duplex operation using time division duplexing (TDD). OFDM and single-carrier frequency division multiplexing (SC-FDM) partition the system bandwidth (e.g., as depicted in FIGS. **4**B and **4**D) into multiple orthogonal subcarriers. Each subcarrier may be modulated with data. Modulation symbols may be sent in the frequency domain with OFDM and/or in the time domain with SC-FDM.

(70) A wireless communications frame structure may be frequency division duplex (FDD), in which, for a particular set of subcarriers, subframes within the set of subcarriers are dedicated for either DL or UL. Wireless communications frame structures may also be time division duplex (TDD), in which, for a particular set of subcarriers, subframes within the set of subcarriers are dedicated for both DL and UL.

(71) In FIGS. **4**A and **4**C, the wireless communications frame structure is TDD where D is DL, U is UL, and X is flexible for use between DL/UL. UEs may be configured with a slot format through a received slot format indicator (SFI) (dynamically through DL control information (DCI), or semi-statically/statically through radio resource control (RRC) signaling). In the depicted examples, a 10 ms frame is divided into 10 equally sized 1 ms subframes. Each subframe may include one or more time slots. In some examples, each slot may include 7 or 14 symbols, depending on the slot format. Subframes may also include mini-slots, which generally have fewer symbols than an entire slot. Other wireless communications technologies may have a different frame structure and/or different channels.

(72) In certain aspects, the number of slots within a subframe is based on a slot configuration and a numerology. For example, for slot configuration 0, different numerologies (μ) 0 to 5 allow for 1, 2, 4, 8, 16, and 32 slots, respectively, per subframe. For slot configuration 1, different numerologies 0 to 2 allow for 2, 4, and 8 slots, respectively, per subframe. Accordingly, for slot configuration 0 and numerology u, there are 14 symbols/slot and 2μ slots/subframe. The subcarrier spacing and symbol length/duration are a function of the numerology. The subcarrier spacing may be equal to $2^4 \times 15$ kHz, where u is the numerology 0 to 5. As such, the numerology $\mu=0$ has a subcarrier spacing of 15 kHz and the numerology $\mu=5$ has a subcarrier spacing of 480 kHz. The symbol length/duration is inversely related to the subcarrier spacing. FIGS. **4**A, **4**B, **4**C, and **4**D provide an example of slot configuration 0 with 14 symbols per slot and numerology $\mu=2$ with 4 slots per subframe. The slot duration is 0.25 ms, the subcarrier spacing is 60 kHz, and the symbol duration is approximately 16.67 μs.

(73) As depicted in FIGS. **4**A, **4**B, **4**C, and **4**D, a resource grid may be used to represent the frame

structure. Each time slot includes a resource block (RB) (also referred to as physical RBs (PRBs)) that extends, for example, 12 consecutive subcarriers. The resource grid is divided into multiple resource elements (REs). The number of bits carried by each RE depends on the modulation scheme.

(74) As illustrated in FIG. **4**A, some of the REs carry reference (pilot) signals (RS) for a UE (e.g., UE **104** of FIGS. **1** and **3**). The RS may include demodulation RS (DMRS) and/or channel state information reference signals (CSI-RS) for channel estimation at the UE. The RS may also include beam measurement RS (BRS), beam refinement RS (BRRS), and/or phase tracking RS (PT-RS).

(75) FIG. **4**B illustrates an example of various DL channels within a subframe of a frame. The physical downlink control channel (PDCCH) carries DCI within one or more control channel elements (CCEs), each CCE including, for example, nine RE groups (REGs), each REG including, for example, four consecutive REs in an OFDM symbol.

(76) A primary synchronization signal (PSS) may be within symbol 2 of particular subframes of a frame. The PSS is used by a UE (e.g., **104** of FIGS. **1** and **3**) to determine subframe/symbol timing and a physical layer identity.

(77) A secondary synchronization signal (SSS) may be within symbol 4 of particular subframes of a frame. The SSS is used by a UE to determine a physical layer cell identity group number and radio frame timing.

(78) Based on the physical layer identity and the physical layer cell identity group number, the UE can determine a physical cell identifier (PCI). Based on the PCI, the UE can determine the locations of the aforementioned DMRS. The physical broadcast channel (PBCH), which carries a master information block (MIB), may be logically grouped with the PSS and SSS to form a synchronization signal (SS)/PBCH block. The MIB provides a number of RBs in the system bandwidth and a system frame number (SFN). The physical downlink shared channel (PDSCH) carries user data, broadcast system information not transmitted through the PBCH such as system information blocks (SIBs), and/or paging messages.

(79) As illustrated in FIG. **4**C, some of the REs carry DMRS (indicated as R for one particular configuration, but other DMRS configurations are possible) for channel estimation at the base station. The UE may transmit DMRS for the PUCCH and DMRS for the PUSCH. The PUSCH DMRS may be transmitted, for example, in the first one or two symbols of the PUSCH. The PUCCH DMRS may be transmitted in different configurations depending on whether short or long PUCCHs are transmitted and depending on the particular PUCCH format used. UE **104** may transmit sounding reference signals (SRS). The SRS may be transmitted, for example, in the last symbol of a subframe. The SRS may have a comb structure, and a UE may transmit SRS on one of the combs. The SRS may be used by a base station for channel quality estimation to enable frequency-dependent scheduling on the UL.

(80) FIG. **4**D illustrates an example of various UL channels within a subframe of a frame. The PUCCH may be located as indicated in one configuration. The PUCCH carries uplink control information (UCI), such as scheduling requests, a channel quality indicator (CQI), a precoding matrix indicator (PMI), a rank indicator (RI), and HARQ ACK/NACK feedback. The PUSCH carries data, and may additionally be used to carry a buffer status report (BSR), a power headroom report (PHR), and/or UCI.

(81) Aspects Related to Cover Coding Data With OCC Using an Interference Randomization

(82) Multiple access schemes are used to multiplex multiple UEs (e.g., **104**, FIGS. **1** and **3**) to increase the capacity of UEs capable of utilizing a predefined set of time-frequency resources for transmissions within a predefined transmission timeframe, T. In conventional multiple access schemes each multiplexed UE is assigned a fixed OCC codeword. However, interference introduced by phase impairments such as CFO cause OCC coded transmissions to be un-decodable at a network receiver, as described herein above. To solve this problem, the herein described interference randomization scheme enables a pseudo-random selection of the OCC codeword by a

UE and utilized for individual transmissions within the predefined transmission timeframe. For example, for each transmission time interval, t, within the predefined transmission timeframe, T, one or more different OCC codewords are selected and used for sending transmissions.

(83) FIG. **5** depicts an illustrative example of cover coding data with OCC codewords using the interference randomization scheme across a predefined transmission timeframe, T. The predefined transmission timeframe, T, includes a plurality of transmission time intervals, e.g., t, t+1, t+2, . . . , t+n, and T−t to T. As depicted in FIG. **5**, the plurality of transmission time intervals illustrates the first three transmission time intervals, t, t+1, and t+2, of the predefined transmission timeframe, T. While not a requirement, the number of transmission time intervals may be equal to or greater than two times the number of UEs being multiplexed to average out average out interference caused by phase impairments due to CFO. FIG. **5** illustrates implementation of cover coding data with OCC codewords using the interference randomization scheme in a wireless communication system multiplexing two UEs. However, the illustrated example of FIG. **5** is extendable to multiplex M number of UEs, which also referred to herein as the multiplexing order, M. The multiplexing order may be included as an element of the interference randomization configuration for a network. That is, more than two UEs can be multiplexed using the with OCC codewords using the interference randomization scheme shown and described herein.

(84) In aspects, a UE informs the network that it can support multiplexing. Whether a UE can support multiplexing may depend on the phase coherence capabilities associated with the UE. In turn, the network configures the UE, for example, via radio resource control (RRC) signaling or medium access control (MAC) control element signaling with information regarding the interference randomization with OCC to be used on the network. For example, the network and each UE to be multiplexed is provided a multiplexing order M based on the phase coherence capability of the UE. Additionally, the network sends the UE information indicating the one or more signals that support application of OCC on the network. For example, the one or more signals may include, but not limited to a physical uplink shared channel (PUSCH) or a demodulation reference signal (DMRS).

(85) In aspects, the network and the UE agree on a seed value(s) for which the plurality of pseudo-random permutation matrices are generated for the predefined transmission timeframe, T. The network and UE need to agree on a seed value(s) and/or be configured beforehand so that the randomization can be deterministically reproduced by the receiver for decoding. As such, the interference randomization scheme is pseudo-random as opposed to being fully random. For example, the network may select and send the seed value to the UEs or the UE may indicate to the network the seed value which is to be used for the interference randomization. In either case, the network and the UE need to agree so that the encoded signals can be decoded. That is, the agreement makes sure that for each transmission time interval, the UE sends the data with the correct OCC codeword and the network uses the same codeword to successfully decode signals for the concerned UE. It should be understood that the network communicates with and reaches an agreement on a seed value(s) that is used for each of the UEs being multiplexed during the predefined transmission timeframe. In other words, each of the UEs being multiplexed utilize the same seed value and a predefined codeword allocator function (e.g., such as a predefined permutation matrix) to generate a plurality of pseudo-random codeword allocator functions (e.g., such as the pseudo-random permutation matrices, where one codeword allocator function (e.g., one permutation matrix) corresponds to each of the transmission time intervals of the predefined transmission timeframe. In aspects, the seed value(s) can be based on at least one of a cell identification number, a user equipment identification number, a frame index, a subframe index, or other value.

(86) As noted above, for purpose of describing the interference randomization scheme the codeword allocator function and pseudo-random codeword allocator function is discussed herein as a permutation matrix and pseudo-random permutation matrix, respectively. However, it is

understood that the pseudo-random codeword allocator function is a function, matrix, or the like that is configured to indicate to a UE which codeword from the OCC matrix is to be selected for a corresponding transmission time interval (e.g., e.g., t, t+1, t+2, . . .) of the predefined transmission timeframe, T. For example, the predefined permutation matrix for a wireless communication system comprising two UEs to be multiplexed may be the following matrix,

(87) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$.

To generate pseudo-random permutation matrices, the UE combines the predefined permutation matrix with the seed value(s). Each row of the pseudo-random permutation matrix corresponds to a particular UE being multiplexed. For example, UE1 may correspond to a first row of the generated pseudo-random permutation matrices, while UE2 correspond to a second row of the generated pseudo-random permutation matrices.

(88) In some aspects, each UE being multiplexed generates a pseudo-random permutation matrix, (e.g., G(t), G(t+1), G(t+2), . . .), for each of the transmission time intervals, (e.g., t, t+1, t+2, . . .), of the predefined transmission timeframe, T. In some aspects, the network may provide each of the UEs being multiplex with the pseudo-random permutation matrix for each of the transmission time intervals of the predefined transmission timeframe and indicate which row of the pseudo-random permutation matrix corresponds to the respective UE.

(89) The generated pseudo-random permutation matrices, (e.g., G(t), G(t+1), G(t+2) . . .), indicate to the UE which row of an OCC matrix to use as the codeword for the corresponding transmission time interval. That is, since the pseudo-random permutation matrices comprise exactly one entry of 1 in each row and each column and 0s elsewhere, the i-th column of the pseudo-random permutation matrices containing an entry of 1 indicate to the UE the k-th row of the OCC matrix which is to be selected for use as the codeword during a transmission occurring during the corresponding transmission time interval. In aspects, the OCC matrix (H) can be a Hadamard matrix or a discrete Fourier transform matrix. The OCC matrix has a dimension based on M, which may be M×M, or M×X, or X×M, where, as above, M is a number of UEs being multiplexed and X may be a dimension not based on the number of UEs.

(90) Referring now specifically to FIG. **5**, a transmission, s, for UE, i, during the first three transmission intervals, j, of a predefined transmission timeframe, T, is illustrated. The bold lines correspond to UE1 and the dashed lines correspond to UE2. In this illustrated example of FIG. **5**, the OCC matrix is a 2×2 Hadamard matrix,

(91) $\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$.

(92) At time interval t, s.sub.1.sup.0 corresponds to a transmission of UE1 to be encoded using a first OCC codeword and s.sub.2.sup.0 corresponds to a transmission of UE2 to be encoded using a second OCC codeword. UE1 and UE2 select the first pseudo-random permutation matrix, G(t), from a plurality of pseudo-random permutation matrices, because the first pseudo-random permutation matrix, G(t), corresponds to the first transmission time interval, t. The first pseudo-random permutation matrix, G(t), may be the following matrix,

(93) $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$,

where UE1 corresponds to the first (top) row of the matrix and UE2 correspond to the second (bottom) row of the matrix. Regarding UE1, since the first column of the first pseudo-random permutation matrix, G(t), contains a 1, this indicates to UE1 to select the OCC codeword from the first row (e.g., the k-th row, where k equals 1) of the OCC matrix **502** as the OCC codeword for the transmission during the first transmission time interval, t. Regarding UE2, since the second column of the pseudo-random permutation matrix, G(t), contains a 1, this indicates to UE2 to select the OCC codeword from the second row (e.g., the k-th row, where k equals 2) of the OCC matrix **502** as the OCC codeword for the transmission during the first transmission time interval, t. UE1 uses

the selected OCC codeword for encoding and sending the transmission **504** during the first transmission time interval, t. UE2 uses the selected OCC codeword for encoding and sending the transmission **506** during the first transmission time interval, t.

(94) At time interval t+1, s.sub.1.sup.1 corresponds to a transmission of UE1 to be encoded using an OCC codeword and s.sub.2.sup.1 corresponds to a transmission of UE2 to be encoded using an OCC codeword. UE1 and UE2 select the second pseudo-random permutation matrix, G(t+1), from a plurality of pseudo-random permutation matrices, because the second pseudo-random permutation matrix, G(t+1), corresponds to the second transmission time interval, t+1. The second pseudo-random permutation matrix, G(t+1), may be the following matrix,

(95) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$,

where UE1 continues to correspond to the first (top) row of the matrix and UE2 continues to correspond to the second (bottom) row of the matrix. Regarding UE1, since the second column of the second pseudo-random permutation matrix, G(t+1), contains a 1, this indicates to UE1 to select the OCC codeword from the second row (e.g., the k-th row, where k equals 2) of the OCC matrix **502** as the OCC codeword for the transmission during the second transmission time interval, t+1. Regarding UE2, since the first column of the second pseudo-random permutation matrix, G(t+1), contains a 1, this indicates to UE2 to select the OCC codeword from the first row (e.g., the k-th row, where k equals 1) of the OCC matrix **502** as the OCC codeword for the transmission during the second transmission time interval, t+1. UE1 uses the selected OCC codeword for encoding and sending the transmission **508** during the second transmission time interval, t+1. UE2 uses the selected OCC codeword for encoding and sending the transmission **510** during the second transmission time interval, t+1. In the present aspect, the first pseudo-random permutation matrix, G(t) is different than the second pseudo-random permutation matrix, G(t+1). However, in some aspects, the first pseudo-random permutation matrix, G(t) may be the same as the second pseudo-random permutation matrix, G(t+1). That is, consecutive pseudo-random permutation matrices for consecutive transmission time intervals may be the same.

(96) At time interval t+2, s.sub.1.sup.2 corresponds to a transmission of UE1 to be encoded using an OCC codeword and s.sub.2.sup.2 corresponds to a transmission of UE2 to be encoded using an OCC codeword. UE1 and UE2 select the third pseudo-random permutation matrix, G(t+2), from a plurality of pseudo-random permutation matrices, because the third pseudo-random permutation matrix, G(t+2), corresponds to the third transmission time interval, t+2. The third pseudo-random permutation matrix, G(t+2), may be the following matrix,

(97) $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$,

where UE1 continues to correspond to the first (top) row of the matrix and UE2 continues to correspond to the second (bottom) row of the matrix. Regarding UE1, since the first column of the third pseudo-random permutation matrix, G(t+2), contains a 1, this indicates to UE1 to select the OCC codeword from the first row (e.g., the k-th row, where k equals 1) of the OCC matrix **502** as the OCC codeword for the transmission during the third transmission time interval, t+2. Regarding UE2, since the second column of the pseudo-random permutation matrix, G(t+2), contains a 1, this indicates to UE2 to select the OCC codeword from the first row (e.g., the k-th row, where k equals 2) of the OCC matrix **502** as the OCC codeword for the transmission during the third transmission time interval, t+2. UE1 uses the selected OCC codeword for encoding and sending the transmission **512** during the third transmission time interval, t+2. UE2 uses the selected OCC codeword for encoding and sending the transmission **514** during the third transmission time interval, t+2.

(98) The aforementioned interference randomization scheme of using a plurality of pseudo-random permutation matrices each corresponding to one of a plurality of transmission time intervals for selecting the OCC codeword enables randomization of assigned OCC codewords to apparatuses through the transmission timeframe. It should be understood that other methods of pseudo-

randomizing may be implemented in the interference randomization scheme. That is, methods of pseudo-randomizing may utilize a pseudo-random codeword allocator function configured as an expression, a matrix, a logical operation, or the like to indicate to a UE which codeword from the OCC matrix is to be selected for a corresponding transmission time interval (e.g., e.g., t, t+1, t+2, . . .) of the predefined transmission timeframe, T.

(99) Additionally, the pseudo-random permutation matrices and/or the OCC matrix may have dimensions that are larger than M equal to two.

(100) Example Operations of a User Equipment

(101) FIG. **6** shows a method **600** for wireless communications by an apparatus, such as UE **104** of FIGS. **1** and **3**.

(102) Method **600** begins at step **605** with selecting a first OCC codeword from an OCC matrix for a transmission occurring during a first transmission time interval based on a first pseudo-random codeword allocator function, such as a first pseudo-random permutation matrix, corresponding to the first transmission time interval. For example, as shown above in FIG. **5** with reference to the first transmission time interval, t.

(103) Method **600** then proceeds to step **610** with sending the transmission during the first transmission time interval using the first OCC codeword.

(104) In one aspect, method **600** further includes selecting, as the first pseudo-random codeword allocator function from a plurality of pseudo-random codeword allocator functions, a pseudo-random codeword allocator function that corresponds to the first transmission time interval, wherein the first transmission time interval is among a plurality of transmission time intervals within a predefined transmission timeframe. For example, the first pseudo-random codeword allocator function may be G(t) as shown and described with reference to FIG. **5** above.

(105) In one aspect, the OCC matrix defines a plurality of OCC codewords. For example, as shown in FIG. **5**, the OCC matrix **502** may be an orthogonal matrix such as a Hadamard matrix.

(106) In one aspect, method **600** further includes generating the first pseudo-random codeword allocator function based on a seed value.

(107) In one aspect, method **600** further includes generating, for each transmission time interval within a predefined transmission timeframe, a pseudo-random codeword allocator function using the seed value.

(108) In one aspect, generation of the pseudo-random codeword allocator function is based on a combination of the seed value and a predefined codeword allocator function.

(109) In one aspect, the seed value is based on at least one of a cell identification number, a user equipment identification number, a frame index, or a subframe index.

(110) In one aspect, method **600** further includes being configured by a network with the seed value.

(111) In one aspect, the first pseudo-random codeword allocator function comprises a pseudo-random permutation matrix having a dimension of M, where M corresponds to a number of user equipment capable of being supported by multiplexing with a network.

(112) In one aspect, the first pseudo-random codeword allocator function comprises a pseudo-random permutation matrix having a dimension of M×M, where M corresponds to a number of user equipment capable of being supported by multiplexing with a network.

(113) In one aspect, the OCC matrix is a Hadamard matrix or a discrete Fourier transformation matrix.

(114) In one aspect, the OCC matrix comprises a dimension of M, where M corresponds to a number of user equipment capable of being supported by multiplexing with a network.

(115) In one aspect, the OCC matrix comprises a dimension of M×M, where M corresponds to a number of user equipment capable of being supported by multiplexing with a network.

(116) In one aspect, method **600** further includes obtaining information comprising a multiplexing order of the network, wherein M is the multiplexing order.

(117) In one aspect, method **600** further includes selecting a second OCC codeword from the OCC matrix for a second transmission occurring during a subsequent transmission time interval based on a second pseudo-random codeword allocator function, wherein the second pseudo-random codeword allocator function corresponds to the subsequent transmission time interval.

(118) In one aspect, method **600** further includes sending the second transmission during the subsequent transmission time interval using the second OCC codeword.

(119) In one aspect, the first OCC codeword for the first transmission time interval and the second OCC codeword for the subsequent transmission time interval are different codewords.

(120) In one aspect, the first OCC codeword for the first transmission time interval and the second OCC codeword for the subsequent transmission time interval comprise matching codewords.

(121) In one aspect, the transmission comprises data and/or a reference signal on at least one of a PUSCH or a DMRS.

(122) In one aspect, method **600** further includes selecting one OCC codeword for use during each transmission time interval of a predefined transmission timeframe, wherein the one OCC codeword is selected from the OCC matrix based on a pseudo-random codeword allocator function corresponding to each transmission time interval of the predefined transmission timeframe.

(123) In one aspect, method **600** further includes sending each transmission using the selected OCC codeword for the transmission time interval during the predefined transmission timeframe.

(124) In one aspect, method **600** further includes sending an indication that the UE supports multiplexing.

(125) In one aspect, the indication further indicates a phase coherence capability of the UE.

(126) In one aspect, method **600** further includes obtaining information indicating one or more signals that support application of OCC on a network.

(127) In one aspect, method **600** further includes obtaining a plurality of pseudo-random codeword allocator functions, such as a plurality of permutation matrices, from a network entity.

(128) In one aspect, method **600**, or any aspect related to it, may be performed by an apparatus, such as communications device **800** of FIG. **8**, which includes various components operable, configured, or adapted to perform the method **600**. Communications device **800** is described below in further detail.

(129) Note that FIG. **6** is just one example of a method, and other methods including fewer, additional, or alternative steps are possible consistent with this disclosure.

(130) Example Operations of a Network Entity

(131) FIG. **7** shows a method **700** for wireless communications at a network entity, such as BS **102** of FIGS. **1** and **3**, or a disaggregated base station as discussed with respect to FIG. **2**.

(132) Method **700** begins at step **705** with obtaining a transmission encoded with an OCC codeword during a first transmission time interval within a predefined transmission timeframe, the transmission from a first user equipment.

(133) Method **700** then proceeds to step **710** with selecting, from a plurality of pseudo-random codeword allocator functions, such as a plurality of pseudo-random permutation matrices, a pseudo-random codeword allocator function, such as a pseudo-random permutation matrix, corresponding to the first transmission time interval.

(134) Method **700** then proceeds to step **715** with selecting the OCC codeword from an OCC matrix corresponding to the first user equipment and based on the selected pseudo-random codeword allocator function.

(135) Method **700** then proceeds to step **720** with decoding the transmission with the selected OCC codeword corresponding to the first user equipment.

(136) In one aspect, method **700** further includes sending information comprising an interference randomization configuration for a network. The interference randomization configuration indicates that the OCC codeword is to be selected for transmission time intervals within the predefined transmission timeframe. For example, the interference randomization configuration indicates the

ability for network and the UE to change the OCC codewords for different time intervals (e.g., based on the generated permutation matrices) during the predefined transmission timeframe.

(137) In one aspect, the interference randomization configuration is configured for transmission using RRC signaling.

(138) In one aspect, the interference randomization configuration is configured for transmission using MAC control element signaling.

(139) In one aspect, method **700** further includes sending a multiplexing order of a network based on a phase coherence capability of a user equipment.

(140) In one aspect, method **700** further includes sending information indicating one or more signals that support application of OCC on a network.

(141) In one aspect, method **700** further includes sending a seed value for use on a network.

(142) In one aspect, method **700** further includes generating the plurality of pseudo-random codeword allocator functions based on a combination of a seed value and a predefined codeword allocator function.

(143) In one aspect, method **700**, or any aspect related to it, may be performed by an apparatus, such as communications device **900** of FIG. **9**, which includes various components operable, configured, or adapted to perform the method **700**. Communications device **900** is described below in further detail.

(144) Note that FIG. **7** is just one example of a method, and other methods including fewer, additional, or alternative steps are possible consistent with this disclosure.

(145) Example Communications Devices

(146) FIG. **8** depicts aspects of an example communications device **800**. In some aspects, communications device **800** is a user equipment, such as UE **104** described above with respect to FIGS. **1** and **3**.

(147) The communications device **800** includes a processing system **805** coupled to a transceiver **875** (e.g., a transmitter and/or a receiver). The transceiver **875** is configured to transmit and receive signals for the communications device **800** via an antenna **880**, such as the various signals as described herein. The processing system **805** may be configured to perform processing functions for the communications device **800**, including processing signals received and/or to be transmitted by the communications device **800**.

(148) The processing system **805** includes one or more processors **810**. In various aspects, the one or more processors **810** may be representative of one or more of receive processor **358**, transmit processor **364**, TX MIMO processor **366**, and/or controller/processor **380**, as described with respect to FIG. **3**. The one or more processors **810** are coupled to a computer-readable medium/memory **840** via a bus **870**. In certain aspects, the computer-readable medium/memory **840** is configured to store instructions (e.g., computer-executable code) that when executed by the one or more processors **810**, enable and cause the one or more processors **810** to perform the method **600** described with respect to FIG. **6**, or any aspect related to it, including any additional steps or sub-steps described in relation to FIG. **6**. Note that reference to a processor performing a function of communications device **800** may include one or more processors performing that function of communications device **800**, such as in a distributed fashion.

(149) In the depicted example, computer-readable medium/memory **840** stores code for selecting **845**, code for sending **850**, code for generating **855**, code for being configured **860**, and code for obtaining **865**. Processing of the code **845-865** may enable and cause the communications device **800** to perform the method **600** described with respect to FIG. **6**, or any aspect related to it.

(150) The one or more processors **810** include circuitry configured to implement (e.g., execute) the code stored in the computer-readable medium/memory **840**, including circuitry for selecting **815**, circuitry for sending **820**, circuitry for generating **825**, circuitry for being configured **830**, and circuitry for obtaining **835**. Processing with circuitry **815-835** may enable and cause the communications device **800** to perform the method **600** described with respect to FIG. **6**, or any

aspect related to it.

(151) More generally, means for communicating, transmitting, sending or outputting for transmission may include the transceivers **354**, antenna(s) **352**, transmit processor **364**, TX MIMO processor **366**, and/or controller/processor **380** of the UE **104** illustrated in FIG. **3**, transceiver **875** and/or antenna **880** of the communications device **800** in FIG. **8**, and/or one or more processors **810** of the communications device **800** in FIG. **8**. Means for communicating, receiving or obtaining may include the transceivers **354**, antenna(s) **352**, receive processor **358**, and/or controller/processor **380** of the UE **104** illustrated in FIG. **3**, transceiver **875** and/or antenna **880** of the communications device **800** in FIG. **8**, and/or one or more processors **810** of the communications device **800** in FIG. **8**.

(152) FIG. **9** depicts aspects of an example communications device **900**. In some aspects, communications device **900** is a network entity, such as BS **102** of FIGS. **1** and **3**, or a disaggregated base station as discussed with respect to FIG. **2**.

(153) The communications device **900** includes a processing system **905** coupled to a transceiver **975** (e.g., a transmitter and/or a receiver) and/or a network interface **985**. The transceiver **975** is configured to transmit and receive signals for the communications device **900** via an antenna **980**, such as the various signals as described herein. The network interface **985** is configured to obtain and send signals for the communications device **900** via communications link(s), such as a backhaul link, midhaul link, and/or fronthaul link as described herein, such as with respect to FIG. **2**. The processing system **905** may be configured to perform processing functions for the communications device **900**, including processing signals received and/or to be transmitted by the communications device **900**.

(154) The processing system **905** includes one or more processors **910**. In various aspects, one or more processors **910** may be representative of one or more of receive processor **338**, transmit processor **320**, TX MIMO processor **330**, and/or controller/processor **340**, as described with respect to FIG. **3**. The one or more processors **910** are coupled to a computer-readable medium/memory **940** via a bus **970**. In certain aspects, the computer-readable medium/memory **940** is configured to store instructions (e.g., computer-executable code) that when executed by the one or more processors **910**, enable and cause the one or more processors **910** to perform the method **700** described with respect to FIG. **7**, or any aspect related to it, including any additional steps or sub-steps described in relation to FIG. **7**. Note that reference to a processor of communications device **900** performing a function may include one or more processors of communications device **900** performing that function, such as in a distributed fashion.

(155) In the depicted example, the computer-readable medium/memory **940** stores code for obtaining **945**, code for selecting **950**, code for decoding **955**, code for sending **960**, and code for generating **965**. Processing of the code **945-965** may enable and cause the communications device **900** to perform the method **700** described with respect to FIG. **7**, or any aspect related to it.

(156) The one or more processors **910** include circuitry configured to implement (e.g., execute) the code stored in the computer-readable medium/memory **940**, including circuitry for obtaining **915**, circuitry for selecting **920**, circuitry for decoding **925**, circuitry for sending **930**, and circuitry for generating **935**. Processing with circuitry **915-935** may enable and cause the communications device **900** to perform the method **700** described with respect to FIG. **7**, or any aspect related to it.

(157) More generally, means for communicating, transmitting, sending or outputting for transmission may include the transceivers **332**, antenna(s) **334**, transmit processor **320**, TX MIMO processor **330**, and/or controller/processor **340** of the BS **102** illustrated in FIG. **3**, transceiver **975** and/or antenna **980** of the communications device **900** in FIG. **9**, and/or one or more processors **910** of the communications device **900** in FIG. **9**. Means for communicating, receiving or obtaining may include the transceivers **332**, antenna(s) **334**, receive processor **338**, and/or controller/processor **340** of the BS **102** illustrated in FIG. **3**, transceiver **975** and/or antenna **980** of the communications device **900** in FIG. **9**, and/or one or more processors **910** of the

communications device **900** in FIG. **9**.

Example Clauses

(158) Implementation examples are described in the following numbered clauses:

(159) Clause 1: A method for wireless communications by an apparatus, comprising: selecting a first OCC codeword from an OCC matrix for a transmission occurring during a first transmission time interval based on a first pseudo-random codeword allocator function corresponding to the first transmission time interval; and sending the transmission during the first transmission time interval using the first OCC codeword.

(160) Clause 2: The method of Clause 1, further comprising selecting, as the first pseudo-random codeword allocator function from a plurality of pseudo-random codeword allocator functions, a pseudo-random codeword allocator function that corresponds to the first transmission time interval, wherein the first transmission time interval is among a plurality of transmission time intervals within a predefined transmission timeframe.

(161) Clause 3: The method of any one of Clauses 1-2, further comprising generating the first pseudo-random codeword allocator function based on a seed value.

(162) Clause 4: The method of Clause 3, further comprising generating, for each transmission time interval within a predefined transmission timeframe, a pseudo-random codeword allocator function using the seed value.

(163) Clause 5: The method of Clause 4, wherein generation of the pseudo-random codeword allocator function is based on a combination of the seed value and a predefined codeword allocator function.

(164) Clause 6: The method of Clause 3, wherein the seed value is based on at least one of a cell identification number, a user equipment identification number, a frame index, or a subframe index.

(165) Clause 7: The method of Clause 3, further comprising being configured by a network with the seed value.

(166) Clause 8: The method of any one of Clauses 1-8, wherein the first pseudo-random codeword allocator function comprises a pseudo-random permutation matrix having a dimension of M×M, where M corresponds to a number of user equipment capable of being supported by multiplexing with a network.

(167) Clause 9: The method of any one of Clauses 1-8, wherein the OCC matrix defines a plurality of OCC codewords and the plurality of OCC codewords is based on M, wherein M is a multiplexing order.

(168) Clause 10: The method of any one of Clauses 1-9, wherein the OCC matrix is an orthogonal matrix.

(169) Clause 11: The method of Clause 10, wherein the OCC matrix is a Hadamard matrix or a discrete Fourier transformation matrix.

(170) Clause 12: The method of any one of Clauses 1-11, wherein the OCC matrix comprises a dimension of M×M, where M corresponds to a number of user equipment capable of being supported by multiplexing with a network.

(171) Clause 13: The method of Clause 12, further comprising obtaining information comprising a multiplexing order of the network, wherein M is the multiplexing order.

(172) Clause 14: The method of any one of Clauses 1-13, further comprising: selecting a second OCC codeword from the OCC matrix for a second transmission occurring during a subsequent transmission time interval based on a second pseudo-random codeword allocator function, wherein the second pseudo-random codeword allocator function corresponds to the subsequent transmission time interval; and sending the second transmission during the subsequent transmission time interval using the second OCC codeword.

(173) Clause 15: The method of Clause 14, wherein the first OCC codeword for the first transmission time interval and the second OCC codeword for the subsequent transmission time interval are different codewords.

(174) Clause 16: The method of Clause 14, wherein the first OCC codeword for the first transmission time interval and the second OCC codeword for the subsequent transmission time interval comprise matching codewords.

(175) Clause 17: The method of any one of Clauses 1-16, wherein the transmission comprises a data signal, a reference signal, or a random access signal.

(176) Clause 18: The method of any one of Clauses 1-17, further comprising: selecting one OCC codeword for use during each transmission time interval of a predefined transmission timeframe, wherein the one OCC codeword is selected from the OCC matrix based on a pseudo-random codeword allocator function corresponding to each transmission time interval of the predefined transmission timeframe; and sending each transmission using the selected OCC codeword for the transmission time interval during the predefined transmission timeframe.

(177) Clause 19: The method of any one of Clauses 1-18, further comprising sending an indication that the apparatus supports multiplexing.

(178) Clause 20: The method of Clause 19, wherein the indication further indicates a phase coherence capability of the apparatus.

(179) Clause 21: The method of any one of Clauses 1-20, further comprising obtaining information indicating one or more signals that support application of OCC on a network.

(180) Clause 22: The method of any one of Clauses 1-21, further comprising obtaining a plurality of pseudo-random codeword allocator functions from a network entity.

(181) Clause 23: A method for wireless communications by an apparatus, comprising: obtaining a transmission encoded with an OCC codeword during a first transmission time interval within a predefined transmission timeframe, the transmission from a first user equipment; selecting, from a plurality of pseudo-random codeword allocator functions, a pseudo-random codeword allocator function corresponding to the first transmission time interval; selecting the OCC codeword from an OCC matrix corresponding to the first user equipment and based on the selected pseudo-random codeword allocator function; and decoding the transmission with the selected OCC codeword corresponding to the first user equipment.

(182) Clause 24: The method of Clause 23, further comprising sending information comprising an interference randomization configuration for a network, wherein the interference randomization configuration indicates that the OCC codeword is to be selected for transmission time intervals within the predefined transmission timeframe.

(183) Clause 25: The method of Clause 24, wherein the interference randomization configuration is configured for transmission using RRC signaling or MAC control element signaling.

(184) Clause 26: The method of Clause 23, wherein the interference randomization configuration is configured for transmission using MAC control element signaling.

(185) Clause 27: The method of any one of Clauses 23-26, further comprising sending a multiplexing order of a network based on a phase coherence capability of a user equipment.

(186) Clause 28: The method of any one of Clauses 23-27, further comprising sending information indicating one or more signals that support application of OCC on a network.

(187) Clause 29: The method of any one of Clauses 23-28, further comprising sending a seed value for use on a network.

(188) Clause 30: The method of any one of Clauses 23-29, further comprising generating the plurality of pseudo-random codeword allocator functions based on a combination of a seed value and a predefined codeword allocator function.

(189) Clause 31: One or more apparatuses, comprising: one or more memories comprising executable instructions; and one or more processors configured to execute the executable instructions and cause the one or more apparatuses to perform a method in accordance with any one of clauses 1-30.

(190) Clause 32: One or more apparatuses, comprising means for performing a method in accordance with any one of clauses 1-30.

(191) Clause 33: One or more non-transitory computer-readable media comprising executable instructions that, when executed by one or more processors of one or more apparatuses, cause the one or more apparatuses to perform a method in accordance with any one of clauses 1-30.

(192) Clause 34: One or more computer program products embodied on one or more computer-readable storage media comprising code for performing a method in accordance with any one of clauses 1-30.

Additional Considerations

(193) The preceding description is provided to enable any person skilled in the art to practice the various aspects described herein. The examples discussed herein are not limiting of the scope, applicability, or aspects set forth in the claims. Various modifications to these aspects will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other aspects. For example, changes may be made in the function and arrangement of elements discussed without departing from the scope of the disclosure. Various examples may omit, substitute, or add various procedures or components as appropriate. For instance, the methods described may be performed in an order different from that described, and various actions may be added, omitted, or combined. Also, features described with respect to some examples may be combined in some other examples. For example, an apparatus may be implemented or a method may be practiced using any number of the aspects set forth herein. In addition, the scope of the disclosure is intended to cover such an apparatus or method that is practiced using other structure, functionality, or structure and functionality in addition to, or other than, the various aspects of the disclosure set forth herein. It should be understood that any aspect of the disclosure disclosed herein may be embodied by one or more elements of a claim.

(194) The various illustrative logical blocks, modules and circuits described in connection with the present disclosure may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an ASIC, a field programmable gate array (FPGA) or other programmable logic device (PLD), discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any commercially available processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, a system on a chip (SoC), or any other such configuration.

(195) 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 (e.g., 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).

(196) As used herein, the term "determining" encompasses a wide variety of actions. For example, "determining" may include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" may include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory) and the like. Also, "determining" may include resolving, selecting, choosing, establishing and the like.

(197) As used herein, "coupled to" and "coupled with" generally encompass direct coupling and indirect coupling (e.g., including intermediary coupled aspects) unless stated otherwise. For example, stating that a processor is coupled to a memory allows for a direct coupling or a coupling via an intermediary aspect, such as a bus.

(198) The methods disclosed herein comprise one or more actions for achieving the methods. The method actions may be interchanged with one another without departing from the scope of the claims. In other words, unless a specific order of actions is specified, the order and/or use of

specific actions may be modified without departing from the scope of the claims. Further, the various operations of methods described above may be performed by any suitable means capable of performing the corresponding functions. The means may include various hardware and/or software component(s) and/or module(s), including, but not limited to a circuit, an application specific integrated circuit (ASIC), or processor.

(199) The following claims are not intended to be limited to the aspects shown herein, but are to be accorded the full scope consistent with the language of the claims. Reference to an element in the singular is not intended to mean only one unless specifically so stated, but rather "one or more." For example, reference to an element (e.g., "a processor," "a controller," "a memory," etc.), unless otherwise specifically stated, should be understood to refer to one or more elements (e.g., "one or more processors," "one or more controllers," "one or more memories," etc.). The terms "set" and "group" are intended to include one or more elements, and may be used interchangeably with "one or more." Where reference is made to one or more elements performing functions (e.g., steps of a method), one element may perform all functions, or more than one element may collectively perform the functions. When more than one element collectively performs the functions, each function need not be performed by each of those elements (e.g., different functions may be performed by different elements) and/or each function need not be performed in whole by only one element (e.g., different elements may perform different sub-functions of a function). Similarly, where reference is made to one or more elements configured to cause another element (e.g., an apparatus) to perform functions, one element may be configured to cause the other element to perform all functions, or more than one element may collectively be configured to cause the other element to perform the functions. Unless specifically stated otherwise, the term "some" refers to one or more. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims.

Claims

1. An apparatus configured for wireless communications, comprising: one or more memories comprising processor-executable instructions; and one or more processors configured to execute the processor-executable instructions and cause the apparatus to: select a first orthogonal cover code (OCC) codeword from an OCC matrix for a transmission occurring during a first transmission time interval based on a first pseudo-random codeword allocator function corresponding to the first transmission time interval; encode the transmission, comprising signals corresponding to data, using the first OCC codeword; send the transmission during the first transmission time interval using the first OCC codeword; select a second OCC codeword from the OCC matrix for a second transmission occurring during a subsequent transmission time interval based on a second pseudo-random codeword allocator function, wherein the second pseudo-random codeword allocator function corresponds to the subsequent transmission time interval and the first pseudo-random codeword allocator function and the second pseudo-random codeword allocator function are different pseudo-random codeword allocator functions; and send the second transmission during the subsequent transmission time interval using the second OCC codeword.

2. The apparatus of claim 1, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to select, as the first pseudo-random codeword allocator function from a plurality of pseudo-random codeword allocator functions, a pseudo-random codeword allocator function that corresponds to the first transmission time interval, wherein the first transmission time interval is among a plurality of transmission time intervals within a predefined transmission timeframe.

3. The apparatus of claim 1, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to generate the first pseudo-random codeword allocator function based on a seed value.

4. The apparatus of claim 3, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to generate, for each transmission time interval within a predefined transmission timeframe, a pseudo-random codeword allocator function using the seed value.

5. The apparatus of claim 4, wherein generation of the pseudo-random codeword allocator function is based on a combination of the seed value and a predefined codeword allocator function.

6. The apparatus of claim 3, wherein the seed value is based on at least one of a cell identification number, a user equipment identification number, a frame index, or a subframe index.

7. The apparatus of claim 3, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to be configured by a network with the seed value.

8. The apparatus of claim 1, wherein the first pseudo-random codeword allocator function comprises a pseudo-random permutation matrix having a dimension based on M, where M corresponds to a number of user equipment capable of being supported by multiplexing with a network.

9. The apparatus of claim 1, wherein the OCC matrix defines a plurality of OCC codewords and the plurality of OCC codewords is based on M, wherein Mis a multiplexing order.

10. The apparatus of claim 1, wherein the OCC matrix is an orthogonal matrix.

11. The apparatus of claim 10, wherein the OCC matrix is a Hadamard matrix or a discrete Fourier transformation matrix.

12. The apparatus of claim 1, wherein the OCC matrix comprises a dimension based on M, where M corresponds to a number of user equipment capable of being supported by multiplexing with a network.

13. The apparatus of claim 12, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to obtain information comprising a multiplexing order of the network, wherein Mis the multiplexing order.

14. The apparatus of claim 1, wherein the first OCC codeword for the first transmission time interval and the second OCC codeword for the subsequent transmission time interval are different codewords.

15. The apparatus of claim 1, wherein the first OCC codeword for the first transmission time interval and the second OCC codeword for the subsequent transmission time interval comprise matching codewords.

16. The apparatus of claim 1, wherein the transmission comprises a data signal, a reference signal, or a random access signal.

17. The apparatus of claim 1, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to: select one OCC codeword for use during each transmission time interval of a predefined transmission timeframe, wherein the one OCC codeword is selected from the OCC matrix based on a pseudo-random codeword allocator function corresponding to each transmission time interval of the predefined transmission timeframe; and send each transmission using the selected OCC codeword selected for the transmission time interval during the predefined transmission timeframe.

18. The apparatus of claim 1, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to send an indication that the apparatus supports multiplexing.

19. The apparatus of claim 18, wherein the indication further indicates a phase coherence capability of the apparatus.

20. The apparatus of claim 1, wherein the one or more processors are configured to execute the

processor-executable instructions and further cause the apparatus to obtain information indicating one or more signals that support application of OCC on a network.

21. The apparatus of claim 1, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to obtain a plurality of pseudo-random codeword allocator functions from a network entity.

22. An apparatus configured for wireless communications, comprising: one or more memories comprising processor-executable instructions; and one or more processors configured to execute the processor-executable instructions and cause the apparatus to: obtain a first transmission comprising signals corresponding to data encoded with a first OCC codeword during a first transmission time interval within a first predefined transmission timeframe, the first transmission from a first user equipment; select, from a plurality of pseudo-random codeword allocator functions, a first pseudo-random codeword allocator function corresponding to the first transmission time interval; select the first OCC codeword from an OCC matrix corresponding to the first user equipment and based on the first pseudo-random codeword allocator function; decode the first transmission with the first OCC codeword corresponding to the first user equipment; obtain a second transmission comprising signals corresponding to data encoded with a second OCC codeword during a second transmission time interval within a second predefined transmission timeframe, the second transmission from the first user equipment; select, from the plurality of pseudo-random codeword allocator functions, a second pseudo-random codeword allocator function corresponding to the second transmission time interval, wherein the first pseudo-random codeword allocator function and the second pseudo-random codeword allocator function are different pseudo-random codeword allocator functions; select the second OCC codeword from the OCC matrix corresponding to the first user equipment and based on the second pseudo-random codeword allocator function; and decode the second transmission with the second OCC codeword.

23. The apparatus of claim 22, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to send information comprising an interference randomization configuration for a network, wherein the interference randomization configuration indicates that the first OCC codeword is to be selected for the first transmission time interval within the first predefined transmission timeframe.

24. The apparatus of claim 23, wherein the interference randomization configuration is configured for transmission using radio resource control (RRC) signaling or medium access control (MAC) control element signaling.

25. The apparatus of claim 22, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to send a multiplexing order of a network based on a phase coherence capability of a user equipment.

26. The apparatus of claim 22, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to send information indicating one or more signals that support application of OCC on a network.

27. The apparatus of claim 22, wherein the one or more processors are configured to execute the processor-executable instructions and further cause the apparatus to generate the plurality of pseudo-random codeword allocator functions based on a combination of a seed value and a predefined codeword allocator function.

28. A method for wireless communications by an apparatus, comprising: selecting a first orthogonal cover code (OCC) codeword from an OCC matrix for a transmission occurring during a first transmission time interval based on a first pseudo-random codeword allocator function corresponding to the first transmission time interval; encoding the transmission, comprising signals corresponding to data, using the first OCC codeword; sending the transmission during the first transmission time interval using the first OCC codeword; selecting a second OCC codeword from the OCC matrix for a second transmission occurring during a subsequent transmission time interval based on a second pseudo-random codeword allocator function, wherein the second pseudo-random

codeword allocator function corresponds to the subsequent transmission time interval and the first pseudo-random codeword allocator function and the second pseudo-random codeword allocator function are different pseudo-random codeword allocator functions; and sending the second transmission during the subsequent transmission time interval using the second OCC codeword.

29. A method for wireless communications by an apparatus, comprising: obtaining a first transmission comprising signals corresponding to data encoded with a first OCC codeword during a first transmission time interval within a first predefined transmission timeframe, the first transmission from a first user equipment; selecting, from a plurality of pseudo-random codeword allocator functions, a first pseudo-random codeword allocator function corresponding to the first transmission time interval; selecting the first OCC codeword from an OCC matrix corresponding to the first user equipment and based on the first pseudo-random codeword allocator function; decoding the first transmission with the first OCC codeword corresponding to the first user equipment; obtaining a second transmission comprising signals corresponding to data encoded with a second OCC codeword during a second transmission time interval within a second predefined transmission timeframe, the second transmission from the first user equipment; selecting, from the plurality of pseudo-random codeword allocator functions, a second pseudo-random codeword allocator function corresponding to the second transmission time interval, wherein the first pseudo-random codeword allocator function and the second pseudo-random codeword allocator function are different pseudo-random codeword allocator functions; selecting the second OCC codeword from the OCC matrix corresponding to the first user equipment and based on the second pseudo-random codeword allocator function; and decoding the second transmission with the second OCC codeword.