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Saggar et al.

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(54) **CYCLIC PREFIX GUARD INTERVAL FOR INCREASED DELAY SPREAD**

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(51) **Int. Cl.**

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H04L 5/00	(2006.01)
H04L 27/26	(2006.01)
H04W 24/10	(2009.01)
H04W 72/0453	(2023.01)

(52) **U.S. Cl.**

CPC ***H04L 27/2636*** (2013.01); ***H04B 7/0617*** (2013.01); ***H04L 5/0007*** (2013.01); ***H04W 24/10*** (2013.01); ***H04W 72/0453*** (2013.01)

(58) **Field of Classification Search**

CPC H04L 27/2636; H04L 5/0007; H04L 27/26025; H04L 27/2607; H04L 27/2646; H04B 7/0617; H04W 24/10; H04W 72/0453

See application file for complete search history.

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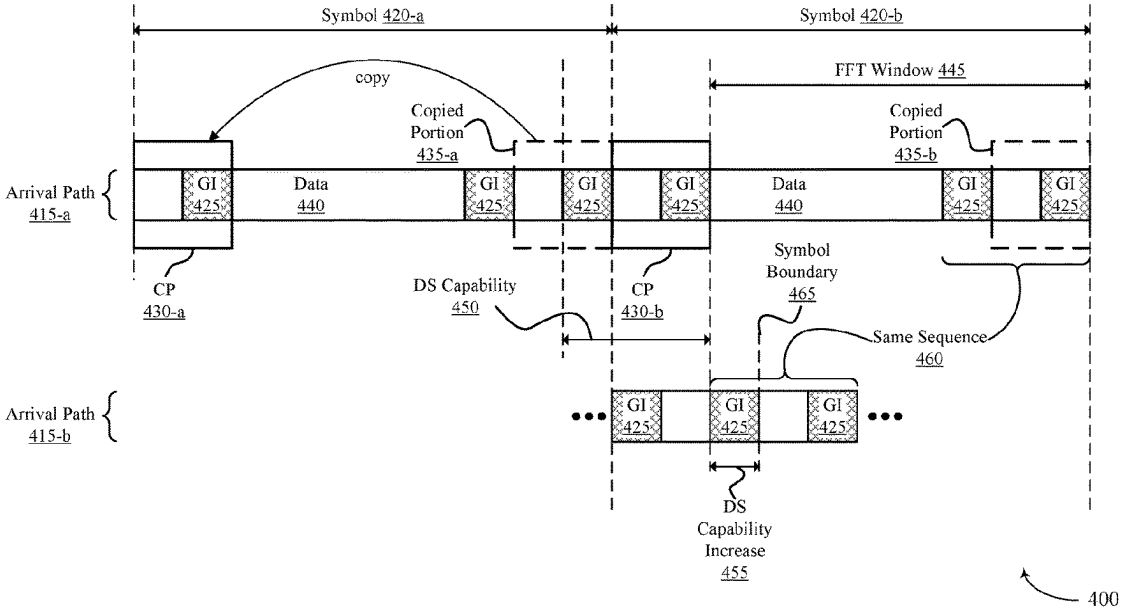
(57) **ABSTRACT**

Methods, systems, and devices for wireless communications are described. A user equipment (UE) may transmit an indication that the UE supports a plurality of cyclic prefix configurations. The UE may receive, from a network entity, an indication of a first cyclic prefix configuration of the plurality of cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based at least in part on a delay spread exceeding a length of the cyclic prefix. The UE may communicate one or more messages with the network entity in accordance with the first cyclic prefix configuration.

30 Claims, 16 Drawing Sheets



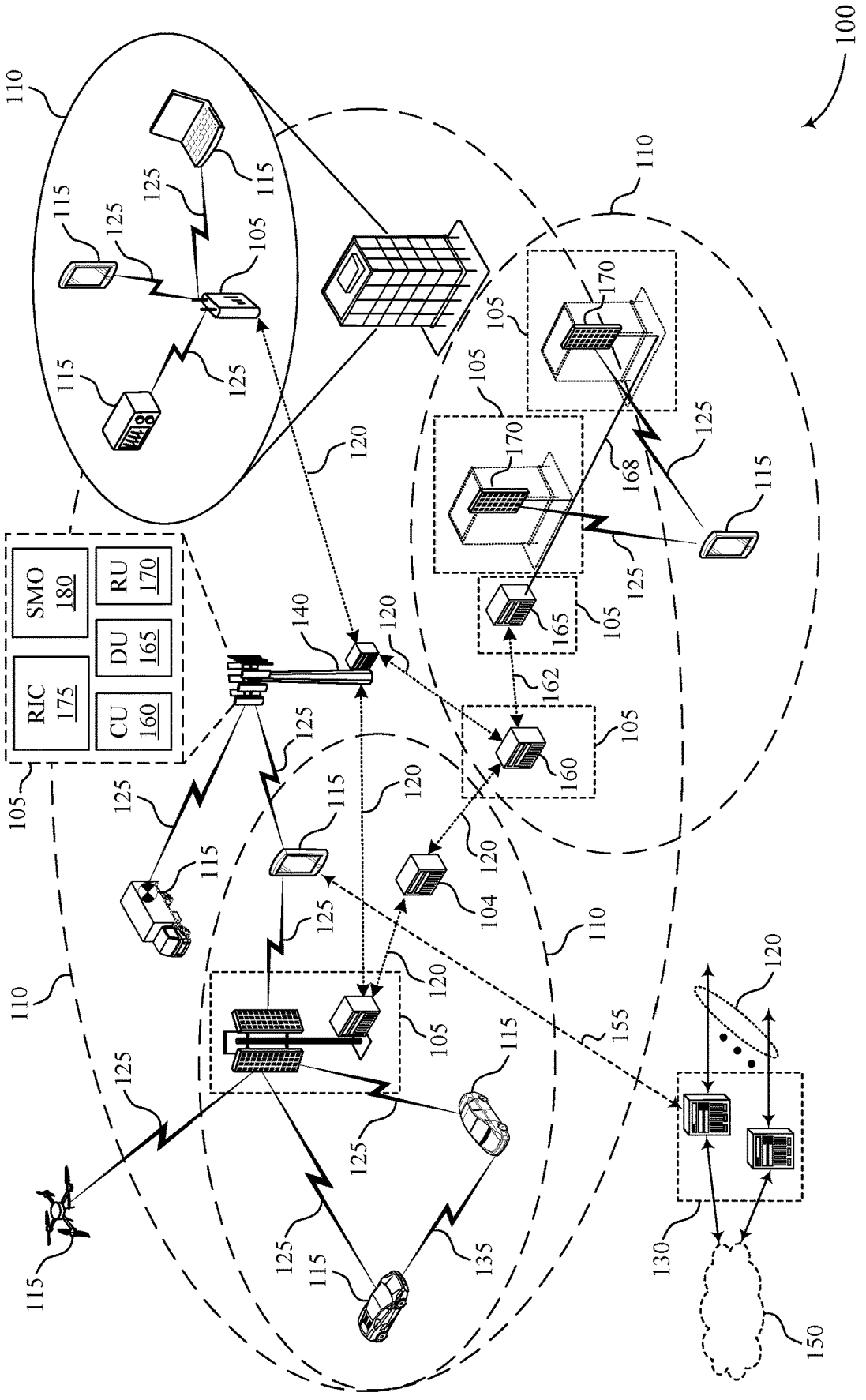

100
110
105
115
120
125
130
135
140
150
155
160
162
165
168
170
180
RIC 175
SMO 180
RU 170
DU 165
CU 160

FIG. 1

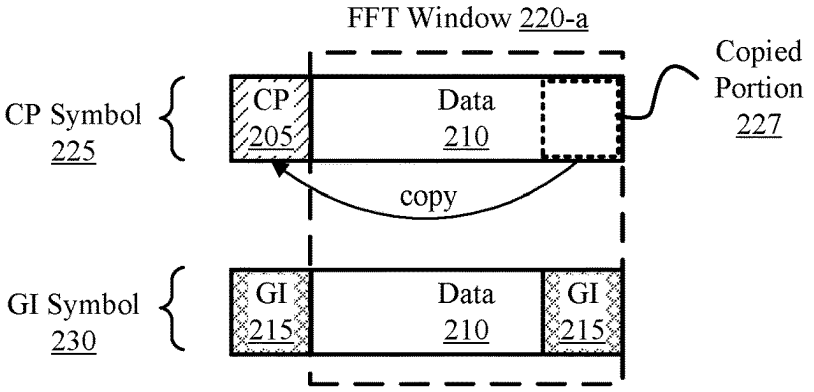


FIG. 2A

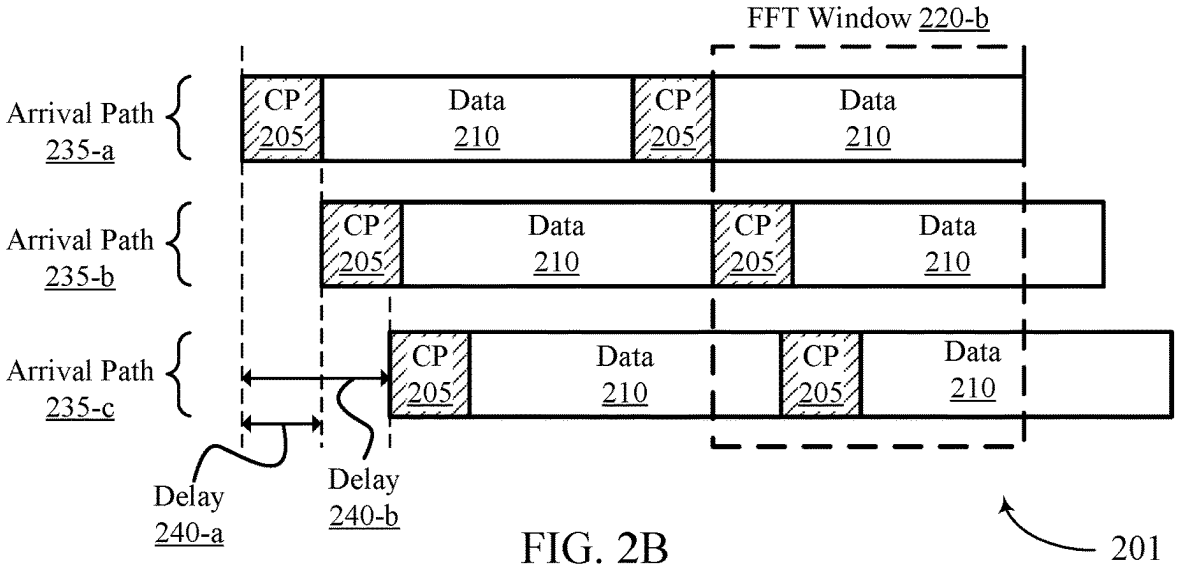


FIG. 2B

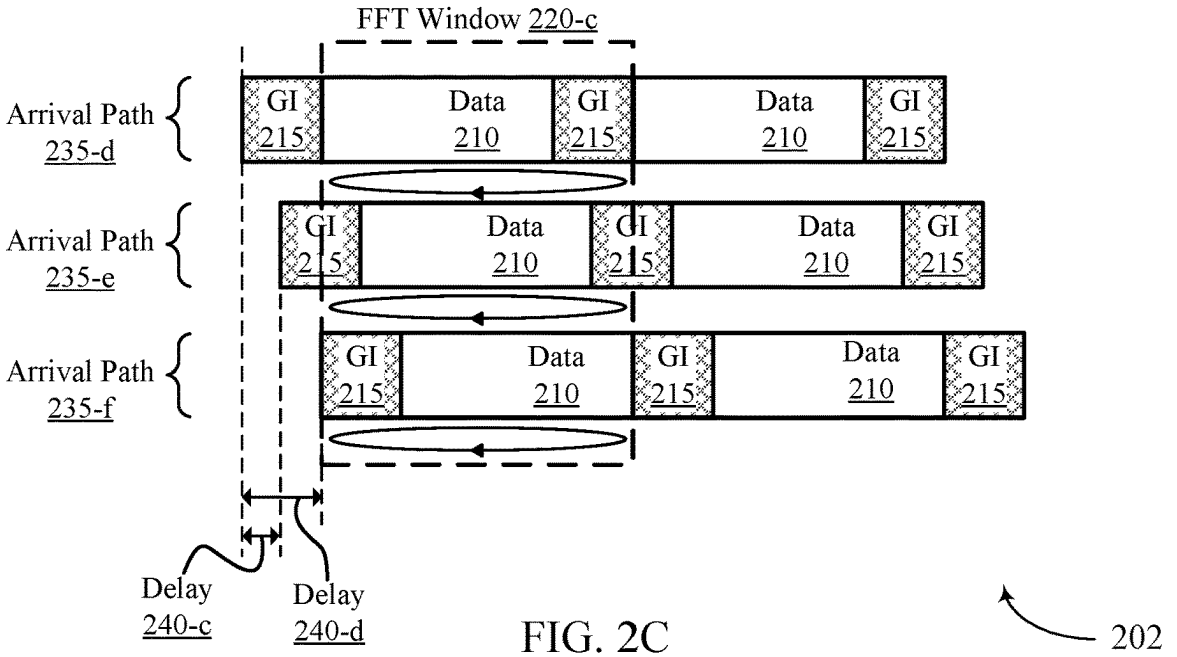
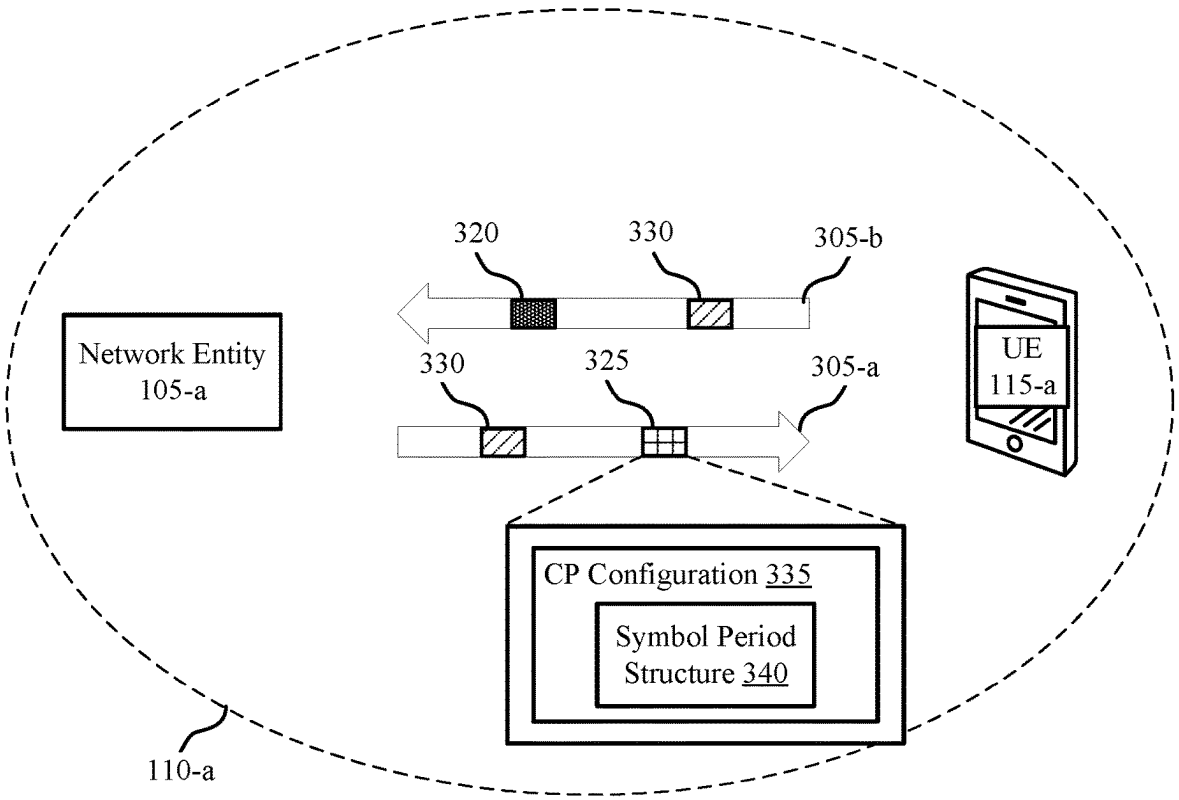


FIG. 2C



CP Configuration Capability Message 320

CP Configuration Indication 325

Data Communications 330

300

FIG. 3

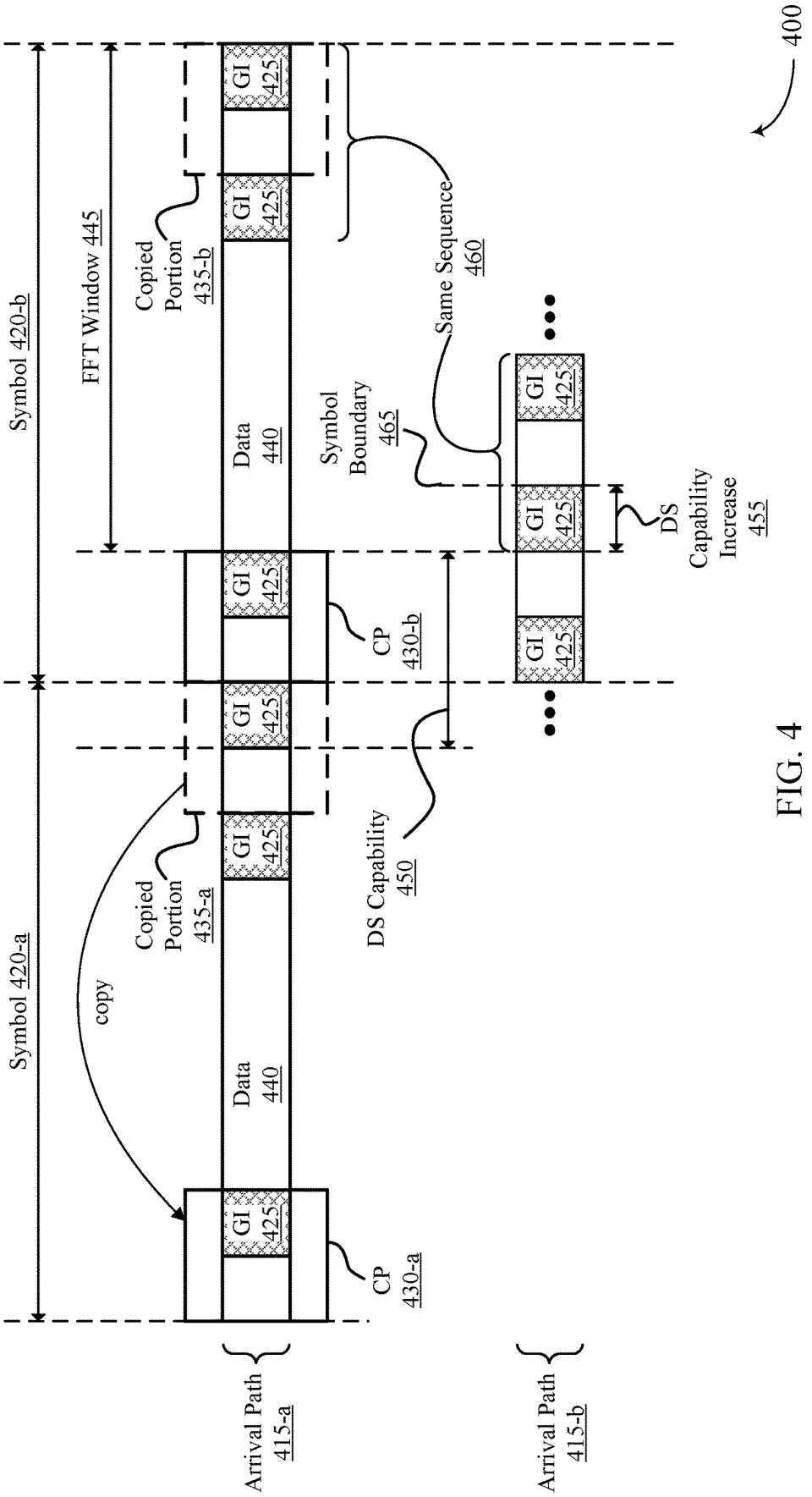

400
Symbol 420-b
FFT Window 445
Copied Portion 435-b
Same Sequence 460
Symbol Boundary 465
DS Capability Increase 455
DS Capability 450
Symbol 420-a
Copied Portion 435-a
copy
CP 430-b
CP 430-a
Data 440
GI 425
Arrival Path 415-a
Arrival Path 415-b

FIG. 4

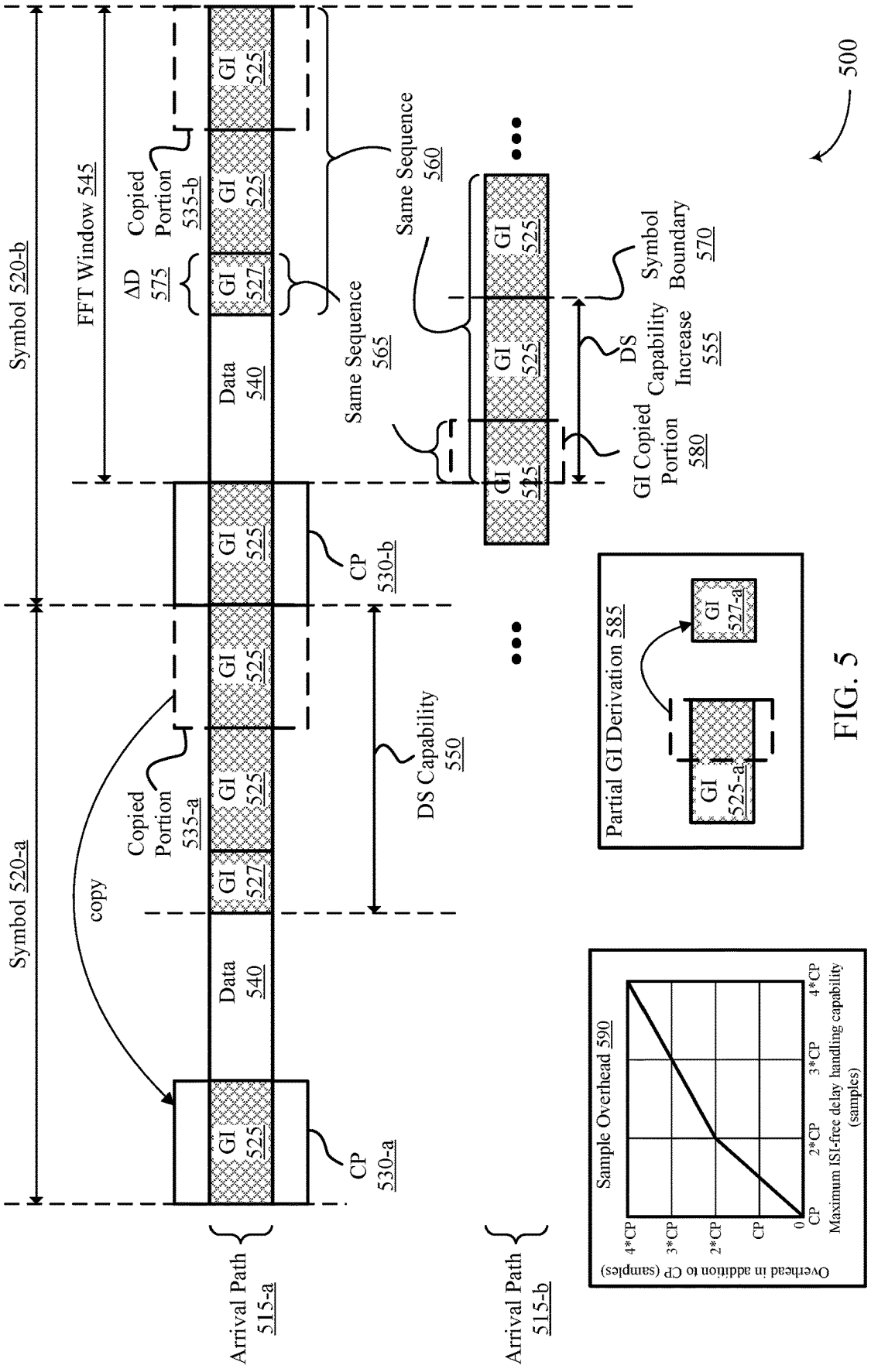

500
Symbol 520-a
Symbol 520-b
FFT Window 545
Arrival Path 515-a
Arrival Path 515-b
Copied Portion 535-a
Copied Portion 535-b
ΔD 575
copy
CP 530-a
CP 530-b
DS Capability 550
Same Sequence 565
Same Sequence 560
GI Copied Portion 580
DS Capability Increase 555
Symbol Boundary 570
Partial GI Derivation 585
GI 525-a
GI 527-a
Sample Overhead 590
Overhead in addition to CP (samples)
Maximum ISI-free delay handling capability (samples)
0
CP
2*CP
3*CP
4*CP
Data 540
GI 525
GI 527

FIG. 5

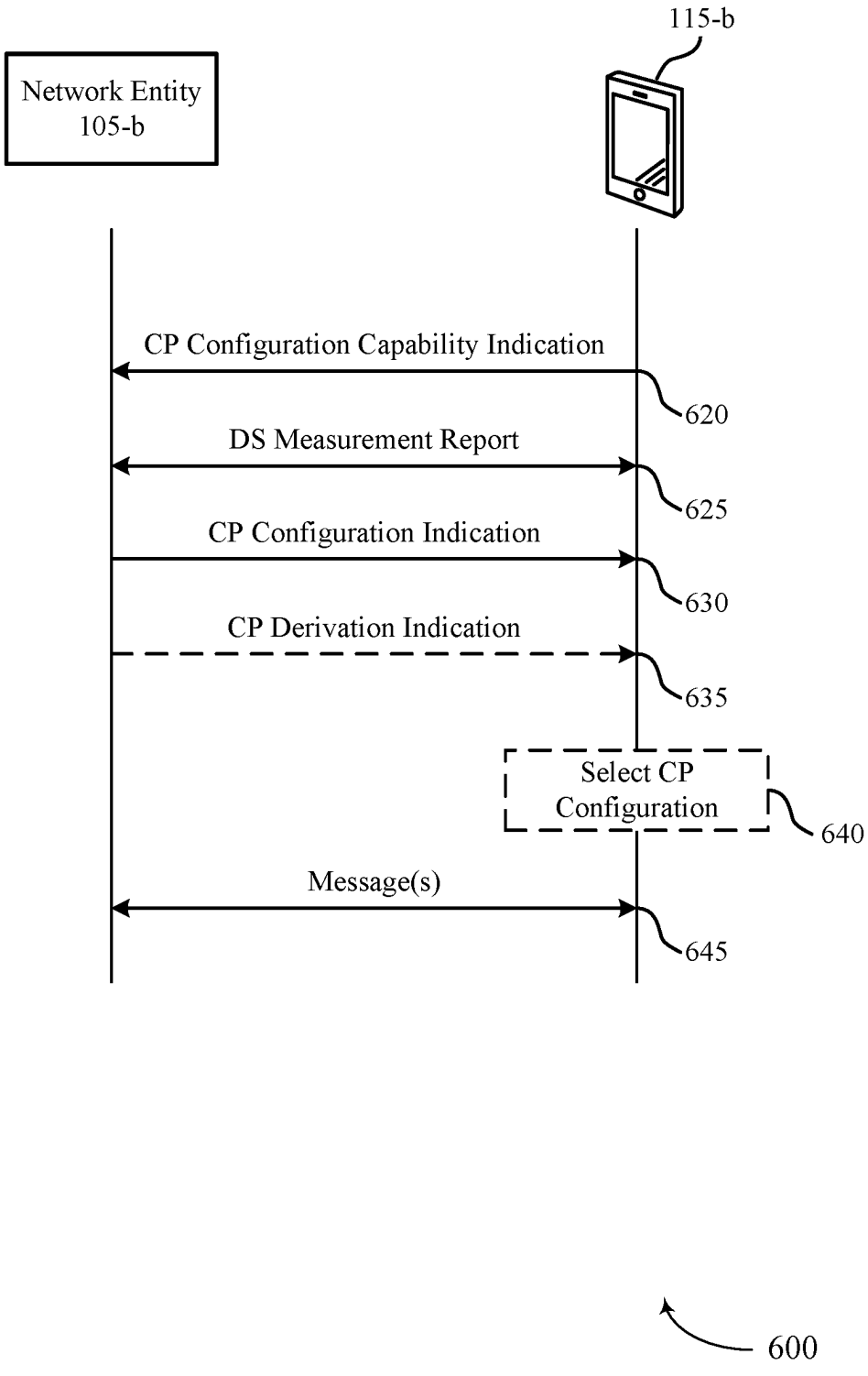

115-b
Network Entity
105-b
CP Configuration Capability Indication
620
DS Measurement Report
625
CP Configuration Indication
630
CP Derivation Indication
635
Select CP
Configuration
640
Message(s)
645
600

FIG. 6

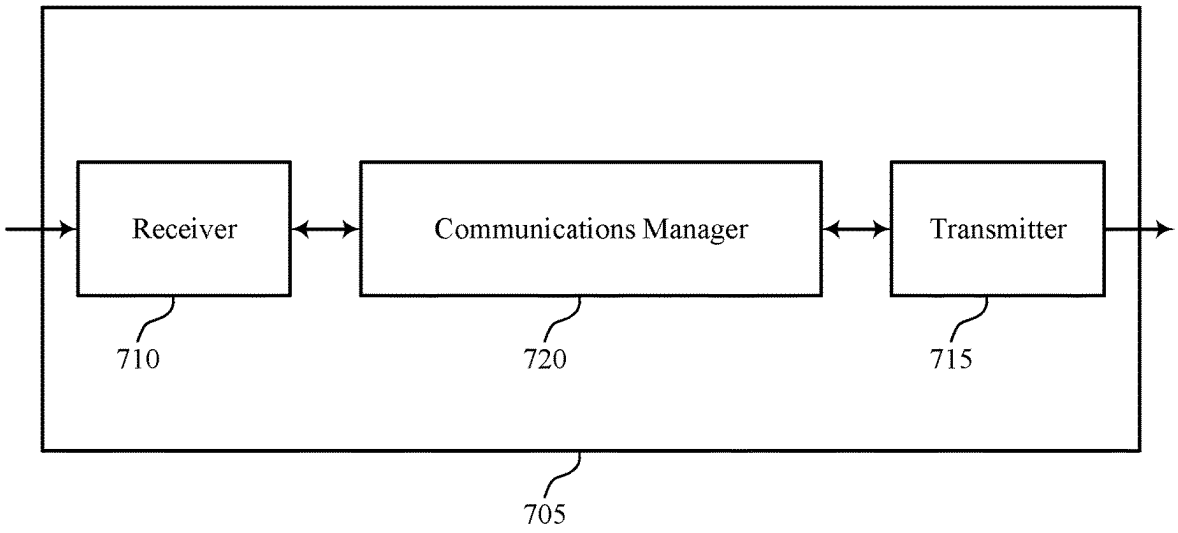

Receiver
Communications Manager
Transmitter
710
720
715
705
700

FIG. 7

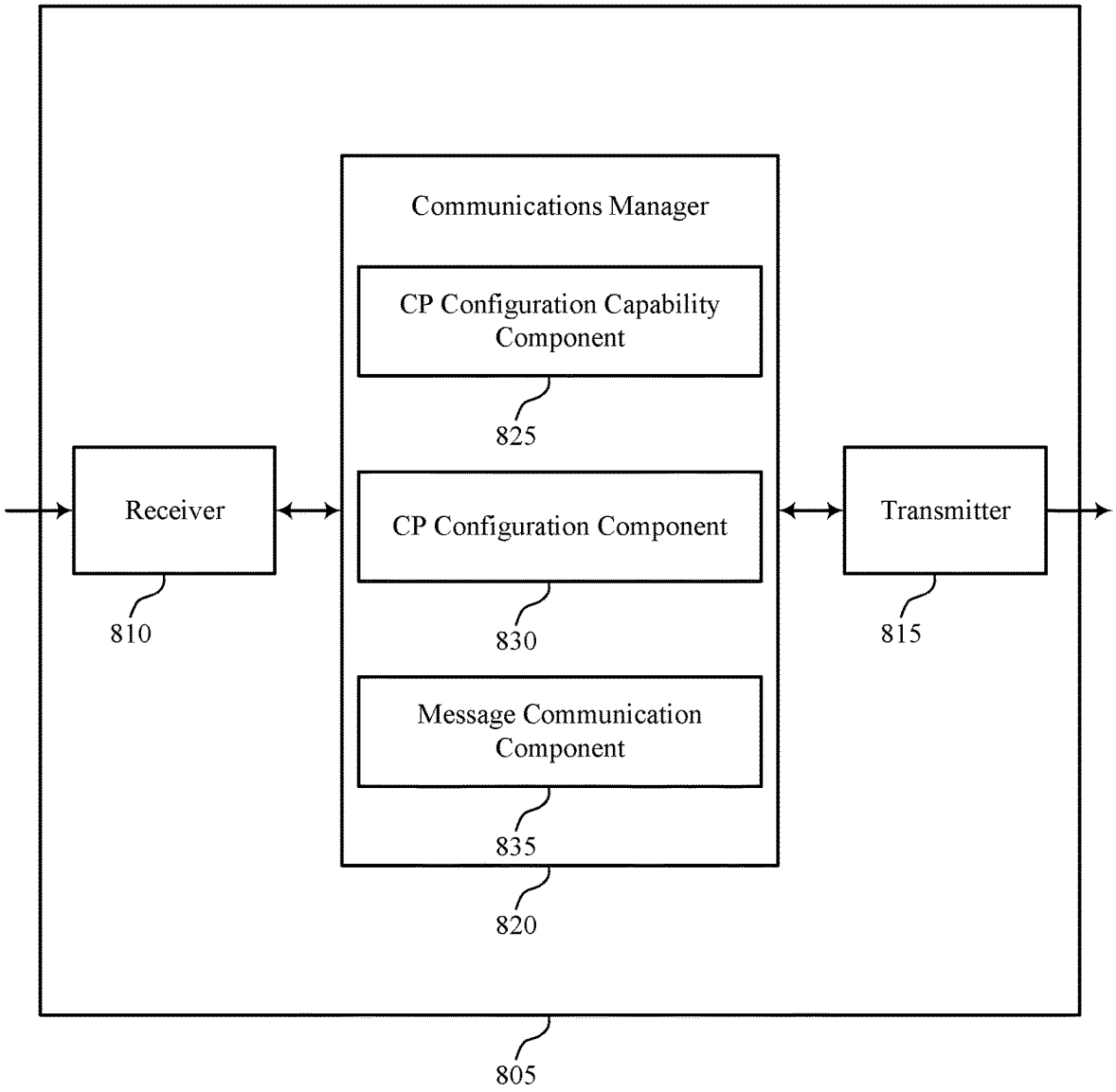

Communications Manager
CP Configuration Capability Component
825
Receiver
CP Configuration Component
Transmitter
810
830
815
Message Communication Component
835
820
805
800

FIG. 8

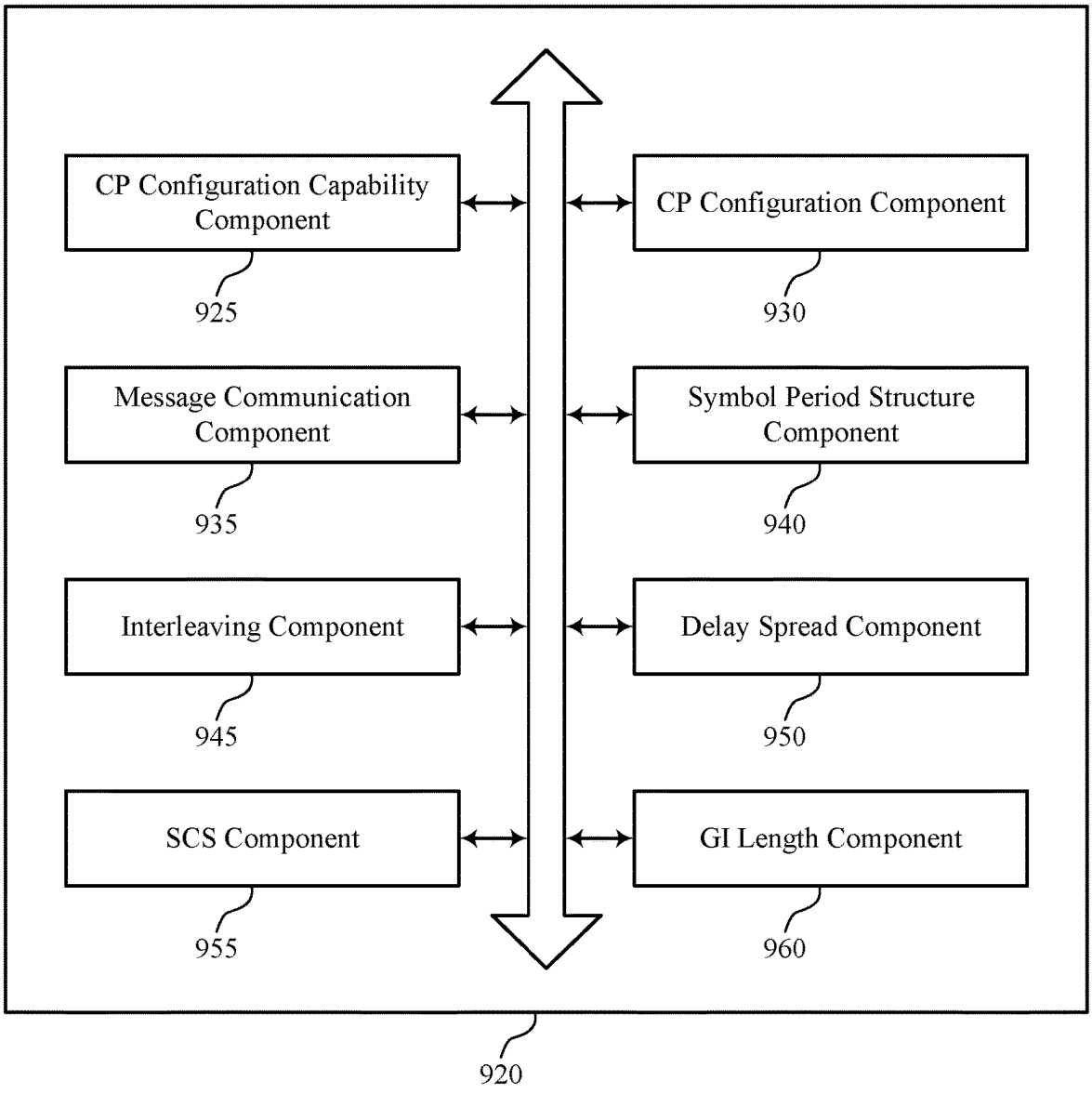

CP Configuration Capability Component
925
CP Configuration Component
930
Message Communication Component
935
Symbol Period Structure Component
940
Interleaving Component
945
Delay Spread Component
950
SCS Component
955
GI Length Component
960
920
900

FIG. 9

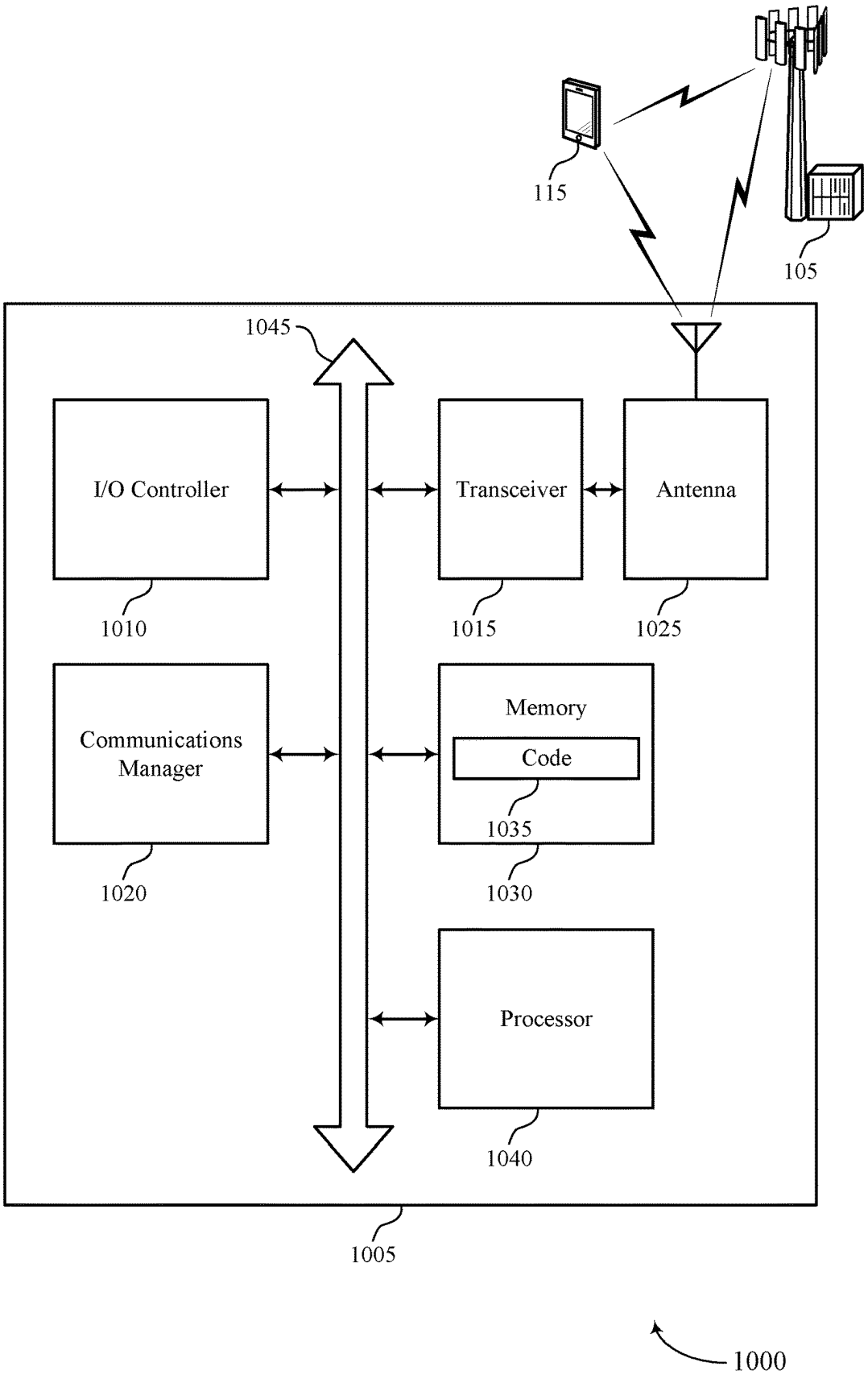

115
105
1045
I/O Controller
Transceiver
Antenna
1010
1015
1025
Communications Manager
Memory
Code
1035
1020
1030
Processor
1040
1005
1000

FIG. 10

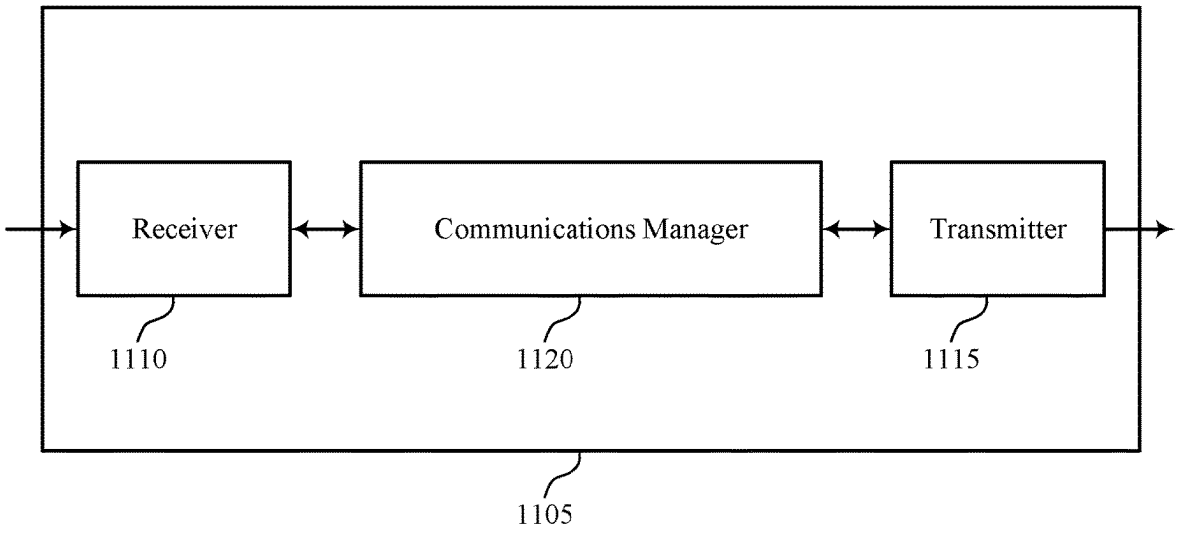

Receiver
Communications Manager
Transmitter
1110
1120
1115
1105
1100

FIG. 11

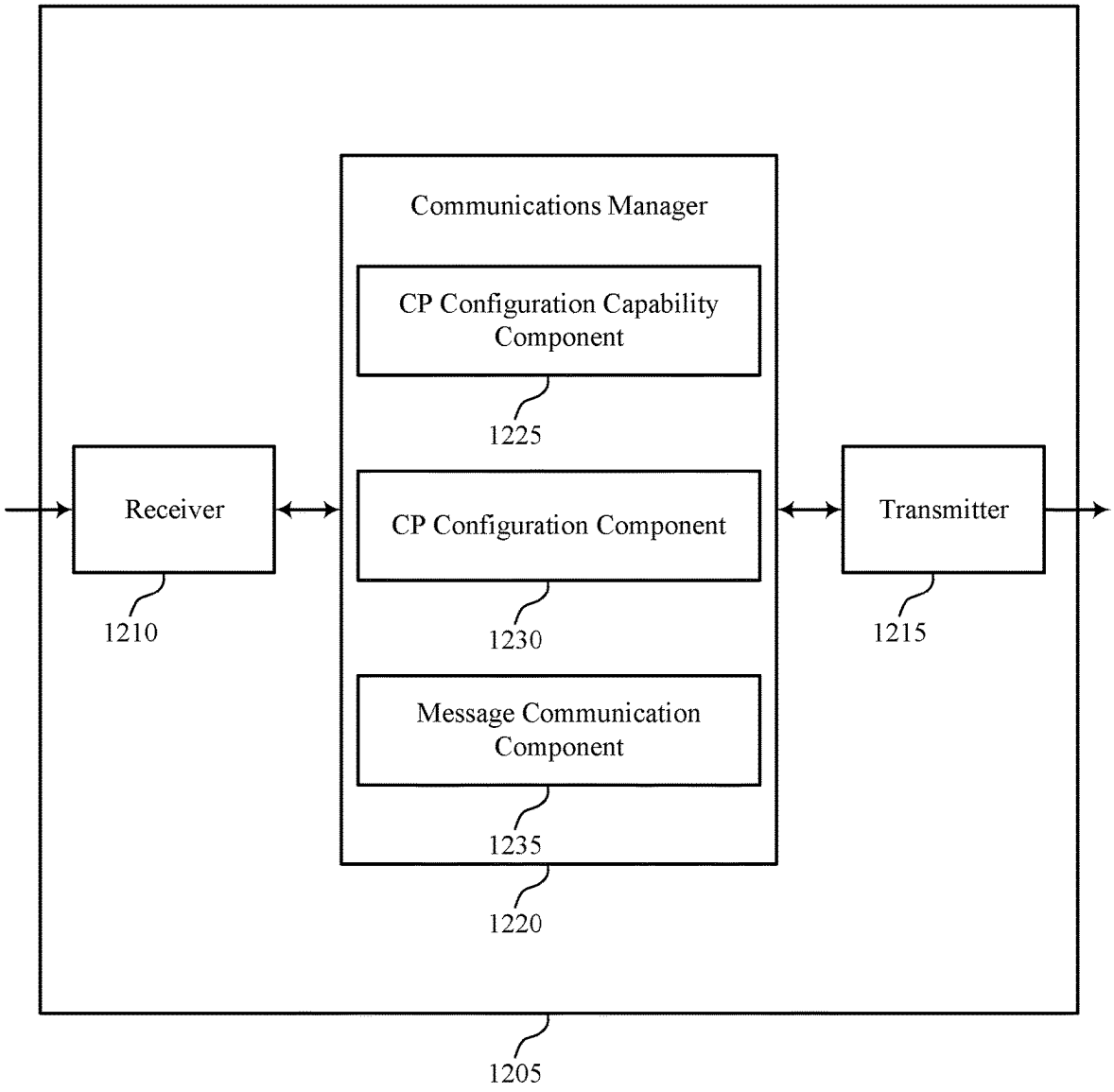

Communications Manager
CP Configuration Capability Component
1225
Receiver
CP Configuration Component
Transmitter
1210
1230
1215
Message Communication Component
1235
1220
1205
1200

FIG. 12

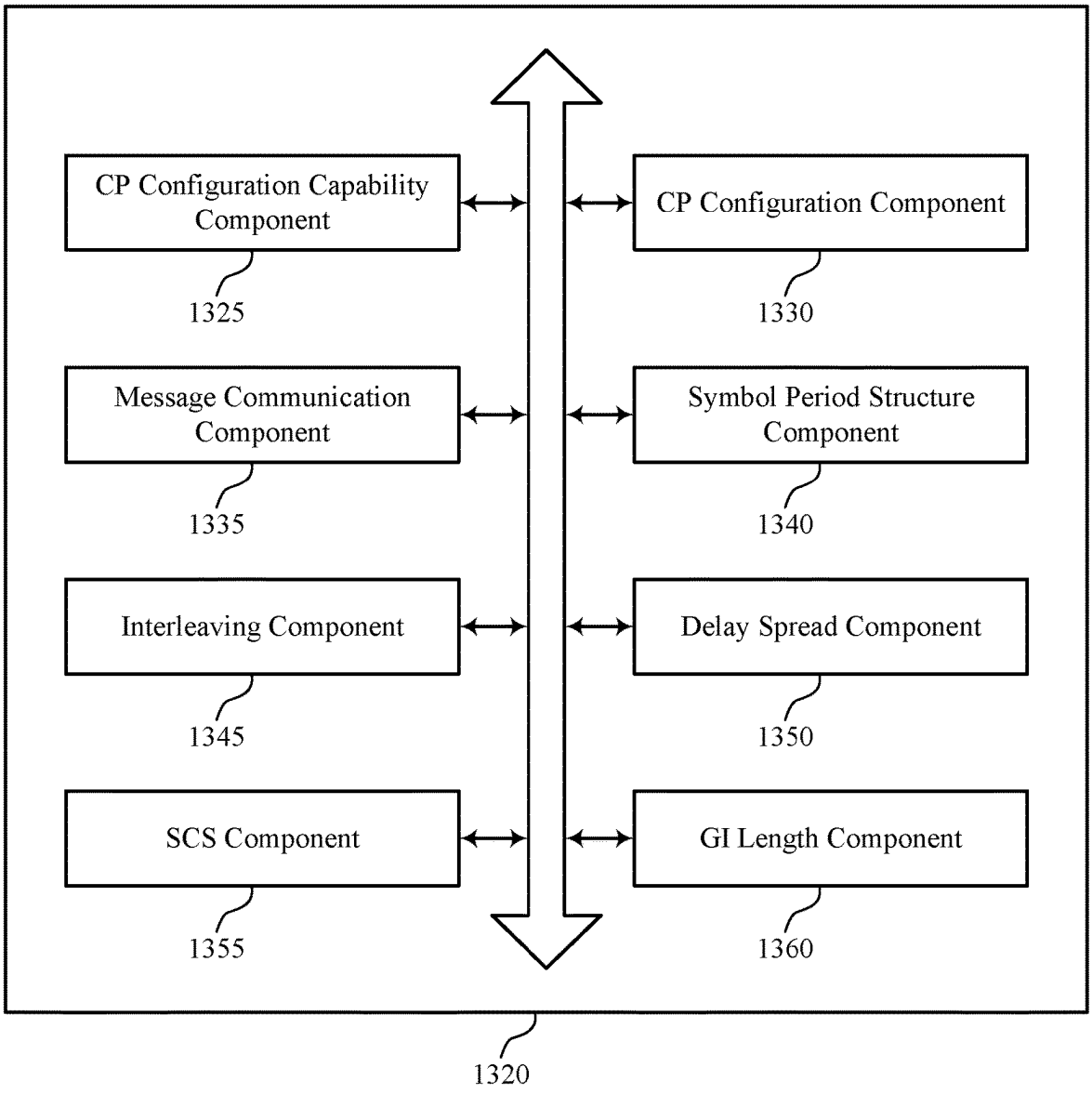

CP Configuration Capability Component
1325
CP Configuration Component
1330
Message Communication Component
1335
Symbol Period Structure Component
1340
Interleaving Component
1345
Delay Spread Component
1350
SCS Component
1355
GI Length Component
1360
1320
1300

FIG. 13

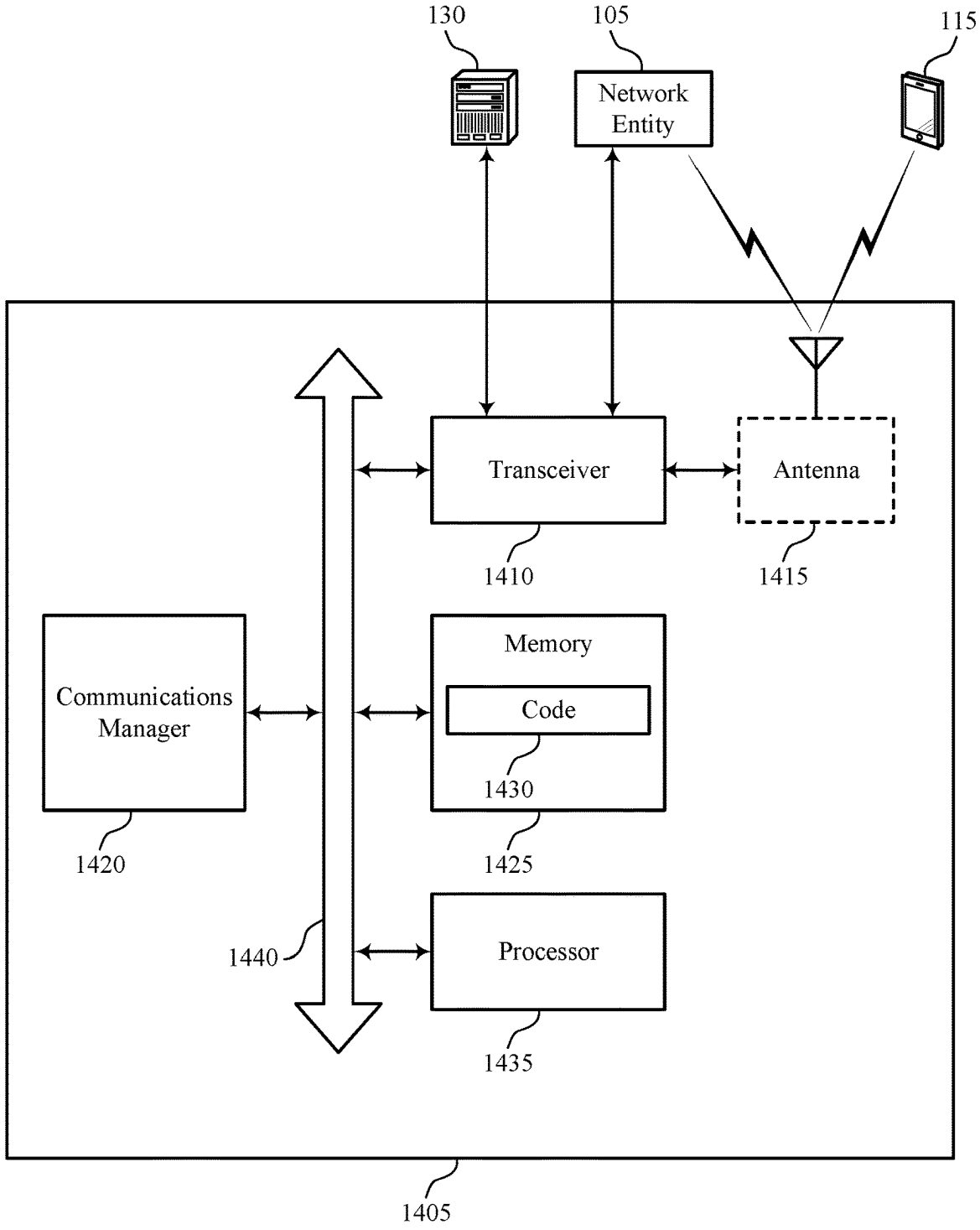

130
105
115
Network Entity
Transceiver
Antenna
1410
1415
Memory
Code
1430
Communications Manager
1420
1425
1440
Processor
1435
1405
1400

FIG. 14

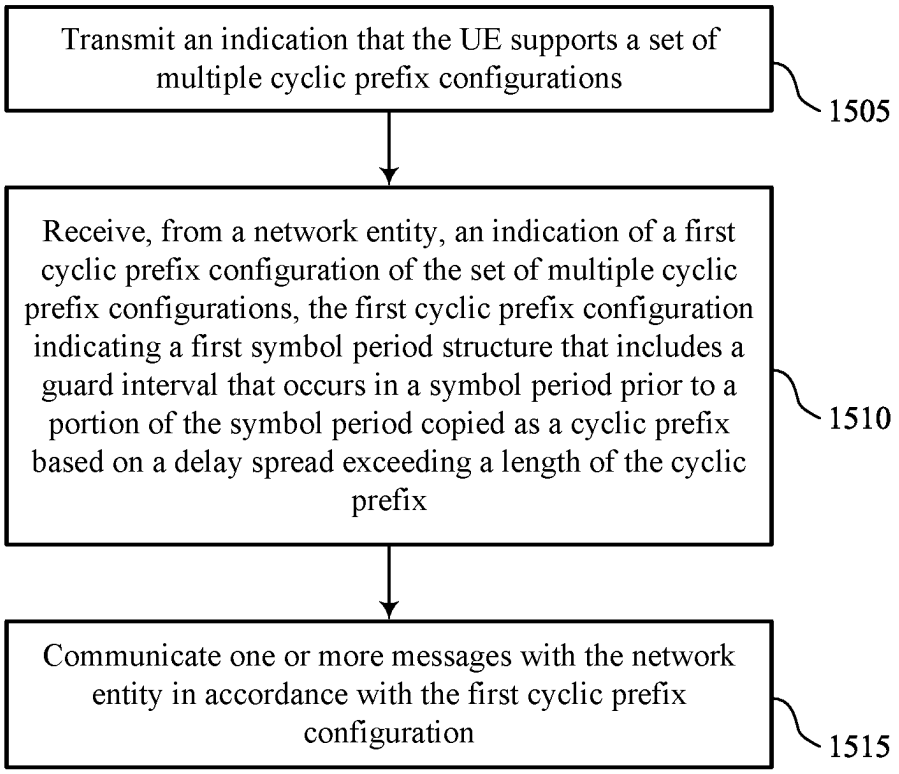

Transmit an indication that the UE supports a set of multiple cyclic prefix configurations
1505
Receive, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix
1510
Communicate one or more messages with the network entity in accordance with the first cyclic prefix configuration
1515
1500

FIG. 15

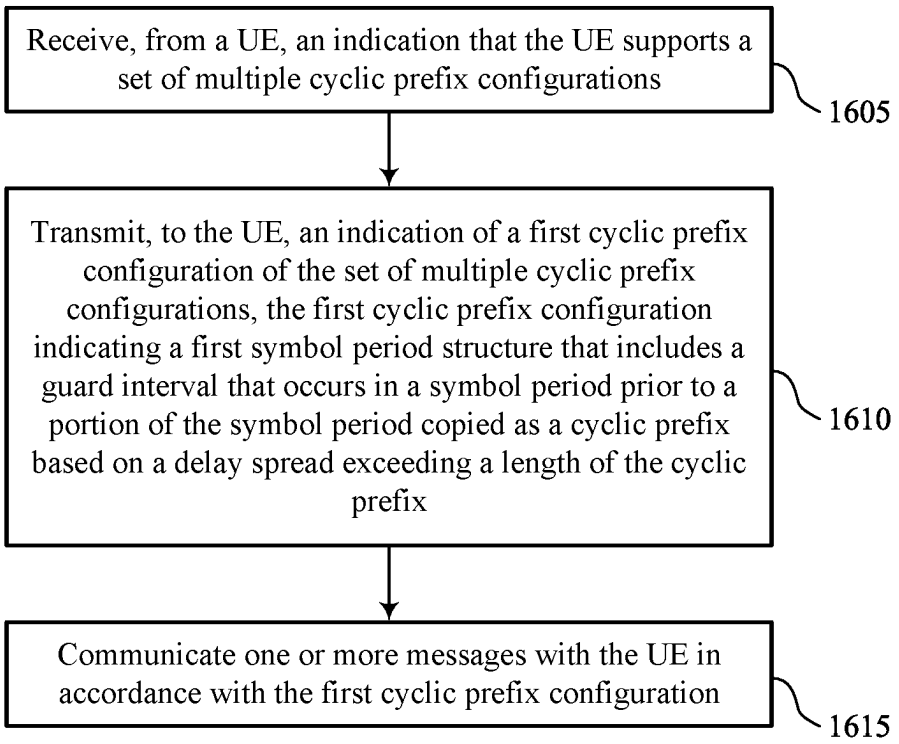

Receive, from a UE, an indication that the UE supports a set of multiple cyclic prefix configurations
1605
Transmit, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix
1610
Communicate one or more messages with the UE in accordance with the first cyclic prefix configuration
1615
1600

FIG. 16

CYCLIC PREFIX GUARD INTERVAL FOR INCREASED DELAY SPREAD

FIELD OF TECHNOLOGY

The following relates to wireless communications, including cyclic prefix guard interval for increased delay spread.

BACKGROUND

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

In some wireless communications systems, a wireless device may communicate symbols with cyclic prefixes. However, such approaches may be improved.

SUMMARY

The described techniques relate to improved methods, systems, devices, and apparatuses that support cyclic prefix guard interval for increased delay spread. A user equipment (UE) may transmit an indication that the UE supports a plurality of cyclic prefix configurations. The UE may receive, from a network entity, an indication of a first cyclic prefix configuration of the plurality of cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based at least in part on a delay spread exceeding a length of the cyclic prefix. The UE may communicate one or more messages with the network entity in accordance with the first cyclic prefix configuration.

A method for wireless communication at a user equipment (UE) is described. The method may include transmitting an indication that the UE supports a set of multiple cyclic prefix symbol configurations, receiving, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix, and communicating one or more messages with the network entity in accordance with the first cyclic prefix configuration.

An apparatus for wireless communication at a UE is described. The apparatus may include a processor, memory coupled with the processor, and instructions stored in the memory. The instructions may be executable by the processor to cause the apparatus to transmit an indication that the UE supports a set of multiple cyclic prefix symbol configurations, receive, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix, and communicate one or more messages with the network entity in accordance with the first cyclic prefix configuration.

Another apparatus for wireless communication at a UE is described. The apparatus may include means for transmitting an indication that the UE supports a set of multiple cyclic prefix symbol configurations, means for receiving, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix, and means for communicating one or more messages with the network entity in accordance with the first cyclic prefix configuration.

A non-transitory computer-readable medium storing code for wireless communication at a UE is described. The code may include instructions executable by a processor to transmit an indication that the UE supports a set of multiple cyclic prefix symbol configurations, receive, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix, and communicate one or more messages with the network entity in accordance with the first cyclic prefix configuration.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure may have a first guard interval located before the portion of the symbol period copied as the cyclic prefix and a second guard interval located at an end of the portion of the symbol period copied as the cyclic prefix.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for receiving the indication of the first cyclic prefix configuration that indicates a length of the first guard interval and a length of the second guard interval may be each less than or equal to a length of the cyclic prefix.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of multiple consecutive guard intervals located at an end of the symbol period.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, each guard interval may be of a length equal to the length of the cyclic prefix and a last guard interval of the set of multiple consecutive guard intervals may be included in the portion of the symbol period copied as the cyclic prefix.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first symbol period structure further includes an additional guard interval that may be of a length that may be less than the length of the cyclic prefix and may be located immediately before the set of multiple consecutive guard intervals.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for receiving the indication of the first cyclic prefix configuration that indicates to interleave that a symbol having the first symbol period structure with a second symbol having a second symbol structure that differs from the first symbol period structure.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for communicating a delay spread measurement report that indicates the delay spread, where the indication of the first cyclic prefix configuration may be based on the delay spread measurement report.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of one or more guard intervals, a quantity of one or more guard intervals, or both.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving an indication of a delay spread associated with uplink transmissions from the UE and selecting the first cyclic prefix configuration based on to indication of the delay spread.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of one or more guard intervals based on a prior cyclic prefix configuration that associates the first symbol period structure with the set of the one or more guard intervals.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for receiving the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration may be applicable to a set of subcarrier spacing values, may be inapplicable to one or more other subcarrier spacing values, or both.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for receiving the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration may be applicable to a first subcarrier spacing.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving an indication that the UE may be to derive a second cyclic prefix configuration for a second subcarrier spacing based on the first cyclic prefix configuration and a delay spread capability of the UE associated with the first cyclic prefix configuration.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the indication of the first cyclic prefix configuration may be transmitted via radio resource control signaling, medium access control control signaling, physical layer control signaling, or any combination thereof.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for receiving the indication of the first cyclic prefix configuration that indicates quantized values corresponding to one or more lengths of one or more guard intervals of the first symbol period structure.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first cyclic prefix configuration may be applicable to uplink communications, downlink communications, or both.

A method for wireless communication at a network entity is described. The method may include receiving, from a UE, an indication that the UE supports a set of multiple cyclic prefix symbol configurations, transmitting, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix, and communicating one or more messages with the UE in accordance with the first cyclic prefix configuration.

An apparatus for wireless communication at a network entity is described. The apparatus may include a processor, memory coupled with the processor, and instructions stored in the memory. The instructions may be executable by the processor to cause the apparatus to receive, from a UE, an indication that the UE supports a set of multiple cyclic prefix symbol configurations, transmit, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix, and communicate one or more messages with the UE in accordance with the first cyclic prefix configuration.

Another apparatus for wireless communication at a network entity is described. The apparatus may include means for receiving, from a UE, an indication that the UE supports a set of multiple cyclic prefix symbol configurations, means for transmitting, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix, and

means for communicating one or more messages with the UE in accordance with the first cyclic prefix configuration.

A non-transitory computer-readable medium storing code for wireless communication at a network entity is described. The code may include instructions executable by a processor to receive, from a UE, an indication that the UE supports a set of multiple cyclic prefix symbol configurations, transmit, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix, and communicate one or more messages with the UE in accordance with the first cyclic prefix configuration.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure may have a first guard interval located before the portion of the symbol period copied as the cyclic prefix and a second guard interval located at an end of the portion of the symbol period copied as the cyclic prefix.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for transmitting the indication of the first cyclic prefix configuration that indicates a length of the first guard interval and a length of the second guard interval may be each less than or equal to a length of the cyclic prefix.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of multiple consecutive guard intervals located at an end of the symbol period.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, each guard interval may be of a length equal to the length of the cyclic prefix and a last guard interval of the set of multiple consecutive guard intervals may be included in the portion of the symbol period copied as the cyclic prefix.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first symbol period structure further includes an additional guard interval that may be of a length that may be less than the length of the cyclic prefix and may be located immediately before the set of multiple consecutive guard intervals.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for transmitting the indication of the first cyclic prefix configuration that indicates to interleave that a symbol having the first symbol period structure with a second symbol having a second symbol structure that differs from the first symbol period structure.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for communicating a delay spread measurement report that indicates the delay spread, where the indication of the first cyclic prefix configuration may be based on the delay spread measurement report.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of one or more guard intervals, a quantity of one or more guard intervals, or both.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of one or more guard intervals based on a prior cyclic prefix configuration that associates the first symbol period structure with the set of the one or more guard intervals.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for transmitting the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration may be applicable to a set of subcarrier spacing values, may be inapplicable to one or more other subcarrier spacing values, or both.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the indication of the first cyclic prefix configuration may include operations, features, means, or instructions for transmitting the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration may be applicable to a first subcarrier spacing.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting an indication that the UE may be to derive a second cyclic prefix configuration for a second subcarrier spacing based on the first cyclic prefix configuration and a delay spread capability of the UE associated with the first cyclic prefix configuration.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the indication of the first cyclic prefix configuration may be transmitted via control signaling.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first cyclic prefix configuration may be applicable to uplink communications, downlink communications, or both.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an example of a wireless communications system that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIGS. **2**A, **2**B, and **2**C illustrate examples of symbol structure schemes that support cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIG. **3** illustrates an example of a wireless communications system that supports cyclic prefix guard interval for

increased delay spread in accordance with one or more examples as disclosed herein.

FIG. **4** illustrates an example of a symbol period structure that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIG. **5** illustrates an example of a symbol period structure that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIG. **6** illustrates an example of a process flow that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIGS. **7** and **8** illustrate block diagrams of devices that support cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIG. **9** illustrates a block diagram of a communications manager that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIG. **10** illustrates a diagram of a system including a device that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIGS. **11** and **12** illustrate block diagrams of devices that support cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIG. **13** illustrates a block diagram of a communications manager that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIG. **14** illustrates a diagram of a system including a device that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIGS. **15** and **16** illustrate flowcharts showing methods that support cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

DETAILED DESCRIPTION

As wireless communications systems move to higher frequency bands, subcarrier spacing (SCS) may be increased for use in the higher bands (e.g., due to fast Fourier transform (FFT) size considerations). As SCS is increased, a length of a cyclic prefix (CP) used may decrease. For example, a CP length may be inversely proportional to the SCS. A shortened CP length may, however, result in a reduced delay spread handling capacity. However, simply increasing the length of the CP may cause symbols to no longer be aligned with slot boundaries. As such, an alternate CP design that increases delay spread handling capacity without affecting slot alignment may be useful.

A wireless communications system may employ the use of guard intervals (GIs) to increase the delay spread handling capability without increasing the length of the CP itself. For example, a user equipment (UE) may communicate with a network entity in accordance with a cyclic prefix configuration that indicates a symbol period structure for a symbol period. The symbol period structure may indicate that the UE is to include at least a portion of a GI in the symbol period prior to a portion of the symbol period that is copied for use as a CP for the symbol period.

By using such a symbol structure, the delay spread handling capability of the wireless communications system may be increased due to the increased length of the symbol structure included in the configurations without increasing the length of the CP itself or affecting slot alignment. Additionally, overhead associated with these configurations only depends on the additional desired delay spread handling capability and there is no fixed overhead. Additionally, as GIs may be used in the symbol period structure, such GIs may offer increased flexibility compared to CPs, as the GIs may use various different sequences, data, or information (e.g., data for acquisition of time, frequency, or phase lock, or any combination thereof) and the GIs may be used for various different purposes (e.g., time, frequency, or phase tracking, channel estimation, providing for a beam-switching gap, or any combination thereof), whereas a CP includes repetitions of data that cannot be used for other purposes. Further, because different sets, configurations, or arrangements of GIs may be used, communications flexibility is increased and scaling for desired delay spread handling capabilities becomes trivial.

Aspects of the disclosure are initially described in the context of wireless communications systems. Aspects of the disclosure are then described with reference to symbol structure schemes, a wireless communications system, a symbol period structures, and a process flow. Aspects of the disclosure are further illustrated by and described with reference to apparatus diagrams, system diagrams, and flowcharts that relate to cyclic prefix guard interval for increased delay spread.

FIG. **1** illustrates an example of a wireless communications system **100** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The wireless communications system **100** may include one or more network entities **105**, one or more UEs **115**, and a core network **130**. In some examples, the wireless communications system **100** may be a Long Term Evolution (LTE) network, an LTE-Advanced (LTE-A) network, an LTE-A Pro network, a New Radio (NR) network, or a network operating in accordance with other systems and radio technologies, including future systems and radio technologies not explicitly mentioned herein.

The network entities **105** may be dispersed throughout a geographic area to form the wireless communications system **100** and may include devices in different forms or having different capabilities. In various examples, a network entity **105** may be referred to as a network element, a mobility element, a radio access network (RAN) node, or network equipment, among other nomenclature. In some examples, network entities **105** and UEs **115** may wirelessly communicate via one or more communication links **125** (e.g., a radio frequency (RF) access link). For example, a network entity **105** may support a coverage area **110** (e.g., a geographic coverage area) over which the UEs **115** and the network entity **105** may establish one or more communication links **125**. The coverage area **110** may be an example of a geographic area over which a network entity **105** and a UE **115** may support the communication of signals according to one or more radio access technologies (RATs).

The UEs **115** may be dispersed throughout a coverage area **110** of the wireless communications system **100**, and each UE **115** may be stationary, or mobile, or both at different times. The UEs **115** may be devices in different forms or having different capabilities. Some example UEs **115** are illustrated in FIG. **1**. The UEs **115** described herein

may be capable of supporting communications with various types of devices, such as other UEs **115** or network entities **105**, as shown in FIG. **1**.

As described herein, a node of the wireless communications system **100**, which may be referred to as a network node, or a wireless node, may be a network entity **105** (e.g., any network entity described herein), a UE **115** (e.g., any UE described herein), a network controller, an apparatus, a device, a computing system, one or more components, or another suitable processing entity configured to perform any of the techniques described herein. For example, a node may be a UE **115**. As another example, a node may be a network entity **105**. As another example, a first node may be configured to communicate with a second node or a third node. In one aspect of this example, the first node may be a UE **115**, the second node may be a network entity **105**, and the third node may be a UE **115**. In another aspect of this example, the first node may be a UE **115**, the second node may be a network entity **105**, and the third node may be a network entity **105**. In yet other aspects of this example, the first, second, and third nodes may be different relative to these examples. Similarly, reference to a UE **115**, network entity **105**, apparatus, device, computing system, or the like may include disclosure of the UE **115**, network entity **105**, apparatus, device, computing system, or the like being a node. For example, disclosure that a UE **115** is configured to receive information from a network entity **105** also discloses that a first node is configured to receive information from a second node.

In some examples, network entities **105** may communicate with the core network **130**, or with one another, or both. For example, network entities **105** may communicate with the core network **130** via one or more backhaul communication links **120** (e.g., in accordance with an S1, N2, N3, or other interface protocol). In some examples, network entities **105** may communicate with one another via a backhaul communication link **120** (e.g., in accordance with an X2, Xn, or other interface protocol) either directly (e.g., directly between network entities **105**) or indirectly (e.g., via a core network **130**). In some examples, network entities **105** may communicate with one another via a midhaul communication link **162** (e.g., in accordance with a midhaul interface protocol) or a fronthaul communication link **168** (e.g., in accordance with a fronthaul interface protocol), or any combination thereof. The backhaul communication links **120**, midhaul communication links **162**, or fronthaul communication links **168** may be or include one or more wired links (e.g., an electrical link, an optical fiber link), one or more wireless links (e.g., a radio link, a wireless optical link), among other examples or various combinations thereof. A UE **115** may communicate with the core network **130** via a communication link **155**.

One or more of the network entities **105** described herein may include or may be referred to as a base station **140** (e.g., a base transceiver station, a radio base station, an NR base station, an access point, a radio transceiver, a NodeB, an eNodeB (eNB), a next-generation NodeB or a giga-NodeB (either of which may be referred to as a gNB), a 5G NB, a next-generation eNB (ng-eNB), a Home NodeB, a Home eNodeB, or other suitable terminology). In some examples, a network entity **105** (e.g., a base station **140**) may be implemented in an aggregated (e.g., monolithic, standalone) base station architecture, which may be configured to utilize a protocol stack that is physically or logically integrated within a single network entity **105** (e.g., a single RAN node, such as a base station **140**).

In some examples, a network entity **105** may be implemented in a disaggregated architecture (e.g., a disaggregated base station architecture, a disaggregated RAN architecture), which may be configured to utilize a protocol stack that is physically or logically distributed among two or more network entities **105**, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity **105** may include one or more of a central unit (CU) **160**, a distributed unit (DU) **165**, a radio unit (RU) **170**, a RAN Intelligent Controller (RIC) **175** (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) **180** system, or any combination thereof. An RU **170** may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities **105** in a disaggregated RAN architecture may be co-located, or one or more components of the network entities **105** may be located in distributed locations (e.g., separate physical locations). In some examples, one or more network entities **105** of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

The split of functionality between a CU **160**, a DU **165**, and an RU **170** is flexible and may support different functionalities depending on which functions (e.g., network layer functions, protocol layer functions, baseband functions, RF functions, and any combinations thereof) are performed at a CU **160**, a DU **165**, or an RU **170**. For example, a functional split of a protocol stack may be employed between a CU **160** and a DU **165** such that the CU **160** may support one or more layers of the protocol stack and the DU **165** may support one or more different layers of the protocol stack. In some examples, the CU **160** may host upper protocol layer (e.g., layer **3** (L**3**), layer **2** (L**2**)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU **160** may be connected to one or more DUs **165** or RUs **170**, and the one or more DUs **165** or RUs **170** may host lower protocol layers, such as layer **1** (L**1**) (e.g., physical (PHY) layer) or L**2** (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU **160**. Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU **165** and an RU **170** such that the DU **165** may support one or more layers of the protocol stack and the RU **170** may support one or more different layers of the protocol stack. The DU **165** may support one or multiple different cells (e.g., via one or more RUs **170**). In some cases, a functional split between a CU **160** and a DU **165**, or between a DU **165** and an RU **170** may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU **160**, a DU **165**, or an RU **170**, while other functions of the protocol layer are performed by a different one of the CU **160**, the DU **165**, or the RU **170**). A CU **160** may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU **160** may be connected to one or more DUs **165** via a midhaul communication link **162** (e.g., F1, F1-c, F1-u), and a DU **165** may be connected to one or more RUs **170** via a fronthaul communication link **168** (e.g., open fronthaul (FH) interface). In some examples, a midhaul communication link **162** or a fronthaul communication link **168** may be implemented

in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities **105** that are in communication via such communication links.

In wireless communications systems (e.g., wireless communications system **100**), infrastructure and spectral resources for radio access may support wireless backhaul link capabilities to supplement wired backhaul connections, providing an IAB network architecture (e.g., to a core network **130**). In some cases, in an IAB network, one or more network entities **105** (e.g., IAB nodes **104**) may be partially controlled by each other. One or more IAB nodes **104** may be referred to as a donor entity or an IAB donor. One or more DUs **165** or one or more RUs **170** may be partially controlled by one or more CUs **160** associated with a donor network entity **105** (e.g., a donor base station **140**). The one or more donor network entities **105** (e.g., IAB donors) may be in communication with one or more additional network entities **105** (e.g., IAB nodes **104**) via supported access and backhaul links (e.g., backhaul communication links **120**). IAB nodes **104** may include an IAB mobile termination (IAB-MT) controlled (e.g., scheduled) by DUs **165** of a coupled IAB donor. An IAB-MT may include an independent set of antennas for relay of communications with UEs **115**, or may share the same antennas (e.g., of an RU **170**) of an IAB node **104** used for access via the DU **165** of the IAB node **104** (e.g., referred to as virtual IAB-MT (vIAB-MT)). In some examples, the IAB nodes **104** may include DUs **165** that support communication links with additional entities (e.g., IAB nodes **104**, UEs **115**) within the relay chain or configuration of the access network (e.g., downstream). In such cases, one or more components of the disaggregated RAN architecture (e.g., one or more IAB nodes **104** or components of IAB nodes **104**) may be configured to operate according to the techniques described herein.

For instance, an access network (AN) or RAN may include communications between access nodes (e.g., an IAB donor), IAB nodes **104**, and one or more UEs **115**. The IAB donor may facilitate connection between the core network **130** and the AN (e.g., via a wired or wireless connection to the core network **130**). That is, an IAB donor may refer to a RAN node with a wired or wireless connection to core network **130**. The IAB donor may include a CU **160** and at least one DU **165** (e.g., and RU **170**), in which case the CU **160** may communicate with the core network **130** via an interface (e.g., a backhaul link). IAB donor and IAB nodes **104** may communicate via an F1 interface according to a protocol that defines signaling messages (e.g., an F1 AP protocol). Additionally, or alternatively, the CU **160** may communicate with the core network via an interface, which may be an example of a portion of backhaul link, and may communicate with other CUs **160** (e.g., a CU **160** associated with an alternative IAB donor) via an Xn-C interface, which may be an example of a portion of a backhaul link.

An IAB node **104** may refer to a RAN node that provides IAB functionality (e.g., access for UEs **115**, wireless self-backhauling capabilities). A DU **165** may act as a distributed scheduling node towards child nodes associated with the IAB node **104**, and the IAB-MT may act as a scheduled node towards parent nodes associated with the IAB node **104**. That is, an IAB donor may be referred to as a parent node in communication with one or more child nodes (e.g., an IAB donor may relay transmissions for UEs through one or more other IAB nodes **104**). Additionally, or alternatively, an IAB node **104** may also be referred to as a parent node or a child node to other IAB nodes **104**, depending on the relay chain or configuration of the AN. Therefore, the IAB-MT entity of IAB nodes **104** may provide a Uu interface for a child IAB node **104** to receive signaling from a parent IAB node **104**, and the DU interface (e.g., DUs **165**) may provide a Uu interface for a parent IAB node **104** to signal to a child IAB node **104** or UE **115**.

For example, IAB node **104** may be referred to as a parent node that supports communications for a child IAB node, or referred to as a child IAB node associated with an IAB donor, or both. The IAB donor may include a CU **160** with a wired or wireless connection (e.g., a backhaul communication link **120**) to the core network **130** and may act as parent node to IAB nodes **104**. For example, the DU **165** of IAB donor may relay transmissions to UEs **115** through IAB nodes **104**, or may directly signal transmissions to a UE **115**, or both. The CU **160** of IAB donor may signal communication link establishment via an F1 interface to IAB nodes **104**, and the IAB nodes **104** may schedule transmissions (e.g., transmissions to the UEs **115** relayed from the IAB donor) through the DUs **165**. That is, data may be relayed to and from IAB nodes **104** via signaling via an NR Uu interface to MT of the IAB node **104**. Communications with IAB node **104** may be scheduled by a DU **165** of IAB donor and communications with IAB node **104** may be scheduled by DU **165** of IAB node **104**.

In the case of the techniques described herein applied in the context of a disaggregated RAN architecture, one or more components of the disaggregated RAN architecture may be configured to support cyclic prefix guard interval for increased delay spread as described herein. For example, some operations described as being performed by a UE **115** or a network entity **105** (e.g., a base station **140**) may additionally, or alternatively, be performed by one or more components of the disaggregated RAN architecture (e.g., IAB nodes **104**, DUs **165**, CUs **160**, RUs **170**, RIC **175**, SMO **180**).

A UE **115** may include or may be referred to as a mobile device, a wireless device, a remote device, a handheld device, or a subscriber device, or some other suitable terminology, where the "device" may also be referred to as a unit, a station, a terminal, or a client, among other examples. A UE **115** may also include or may be referred to as a personal electronic device such as a cellular phone, a personal digital assistant (PDA), a tablet computer, a laptop computer, or a personal computer. In some examples, a UE **115** may include or be referred to as a wireless local loop (WLL) station, an Internet of Things (IoT) device, an Internet of Everything (IoE) device, or a machine type communications (MTC) device, among other examples, which may be implemented in various objects such as appliances, or vehicles, meters, among other examples.

The UEs **115** described herein may be able to communicate with various types of devices, such as other UEs **115** that may sometimes act as relays as well as the network entities **105** and the network equipment including macro eNBs or gNBs, small cell eNBs or gNBs, or relay base stations, among other examples, as shown in FIG. **1**.

The UEs **115** and the network entities **105** may wirelessly communicate with one another via one or more communication links **125** (e.g., an access link) using resources associated with one or more carriers. The term "carrier" may refer to a set of RF spectrum resources having a defined physical layer structure for supporting the communication links **125**. For example, a carrier used for a communication link **125** may include a portion of a RF spectrum band (e.g., a bandwidth part (BWP)) that is operated according to one or more physical layer channels for a given radio access

technology (e.g., LTE, LTE-A, LTE-A Pro, NR). Each physical layer channel may carry acquisition signaling (e.g., synchronization signals, system information), control signaling that coordinates operation for the carrier, user data, or other signaling. The wireless communications system **100** may support communication with a UE **115** using carrier aggregation or multi-carrier operation. A UE **115** may be configured with multiple downlink component carriers and one or more uplink component carriers according to a carrier aggregation configuration. Carrier aggregation may be used with both frequency division duplexing (FDD) and time division duplexing (TDD) component carriers. Communication between a network entity **105** and other devices may refer to communication between the devices and any portion (e.g., entity, sub-entity) of a network entity **105**. For example, the terms "transmitting," "receiving," or "communicating," when referring to a network entity **105**, may refer to any portion of a network entity **105** (e.g., a base station **140**, a CU **160**, a DU **165**, a RU **170**) of a RAN communicating with another device (e.g., directly or via one or more other network entities **105**).

In some examples, such as in a carrier aggregation configuration, a carrier may also have acquisition signaling or control signaling that coordinates operations for other carriers. A carrier may be associated with a frequency channel (e.g., an evolved universal mobile telecommunication system terrestrial radio access (E-UTRA) absolute RF channel number (EARFCN)) and may be identified according to a channel raster for discovery by the UEs **115**. A carrier may be operated in a standalone mode, in which case initial acquisition and connection may be conducted by the UEs **115** via the carrier, or the carrier may be operated in a non-standalone mode, in which case a connection is anchored using a different carrier (e.g., of the same or a different radio access technology).

The communication links **125** shown in the wireless communications system **100** may include downlink transmissions (e.g., forward link transmissions) from a network entity **105** to a UE **115**, uplink transmissions (e.g., return link transmissions) from a UE **115** to a network entity **105**, or both, among other configurations of transmissions. Carriers may carry downlink or uplink communications (e.g., in an FDD mode) or may be configured to carry downlink and uplink communications (e.g., in a TDD mode).

A carrier may be associated with a particular bandwidth of the RF spectrum and, in some examples, the carrier bandwidth may be referred to as a "system bandwidth" of the carrier or the wireless communications system **100**. For example, the carrier bandwidth may be one of a set of bandwidths for carriers of a particular radio access technology (e.g., 1.4, 3, 5, 10, 15, 20, 40, or 80 megahertz (MHz)). Devices of the wireless communications system **100** (e.g., the network entities **105**, the UEs **115**, or both) may have hardware configurations that support communications using a particular carrier bandwidth or may be configurable to support communications using one of a set of carrier bandwidths. In some examples, the wireless communications system **100** may include network entities **105** or UEs **115** that support concurrent communications using carriers associated with multiple carrier bandwidths. In some examples, each served UE **115** may be configured for operating using portions (e.g., a sub-band, a BWP) or all of a carrier bandwidth.

Signal waveforms transmitted via a carrier may be made up of multiple subcarriers (e.g., using multi-carrier modulation (MCM) techniques such as orthogonal frequency division multiplexing (OFDM) or discrete Fourier transform spread OFDM (DFT-S-OFDM)). In a system employing MCM techniques, a resource element may refer to resources of one symbol period (e.g., a duration of one modulation symbol) and one subcarrier, in which case the symbol period and subcarrier spacing may be inversely related. The quantity of bits carried by each resource element may depend on the modulation scheme (e.g., the order of the modulation scheme, the coding rate of the modulation scheme, or both), such that a relatively higher quantity of resource elements (e.g., in a transmission duration) and a relatively higher order of a modulation scheme may correspond to a relatively higher rate of communication. A wireless communications resource may refer to a combination of an RF spectrum resource, a time resource, and a spatial resource (e.g., a spatial layer, a beam), and the use of multiple spatial resources may increase the data rate or data integrity for communications with a UE **115**.

One or more numerologies for a carrier may be supported, and a numerology may include a subcarrier spacing (Δf) and a cyclic prefix. A carrier may be divided into one or more BWPs having the same or different numerologies. In some examples, a UE **115** may be configured with multiple BWPs. In some examples, a single BWP for a carrier may be active at a given time and communications for the UE **115** may be restricted to one or more active BWPs.

The time intervals for the network entities **105** or the UEs **115** may be expressed in multiples of a basic time unit which may, for example, refer to a sampling period of $T_s=1/(\Delta f_{max} \cdot N_f)$ seconds, for which Δf_{max} may represent a supported subcarrier spacing, and N_f may represent a supported discrete Fourier transform (DFT) size. Time intervals of a communications resource may be organized according to radio frames each having a specified duration (e.g., 10 milliseconds (ms)). Each radio frame may be identified by a system frame number (SFN) (e.g., ranging from 0 to 1023).

Each frame may include multiple consecutively-numbered subframes or slots, and each subframe or slot may have the same duration. In some examples, a frame may be divided (e.g., in the time domain) into subframes, and each subframe may be further divided into a quantity of slots. Alternatively, each frame may include a variable quantity of slots, and the quantity of slots may depend on subcarrier spacing. Each slot may include a quantity of symbol periods (e.g., depending on the length of the cyclic prefix prepended to each symbol period). In some wireless communications systems **100**, a slot may further be divided into multiple mini-slots associated with one or more symbols. Excluding the cyclic prefix, each symbol period may be associated with one or more (e.g., N_f) sampling periods. The duration of a symbol period may depend on the subcarrier spacing or frequency band of operation.

A subframe, a slot, a mini-slot, or a symbol may be the smallest scheduling unit (e.g., in the time domain) of the wireless communications system **100** and may be referred to as a transmission time interval (TTI). In some examples, the TTI duration (e.g., a quantity of symbol periods in a TTI) may be variable. Additionally, or alternatively, the smallest scheduling unit of the wireless communications system **100** may be dynamically selected (e.g., in bursts of shortened TTIs (STTIs)).

Physical channels may be multiplexed for communication using a carrier according to various techniques. A physical control channel and a physical data channel may be multiplexed for signaling via a downlink carrier, for example, using one or more of time division multiplexing (TDM) techniques, frequency division multiplexing (FDM) techniques, or hybrid TDM-FDM techniques. A control region

(e.g., a control resource set (CORESET)) for a physical control channel may be defined by a set of symbol periods and may extend across the system bandwidth or a subset of the system bandwidth of the carrier. One or more control regions (e.g., CORESETs) may be configured for a set of the UEs **115**. For example, one or more of the UEs **115** may monitor or search control regions for control information according to one or more search space sets, and each search space set may include one or multiple control channel candidates in one or more aggregation levels arranged in a cascaded manner. An aggregation level for a control channel candidate may refer to an amount of control channel resources (e.g., control channel elements (CCEs)) associated with encoded information for a control information format having a given payload size. Search space sets may include common search space sets configured for sending control information to multiple UEs **115** and UE-specific search space sets for sending control information to a specific UE **115**.

A network entity **105** may provide communication coverage via one or more cells, for example a macro cell, a small cell, a hot spot, or other types of cells, or any combination thereof. The term "cell" may refer to a logical communication entity used for communication with a network entity **105** (e.g., using a carrier) and may be associated with an identifier for distinguishing neighboring cells (e.g., a physical cell identifier (PCID), a virtual cell identifier (VCID), or others). In some examples, a cell also may refer to a coverage area **110** or a portion of a coverage area **110** (e.g., a sector) over which the logical communication entity operates. Such cells may range from smaller areas (e.g., a structure, a subset of structure) to larger areas depending on various factors such as the capabilities of the network entity **105**. For example, a cell may be or include a building, a subset of a building, or exterior spaces between or overlapping with coverage areas **110**, among other examples.

A macro cell generally covers a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by the UEs **115** with service subscriptions with the network provider supporting the macro cell. A small cell may be associated with a lower-powered network entity **105** (e.g., a lower-powered base station **140**), as compared with a macro cell, and a small cell may operate using the same or different (e.g., licensed, unlicensed) frequency bands as macro cells. Small cells may provide unrestricted access to the UEs **115** with service subscriptions with the network provider or may provide restricted access to the UEs **115** having an association with the small cell (e.g., the UEs **115** in a closed subscriber group (CSG), the UEs **115** associated with users in a home or office). A network entity **105** may support one or multiple cells and may also support communications via the one or more cells using one or multiple component carriers.

In some examples, a carrier may support multiple cells, and different cells may be configured according to different protocol types (e.g., MTC, narrowband IoT (NB-IoT), enhanced mobile broadband (eMBB)) that may provide access for different types of devices.

In some examples, a network entity **105** (e.g., a base station **140**, an RU **170**) may be movable and therefore provide communication coverage for a moving coverage area **110**. In some examples, different coverage areas **110** associated with different technologies may overlap, but the different coverage areas **110** may be supported by the same network entity **105**. In some other examples, the overlapping coverage areas **110** associated with different technologies may be supported by different network entities **105**. The wireless communications system **100** may include, for example, a heterogeneous network in which different types of the network entities **105** provide coverage for various coverage areas **110** using the same or different radio access technologies.

The wireless communications system **100** may support synchronous or asynchronous operation. For synchronous operation, network entities **105** (e.g., base stations **140**) may have similar frame timings, and transmissions from different network entities **105** may be approximately aligned in time. For asynchronous operation, network entities **105** may have different frame timings, and transmissions from different network entities **105** may, in some examples, not be aligned in time. The techniques described herein may be used for either synchronous or asynchronous operations.

Some UEs **115**, such as MTC or IoT devices, may be low cost or low complexity devices and may provide for automated communication between machines (e.g., via Machine-to-Machine (M2M) communication). M2M communication or MTC may refer to data communication technologies that allow devices to communicate with one another or a network entity **105** (e.g., a base station **140**) without human intervention. In some examples, M2M communication or MTC may include communications from devices that integrate sensors or meters to measure or capture information and relay such information to a central server or application program that uses the information or presents the information to humans interacting with the application program. Some UEs **115** may be designed to collect information or enable automated behavior of machines or other devices. Examples of applications for MTC devices include smart metering, inventory monitoring, water level monitoring, equipment monitoring, healthcare monitoring, wildlife monitoring, weather and geological event monitoring, fleet management and tracking, remote security sensing, physical access control, and transaction-based business charging.

Some UEs **115** may be configured to employ operating modes that reduce power consumption, such as half-duplex communications (e.g., a mode that supports one-way communication via transmission or reception, but not transmission and reception concurrently). In some examples, half-duplex communications may be performed at a reduced peak rate. Other power conservation techniques for the UEs **115** include entering a power saving deep sleep mode when not engaging in active communications, operating using a limited bandwidth (e.g., according to narrowband communications), or a combination of these techniques. For example, some UEs **115** may be configured for operation using a narrowband protocol type that is associated with a defined portion or range (e.g., set of subcarriers or resource blocks (RBs)) within a carrier, within a guard-band of a carrier, or outside of a carrier.

The wireless communications system **100** may be configured to support ultra-reliable communications or low-latency communications, or various combinations thereof. For example, the wireless communications system **100** may be configured to support ultra-reliable low-latency communications (URLLC). The UEs **115** may be designed to support ultra-reliable, low-latency, or critical functions. Ultra-reliable communications may include private communication or group communication and may be supported by one or more services such as push-to-talk, video, or data. Support for ultra-reliable, low-latency functions may include prioritization of services, and such services may be used for public safety or general commercial applications.

The terms ultra-reliable, low-latency, and ultra-reliable low-latency may be used interchangeably herein.

In some examples, a UE **115** may be configured to support communicating directly with other UEs **115** via a device-to-device (D2D) communication link **135** (e.g., in accordance with a peer-to-peer (P2P), D2D, or sidelink protocol). In some examples, one or more UEs **115** of a group that are performing D2D communications may be within the coverage area **110** of a network entity **105** (e.g., a base station **140**, an RU **170**), which may support aspects of such D2D communications being configured by (e.g., scheduled by) the network entity **105**. In some examples, one or more UEs **115** of such a group may be outside the coverage area **110** of a network entity **105** or may be otherwise unable to or not configured to receive transmissions from a network entity **105**. In some examples, groups of the UEs **115** communicating via D2D communications may support a one-to-many (1:M) system in which each UE **115** transmits to each of the other UEs **115** in the group. In some examples, a network entity **105** may facilitate the scheduling of resources for D2D communications. In some other examples, D2D communications may be carried out between the UEs **115** without an involvement of a network entity **105**.

In some systems, a D2D communication link **135** may be an example of a communication channel, such as a sidelink communication channel, between vehicles (e.g., UEs **115**). In some examples, vehicles may communicate using vehicle-to-everything (V2X) communications, vehicle-to-vehicle (V2V) communications, or some combination of these. A vehicle may signal information related to traffic conditions, signal scheduling, weather, safety, emergencies, or any other information relevant to a V2X system. In some examples, vehicles in a V2X system may communicate with roadside infrastructure, such as roadside units, or with the network via one or more network nodes (e.g., network entities **105**, base stations **140**, RUs **170**) using vehicle-to-network (V2N) communications, or with both.

The core network **130** may provide user authentication, access authorization, tracking, Internet Protocol (IP) connectivity, and other access, routing, or mobility functions. The core network **130** may be an evolved packet core (EPC) or 5G core (5GC), which may include at least one control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management function (AMF)) and at least one user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). The control plane entity may manage non-access stratum (NAS) functions such as mobility, authentication, and bearer management for the UEs **115** served by the network entities **105** (e.g., base stations **140**) associated with the core network **130**. User IP packets may be transferred through the user plane entity, which may provide IP address allocation as well as other functions. The user plane entity may be connected to IP services **150** for one or more network operators. The IP services **150** may include access to the Internet, Intranet(s), an IP Multimedia Subsystem (IMS), or a Packet-Switched Streaming Service.

The wireless communications system **100** may operate using one or more frequency bands, which may be in the range of 300 megahertz (MHz) to 300 gigahertz (GHz). Generally, the region from 300 MHz to 3 GHz is known as the ultra-high frequency (UHF) region or decimeter band because the wavelengths range from approximately one decimeter to one meter in length. UHF waves may be blocked or redirected by buildings and environmental features, which may be referred to as clusters, but the waves may penetrate structures sufficiently for a macro cell to provide service to the UEs **115** located indoors. Communications using UHF waves may be associated with smaller antennas and shorter ranges (e.g., less than 100 kilometers) compared to communications using the smaller frequencies and longer waves of the high frequency (HF) or very high frequency (VHF) portion of the spectrum below 300 MHz.

The wireless communications system **100** may also operate using a super high frequency (SHF) region, which may be in the range of 3 GHz to 30 GHz, also known as the centimeter band, or using an extremely high frequency (EHF) region of the spectrum (e.g., from 30 GHz to 300 GHz), also known as the millimeter band. In some examples, the wireless communications system **100** may support millimeter wave (mmW) communications between the UEs **115** and the network entities **105** (e.g., base stations **140**, RUs **170**), and EHF antennas of the respective devices may be smaller and more closely spaced than UHF antennas. In some examples, such techniques may facilitate using antenna arrays within a device. The propagation of EHF transmissions, however, may be subject to even greater attenuation and shorter range than SHF or UHF transmissions. The techniques disclosed herein may be employed across transmissions that use one or more different frequency regions, and designated use of bands across these frequency regions may differ by country or regulating body.

The wireless communications system **100** may utilize both licensed and unlicensed RF spectrum bands. For example, the wireless communications system **100** may employ License Assisted Access (LAA), LTE-Unlicensed (LTE-U) radio access technology, or NR technology using an unlicensed band such as the 5 GHz industrial, scientific, and medical (ISM) band. While operating using unlicensed RF spectrum bands, devices such as the network entities **105** and the UEs **115** may employ carrier sensing for collision detection and avoidance. In some examples, operations using unlicensed bands may be based on a carrier aggregation configuration in conjunction with component carriers operating using a licensed band (e.g., LAA). Operations using unlicensed spectrum may include downlink transmissions, uplink transmissions, P2P transmissions, or D2D transmissions, among other examples.

A network entity **105** (e.g., a base station **140**, an RU **170**) or a UE **115** may be equipped with multiple antennas, which may be used to employ techniques such as transmit diversity, receive diversity, multiple-input multiple-output (MIMO) communications, or beamforming. The antennas of a network entity **105** or a UE **115** may be located within one or more antenna arrays or antenna panels, which may support MIMO operations or transmit or receive beamforming. For example, one or more base station antennas or antenna arrays may be co-located at an antenna assembly, such as an antenna tower. In some examples, antennas or antenna arrays associated with a network entity **105** may be located at diverse geographic locations. A network entity **105** may include an antenna array with a set of rows and columns of antenna ports that the network entity **105** may use to support beamforming of communications with a UE **115**. Likewise, a UE **115** may include one or more antenna arrays that may support various MIMO or beamforming operations. Additionally, or alternatively, an antenna panel may support RF beamforming for a signal transmitted via an antenna port.

The network entities **105** or the UEs **115** may use MIMO communications to exploit multipath signal propagation and increase spectral efficiency by transmitting or receiving multiple signals via different spatial layers. Such techniques

may be referred to as spatial multiplexing. The multiple signals may, for example, be transmitted by the transmitting device via different antennas or different combinations of antennas. Likewise, the multiple signals may be received by the receiving device via different antennas or different combinations of antennas. Each of the multiple signals may be referred to as a separate spatial stream and may carry information associated with the same data stream (e.g., the same codeword) or different data streams (e.g., different codewords). Different spatial layers may be associated with different antenna ports used for channel measurement and reporting. MIMO techniques include single-user MIMO (SU-MIMO), for which multiple spatial layers are transmitted to the same receiving device, and multiple-user MIMO (MU-MIMO), for which multiple spatial layers are transmitted to multiple devices.

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

A network entity **105** or a UE **115** may use beam sweeping techniques as part of beamforming operations. For example, a network entity **105** (e.g., a base station **140**, an RU **170**) may use multiple antennas or antenna arrays (e.g., antenna panels) to conduct beamforming operations for directional communications with a UE **115**. Some signals (e.g., synchronization signals, reference signals, beam selection signals, or other control signals) may be transmitted by a network entity **105** multiple times along different directions. For example, the network entity **105** may transmit a signal according to different beamforming weight sets associated with different directions of transmission. Transmissions along different beam directions may be used to identify (e.g., by a transmitting device, such as a network entity **105**, or by a receiving device, such as a UE **115**) a beam direction for later transmission or reception by the network entity **105**.

Some signals, such as data signals associated with a particular receiving device, may be transmitted by transmitting device (e.g., a transmitting network entity **105**, a transmitting UE **115**) along a single beam direction (e.g., a direction associated with the receiving device, such as a receiving network entity **105** or a receiving UE **115**). In some examples, the beam direction associated with transmissions along a single beam direction may be determined based on a signal that was transmitted along one or more beam directions. For example, a UE **115** may receive one or more of the signals transmitted by the network entity **105** along different directions and may report to the network entity **105** an indication of the signal that the UE **115** received with a highest signal quality or an otherwise acceptable signal quality.

In some examples, transmissions by a device (e.g., by a network entity **105** or a UE **115**) may be performed using multiple beam directions, and the device may use a combination of digital precoding or beamforming to generate a combined beam for transmission (e.g., from a network entity **105** to a UE **115**). The UE **115** may report feedback that indicates precoding weights for one or more beam directions, and the feedback may correspond to a configured set of beams across a system bandwidth or one or more subbands. The network entity **105** may transmit a reference signal (e.g., a cell-specific reference signal (CRS), a channel state information reference signal (CSI-RS)), which may be precoded or unprecoded. The UE **115** may provide feedback for beam selection, which may be a precoding matrix indicator (PMI) or codebook-based feedback (e.g., a multi-panel type codebook, a linear combination type codebook, a port selection type codebook). Although these techniques are described with reference to signals transmitted along one or more directions by a network entity **105** (e.g., a base station **140**, an RU **170**), a UE **115** may employ similar techniques for transmitting signals multiple times along different directions (e.g., for identifying a beam direction for subsequent transmission or reception by the UE **115**) or for transmitting a signal along a single direction (e.g., for transmitting data to a receiving device).

A receiving device (e.g., a UE **115**) may perform reception operations in accordance with multiple receive configurations (e.g., directional listening) when receiving various signals from a receiving device (e.g., a network entity **105**), such as synchronization signals, reference signals, beam selection signals, or other control signals. For example, a receiving device may perform reception in accordance with multiple receive directions by receiving via different antenna subarrays, by processing received signals according to different antenna subarrays, by receiving according to different receive beamforming weight sets (e.g., different directional listening weight sets) applied to signals received at multiple antenna elements of an antenna array, or by processing received signals according to different receive beamforming weight sets applied to signals received at multiple antenna elements of an antenna array, any of which may be referred to as "listening" according to different receive configurations or receive directions. In some examples, a receiving device may use a single receive configuration to receive along a single beam direction (e.g., when receiving a data signal). The single receive configuration may be aligned along a beam direction determined based on listening according to different receive configuration directions (e.g., a beam direction determined to have a highest signal strength, highest signal-to-noise ratio (SNR), or otherwise acceptable signal quality based on listening according to multiple beam directions).

The wireless communications system **100** may be a packet-based network that operates according to a layered protocol stack. In the user plane, communications at the bearer or PDCP layer may be IP-based. An RLC layer may perform packet segmentation and reassembly to communicate via logical channels. A MAC layer may perform priority handling and multiplexing of logical channels into transport channels. The MAC layer also may implement error detection techniques, error correction techniques, or both to support retransmissions to improve link efficiency. In the control plane, an RRC layer may provide establishment, configuration, and maintenance of an RRC connection

between a UE **115** and a network entity **105** or a core network **130** supporting radio bearers for user plane data. A PHY layer may map transport channels to physical channels.

The UEs **115** and the network entities **105** may support retransmissions of data to increase the likelihood that data is received successfully. Hybrid automatic repeat request (HARQ) feedback is one technique for increasing the likelihood that data is received correctly via a communication link (e.g., a communication link **125**, a D2D communication link **135**). HARQ may include a combination of error detection (e.g., using a cyclic redundancy check (CRC)), forward error correction (FEC), and retransmission (e.g., automatic repeat request (ARQ)). HARQ may improve throughput at the MAC layer in poor radio conditions (e.g., low signal-to-noise conditions). In some examples, a device may support same-slot HARQ feedback, in which case the device may provide HARQ feedback in a specific slot for data received via a previous symbol in the slot. In some other examples, the device may provide HARQ feedback in a subsequent slot, or according to some other time interval.

In some implementations, the wireless communications system **100** (e.g., including the UE **115** and the network entity **105**) may employ the use of GIs to increase the delay spread handling capability without increasing the length of the CP itself. In some examples, a CP configuration may include a first GI portion located at an end of a symbol period in a portion of a symbol period that is copied for use as the CP and a second GI portion located immediately before the portion of the symbol period that is copied for use as the CP. The two GI portions may be separated by a data portion included in the portion of the symbol period copied for use as the CP. In other examples, a CP configuration may include a plurality of repetitions of a GI portion (e.g., one or more of which may be of a length equal to the length of the CP) included in the symbol period to increase the delay spread handling capability as much as desired. In some examples, different sets, configurations, or selections of GIs (e.g., complete GIs, partial GIs, or both) may be used. In some examples, the GIs themselves may be used for various other purposes, including beam switching or frequency, phase, or non-linearity tracking.

FIGS. **2**A, **2**B, and **2**C illustrate examples of symbol structure scheme **200**, symbol structure scheme **201**, and symbol structure scheme **202** that support cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

FIG. **2**A depicts symbol structure scheme **200** that may include a CP symbol **225** and a GI symbol **230**. In the CP symbol **225**, the copied portion **227** of the data **210** may be copied and used as the CP **205**. As such, in some examples, the CP **205** may be data dependent (e.g., the data included in the CP **205** depends on or includes the same data from the copied portion **227**). In the CP symbol **225**, the CP **205** is located outside of the FFT window **220**-*a*, and is used to maintain the integrity of circular convolution.

The GI symbol **230** includes the GI **215**. In contrast to the CP symbol **225**, the GI **215** is located inside the FFT window **220**-*a* and may not be data dependent. For example, the GI **215** may include different types of data or may serve different purposes, such as "filler" values (e.g., all zeros, all ones, or other values not associated with the data **210**); data for acquisition of time, frequency, or phase lock; time, frequency, or phase tracking; channel estimation; providing for a beam-switching gap; or any combination thereof. A GI **215** may be added to any communication waveform (e.g., a single carrier waveform, an OFDM waveform, or other waveforms). In some examples, the type of GI **215** used may depend on or may be based on the waveform to which the GI **215** is to be added. By using the same GI **215** sequence across different symbols (e.g., consecutive symbols), the integrity of circular convolution may be maintained (e.g., in a multipath scenario) while reducing inter-symbol interference, inter-channel interference, or both.

As wireless communications systems begin to utilize some frequency bands (e.g., 100 GHz and above), SCS values may be increased (e.g., to aid in maintaining an associated FFT size. Such SCS values may also aid in mitigation of increased phase noise characteristics at some frequency bands. In some examples, a CP length may be inversely proportional to a SCS. For example, as the SCS increases, the CP length may be reduced. Such reduced CP lengths may be associated with reduced delay spread (DS) handling capabilities. Since, in some examples, a longest permissible delay path that conforms with the DS handling capabilities may cause the CP to fall within a FFT window, a DS handling capability may be further reduced. Due to at least these factors, in some cases, a DS handling capability at some frequency bands may be reduced.

For example, as depicted in the symbol structure scheme **201** of FIG. **2**B, various arrival paths **235** may carry signals that may be delayed at various delays **240**. A first-received or non-delayed signal may be transmitted over arrival path **235**-*a*, and subsequently delayed signals may be transmitted over arrival path **235**-*b* and arrival path **235**-*c*. Arrival path **235**-*b* may be associated with delay **240**-*a* relative to arrival path **235**-*a* and arrival path **235**-*c* may be associated with delay **240**-*b* relative to arrival path **235**-*a*. Arrival path **235**-*b* may represent a delay path that is a largest interference-free delay path and circular convolution may be maintained, because, though the signal is delayed, the delay **240**-*a* is not longer than the CP length of the CP **205** and no portion of the preceding symbol encroaches into the FFT window **220**-*b*. In contrast, arrival path **235**-*c* may introduce excessive delay or interference and circular convolution may not be maintained, as the delay **240**-*b* is longer than a length of the CP **205**. As such, the CP **205** of the arrival path **235**-*c* (e.g., the data **210** of the preceding symbol) was pushed beyond the beginning of the FFT window **220**-*b* and a portion of the preceding symbol is now present in the FFT window **220**-*b*.

Similarly, as depicted in the symbol structure scheme **202** of FIG. **2**C, a GI **215** may be employed to handle some multipath delays. Arrival path **235**-*d* may be a first-received path with no delay, arrival path **235**-*e* may be associated with delay **240**-*c*, and arrival path **235**-*f* may be associated with delay **240**-*d*. As shown, the use of the GI **215** may handle a multipath delay up to a delay that is the length of the GI **215** itself. For example, delay **240**-*d* associated with arrival path **235**-*f* is the same as the length of GI **215**. In such a case, there may be minimal or no interference from other symbols, as the GI **215** from a previous symbol (e.g., a GI **215** that is pushed into the FFT window **220**-*c* due to delay of an arrival path **235**) may be used to maintain circular convolution. For example, in arrival path **235**-*e* associated with delay **240**-*c* that is approximately one half of the length of the GI **215**, the second half of the first GI **215** and the first half of the second GI **215**, when combined in the circular convolution operation, include the same contents as a complete GI **215**, thereby maintaining integrity of the circular convolution operation. Similarly, in arrival path **235**-*f* associated with the delay **240**-*d* that is approximately the same length as the GI **215**, even though the second GI **215** is pushed beyond the FFT window **220**-*c*, the first GI **215** is

pushed into the FFT window **220**-*c* and is available for use in the circular convolution operation.

FIG. **3** illustrates an example of a wireless communications system **300** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The wireless communications system **300** may include the network entity **105**-*a*, which may be an example of one or more network entities discussed in relation to other figures. The wireless communications system **300** may include the UE **115**-*a*, which may be an example of one or more UEs discussed in relation to other figures.

In some examples, the UE **115**-*a* may be located in a geographic coverage area **110**-*a* that may be associated with the network entity **105**-*a*. The network entity **105**-*a* and UE **115**-*a* may communicate via one or more downlink communication links **305**-*a* and one or more uplink communication links **305**-*b*.

The UE **115**-*a* may transmit the CP configuration capability message **320** to the network entity **105**-*a*. The CP configuration capability message **320** may indicate that the UE **115**-*a* is capable of communicating in accordance with a CP configuration **335**, a symbol period structure **340**, or both.

The network entity **105**-*a* may transmit the CP configuration indication **325** to the UE **115**-*a*. The CP configuration indication **325** may indicate the symbol period structure **340**. The symbol period structure **340** may indicate or include one or more GIs that are to occur in a symbol period. For example, the symbol period structure **340** may indicate at least a fraction of a GI that is to occur in the symbol period before a portion of the symbol period that is to be copied for use as a CP for the symbol period structure **340**. In some examples, the symbol period structure **340** or one or more elements included or indicated in the symbol period structure **340** may be based on a delay spread, such as a delay spread associated with transmissions to or from the UE **115**-*a*.

The UE **115**-*a* and the network entity **105**-*a* may communicate with one another via one or more data communications **330**. Such data communications **330** may be transmitted in accordance with the CP configuration **335**, the symbol period structure **340**, or both. For example, the UE **115**-*a* and the network entity **105**-*a* may communicate the data communications **330** using one or more symbols that may employ the symbol period structure **340** that may include at least a portion of a GI in the symbol period structure **340**.

Through these techniques, other techniques described herein, or both, the delay spread handling capability of the wireless communications system **300** may be increased due to the symbol period structure **340** included in the CP configuration **335** without increasing the length of the CP itself or affecting slot alignment. Further, overhead for such a scheme may depend on the additional desired delay spread handling capability (e.g., without a fixed overhead). Further, because different sets, configurations, or arrangements of whole GIs, partial GIs, or both, may be used, communications flexibility is increased and scaling for desired delay spread handling capabilities is straightforward (e.g., by increasing a quantity of whole or partial GIs included in the symbol period structure **340**).

In some examples, a symbol generated or transmitted in accordance with the symbol period structure **340** may be interleaved with a symbol that does not contain a GI (e.g., the CP symbol **225** depicted in FIG. **2**A and FIG. **2**B), a symbol that contains a GI (e.g., in place of a CP, such as GI symbol **230** depicted in FIG. **2**C), or a hybrid CP/GI symbol. For example, the symbol **420**-*a* or symbol **420**-*b* depicted in FIG. **4** or the symbol **520**-*a* or the symbol **520**-*b* depicted in FIG. **5** are examples of symbols that may be interleaved with a symbol without a GI, a symbol with a GI, or a hybrid CP/GI symbol. Such interleaving may be performed in the same slot or may be performed in different slots.

In some examples, the network entity **105**-*a* may request that the UE **115**-*a* transmit a DS measurement report. The DS measurement report may include one or more indications of DS associated with communications of the UE **115**-*a*. For example, such a DS may be an amount of delay between different arrival paths in a multipath delay scenario. For example, a first (e.g., non-delayed) arrival path may receive a series of symbols, each associated with an FFT window. This same series of symbols may also be received through a second arrival path, but the series of symbols may be delayed, and the difference in arrival times between the two arrival paths may be referred to as a DS. In some cases, a receiving device may receive a first symbol (e.g., along the first, non-delayed, arrival path) and may establish an FFT window for processing the first symbol. However, if the DS between the first and second arrival paths is sufficiently large, the reception of the series of symbols along the second arrival path may be delayed and a portion of a previous symbol (e.g., a symbol located before the first symbol in the series of symbols) may fall within the time period defined by the FFT window for processing the first symbol. As such, data from multiple symbols may be received at the same time, causing inter-symbol interference.

The network entity **105**-*a* may select the CP configuration **335** based on the DS measurement report. For example, the network entity **105**-*a* may select a CP configuration **335** that includes a DS handling capability that is greater than or equal to a DS indicated in the DS measurement report. Such a DS handling capability may indicate an amount of DS (e.g., a duration of time delay between multiple arrival paths) that may occur in a multipath delay scenario without the presence of inter-symbol interference (e.g., when the network entity **105**-*a* and the UE **115**-*a* are communicating in accordance with a CP configuration **335**, a symbol period structure **340**, or both). Thus, in some examples, the network entity **105**-*a* may select or configure a CP configuration **335** (e.g., that includes such a DS handling capability) such that a duration, in time, of one or more CPs, one or more GIs, or both, that are indicated in the CP configuration **335** may be greater than or equal to a DS. For example, the network entity **105**-*a* may select one or more time durations or lengths of one or more GIs included in the symbol period structure **340** based on the DS measurement report (e.g., one or more DSs indicated in the DS measurement report) such that the duration (e.g., in time) of the one or more GIs in the symbol period is greater than or equal a DS indicated in the DS measurement report.

In some examples, the network entity **105**-*a* may indicate a GI sequence (e.g., data or values that are to be included in one or more GIs) that is to be included in one or more GIs indicated in the symbol period structure **340** (e.g., so that a receiving device may know which GI is to be used for communications). For example, the network entity **105**-*a* may indicate (e.g., to the UE **115**-*a*) that the symbol period structure **340** is to include one or more GIs that contain a first data sequence or set of values. For example, GIs may include different types of data, such as "filler" values (e.g., all zeros, all ones, or other values not associated with the data **210**), data for acquisition of time, frequency, or phase lock, or any combination thereof. Additionally, or alterna-

tively, GIs may include data, values, or information for one or more operations, such as time, frequency, or phase tracking, channel estimation, providing for a beam-switching gap, or any combination thereof.

In some examples, GI sequences included in one or more GIs may be different for different CP configurations **335**, symbol period structures **340**, or both. By including different GI sequences in different situations, reception properties of the symbols may be adjusted for improved reception. For example, different GI sequences may be used based on an amount of DS. As such, in some examples, a GI sequence to be included in one or more GIs may be signaled or indicated explicitly (e.g., by the network entity **105**-*a* to the UE **115**-*a*). Such signaling may be control signaling, RRC signaling, DCI signaling, MAC-CE signaling, or any combination thereof.

Additionally, or alternatively, the data or information to be included in the one or more GIs may be implicitly indicated. For example, the GI sequence to be included in the one or more GIs may be determined or selected based on a prior CP configuration **335**, symbol period structure **340**, prior signaling (e.g., implicit or explicit) of prior data or information to be included in one or more prior GIs, or any combination thereof. Such prior signaling may link the symbol period structure **340** to the data or information to be included in the one or more GIs.

In some examples, the network entity **105**-*a* may indicate a length of time of one or more GIs (e.g., that may be the same length of time as a DS), a quantity of GIs to be included in the symbol period structure **340** (e.g., based on the length of time of a DS), or both. For example, the network entity **105**-*a* may indicate a time duration of a DS that may be associated with communications between the network entity **105**-*a* and the UE **115**-*a*. The UE **115**-*a* may then expect to receive symbols in downlink transmissions that have a symbol structure (e.g., the symbol period structure **340**) that may tolerate the time duration of the DS or may transmit uplink transmissions to the network entity **105**-*a* using the symbol period structure **340** that may tolerate the time duration of the DS. As such, the UE **115**-*a* may select or generate the symbol period structure **340** (e.g., for receiving downlink transmissions, transmitting uplink transmissions, or both) based on the configured DS handling capability, a SCS, a length of a CP, or any combination thereof. For example, the UE **115**-*a* may select a CP configuration **335** with a symbol period structure **340** that may include a DS handling capability greater than or equal to the configured DS handling capability received from the network entity **105**-*a*.

Additionally, or alternatively, the network entity **105**-*a* may indicate the one or more lengths, quantities, or both directly (e.g., in terms of integer quantities of GIs, a quantity of samples for a length of one or more GIs, or both). For example, the network entity **105**-*a* may indicate {2 GI, 128 samples} to the UE **115**-*a*, meaning that the symbol period structure **340** is to include two GIs (e.g., two GIs with length equal to a length of the CP, such as the GIs **425** or the GIs **525**, discussed in relation to FIGS. **4** and **5**, respectively), an additional GI portion with a length of 128 samples (e.g., such as GI **527**) and that a DS handling capability (e.g., the DS capability **450** or the DS capability **550**, discussed in relation to FIGS. **4** and **5**, respectively) of the symbol period structure **340** is to be of a length equal to $2*CP_{length}+128$ samples (e.g., where the CP_{length} may be a length of the CP **430**-*a* or the CP **530**-*a*, discussed in relation to FIGS. **4** and **5**, respectively). Additionally, or alternatively, the network entity **105**-*a* may indicate {128 samples}, meaning that the symbol period structure **340** is to include two GI portions, each of length 128 samples (e.g., GI and a total DS handling capability of $CP_{length}+128$ samples (e.g., where the CP_{length} may be a length of the CP **430**-*a* or the CP **530**-*a*, discussed in relation to FIGS. **4** and **5**, respectively).

Further, such indications may explicitly or implicitly indicate a symbol structure scheme or symbol period structure that the UE **115**-*a* is to use for communications. For example, by indicating {2 GI, 128 samples}, the network entity **105**-*a* may be implicitly indicating that the UE **115**-*a* is to employ the use of symbol period structure **500** as described in FIG. **5** (e.g., the UE **115**-*a* may interpret the indication to mean that the UE **115**-*a* is to use the symbol period structure **500**). Additionally, or alternatively, by indicating {128 samples}, the network entity **105**-*a* may be implicitly indicating that the UE **115**-*a* is to employ the use of symbol period structure **400** as described in FIG. **4** (e.g., the UE **115**-*a* may interpret the indication to mean that the UE **115**-*a* is to use the symbol period structure **400**).

In some examples, a length of a GI (either a whole or partial GI, such as the GIs **425**, the GIs **525**, the GIs **527**, or any combination thereof, discussed in relation to FIGS. **4** and **5**, respectively) included in a CP configuration **335** or a symbol period structure **340** may be a quantized length. Such a quantized length may be based on a length of a CP (e.g., ¼ CP, ½ CP, CP, or other value based on the length of a CP). For example, as depicted in FIG. **5**, the GIs **525** may be of a length of a whole (e.g., one) CP **530**-*a* or CP **530**-*b*. Similarly, the GI **527** may be an example of a partial GI (e.g., a GI that is shorter than a length of the GIs **525**) and may be of a quantized length, such as a length that is one half the length of the CP **530**-*a* or CP **530**-*b*.

In some examples, the CP configuration **335**, the symbol period structure **340**, or both may apply to some SCSs and may not apply to other SCSs. For example, the CP configuration **335**, the symbol period structure **340**, or both may apply to an SCS where a length of a CP for such an SCS may not offer sufficient DS handling capability (e.g., where a length of a CP may equal or fall below a DS handling capability metric or threshold).

In some examples, the network entity **105**-*a* may configure the UE **115**-*a* to use a particular SCS for communications between the network entity **105**-*a* and the UE **115**-*a*. As such, the UE **115**-*a* may implicitly identify a symbol period structure **340** for communications based on the SCS, as the SCS may be associated with the symbol period structure **340**. In other words, by configuring the UE **115**-*a* to use the SCS, the network entity **105**-*a* may also be implicitly indicating (e.g., based on the SCS with which the UE **115**-*a* is configured) the symbol period structure **340** that the UE **115**-*a* is to use.

In some examples, an amount or time duration of DS associated with communications between the network entity **105**-*a* and the UE **115**-*a* may be independent of an SCS used for the communications. For example, the network entity **105**-*a* may indicate that the UE **115**-*a* is to derive the symbol period structure **340** (e.g., select a symbol period structure **340**) such that communications associated with a second SCS (e.g., 1920 kHz) may employ a symbol period structure **340** that may tolerate the same time duration of DS that a symbol period structure **340** associated with a first SCS (e.g., 960 kHz) may tolerate.

FIG. **4** illustrates an example of a symbol period structure **400** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The symbol period structure **400** may be described in relation to an arrival path **415**-*a* and a delayed

arrival path **415**-*b* that may be arrival paths of a multipath arrival scenario. The arrival path **415**-*a* may include a symbol **420**-*a* and a symbol **420**-*b*. Though these symbols are depicted as an example, the techniques described herein may be applied to any quantity of symbols **420**.

In some examples, a network entity may indicate (e.g., to a UE) a CP configuration. The CP configuration may indicate a symbol period structure, such as the symbol period structure **400** that may include one or more GIs **425** that may aid in allowing communications between the network entity and the UE to tolerate an increased DS. In some examples, the CP configuration may indicate other information related to the CP or the symbol period structure **400**. For example, the CP configuration may indicate that the symbol period structure **400** is applicable or is not applicable to communications using one or more particular SCSs, that the UE is to derive or select the symbol period structure **400** based on another symbol period structure associated with a different SCS. In some examples, the CP configuration may be transmitted via control signaling, such as RRC signaling, MAC-CE signaling, physical layer signaling, or any combination thereof.

In the symbol period structure **400**, a symbol (e.g., the symbol **420**-*a* or the symbol **420**-*b*) may include a CP **430** and a copied portion **435** that is copied to form the CP **430**. For example, the symbol **420**-*a* includes the CP **430**-*a* and the copied portion **435**-*a*, and the symbol **420**-*b* includes the CP **430**-*b* and the copied portion **435**-*b*. A symbol may include data **440** (e.g., data that is to be transmitted to another device).

The symbol may further include one or more GIs **425**. In some examples, one or more of the GIs **425** may be of a length that is less than the length of the CP **430**-*a*. For example, the length of the GIs **425** in FIG. **4** may be approximately one-half the length of the CP **430**-*a*, though the symbol period structure **400** may be used with GIs **425** of any length. For example, the symbol period structure **400** may include one or more GIs **425** of a length less than or equal to the length of a CP, such as CP **530**-*a*. In some examples, such a length of a GI (e.g., GI **425**, GI **525**, GI **527**, one or more other GIs, or any combination thereof) may be considered a fractional length in that such a length may be a fraction of a length of the CP. Such a length of the CP **430**-*a*, the GIs **425**, or both, may be a length measured in samples, in time, or in another unit of measurement. In some examples, each GI **425** may include the same data sequence or content.

In some examples, the GI **425** may be a portion of the CP **430**-*a* and the length of the GI **425** may therefore be a fraction of the length of the CP **430**-*a*. In other words, the GI **425** may be a known sequence found within the CP **430**-*a* (or other CP described herein) and this known sequence may be included one or more times within the FFT window **445** (e.g., at least one of which may be included in the FFT window **445** before copied portion **435**-*b* or the CP **430**-*b*).

In the example symbol period structure **400** depicted in FIG. **4**, a GI **425** is included immediately before the copied portion **435**-*a* and another GI **425** is included at the end of the symbol (which may be within the copied portion **435**-*a*). By including these GIs **425** in this way, a symmetric "GI-data-GI" structure may be located at the end of the symbol **420**-*a*. This symmetric structure allows the integrity of circular convolution operations to hold, as the same "GI-data-GI" sequence "wraps around" within the FFT window **445** even when an arrival path is delayed (e.g., as shown by the same sequence **460** highlighted within the FFT window **445**).

Arrival path **415**-*b* depicts an arrival path that is delayed as compared to arrival path **415**-*a*. However, even though arrival path **415**-*b* is delayed (e.g., as shown by the difference between the symbol boundary **465** and the boundary between symbol **420**-*a* and symbol **420**-*b* of the arrival path **415**-*a*), the "GI-data-GI" sequence is still present within the FFT window **445** and the same sequence **460** is present in both arrival path **415**-*a* and arrival path **415**-*b*.

The DS capability **450** represents a DS handling capability of the symbol period structure **400**. As depicted in FIG. **4**, the DS capability **450** is equal to the length of the CP **430** plus the length of the GI **425**, and may indicate how much DS (e.g., a time duration) that may be tolerated in communications employing the symbol period structure **400**. In some examples, such a DS capability **450** may be less than or equal to two times the length of the CP **430**. The DS capability increase **455** represents an additional length or amount of time included in the DS capability **450** as compared to other approaches that do not utilize the symbol period structure **400**. In other words, the DS capability increase **455** may represent an amount of additional DS that may be tolerated in communications employing the symbol period structure **400** beyond an amount of DS that may be tolerated by a symbol period structure that does not include the GIs **425**.

FIG. **5** illustrates an example of a symbol period structure **500** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The symbol period structure **500** may be described in relation to an arrival path **515**-*a* and a delayed arrival path **515**-*b* that may be arrival paths of a multipath arrival scenario. The arrival path **515**-*a* may include a symbol **520**-*a* and a symbol **520**-*b*. Though these symbols are depicted as an example, the techniques described herein may be applied to any quantity of symbols **520**.

In some examples, a network entity may indicate (e.g., to a UE) a CP configuration. The CP configuration may indicate a symbol period structure, such as the symbol period structure **500** that may include one or more GIs **525**, one or more GIs **527**, or any combination thereof, that may aid in allowing communications between the network entity and the UE to tolerate an increased DS. In some examples, the CP configuration may indicate other information related to the CP or the symbol period structure **500**. For example, the CP configuration may indicate that the symbol period structure **500** is applicable or is not applicable to communications using one or more particular SCSs, that the UE is to derive or select the symbol period structure **500** based on another symbol period structure associated with a different SCS. In some examples, the CP configuration may be transmitted via control signaling, such as RRC signaling, MAC-CE signaling, physical layer signaling, or any combination thereof.

In the symbol period structure **500**, a symbol (e.g., the symbol **520**-*a* or the symbol **520**-*b*) may include a CP **530** and a copied portion **535** that is copied to form the CP **530**. For example, the symbol **520**-*a* includes the CP **530**-*a* and the copied portion **535**-*a*, and the symbol **520**-*b* includes the CP **530**-*b* and the copied portion **535**-*b*. A symbol may include data **540** (e.g., data that is to be transmitted to another device).

The symbol may further include one or more GIs **525**. In some examples, one or more of the GIs **525** may be of a length equal to the length of the CP **530**. In the example symbol period structure **500** depicted in FIG. **5**, multiple GIs **525** may be included in the symbol **520**-*a*. For example, a GI **525** may be located in the copied portion **535**-*a* that is copied to form the CP **530**-*a*. Further, at least a portion of a GI **525**

may be included in the symbol **520**-*a* before the copied portion **535**-*a*. In some examples, GIs **525** that are of the length of the CP **530**-*a* may be included in the symbol **520**-*a*, the symbol **520**-*b*, or both. In some examples, another GI **527** that may be of a length less than the length of the CP **530**-*a* may be included in the symbol **520**-*a*, the symbol **520**-*b*, or both. For example, as shown in the partial GI derivation **585**, the GI **527**-*a* may be a fractional portion of the GI **525**-*a*, such as an end of the GI **525**-*a*. As such, the GI **527**-*a* may include a corresponding portion of the GI sequence included in GI **525**-*a*. Similarly, the GI **527** may be a fractional portion of the GI **525** and may include a corresponding portion of the GI sequence included in GI **525**. In some examples, both one or more GIs **525** that are of the same length of the CP **530**-*a* and one or more GIs **527** that are of a length less than the length of the CP **530**-*a* may be included in the symbol **520**-*a*, the symbol **520**-*b*, or both. This structure of GIs **525** (and optionally GIs **527**) allows the integrity of circular convolution operations to hold, as the same GI sequence "wraps around" within the FFT window **545** even when an arrival path is delayed (e.g., as shown by the same sequence **560** highlighted within the FFT window **445**, as well as by the same sequence **565**).

The ΔD **575** may represent or correspond to a difference between a combined length of one or more CP-length GIs **525** and a time duration of DS that may be present in communications. Additionally, or alternatively, the AD **575** may represent or correspond to a length of the GI **527**, which may be a partial or fractional GI. In some examples, a partial GI, such as the GI **527**, be of the length AD **575** such that the combined length of the GIs **525** and the GI **527** of a single symbol (e.g., symbol **520**-*b*) may be equal to or greater than the time duration of the DS present in the communications. As such, in some examples the DS capability **550** (e.g., which may be designed or configured to be of a length greater than or equal to a DS present in communications) may be of a length that is equal to two times the length of the CP **530**-*b* plus the length of the AD **575**.

In some examples, a total DS capability (e.g., DS capability **550**) of the symbol structure **500** (or other example symbol structures) may be different than the actual DS (e.g., a measured DS or a DS received from another device) in the communication system. For example, a DS may be equal to 100 ns, but a DS capability (e.g., DS capability **550**) may only be 80 ns, and an MCS used may be one that may sustain or handle some inter-symbol interference with an acceptable or minimal degradation in block error rate. As such, the total DS capability (e.g., DS capability **550**) may be configured to match or correspond to a desired DS capability for a symbol as needed for communications and may not be the same as or correspond to an actual DS present in a communication system. Thus, AD **575** may, in some examples, be described as or correspond to a length of a partial GI (e.g., GI **527**) and may not be the same as the actual DS in the system.

For example, a measured DS may be of a length that falls between two CP lengths and three CP lengths (e.g., where a CP length is a length of CP **530**-*b*), such 2.5 CP lengths. In such a scenario, if the symbol period structure **500** included only two CP-length GIs **525**, the symbol period structure **500** would not be able to tolerate the DS of 2.5 CP lengths. Using three GIs **525** would allow the symbol period structure **500** to tolerate the DS of the length of 2.5 CPs **530**-*b*, but may involve increased overhead or a reduced amount of time within the FFT window **545** for the data **540**. As such, the symbol period structure **500** may include the GI **527** that may correspond to the length AD **575** and the length of the GIs **525** and the GI **527** combined (e.g., which may be represented by the DS capability **550**) may be greater than or equal to the length of the DS, thereby tolerating the DS and reducing or eliminating inter-symbol interference or other complications that may arise from DS.

Arrival path **515**-*b* depicts an arrival path that is delayed as compared to arrival path **515**-*a*. However, even though arrival path **515**-*b* is delayed (e.g., as shown by the difference between the symbol boundary **570** and the boundary between symbol **520**-*a* and symbol **520**-*b* of the arrival path **515**-*a*), set of GIs **525** (and optionally the GI **527**) is still present within the FFT window **545** and the same sequence **560** is present in both arrival path **515**-*a* and arrival path **515**-*b*. Similarly, in those cases that may include the GI **527**, the same sequence **565** may be present in the GI **527** and a portion of the GI **525**, since, in some cases, the GI **527** that is of a length less than a length of the CP **530** may be the same as a portion of a GI **525** that is of a length of the CP **530**. In other words, the information included in the GI **527** may also be included in a portion of the GI **525**. For example, the copied portion **580** may be a copy of information included in the GI **527** or the GI **527**-*a*, which information itself may be a copy of information included in the GI **525** or the GI **525**-*a*. Thus, even if GI **527** is a different fractional portion of the GI **525** (the GI copied portion **580** necessarily being of the different fractional portion), the GI **527** and the GI copied portion **580** include the same portions of a GI sequence, thus preserving or supporting the integrity of the circular convolution used in connection with the FFT window **545**.

The DS capability **550** represents a DS handling capability of the symbol period structure **500**. As depicted in FIG. **5**, the DS capability **550** is equal to the length of the two times the length of the CP **530** plus the length of any additional GIs added (including one or more GIs **525**, one or more GIs **527**, or both) before the last two GIs **525** of a symbol **520**, and may indicate how much DS (e.g., a time duration) that may be tolerated in communications employing the symbol period structure **500**. For example, as shown in FIG. **5**, the DS capability **550** may be equal to two times the length of the CP **530** (which is also the length of the GI **525**) plus the length of GI **527**. The DS capability increase **555** represents an additional length or amount of time included in the DS capability **550** as compared to some other approaches that do not utilize the symbol period structure **500**. In other words, the DS capability increase **555** may represent an amount of additional DS that may be tolerated in communications employing the symbol period structure **500** beyond an amount of DS that may be tolerated by a symbol period structure that does not include the GIs **525**, GI **527**, or both.

By using the GIs **525** (and optionally the GI **527**), the DS capability **550** (also referred to as a DS handling capability) may be extended (e.g., beyond a DS capability of two times the length of a CP as described in some examples relating to FIG. **4**). In some examples, depending on a DS that is to be handled, a quantity of GIs **525** (and optionally the GI **527**) may be used to adjust or change the symbol period structure **500** to accommodate the DS and provide a DS capability **550** that is greater than or equal to a DS to be handled. For example, an integer quantity of GIs **527** (and optionally one or more GIs **527**) may be included in the symbol period structure **500** to adjust or change the DS capability **550** and accommodate a DS to be handled.

By using the symbol period structure **400**, the symbol period structure **500**, or both, the delay spread handling capability of a wireless communications system may be

increased due to the increased length of the symbol structure included in the configurations without increasing the length of the CPs **430** or CPs **530** themselves or affecting slot alignment. Additionally, overhead associated with the symbol period structure **400**, the symbol period structure **500**, or both, may depend on the additional desired delay spread handling capability and there may be no fixed overhead. For example, the overhead may be piecewise linearly proportional to a desired DS handling capability. In some examples, the overhead associated with the symbol period structure **400**, the symbol period structure **500**, or both in may follow the sample overhead **590** chart depicted in FIG. **5**. Additionally, or alternatively, the sample overhead **590** may follow an equation, such as Equation 1 describing a piecewise linear function, where x is a total DS capability and y is an amount of overhead present beyond the length of a CP (e.g., CP **430** or CP **530**).

$$y = \{2(x - CP),\ CP \le x \le 2 * CP,\ \text{or}\ x,\ x \ge 2 * CP\} \quad (1)$$

Additionally, as the GIs **425**, GIs **525**, GIs **527**, or any combination thereof may be used in the symbol period structure, such GIs may offer increased flexibility compared to the use of CPs **430** or CPs **530** without the GIs **425**, GIs **525**, GIs **527**, or any combination thereof, as the GIs **425**, GIs **525**, GIs **527**, or any combination thereof may use various different sequences, data, or information (e.g., data for acquisition of time, frequency, or phase lock, or any combination thereof) and the GIs **425**, GIs **525**, GIs **527**, or any combination thereof may be used for various different purposes (e.g., time, frequency, or phase tracking, channel estimation, providing for a beam-switching gap, or any combination thereof), whereas a CPs **430** or CPs **530** includes repetitions of data that cannot be used for other purposes. Further, because different sets, configurations, or arrangements of the GIs **425**, GIs **525**, and GIs **527** may be used, communications flexibility is increased and scaling for desired delay spread handling capabilities becomes trivial.

FIG. **6** illustrates an example of a process flow **600** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein.

The process flow **600** may implement various aspects of the present disclosure described herein. The elements described in the process flow **600** (e.g., the network entity **105**-*b* and the UE **115**-*b*) may be examples of similarly-named elements described herein.

In the following description of the process flow **600**, the operations between the various entities or elements may be performed in different orders or at different times. Some operations may also be left out of the process flow **600**, or other operations may be added. Although the various entities or elements are shown performing the operations of the process flow **600**, some aspects of some operations may also be performed by other entities or elements of the process flow **600** or by entities or elements that are not depicted in the process flow, or any combination thereof.

At **620**, in some examples, the UE **115**-*b* may transmit an indication that the UE supports a plurality of cyclic prefix configurations and the network entity **105**-*b* may receive the indication. For example, the UE may transmit a message indicating that the UE includes a capability for communications with one or more cyclic prefix configurations (e.g., the CP configuration **335**, one or more symbol period structures (e.g., symbol period structure **340**, symbol period structure **400**, or symbol period structure **500**), or both. For example, the UE **115**-*b* may indicate that the UE **115**-*b* supports the use of the GI **425** in the symbol period structure **400** or that the UE **115**-*b* supports the use of GIs **525** and GI **527** in the symbol period structure **500**. In some examples, the indication that the UE supports a plurality of cyclic prefix configurations may not be transmitted or received for each symbol communicated. For example, such an indication may be transmitted or received based on or as part of an initial connection and may not be performed after such an initial connection. However, in some examples, a CP configuration or symbol period structure may be changed dynamically (e.g., by the network entity **105**-*b*) or based on receiving such a capability indication (e.g., from the UE **115**-*b*).

In some examples, a capability to support or not support one or more CP configurations or symbol period structures may be determined, selected, calculated, or otherwise identified (e.g., on an implicit or explicit basis) based on other signaling which is exchanged between the UE **115**-*b* and the network entity **105**-*b*. For example, the UE **115**-*b* may indicate another capability of the UE **115**-*b* (e.g., a set of one or more wireless communications capabilities, such as those described in a standards agreement, such as a Third Generation Partnership Project (3GPP) standards release). Additionally, or alternatively, the UE **115**-*b* may indicate (e.g., to the network entity **105**-*b*) one or more air-interface waveforms supported by the UE **115**-*b* (e.g., which may indicate whether a GI-based waveform is supported or not).

At **625**, in some examples, the UE **115**-*b* may communicate (e.g., transmit, receive, or both) a delay spread measurement report that indicates the delay spread. For example, the UE may receive, from network entity **105**-*b*, a delay spread measurement report indicating the delay spread (e.g., measured at the network entity **105**-*b*). Additionally, or alternatively, the UE may transmit a delay spread measurement report indicating the delay spread (e.g., measured at the UE **115**-*b*) and the network entity **105**-*b* may transmit an indication of a cyclic prefix configuration (e.g., the first cyclic prefix configuration) to the UE **115**-*b* to use for communications. For example, the UE **115**-*b* may receive (e.g., from the network entity **105**-*b*) a request for a DS measurement report and the UE **115**-*b* may transmit (e.g., based on the request or receiving the request) the DS measurement report.

In some examples, the network entity **105**-*b* may transmit a DS measurement report (e.g., regarding an uplink DS associated with communications between the network entity **105**-*b* and the UE **115**-*b*) to the UE **115**-*b*. In some examples, the UE **115**-*b* may transmit (e.g., based on the DS measurement report or receiving the DS measurement report) an indication of a CP configuration (e.g., a preferred CP configuration based on the DS or other information indicated in the DS measurement report) to the network entity **105**-*b*. Additionally, or alternatively, the UE **115**-*b* may measure a DS associated with downlink communications between the UE **115**-*b* and the network entity **105**-*b* and may transmit an indication of a CP configuration (e.g., a preferred CP configuration based on the measured downlink DS) to the network entity **105**-*b*.

In some examples, the DS measurement report may include an indication of a delay spread associated with uplink transmissions from the UE **115**-*b*. For example, the indication of the delay spread may be an indication of the delay spread measured at the network entity **105**-*b*, at one or more other devices, or any combination thereof. The indication of the delay spread associated with uplink transmis-

sions from the UE **115**-*b* may be used by the UE **115**-*b* to select (e.g., autonomously or without indication or direction from the network entity **105**-*b*) the first cyclic prefix configuration for use in communications (e.g., at **645** of the process flow **600**).

At **630**, in some examples, the UE **115**-*b* may receive, from the network entity **105**-*b*, an indication of a first cyclic prefix configuration of the plurality of cyclic prefix configurations. The first cyclic prefix configuration may indicate a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The guard interval may be of a length that may be shorter than the length of the cyclic prefix (e.g., a fractional length of the length of the cyclic prefix), longer than the length of the cyclic prefix, or equal to the length of the cyclic prefix. In some examples, the indication of the first cyclic prefix configuration may apply to uplink communications, downlink communications, or both.

For example, as shown in FIG. **4**, the symbol period structure **400** may include multiple GIs **425**, which may be of a length less than or equal to the length of a CP **430**, such as CP **430**-*a* or CP **430**-*b*. Such GIs may be referred to as "complete" or "whole" GIs, as they may contain a complete GI sequence.

In other examples, such as the examples shown in FIG. **5**, the symbol period structure **500** may include one or more GIs **525** that are of a length of the CP **530** (e.g., which may be "complete" or "whole" GIs that include or contain a complete GI sequence). Further, the symbol period structure **500** may include the GI **527** that may be a fractional portion of the GI **525**. For example, as shown in the partial GI derivation **585**, the GI **527**-*a* may be a fractional portion of the GI **525**-*a*. As such, the GI **527**-*a* may include a corresponding portion of the GI sequence included in GI **525**-*a*. Similarly, the GI **527** may be a fractional portion of the GI **525** and may include a corresponding portion of the GI sequence included in GI **525**.

In some examples, the indication of the first cyclic prefix configuration is based on the delay spread measurement report. For example, the first cyclic prefix configuration may indicate a symbol period structure that may include one or more GIs that may collectively be of a time duration that is greater than or equal to a time duration of the delay spread indicated in the delay spread measurement report.

In some examples, the UE **115**-*b* may receive the indication of the first cyclic prefix configuration that may indicate the first symbol period structure may have a first guard interval located before the portion of the symbol period copied as the cyclic prefix and a second guard interval located at an end of the portion of the symbol period copied as the cyclic prefix. In some examples, the UE **115**-*b* may receive the indication of the first cyclic prefix configuration that may indicate a length of the first guard interval and a length of the second guard interval are each less than or equal to a length of the cyclic prefix.

In some examples, the UE **115**-*b* may receive the indication of the first cyclic prefix configuration that may indicate the first symbol period structure includes a plurality of consecutive guard intervals located at an end of the symbol period. In some examples, each guard interval is of a length equal to the length of the cyclic prefix and a last guard interval of the plurality of consecutive guard intervals is comprised in the portion of the symbol period copied as the cyclic prefix. In some examples, the first symbol period structure further includes an additional guard interval that is of a length that is less than the length of the cyclic prefix and is located immediately before the plurality of consecutive guard intervals.

In some examples, the UE **115**-*b* may receive the indication of the first cyclic prefix configuration that may indicate to interleave that a symbol having the first symbol period structure with a second symbol having a second symbol structure that differs from the first symbol period structure.

In some examples, the UE **115**-*b* may receive the indication of the first cyclic prefix configuration that may indicate the first symbol period structure may include a set of one or more guard intervals, a quantity of one or more guard intervals, or both.

In some examples, the UE **115**-*b* may receive the indication of the first cyclic prefix configuration that may indicate the first symbol period structure may include a set of one or more guard intervals based on a prior cyclic prefix configuration that associates the first symbol period structure with the set of the one or more guard intervals.

In some examples, the UE **115**-*b* may receive the indication of the first cyclic prefix configuration that may indicate the first cyclic prefix configuration is applicable to a set of subcarrier spacing values, is inapplicable to one or more other subcarrier spacing values, or both.

In some examples, the UE **115**-*b* may receive the indication of the first cyclic prefix configuration that may indicate the first cyclic prefix configuration is applicable to a first subcarrier spacing.

In some examples, the UE **115**-*b* may receive the indication of the first cyclic prefix configuration that may indicate quantized values corresponding to one or more lengths of one or more guard intervals of the first symbol period structure.

In some examples, the indication of the first cyclic prefix configuration is transmitted via radio resource control signaling, medium access control control signaling, physical layer control signaling, or any combination thereof.

At **635**, in some examples, the UE **115**-*b* may receive, from the network entity **105**-*b*, an indication that the UE is to derive a second cyclic prefix configuration for a second subcarrier spacing based on the first cyclic prefix configuration and a delay spread capability of the UE associated with the first cyclic prefix configuration. For example, the UE **115**-*b* may derive the second cyclic prefix configuration for use in connection with a second SCS (e.g., an SCS of 1920 kHz) based on the first cyclic prefix configuration being used with a first SCS (e.g., an SCS of 960 KHz). In some examples, the second cyclic prefix configuration may be stored and later applied to communications associated with the second SCS. Communications associated with the second SCS (e.g., one or more of the messages communicated at **645**) may be performed at least partially overlapping in time with communications associated with the first SCS (e.g., one or more of the messages communicated at **645**), such as in a carrier aggregation scenario (e.g., where communications associated with the first SCS may be performed using a first carrier and communications associated with the second SCS may be performed using a second carrier). Additionally, or alternatively, communications associated with the second SCS may be performed in response to or based on a change from the first SCS to the second SCS (e.g., through signaling to the UE **115**-*b* by the network entity **105**-*b*).

At **640**, in some examples, the UE **115**-*b* may select the first cyclic prefix configuration based on the indication of the delay spread (e.g. described at **630** of the process flow **600**). For example, the first cyclic prefix configuration may be

selected (e.g., from the plurality of cyclic prefix configurations supported by the UE **115**-*b*, such as the plurality of cyclic prefix indications included in the cyclic prefix configuration capability information at **620** of the process flow **600**) based on the first cyclic prefix configuration including a delay spread handling capability that may be greater than or equal to the delay spread indicated in the indication of the delay spread. Such selection of the cyclic prefix configuration may be performed in examples in which the UE **115**-*b* does not receive the indication of the first cyclic prefix configuration that is described at **635** in the process flow **600**.

At **645**, in some examples, the UE **115**-*b* may communicate one or more messages with the network entity **105**-*b* in accordance with the first cyclic prefix configuration. For example, the UE **115**-*b* may transmit one or more messages, receive one or more messages, or both, and such messages may include the symbol period structure indicated in the first cyclic prefix configuration.

FIG. **7** illustrates a block diagram **700** of a device **705** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The device **705** may be an example of aspects of a UE **115** as described herein. The device **705** may include a receiver **710**, a transmitter **715**, and a communications manager **720**. The device **705** may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

The receiver **710** may provide a means for receiving information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to cyclic prefix guard interval for increased delay spread). Information may be passed on to other components of the device **705**. The receiver **710** may utilize a single antenna or a set of multiple antennas.

The transmitter **715** may provide a means for transmitting signals generated by other components of the device **705**. For example, the transmitter **715** may transmit information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to cyclic prefix guard interval for increased delay spread). In some examples, the transmitter **715** may be co-located with a receiver **710** in a transceiver module. The transmitter **715** may utilize a single antenna or a set of multiple antennas.

The communications manager **720**, the receiver **710**, the transmitter **715**, or various combinations thereof or various components thereof may be examples of means for performing various aspects of cyclic prefix guard interval for increased delay spread as described herein. For example, the communications manager **720**, the receiver **710**, the transmitter **715**, or various combinations or components thereof may support a method for performing one or more of the functions described herein.

In some examples, the communications manager **720**, the receiver **710**, the transmitter **715**, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), a central processing unit (CPU), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a microcontroller, discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some examples, a processor and memory coupled with the processor may be configured to perform one or more of the functions described herein (e.g., by executing, by the processor, instructions stored in the memory).

Additionally, or alternatively, in some examples, the communications manager **720**, the receiver **710**, the transmitter **715**, or various combinations or components thereof may be implemented in code (e.g., as communications management software or firmware) executed by a processor. If implemented in code executed by a processor, the functions of the communications manager **720**, the receiver **710**, the transmitter **715**, or various combinations or components thereof may be performed by a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, a microcontroller, or any combination of these or other programmable logic devices (e.g., configured as or otherwise supporting a means for performing the functions described in the present disclosure).

In some examples, the communications manager **720** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **710**, the transmitter **715**, or both. For example, the communications manager **720** may receive information from the receiver **710**, send information to the transmitter **715**, or be integrated in combination with the receiver **710**, the transmitter **715**, or both to obtain information, output information, or perform various other operations as described herein.

Additionally, or alternatively, the communications manager **720** may support wireless communication at a UE in accordance with examples as disclosed herein. For example, the communications manager **720** may be configured as or otherwise support a means for transmitting an indication that the UE supports a set of multiple cyclic prefix configurations. The communications manager **720** may be configured as or otherwise support a means for receiving, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The communications manager **720** may be configured as or otherwise support a means for communicating one or more messages with the network entity in accordance with the first cyclic prefix configuration.

By including or configuring the communications manager **720** in accordance with examples as described herein, the device **705** (e.g., a processor controlling or otherwise coupled with the receiver **710**, the transmitter **715**, the communications manager **720**, or a combination thereof) may support techniques for reduced processing, reduced power consumption, more efficient utilization of communication resources, or any combination thereof.

FIG. **8** illustrates a block diagram **800** of a device **805** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The device **805** may be an example of aspects of a device **705** or a UE **115** as described herein. The device **805** may include a receiver **810**, a transmitter **815**, and a communications manager **820**. The device **805** may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

The receiver **810** may provide a means for receiving information such as packets, user data, control information,

or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to cyclic prefix guard interval for increased delay spread). Information may be passed on to other components of the device **805**. The receiver **810** may utilize a single antenna or a set of multiple antennas.

The transmitter **815** may provide a means for transmitting signals generated by other components of the device **805**. For example, the transmitter **815** may transmit information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to cyclic prefix guard interval for increased delay spread). In some examples, the transmitter **815** may be co-located with a receiver **810** in a transceiver module. The transmitter **815** may utilize a single antenna or a set of multiple antennas.

The device **805**, or various components thereof, may be an example of means for performing various aspects of cyclic prefix guard interval for increased delay spread as described herein. For example, the communications manager **820** may include a CP configuration capability component **825**, a CP configuration component **830**, a message communication component **835**, or any combination thereof. The communications manager **820** may be an example of aspects of a communications manager **720** as described herein. In some examples, the communications manager **820**, or various components thereof, may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **810**, the transmitter **815**, or both. For example, the communications manager **820** may receive information from the receiver **810**, send information to the transmitter **815**, or be integrated in combination with the receiver **810**, the transmitter **815**, or both to obtain information, output information, or perform various other operations as described herein.

The communications manager **820** may support wireless communication at a UE in accordance with examples as disclosed herein. The CP configuration capability component **825** may be configured as or otherwise support a means for transmitting an indication that the UE supports a set of multiple cyclic prefix configurations. The CP configuration component **830** may be configured as or otherwise support a means for receiving, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The message communication component **835** may be configured as or otherwise support a means for communicating one or more messages with the network entity in accordance with the first cyclic prefix configuration.

FIG. **9** illustrates a block diagram **900** of a communications manager **920** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The communications manager **920** may be an example of aspects of a communications manager **720**, a communications manager **820**, or both, as described herein. The communications manager **920**, or various components thereof, may be an example of means for performing various aspects of cyclic prefix guard interval for increased delay spread as described herein. For example, the communications manager **920** may include a CP configuration capability component **925**, a CP configuration component **930**, a message communication component **935**, a symbol period structure component **940**, an interleaving component **945**, a delay spread component **950**, an SCS component **955**, a GI length component **960**, or any combination thereof. Each of these components may communicate, directly or indirectly, with one another (e.g., via one or more buses).

Additionally, or alternatively, the communications manager **920** may support wireless communication at a UE in accordance with examples as disclosed herein. The CP configuration capability component **925** may be configured as or otherwise support a means for transmitting an indication that the UE supports a set of multiple cyclic prefix configurations. The CP configuration component **930** may be configured as or otherwise support a means for receiving, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The message communication component **935** may be configured as or otherwise support a means for communicating one or more messages with the network entity in accordance with the first cyclic prefix configuration.

In some examples, to support receiving the indication of the first cyclic prefix configuration, the symbol period structure component **940** may be configured as or otherwise support a means for receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure has a first guard interval located before the portion of the symbol period copied as the cyclic prefix and a second guard interval located at an end of the portion of the symbol period copied as the cyclic prefix.

In some examples, to support receiving the indication of the first cyclic prefix configuration, the symbol period structure component **940** may be configured as or otherwise support a means for receiving the indication of the first cyclic prefix configuration that indicates a length of the first guard interval and a length of the second guard interval are each less than or equal to a length of the cyclic prefix.

In some examples, to support receiving the indication of the first cyclic prefix configuration, the symbol period structure component **940** may be configured as or otherwise support a means for receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of multiple consecutive guard intervals located at an end of the symbol period.

In some examples, each guard interval is of a length equal to the length of the cyclic prefix and a last guard interval of the set of multiple consecutive guard intervals is included in the portion of the symbol period copied as the cyclic prefix.

In some examples, the first symbol period structure further includes an additional guard interval that is of a length that is less than the length of the cyclic prefix and is located immediately before the set of multiple consecutive guard intervals.

In some examples, to support receiving the indication of the first cyclic prefix configuration, the interleaving component **945** may be configured as or otherwise support a means for receiving the indication of the first cyclic prefix configuration that indicates to interleave that a symbol having

the first symbol period structure with a second symbol having a second symbol structure that differs from the first symbol period structure.

In some examples, the delay spread component **950** may be configured as or otherwise support a means for communicating a delay spread measurement report that indicates the delay spread, where the indication of the first cyclic prefix configuration is based on the delay spread measurement report.

In some examples, to support receiving the indication of the first cyclic prefix configuration, the symbol period structure component **940** may be configured as or otherwise support a means for receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of one or more guard intervals, a quantity of one or more guard intervals, or both.

In some examples, the delay spread component **950** may be configured as or otherwise support a means for receiving an indication of a delay spread associated with uplink transmissions from the UE. In some examples, the CP configuration component **930** may be configured as or otherwise support a means for selecting the first cyclic prefix configuration based on the indication of the delay spread.

In some examples, to support receiving the indication of the first cyclic prefix configuration, the CP configuration component **930** may be configured as or otherwise support a means for receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of one or more guard intervals based on a prior cyclic prefix configuration that associates the first symbol period structure with the set of the one or more guard intervals.

In some examples, to support receiving the indication of the first cyclic prefix configuration, the SCS component **955** may be configured as or otherwise support a means for receiving the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a set of subcarrier spacing values, is inapplicable to one or more other subcarrier spacing values, or both.

In some examples, to support receiving the indication of the first cyclic prefix configuration, the SCS component **955** may be configured as or otherwise support a means for receiving the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a first subcarrier spacing.

In some examples, the SCS component **955** may be configured as or otherwise support a means for receiving an indication that the UE is to derive a second cyclic prefix configuration for a second subcarrier spacing based on the first cyclic prefix configuration and a delay spread capability of the UE associated with the first cyclic prefix configuration.

In some examples, the indication of the first cyclic prefix configuration is transmitted via radio resource control signaling, medium access control control signaling, physical layer control signaling, or any combination thereof.

In some examples, to support receiving the indication of the first cyclic prefix configuration, the CP configuration component **930** may be configured as or otherwise support a means for receiving the indication of the first cyclic prefix configuration that indicates quantized values corresponding to one or more lengths of one or more guard intervals of the first symbol period structure.

In some examples, the first cyclic prefix configuration is applicable to uplink communications, downlink communications, or both.

FIG. **10** illustrates a diagram of a system **1000** including a device **1005** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The device **1005** may be an example of or include the components of a device **705**, a device **805**, or a UE **115** as described herein. The device **1005** may communicate (e.g., wirelessly) with one or more network entities **105**, one or more UEs **115**, or any combination thereof. The device **1005** may include components for bi-directional voice and data communications including components for transmitting and receiving communications, such as a communications manager **1020**, an input/output (I/O) controller **1010**, a transceiver **1015**, an antenna **1025**, a memory **1030**, code **1035**, and a processor **1040**. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more buses (e.g., a bus **1045**).

The I/O controller **1010** may manage input and output signals for the device **1005**. The I/O controller **1010** may also manage peripherals not integrated into the device **1005**. In some cases, the I/O controller **1010** may represent a physical connection or port to an external peripheral. In some cases, the I/O controller **1010** may utilize an operating system such as iOS®, ANDROID®, MS-DOS®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. Additionally, or alternatively, the I/O controller **1010** may represent or interact with a modem, a keyboard, a mouse, a touchscreen, or a similar device. In some cases, the I/O controller **1010** may be implemented as part of a processor, such as the processor **1040**. In some cases, a user may interact with the device **1005** via the I/O controller **1010** or via hardware components controlled by the I/O controller **1010**.

In some cases, the device **1005** may include a single antenna **1025**. However, in some other cases, the device **1005** may have more than one antenna **1025**, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver **1015** may communicate bi-directionally, via the one or more antennas **1025**, wired, or wireless links as described herein. For example, the transceiver **1015** may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver **1015** may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas **1025** for transmission, and to demodulate packets received from the one or more antennas **1025**. The transceiver **1015**, or the transceiver **1015** and one or more antennas **1025**, may be an example of a transmitter **715**, a transmitter **815**, a receiver **710**, a receiver **810**, or any combination thereof or component thereof, as described herein.

The memory **1030** may include random access memory (RAM) and read-only memory (ROM). The memory **1030** may store computer-readable, computer-executable code **1035** including instructions that, when executed by the processor **1040**, cause the device **1005** to perform various functions described herein. The code **1035** may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some cases, the code **1035** may not be directly executable by the processor **1040** but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some cases, the memory **1030** may contain, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

The processor **1040** may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some cases, the processor **1040** may be configured to operate a memory array using a memory controller. In some other cases, a memory controller may be integrated into the processor **1040**. The processor **1040** may be configured to execute computer-readable instructions stored in a memory (e.g., the memory **1030**) to cause the device **1005** to perform various functions (e.g., functions or tasks supporting cyclic prefix guard interval for increased delay spread). For example, the device **1005** or a component of the device **1005** may include a processor **1040** and memory **1030** coupled with or to the processor **1040**, the processor **1040** and memory **1030** configured to perform various functions described herein.

Additionally, or alternatively, the communications manager **1020** may support wireless communication at a UE in accordance with examples as disclosed herein. For example, the communications manager **1020** may be configured as or otherwise support a means for transmitting an indication that the UE supports a set of multiple cyclic prefix configurations. The communications manager **1020** may be configured as or otherwise support a means for receiving, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The communications manager **1020** may be configured as or otherwise support a means for communicating one or more messages with the network entity in accordance with the first cyclic prefix configuration.

By including or configuring the communications manager **1020** in accordance with examples as described herein, the device **1005** may support techniques for improved communication reliability, reduced latency, improved user experience related to reduced processing, reduced power consumption, more efficient utilization of communication resources, improved coordination between devices, longer battery life, improved utilization of processing capability, or any combination thereof.

In some examples, the communications manager **1020** may be configured to perform various operations (e.g., receiving, monitoring, transmitting) using or otherwise in cooperation with the transceiver **1015**, the one or more antennas **1025**, or any combination thereof. Although the communications manager **1020** is illustrated as a separate component, in some examples, one or more functions described with reference to the communications manager **1020** may be supported by or performed by the processor **1040**, the memory **1030**, the code **1035**, or any combination thereof. For example, the code **1035** may include instructions executable by the processor **1040** to cause the device **1005** to perform various aspects of cyclic prefix guard interval for increased delay spread as described herein, or the processor **1040** and the memory **1030** may be otherwise configured to perform or support such operations.

FIG. **11** illustrates a block diagram **1100** of a device **1105** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The device **1105** may be an example of aspects of a network entity **105** as described herein. The device **1105** may include a receiver **1110**, a transmitter **1115**, and a communications manager **1120**. The device **1105** may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

The receiver **1110** may provide a means for obtaining (e.g., receiving, determining, identifying) information such as user data, control information, or any combination thereof (e.g., I/Q samples, symbols, packets, protocol data units, service data units) associated with various channels (e.g., control channels, data channels, information channels, channels associated with a protocol stack). Information may be passed on to other components of the device **1105**. In some examples, the receiver **1110** may support obtaining information by receiving signals via one or more antennas. Additionally, or alternatively, the receiver **1110** may support obtaining information by receiving signals via one or more wired (e.g., electrical, fiber optic) interfaces, wireless interfaces, or any combination thereof.

The transmitter **1115** may provide a means for outputting (e.g., transmitting, providing, conveying, sending) information generated by other components of the device **1105**. For example, the transmitter **1115** may output information such as user data, control information, or any combination thereof (e.g., I/Q samples, symbols, packets, protocol data units, service data units) associated with various channels (e.g., control channels, data channels, information channels, channels associated with a protocol stack). In some examples, the transmitter **1115** may support outputting information by transmitting signals via one or more antennas. Additionally, or alternatively, the transmitter **1115** may support outputting information by transmitting signals via one or more wired (e.g., electrical, fiber optic) interfaces, wireless interfaces, or any combination thereof. In some examples, the transmitter **1115** and the receiver **1110** may be co-located in a transceiver, which may include or be coupled with a modem.

The communications manager **1120**, the receiver **1110**, the transmitter **1115**, or various combinations thereof or various components thereof may be examples of means for performing various aspects of cyclic prefix guard interval for increased delay spread as described herein. For example, the communications manager **1120**, the receiver **1110**, the transmitter **1115**, or various combinations or components thereof may support a method for performing one or more of the functions described herein.

In some examples, the communications manager **1120**, the receiver **1110**, the transmitter **1115**, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a DSP, a CPU, an ASIC, an FPGA or other programmable logic device, a microcontroller, discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some examples, a processor and memory coupled with the processor may be configured to perform one or more of the functions described herein (e.g., by executing, by the processor, instructions stored in the memory).

Additionally, or alternatively, in some examples, the communications manager **1120**, the receiver **1110**, the transmitter **1115**, or various combinations or components thereof may be implemented in code (e.g., as communications management software or firmware) executed by a processor. If implemented in code executed by a processor, the functions of the communications manager **1120**, the receiver **1110**, the transmitter **1115**, or various combinations or

components thereof may be performed by a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, a microcontroller, or any combination of these or other programmable logic devices (e.g., configured as or otherwise supporting a means for performing the functions described in the present disclosure).

In some examples, the communications manager **1120** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **1110**, the transmitter **1115**, or both. For example, the communications manager **1120** may receive information from the receiver **1110**, send information to the transmitter **1115**, or be integrated in combination with the receiver **1110**, the transmitter **1115**, or both to obtain information, output information, or perform various other operations as described herein.

Additionally, or alternatively, the communications manager **1120** may support wireless communication at a network entity in accordance with examples as disclosed herein. For example, the communications manager **1120** may be configured as or otherwise support a means for receiving, from a UE, an indication that the UE supports a set of multiple cyclic prefix configurations. The communications manager **1120** may be configured as or otherwise support a means for transmitting, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The communications manager **1120** may be configured as or otherwise support a means for communicating one or more messages with the UE in accordance with the first cyclic prefix configuration.

By including or configuring the communications manager **1120** in accordance with examples as described herein, the device **1105** (e.g., a processor controlling or otherwise coupled with the receiver **1110**, the transmitter **1115**, the communications manager **1120**, or a combination thereof) may support techniques for reduced processing, reduced power consumption, more efficient utilization of communication resources, or any combination thereof.

FIG. **12** illustrates a block diagram **1200** of a device **1205** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The device **1205** may be an example of aspects of a device **1105** or a network entity **105** as described herein. The device **1205** may include a receiver **1210**, a transmitter **1215**, and a communications manager **1220**. The device **1205** may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

The receiver **1210** may provide a means for obtaining (e.g., receiving, determining, identifying) information such as user data, control information, or any combination thereof (e.g., I/Q samples, symbols, packets, protocol data units, service data units) associated with various channels (e.g., control channels, data channels, information channels, channels associated with a protocol stack). Information may be passed on to other components of the device **1205**. In some examples, the receiver **1210** may support obtaining information by receiving signals via one or more antennas. Additionally, or alternatively, the receiver **1210** may support obtaining information by receiving signals via one or more wired (e.g., electrical, fiber optic) interfaces, wireless interfaces, or any combination thereof.

The transmitter **1215** may provide a means for outputting (e.g., transmitting, providing, conveying, sending) information generated by other components of the device **1205**. For example, the transmitter **1215** may output information such as user data, control information, or any combination thereof (e.g., I/Q samples, symbols, packets, protocol data units, service data units) associated with various channels (e.g., control channels, data channels, information channels, channels associated with a protocol stack). In some examples, the transmitter **1215** may support outputting information by transmitting signals via one or more antennas. Additionally, or alternatively, the transmitter **1215** may support outputting information by transmitting signals via one or more wired (e.g., electrical, fiber optic) interfaces, wireless interfaces, or any combination thereof. In some examples, the transmitter **1215** and the receiver **1210** may be co-located in a transceiver, which may include or be coupled with a modem.

The device **1205**, or various components thereof, may be an example of means for performing various aspects of cyclic prefix guard interval for increased delay spread as described herein. For example, the communications manager **1220** may include a CP configuration capability component **1225**, a CP configuration component **1230**, a message communication component **1235**, or any combination thereof. The communications manager **1220** may be an example of aspects of a communications manager **1120** as described herein. In some examples, the communications manager **1220**, or various components thereof, may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **1210**, the transmitter **1215**, or both. For example, the communications manager **1220** may receive information from the receiver **1210**, send information to the transmitter **1215**, or be integrated in combination with the receiver **1210**, the transmitter **1215**, or both to obtain information, output information, or perform various other operations as described herein.

The communications manager **1220** may support wireless communication at a network entity in accordance with examples as disclosed herein. The CP configuration capability component **1225** may be configured as or otherwise support a means for receiving, from a UE, an indication that the UE supports a set of multiple cyclic prefix configurations. The CP configuration component **1230** may be configured as or otherwise support a means for transmitting, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The message communication component **1235** may be configured as or otherwise support a means for communicating one or more messages with the UE in accordance with the first cyclic prefix configuration.

FIG. **13** illustrates a block diagram **1300** of a communications manager **1320** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The communications manager **1320** may be an example of aspects of a communications manager **1120**, a communications manager **1220**, or both, as described herein. The communications manager **1320**, or various components thereof, may be an example of means for performing various aspects of cyclic prefix guard interval for increased delay spread as described herein. For example, the communications manager **1320** may include a

CP configuration capability component **1325**, a CP configuration component **1330**, a message communication component **1335**, a symbol period structure component **1340**, an interleaving component **1345**, a delay spread component **1350**, an SCS component **1355**, a GI length component **1360**, or any combination thereof. Each of these components may communicate, directly or indirectly, with one another (e.g., via one or more buses) which may include communications within a protocol layer of a protocol stack, communications associated with a logical channel of a protocol stack (e.g., between protocol layers of a protocol stack, within a device, component, or virtualized component associated with a network entity **105**, between devices, components, or virtualized components associated with a network entity **105**), or any combination thereof.

Additionally, or alternatively, the communications manager **1320** may support wireless communication at a network entity in accordance with examples as disclosed herein. The CP configuration capability component **1325** may be configured as or otherwise support a means for receiving, from a UE, an indication that the UE supports a set of multiple cyclic prefix configurations. The CP configuration component **1330** may be configured as or otherwise support a means for transmitting, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The message communication component **1335** may be configured as or otherwise support a means for communicating one or more messages with the UE in accordance with the first cyclic prefix configuration.

In some examples, to support transmitting the indication of the first cyclic prefix configuration, the symbol period structure component **1340** may be configured as or otherwise support a means for transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure has a first guard interval located before the portion of the symbol period copied as the cyclic prefix and a second guard interval located at an end of the portion of the symbol period copied as the cyclic prefix.

In some examples, to support transmitting the indication of the first cyclic prefix configuration, the symbol period structure component **1340** may be configured as or otherwise support a means for transmitting the indication of the first cyclic prefix configuration that indicates a length of the first guard interval and a length of the second guard interval are each less than or equal to a length of the cyclic prefix.

In some examples, to support transmitting the indication of the first cyclic prefix configuration, the symbol period structure component **1340** may be configured as or otherwise support a means for transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of multiple consecutive guard intervals located at an end of the symbol period.

In some examples, each guard interval is of a length equal to the length of the cyclic prefix and a last guard interval of the set of multiple consecutive guard intervals is included in the portion of the symbol period copied as the cyclic prefix.

In some examples, the first symbol period structure further includes an additional guard interval that is of a length that is less than the length of the cyclic prefix and is located immediately before the set of multiple consecutive guard intervals.

In some examples, to support transmitting the indication of the first cyclic prefix configuration, the interleaving component **1345** may be configured as or otherwise support a means for transmitting the indication of the first cyclic prefix configuration that indicates to interleave that a symbol having the first symbol period structure with a second symbol having a second symbol structure that differs from the first symbol period structure.

In some examples, the delay spread component **1350** may be configured as or otherwise support a means for communicating a delay spread measurement report that indicates the delay spread, where the indication of the first cyclic prefix configuration is based on the delay spread measurement report.

In some examples, to support transmitting the indication of the first cyclic prefix configuration, the symbol period structure component **1340** may be configured as or otherwise support a means for transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of one or more guard intervals, a quantity of one or more guard intervals, or both.

In some examples, to support transmitting the indication of the first cyclic prefix configuration, the CP configuration component **1330** may be configured as or otherwise support a means for transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a set of one or more guard intervals based on a prior cyclic prefix configuration that associates the first symbol period structure with the set of the one or more guard intervals.

In some examples, to support transmitting the indication of the first cyclic prefix configuration, the SCS component **1355** may be configured as or otherwise support a means for transmitting the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a set of subcarrier spacing values, is inapplicable to one or more other subcarrier spacing values, or both.

In some examples, to support transmitting the indication of the first cyclic prefix configuration, the SCS component **1355** may be configured as or otherwise support a means for transmitting the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a first subcarrier spacing.

In some examples, the SCS component **1355** may be configured as or otherwise support a means for transmitting an indication that the UE is to derive a second cyclic prefix configuration for a second subcarrier spacing based on the first cyclic prefix configuration and a delay spread capability of the UE associated with the first cyclic prefix configuration.

In some examples, the indication of the first cyclic prefix configuration is transmitted via control signaling.

In some examples, the first cyclic prefix configuration is applicable to uplink communications, downlink communications, or both.

FIG. **14** illustrates a diagram of a system **1400** including a device **1405** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The device **1405** may be an example of or include the components of a device **1105**, a device **1205**, or a network entity **105** as described herein. The device **1405** may communicate with one or more network entities **105**, one or more UEs **115**, or any combination thereof, which may include communications over one or more wired interfaces, over one or more wireless interfaces, or any combination thereof. The device **1405** may include components that support outputting and obtaining

communications, such as a communications manager **1420**, a transceiver **1410**, an antenna **1415**, a memory **1425**, code **1430**, and a processor **1435**. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more buses (e.g., a bus **1440**).

The transceiver **1410** may support bi-directional communications via wired links, wireless links, or both as described herein. In some examples, the transceiver **1410** may include a wired transceiver and may communicate bi-directionally with another wired transceiver. Additionally, or alternatively, in some examples, the transceiver **1410** may include a wireless transceiver and may communicate bi-directionally with another wireless transceiver. In some examples, the device **1405** may include one or more antennas **1415**, which may be capable of transmitting or receiving wireless transmissions (e.g., concurrently). The transceiver **1410** may also include a modem to modulate signals, to provide the modulated signals for transmission (e.g., by one or more antennas **1415**, by a wired transmitter), to receive modulated signals (e.g., from one or more antennas **1415**, from a wired receiver), and to demodulate signals. In some implementations, the transceiver **1410** may include one or more interfaces, such as one or more interfaces coupled with the one or more antennas **1415** that are configured to support various receiving or obtaining operations, or one or more interfaces coupled with the one or more antennas **1415** that are configured to support various transmitting or outputting operations, or a combination thereof. In some implementations, the transceiver **1410** may include or be configured for coupling with one or more processors or memory components that are operable to perform or support operations based on received or obtained information or signals, or to generate information or other signals for transmission or other outputting, or any combination thereof. In some implementations, the transceiver **1410**, or the transceiver **1410** and the one or more antennas **1415**, or the transceiver **1410** and the one or more antennas **1415** and one or more processors or memory components (for example, the processor **1435**, or the memory **1425**, or both), may be included in a chip or chip assembly that is installed in the device **1405**. In some examples, the transceiver may be operable to support communications via one or more communications links (e.g., a communication link **125**, a backhaul communication link **120**, a midhaul communication link **162**, a fronthaul communication link **168**).

The memory **1425** may include RAM and ROM. The memory **1425** may store computer-readable, computer-executable code **1430** including instructions that, when executed by the processor **1435**, cause the device **1405** to perform various functions described herein. The code **1430** may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some cases, the code **1430** may not be directly executable by the processor **1435** but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some cases, the memory **1425** may contain, among other things, a BIOS which may control basic hardware or software operation such as the interaction with peripheral components or devices.

The processor **1435** may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA, a microcontroller, a programmable logic device, discrete gate or transistor logic, a discrete hardware component, or any combination thereof). In some cases, the processor **1435** may be configured to operate a memory array using a memory controller. In some other cases, a memory controller may be integrated into the processor **1435**. The processor **1435** may be configured to execute computer-readable instructions stored in a memory (e.g., the memory **1425**) to cause the device **1405** to perform various functions (e.g., functions or tasks supporting cyclic prefix guard interval for increased delay spread). For example, the device **1405** or a component of the device **1405** may include a processor **1435** and memory **1425** coupled with the processor **1435**, the processor **1435** and memory **1425** configured to perform various functions described herein. The processor **1435** may be an example of a cloud-computing platform (e.g., one or more physical nodes and supporting software such as operating systems, virtual machines, or container instances) that may host the functions (e.g., by executing code **1430**) to perform the functions of the device **1405**. The processor **1435** may be any one or more suitable processors capable of executing scripts or instructions of one or more software programs stored in the device **1405** (such as within the memory **1425**). In some implementations, the processor **1435** may be a component of a processing system. A processing system may generally refer to a system or series of machines or components that receives inputs and processes the inputs to produce a set of outputs (which may be passed to other systems or components of, for example, the device **1405**). For example, a processing system of the device **1405** may refer to a system including the various other components or subcomponents of the device **1405**, such as the processor **1435**, or the transceiver **1410**, or the communications manager **1420**, or other components or combinations of components of the device **1405**. The processing system of the device **1405** may interface with other components of the device **1405**, and may process information received from other components (such as inputs or signals) or output information to other components. For example, a chip or modem of the device **1405** may include a processing system and one or more interfaces to output information, or to obtain information, or both. The one or more interfaces may be implemented as or otherwise include a first interface configured to output information and a second interface configured to obtain information, or a same interface configured to output information and to obtain information, among other implementations. In some implementations, the one or more interfaces may refer to an interface between the processing system of the chip or modem and a transmitter, such that the device **1405** may transmit information output from the chip or modem. Additionally, or alternatively, in some implementations, the one or more interfaces may refer to an interface between the processing system of the chip or modem and a receiver, such that the device **1405** may obtain information or signal inputs, and the information may be passed to the processing system. A person having ordinary skill in the art will readily recognize that a first interface also may obtain information or signal inputs, and a second interface also may output information or signal outputs.

In some examples, a bus **1440** may support communications of (e.g., within) a protocol layer of a protocol stack. In some examples, a bus **1440** may support communications associated with a logical channel of a protocol stack (e.g., between protocol layers of a protocol stack), which may include communications performed within a component of the device **1405**, or between different components of the device **1405** that may be co-located or located in different locations (e.g., where the device **1405** may refer to a system in which one or more of the communications manager **1420**, the transceiver **1410**, the memory **1425**, the code **1430**, and

the processor **1435** may be located in one of the different components or divided between different components).

In some examples, the communications manager **1420** may manage aspects of communications with a core network **130** (e.g., via one or more wired or wireless backhaul links). For example, the communications manager **1420** may manage the transfer of data communications for client devices, such as one or more UEs **115**. In some examples, the communications manager **1420** may manage communications with other network entities **105**, and may include a controller or scheduler for controlling communications with UEs **115** in cooperation with other network entities **105**. In some examples, the communications manager **1420** may support an X2 interface within an LTE/LTE-A wireless communications network technology to provide communication between network entities **105**.

Additionally, or alternatively, the communications manager **1420** may support wireless communication at a network entity in accordance with examples as disclosed herein. For example, the communications manager **1420** may be configured as or otherwise support a means for receiving, from a UE, an indication that the UE supports a set of multiple cyclic prefix configurations. The communications manager **1420** may be configured as or otherwise support a means for transmitting, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The communications manager **1420** may be configured as or otherwise support a means for communicating one or more messages with the UE in accordance with the first cyclic prefix configuration.

By including or configuring the communications manager **1420** in accordance with examples as described herein, the device **1405** may support techniques for improved communication reliability, reduced latency, improved user experience related to reduced processing, reduced power consumption, more efficient utilization of communication resources, improved coordination between devices, longer battery life, improved utilization of processing capability, or any combination thereof.

In some examples, the communications manager **1420** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the transceiver **1410**, the one or more antennas **1415** (e.g., where applicable), or any combination thereof. Although the communications manager **1420** is illustrated as a separate component, in some examples, one or more functions described with reference to the communications manager **1420** may be supported by or performed by the transceiver **1410**, the processor **1435**, the memory **1425**, the code **1430**, or any combination thereof. For example, the code **1430** may include instructions executable by the processor **1435** to cause the device **1405** to perform various aspects of cyclic prefix guard interval for increased delay spread as described herein, or the processor **1435** and the memory **1425** may be otherwise configured to perform or support such operations.

FIG. **15** illustrates a flowchart showing a method **1500** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The operations of the method **1500** may be implemented by a UE or its components as described herein. For example, the operations of the method **1500** may be performed by a UE **115** as described with reference to FIGS. **1** through **10**. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the described functions. Additionally, or alternatively, the UE may perform aspects of the described functions using special-purpose hardware.

At **1505**, the method may include transmitting an indication that the UE supports a set of multiple cyclic prefix configurations. The operations of **1505** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1505** may be performed by a CP configuration capability component **925** as described with reference to FIG. **9**.

At **1510**, the method may include receiving, from a network entity, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The operations of **1510** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1510** may be performed by a CP configuration component **930** as described with reference to FIG. **9**.

At **1515**, the method may include communicating one or more messages with the network entity in accordance with the first cyclic prefix configuration. The operations of **1515** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1515** may be performed by a message communication component **935** as described with reference to FIG. **9**.

FIG. **16** illustrates a flowchart showing a method **1600** that supports cyclic prefix guard interval for increased delay spread in accordance with one or more examples as disclosed herein. The operations of the method **1600** may be implemented by a network entity or its components as described herein. For example, the operations of the method **1600** may be performed by a network entity as described with reference to FIGS. **1** through **6** and **11** through **14**. In some examples, a network entity may execute a set of instructions to control the functional elements of the network entity to perform the described functions. Additionally, or alternatively, the network entity may perform aspects of the described functions using special-purpose hardware.

At **1605**, the method may include receiving, from a UE, an indication that the UE supports a set of multiple cyclic prefix configurations. The operations of **1605** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1605** may be performed by a CP configuration capability component **1325** as described with reference to FIG. **13**.

At **1610**, the method may include transmitting, to the UE, an indication of a first cyclic prefix configuration of the set of multiple cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes (in some cases, at least a fraction of) a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based on a delay spread exceeding a length of the cyclic prefix. The operations of **1610** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1610** may be performed by a CP configuration component **1330** as described with reference to FIG. **13**.

At **1615**, the method may include communicating one or more messages with the UE in accordance with the first cyclic prefix configuration. The operations of **1615** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1615** may be performed by a message communication component **1335** as described with reference to FIG. **13**.

The following provides an overview of aspects of the present disclosure:

Aspect 1: A method for wireless communication at a UE, comprising: transmitting an indication that the UE supports a plurality of cyclic prefix symbol configurations; receiving, from a network entity, an indication of a first cyclic prefix configuration of the plurality of cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based at least in part on a delay spread exceeding a length of the cyclic prefix; and communicating one or more messages with the network entity in accordance with the first cyclic prefix configuration.

Aspect 2: The method of aspect 1, wherein receiving the indication of the first cyclic prefix configuration further comprises: receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure has a first guard interval located before the portion of the symbol period copied as the cyclic prefix and a second guard interval located at an end of the portion of the symbol period copied as the cyclic prefix.

Aspect 3: The method of aspect 2, wherein receiving the indication of the first cyclic prefix configuration further comprises: receiving the indication of the first cyclic prefix configuration that indicates a length of the first guard interval and a length of the second guard interval are each less than or equal to a length of the cyclic prefix.

Aspect 4: The method of any of aspects 1 through 3, wherein receiving the indication of the first cyclic prefix configuration further comprises: receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a plurality of consecutive guard intervals located at an end of the symbol period.

Aspect 5: The method of aspect 4, wherein each guard interval is of a length equal to the length of the cyclic prefix and a last guard interval of the plurality of consecutive guard intervals is comprised in the portion of the symbol period copied as the cyclic prefix.

Aspect 6: The method of any of aspects 4 through 5, wherein the first symbol period structure further includes an additional guard interval that is of a length that is less than the length of the cyclic prefix and is located immediately before the plurality of consecutive guard intervals.

Aspect 7: The method of any of aspects 1 through 6, wherein receiving the indication of the first cyclic prefix configuration further comprises: receiving the indication of the first cyclic prefix configuration that indicates to interleave that a symbol having the first symbol period structure with a second symbol having a second symbol structure that differs from the first symbol period structure.

Aspect 8: The method of any of aspects 1 through 7, further comprising: communicating a delay spread measurement report that indicates the delay spread, wherein the indication of the first cyclic prefix configuration is based at least in part on the delay spread measurement report.

Aspect 9: The method of any of aspects 1 through 8, wherein receiving the indication of the first cyclic prefix configuration further comprises: receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure comprises a set of one or more guard intervals, a quantity of one or more guard intervals, or both.

Aspect 10: The method of any of aspects 1 through 9, further comprising: receiving an indication of a delay spread associated with uplink transmissions from the UE; and selecting the first cyclic prefix configuration based at least in part on to indication of the delay spread.

Aspect 11: The method of any of aspects 1 through 10, wherein receiving the indication of the first cyclic prefix configuration further comprises: receiving the indication of the first cyclic prefix configuration that indicates the first symbol period structure comprises a set of one or more guard intervals based at least in part on a prior cyclic prefix configuration that associates the first symbol period structure with the set of the one or more guard intervals.

Aspect 12: The method of any of aspects 1 through 11, wherein receiving the indication of the first cyclic prefix configuration further comprises: receiving the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a set of subcarrier spacing values, is inapplicable to one or more other subcarrier spacing values, or both.

Aspect 13: The method of any of aspects 1 through 12, wherein receiving the indication of the first cyclic prefix configuration further comprises: receiving the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a first subcarrier spacing.

Aspect 14: The method of aspect 13, further comprising: receiving an indication that the UE is to derive a second cyclic prefix configuration for a second subcarrier spacing based at least in part on the first cyclic prefix configuration and a delay spread capability of the UE associated with the first cyclic prefix configuration.

Aspect 15: The method of any of aspects 1 through 14, wherein the indication of the first cyclic prefix configuration is transmitted via radio resource control signaling, medium access control control signaling, physical layer control signaling, or any combination thereof.

Aspect 16: The method of any of aspects 1 through 15, wherein receiving the indication of the first cyclic prefix configuration further comprises: receiving the indication of the first cyclic prefix configuration that indicates quantized values corresponding to one or more lengths of one or more guard intervals of the first symbol period structure.

Aspect 17: The method of any of aspects 1 through 16, wherein the first cyclic prefix configuration is applicable to uplink communications, downlink communications, or both.

Aspect 18: A method for wireless communication at a network entity, comprising: receiving, from a UE, an indication that the UE supports a plurality of cyclic prefix symbol configurations; transmitting, to the UE,

an indication of a first cyclic prefix configuration of the plurality of cyclic prefix symbol configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based at least in part on a delay spread exceeding a length of the cyclic prefix; and communicating one or more messages with the UE in accordance with the first cyclic prefix configuration.

Aspect 19: The method of aspect 18, wherein transmitting the indication of the first cyclic prefix configuration further comprises: transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure has a first guard interval located before the portion of the symbol period copied as the cyclic prefix and a second guard interval located at an end of the portion of the symbol period copied as the cyclic prefix.

Aspect 20: The method of aspect 19, wherein transmitting the indication of the first cyclic prefix configuration further comprises: transmitting the indication of the first cyclic prefix configuration that indicates a length of the first guard interval and a length of the second guard interval are each less than or equal to a length of the cyclic prefix.

Aspect 21: The method of any of aspects 18 through 20, wherein transmitting the indication of the first cyclic prefix configuration further comprises: transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a plurality of consecutive guard intervals located at an end of the symbol period.

Aspect 22: The method of aspect 21, wherein each guard interval is of a length equal to the length of the cyclic prefix and a last guard interval of the plurality of consecutive guard intervals is comprised in the portion of the symbol period copied as the cyclic prefix.

Aspect 23: The method of any of aspects 21 through 22, wherein the first symbol period structure further includes an additional guard interval that is of a length that is less than the length of the cyclic prefix and is located immediately before the plurality of consecutive guard intervals.

Aspect 24: The method of any of aspects 18 through 23, wherein transmitting the indication of the first cyclic prefix configuration further comprises: transmitting the indication of the first cyclic prefix configuration that indicates to interleave that a symbol having the first symbol period structure with a second symbol having a second symbol structure that differs from the first symbol period structure.

Aspect 25: The method of any of aspects 18 through 24, further comprising: communicating a delay spread measurement report that indicates the delay spread, wherein the indication of the first cyclic prefix configuration is based at least in part on the delay spread measurement report.

Aspect 26: The method of any of aspects 18 through 25, wherein transmitting the indication of the first cyclic prefix configuration further comprises: transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure comprises a set of one or more guard intervals, a quantity of one or more guard intervals, or both.

Aspect 27: The method of any of aspects 18 through 26, wherein transmitting the indication of the first cyclic prefix configuration further comprises: transmitting the indication of the first cyclic prefix configuration that indicates the first symbol period structure comprises a set of one or more guard intervals based at least in part on a prior cyclic prefix configuration that associates the first symbol period structure with the set of the one or more guard intervals.

Aspect 28: The method of any of aspects 18 through 27, wherein transmitting the indication of the first cyclic prefix configuration further comprises: transmitting the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a set of subcarrier spacing values, is inapplicable to one or more other subcarrier spacing values, or both.

Aspect 29: The method of any of aspects 18 through 28, wherein transmitting the indication of the first cyclic prefix configuration further comprises: transmitting the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a first subcarrier spacing.

Aspect 30: The method of aspect 29, further comprising: transmitting an indication that the UE is to derive a second cyclic prefix configuration for a second subcarrier spacing based at least in part on the first cyclic prefix configuration and a delay spread capability of the UE associated with the first cyclic prefix configuration.

Aspect 31: The method of any of aspects 18 through 30, wherein the indication of the first cyclic prefix configuration is transmitted via control signaling.

Aspect 32: The method of any of aspects 18 through 31, wherein the first cyclic prefix configuration is applicable to uplink communications, downlink communications, or both.

Aspect 33: An apparatus for wireless communication at a UE, comprising a processor; memory coupled with the processor; and instructions stored in the memory and executable by the processor to cause the apparatus to perform a method of any of aspects 1 through 17.

Aspect 34: An apparatus for wireless communication at a UE, comprising at least one means for performing a method of any of aspects 1 through 17.

Aspect 35: A non-transitory computer-readable medium storing code for wireless communication at a UE, the code comprising instructions executable by a processor to perform a method of any of aspects 1 through 17.

Aspect 36: An apparatus for wireless communication at a network entity, comprising a processor; memory coupled with the processor; and instructions stored in the memory and executable by the processor to cause the apparatus to perform a method of any of aspects 18 through 32.

Aspect 37: An apparatus for wireless communication at a network entity, comprising at least one means for performing a method of any of aspects 18 through 32.

Aspect 38: A non-transitory computer-readable medium storing code for wireless communication at a network entity, the code comprising instructions executable by a processor to perform a method of any of aspects 18 through 32.

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

Although aspects of an LTE, LTE-A, LTE-A Pro, or NR system may be described for purposes of example, and LTE,

LTE-A, LTE-A Pro, or NR terminology may be used in much of the description, the techniques described herein are applicable beyond LTE, LTE-A, LTE-A Pro, or NR networks. For example, the described techniques may be applicable to various other wireless communications systems such as Ultra Mobile Broadband (UMB), Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, as well as other systems and radio technologies not explicitly mentioned herein.

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

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

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

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

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

The term "determine" or "determining" encompasses a variety of actions and, therefore, "determining" can include calculating, computing, processing, deriving, investigating, looking up (such as via looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" can include receiving (e.g., receiving information), accessing (e.g., accessing data stored in memory) and the like. Also, "determining" can include resolving, obtaining, selecting, choosing, establishing, and other such similar actions.

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

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

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

What is claimed is:

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

a processor;

memory coupled with the processor; and

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

transmit an indication that the UE supports a plurality of cyclic prefix configurations;

receive, from a network entity, an indication of a first cyclic prefix configuration of the plurality of cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based at least in part on a delay spread exceeding a length of the cyclic prefix; and

communicate one or more messages with the network entity in accordance with the first cyclic prefix configuration.

2. The apparatus of claim **1**, wherein the instructions to receive the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

receive the indication of the first cyclic prefix configuration that indicates the first symbol period structure has a first guard interval located before the portion of the symbol period copied as the cyclic prefix and a second guard interval located at an end of the portion of the symbol period copied as the cyclic prefix.

3. The apparatus of claim **2**, wherein the instructions to receive the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

receive the indication of the first cyclic prefix configuration that indicates a length of the first guard interval and a length of the second guard interval are each less than or equal to a length of the cyclic prefix.

4. The apparatus of claim **1**, wherein the instructions to receive the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

receive the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a plurality of consecutive guard intervals located at an end of the symbol period.

5. The apparatus of claim **4**, wherein each guard interval is of a length equal to the length of the cyclic prefix and a last guard interval of the plurality of consecutive guard intervals is comprised in the portion of the symbol period copied as the cyclic prefix.

6. The apparatus of claim **4**, wherein the first symbol period structure further includes an additional guard interval that is of a length that is less than the length of the cyclic prefix and is located immediately before the plurality of consecutive guard intervals.

7. The apparatus of claim **1**, wherein the instructions to receive the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

receive the indication of the first cyclic prefix configuration that indicates to interleave that a symbol having the first symbol period structure with a second symbol having a second symbol structure that differs from the first symbol period structure.

8. The apparatus of claim **1**, wherein the instructions are further executable by the processor to cause the apparatus to:

communicate a delay spread measurement report that indicates the delay spread;

wherein the indication of the first cyclic prefix configuration is based at least in part on the delay spread measurement report.

9. The apparatus of claim **1**, wherein the instructions to receive the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

receive the indication of the first cyclic prefix configuration that indicates the first symbol period structure comprises a set of one or more guard intervals, a quantity of one or more guard intervals, or both.

10. The apparatus of claim **1**, wherein the instructions are further executable by the processor to cause the apparatus to:

receive an indication of a delay spread associated with uplink transmissions from the UE; and

select the first cyclic prefix configuration based at least in part on the indication of the delay spread.

11. The apparatus of claim **1**, wherein the instructions to receive the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

receive the indication of the first cyclic prefix configuration that indicates the first symbol period structure comprises a set of one or more guard intervals based at least in part on a prior cyclic prefix configuration that associates the first symbol period structure with the set of the one or more guard intervals.

12. The apparatus of claim **1**, wherein the instructions to receive the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

receive the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a set of subcarrier spacing values, is inapplicable to one or more other subcarrier spacing values, or both.

13. The apparatus of claim **1**, wherein the instructions to receive the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

receive the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a first subcarrier spacing.

14. The apparatus of claim **13**, wherein the instructions are further executable by the processor to cause the apparatus to:

receive an indication that the UE is to derive a second cyclic prefix configuration for a second subcarrier spacing based at least in part on the first cyclic prefix configuration and a delay spread capability of the UE associated with the first cyclic prefix configuration.

15. The apparatus of claim **1**, wherein the indication of the first cyclic prefix configuration is transmitted via radio resource control signaling, medium access control control signaling, physical layer control signaling, or any combination thereof.

16. The apparatus of claim **1**, wherein the instructions to receive the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

receive the indication of the first cyclic prefix configuration that indicates quantized values corresponding to one or more lengths of one or more guard intervals of the first symbol period structure.

17. The apparatus of claim **1**, wherein the first cyclic prefix configuration is applicable to uplink communications, downlink communications, or both.

18. An apparatus for wireless communication at a network entity, comprising:

a processor;

memory coupled with the processor; and

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

receive, from a user equipment (UE), an indication that the UE supports a plurality of cyclic prefix configurations;

transmit, to the UE, an indication of a first cyclic prefix configuration of the plurality of cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based at least in part on a delay spread exceeding a length of the cyclic prefix; and

communicate one or more messages with the UE in accordance with the first cyclic prefix configuration.

19. The apparatus of claim 18, wherein the instructions to transmit the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

transmit the indication of the first cyclic prefix configuration that indicates the first symbol period structure has a first guard interval located before the portion of the symbol period copied as the cyclic prefix and a second guard interval located at an end of the portion of the symbol period copied as the cyclic prefix.

20. The apparatus of claim 19, wherein the instructions to transmit the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

transmit the indication of the first cyclic prefix configuration that indicates a length of the first guard interval and a length of the second guard interval are each less than or equal to a length of the cyclic prefix.

21. The apparatus of claim 18, wherein the instructions to transmit the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

transmit the indication of the first cyclic prefix configuration that indicates the first symbol period structure includes a plurality of consecutive guard intervals located at an end of the symbol period.

22. The apparatus of claim 21, wherein each guard interval is of a length equal to the length of the cyclic prefix and a last guard interval of the plurality of consecutive guard intervals is comprised in the portion of the symbol period copied as the cyclic prefix.

23. The apparatus of claim 21, wherein the first symbol period structure further includes an additional guard interval that is of a length that is less than the length of the cyclic prefix and is located immediately before the plurality of consecutive guard intervals.

24. The apparatus of claim 18, wherein the instructions to transmit the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

transmit the indication of the first cyclic prefix configuration that indicates to interleave that a symbol having the first symbol period structure with a second symbol having a second symbol structure that differs from the first symbol period structure.

25. The apparatus of claim 18, wherein the instructions are further executable by the processor to cause the apparatus to:

communicate a delay spread measurement report that indicates the delay spread;

wherein the indication of the first cyclic prefix configuration is based at least in part on the delay spread measurement report.

26. The apparatus of claim 18, wherein the instructions to transmit the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

transmit the indication of the first cyclic prefix configuration that indicates the first symbol period structure comprises a set of one or more guard intervals based at least in part on a prior cyclic prefix configuration that associates the first symbol period structure with the set of the one or more guard intervals.

27. The apparatus of claim 18, wherein the instructions to transmit the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

transmit the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a set of subcarrier spacing values, is inapplicable to one or more other subcarrier spacing values, or both.

28. The apparatus of claim 18, wherein the instructions to transmit the indication of the first cyclic prefix configuration are further executable by the processor to cause the apparatus to:

transmit the indication of the first cyclic prefix configuration that indicates the first cyclic prefix configuration is applicable to a first subcarrier spacing.

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

transmitting an indication that the UE supports a plurality of cyclic prefix configurations;

receiving, from a network entity, an indication of a first cyclic prefix configuration of the plurality of cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based at least in part on a delay spread exceeding a length of the cyclic prefix; and

communicating one or more messages with the network entity in accordance with the first cyclic prefix configuration.

30. A method for wireless communication at a network entity, comprising:

receiving, from a user equipment (UE), an indication that the UE supports a plurality of cyclic prefix configurations;

transmitting, to the UE, an indication of a first cyclic prefix configuration of the plurality of cyclic prefix configurations, the first cyclic prefix configuration indicating a first symbol period structure that includes a guard interval that occurs in a symbol period prior to a portion of the symbol period copied as a cyclic prefix based at least in part on a delay spread exceeding a length of the cyclic prefix; and

communicating one or more messages with the UE in accordance with the first cyclic prefix configuration.

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