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Wang et al.

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(54) **TECHNIQUES FOR SCHEDULING USING TWO-STAGE CONTROL MESSAGES**

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H04W 72/21 (2023.01)

(52) **U.S. Cl.**
CPC ***H04W 72/23*** (2023.01); ***H04W 72/21*** (2023.01)

(58) **Field of Classification Search**
CPC ... H04W 72/23; H04W 72/21; H04W 72/232; H04L 5/0044; H04L 5/0094
USPC 370/310, 328, 329, 330
See application file for complete search history.

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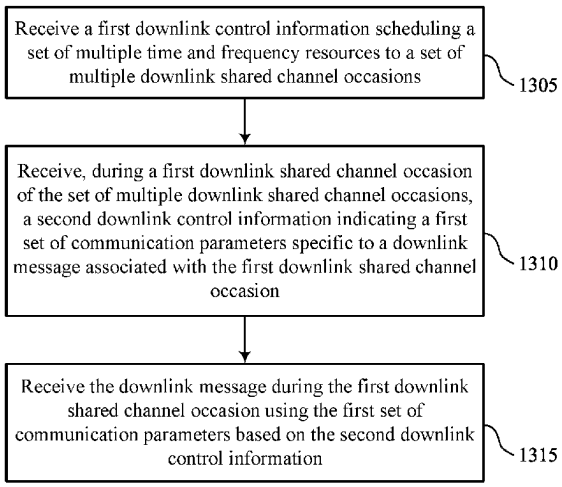
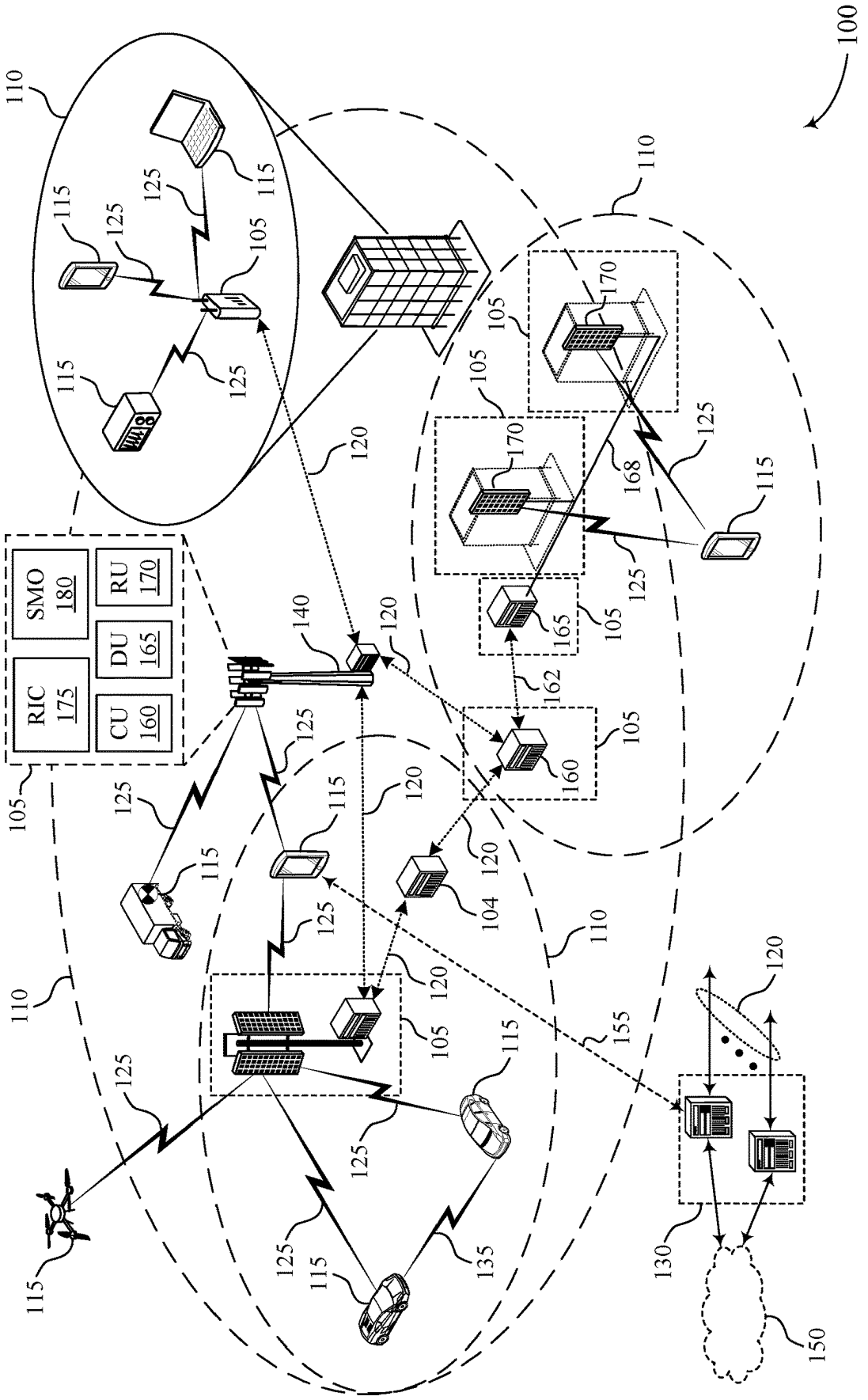
(57) **ABSTRACT**

Methods, systems, and devices for method for wireless communication are described. A user equipment (UE) may receive a first downlink control information scheduling a set of time and frequency resources to a set of downlink shared channel occasions. The UE may also receive, during a first downlink shared channel occasion of the set of downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The UE may then receive the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

14 Claims, 20 Drawing Sheets




100
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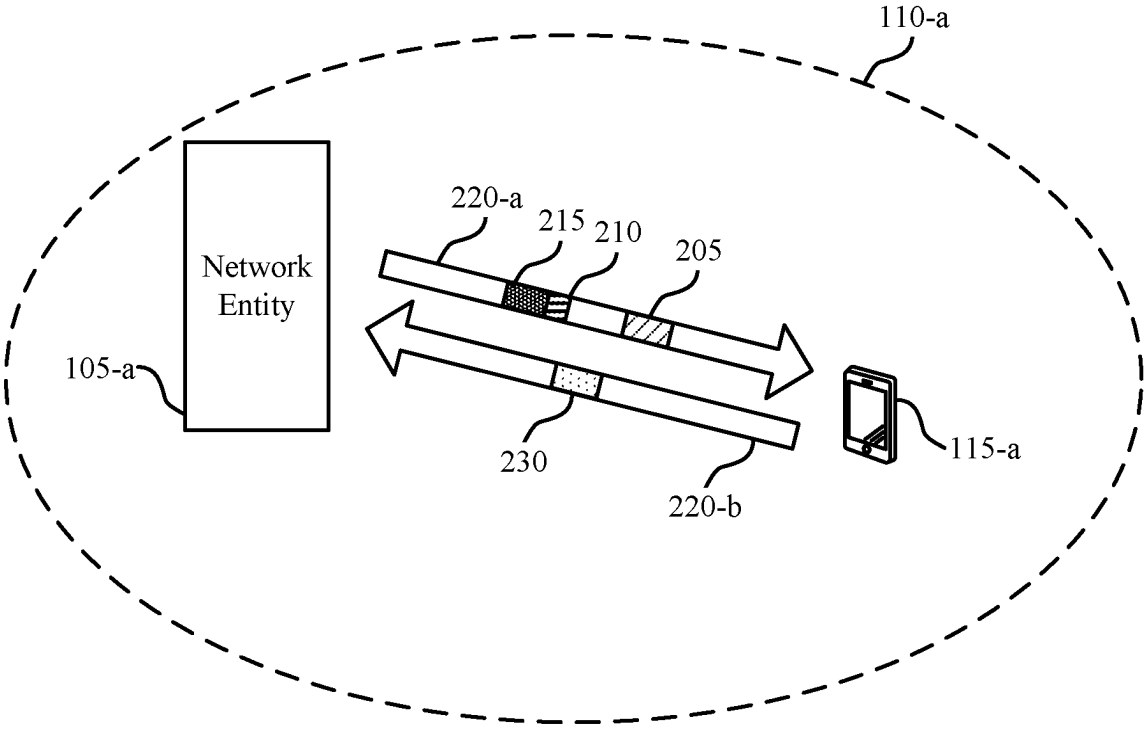
DU
CU
RIC

FIG. 1



First Downlink Control Information

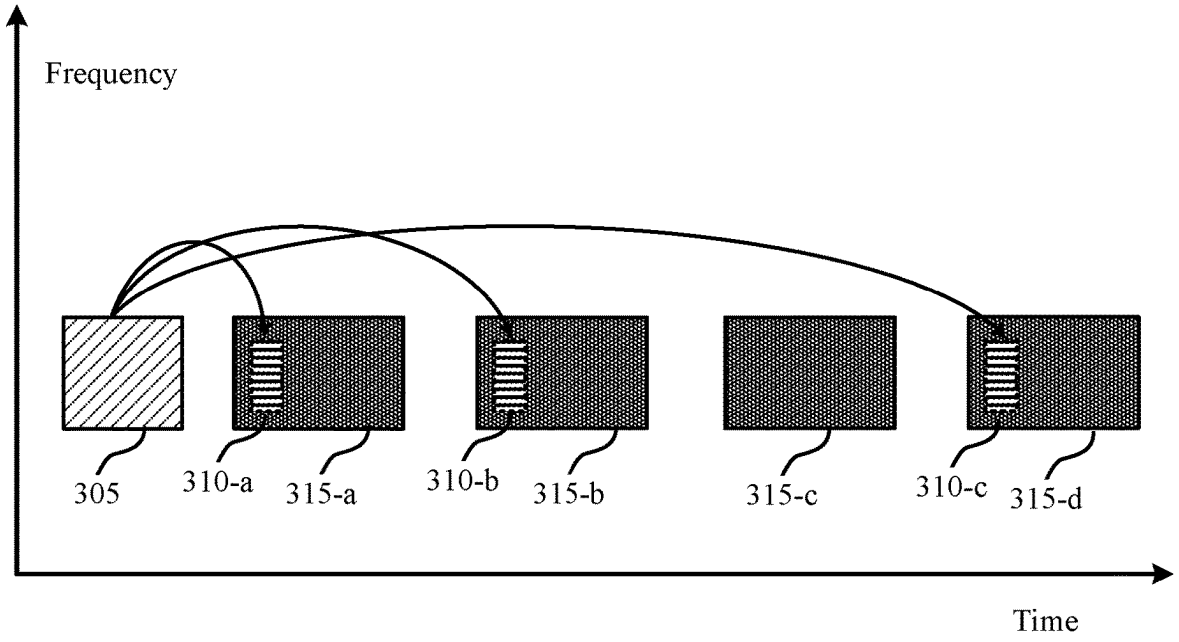
Second Downlink Control Information

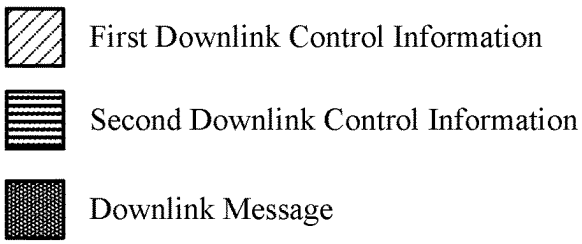
Downlink Message

Uplink Message

200

FIG. 2


Frequency
305
310-a
315-a
310-b
315-b
315-c
310-c
315-d
Time


First Downlink Control Information
Second Downlink Control Information
Downlink Message

300

FIG. 3

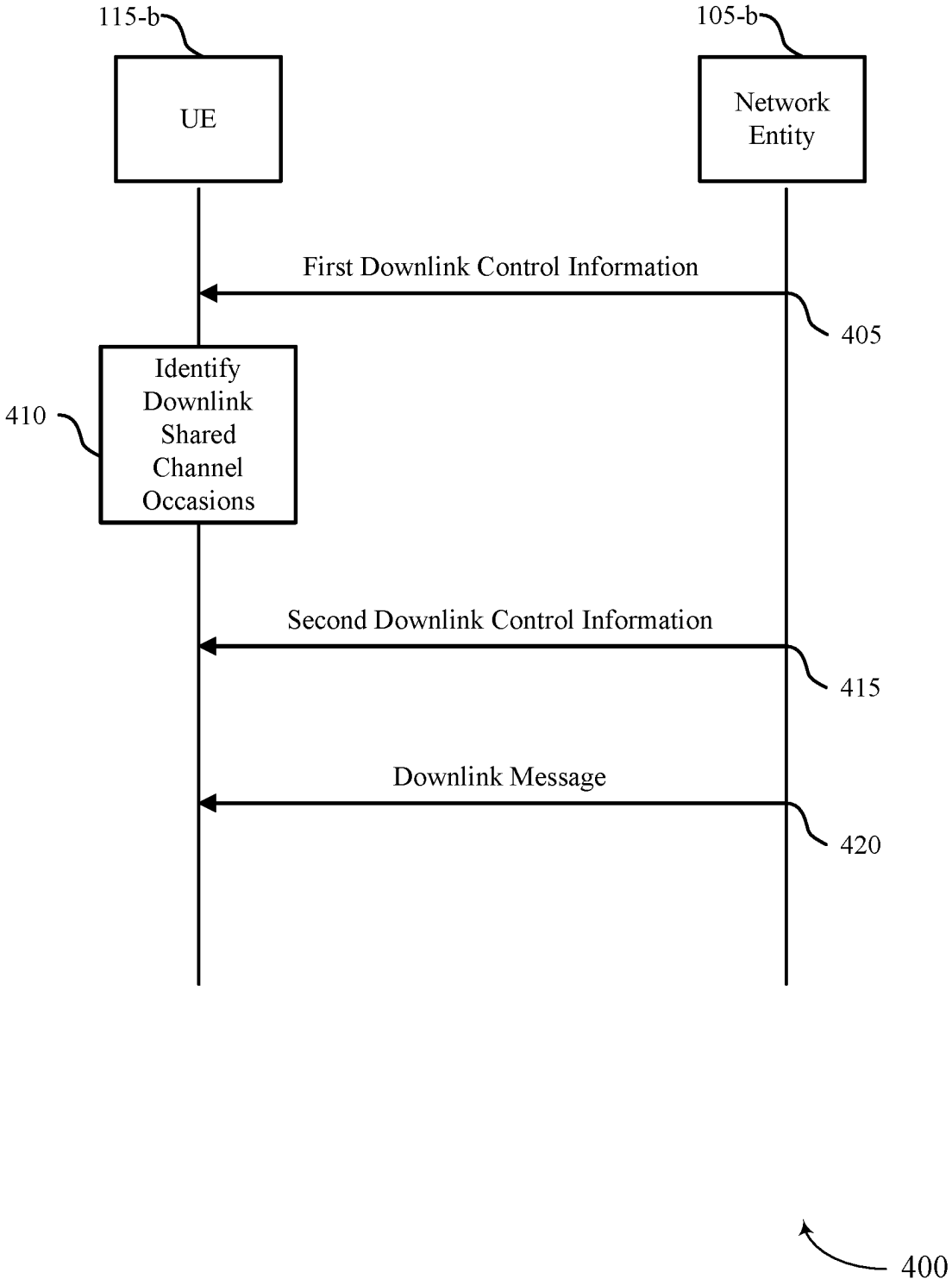

115-b
105-b
UE
Network Entity
First Downlink Control Information
405
Identify Downlink Shared Channel Occasions
410
Second Downlink Control Information
415
Downlink Message
420
400

FIG. 4

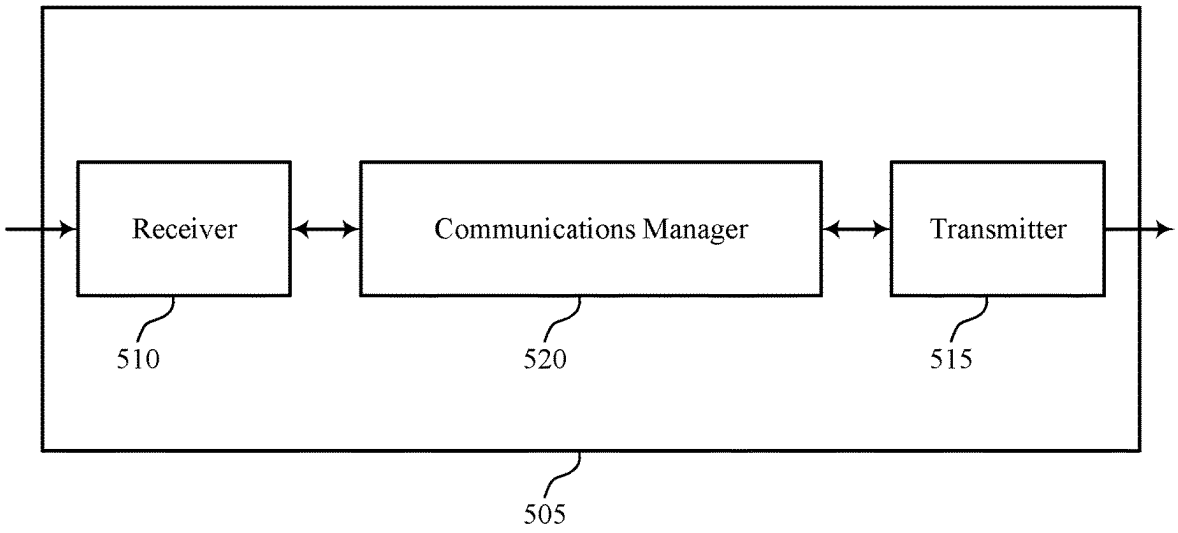

Receiver
Communications Manager
Transmitter
510
520
515
505
500

FIG. 5

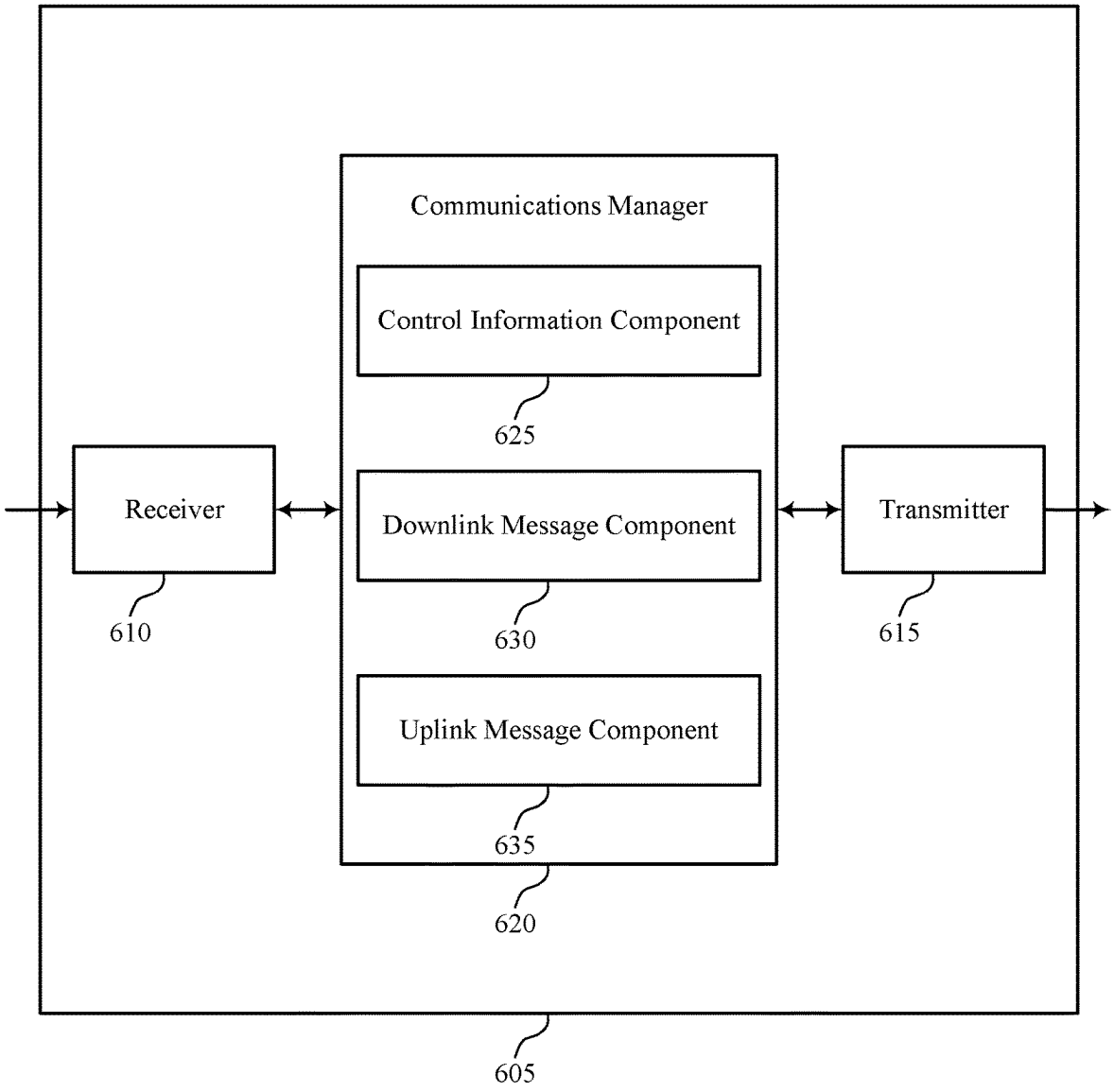

Communications Manager
Control Information Component
625
Receiver
Downlink Message Component
Transmitter
610
630
615
Uplink Message Component
635
620
605
600

FIG. 6

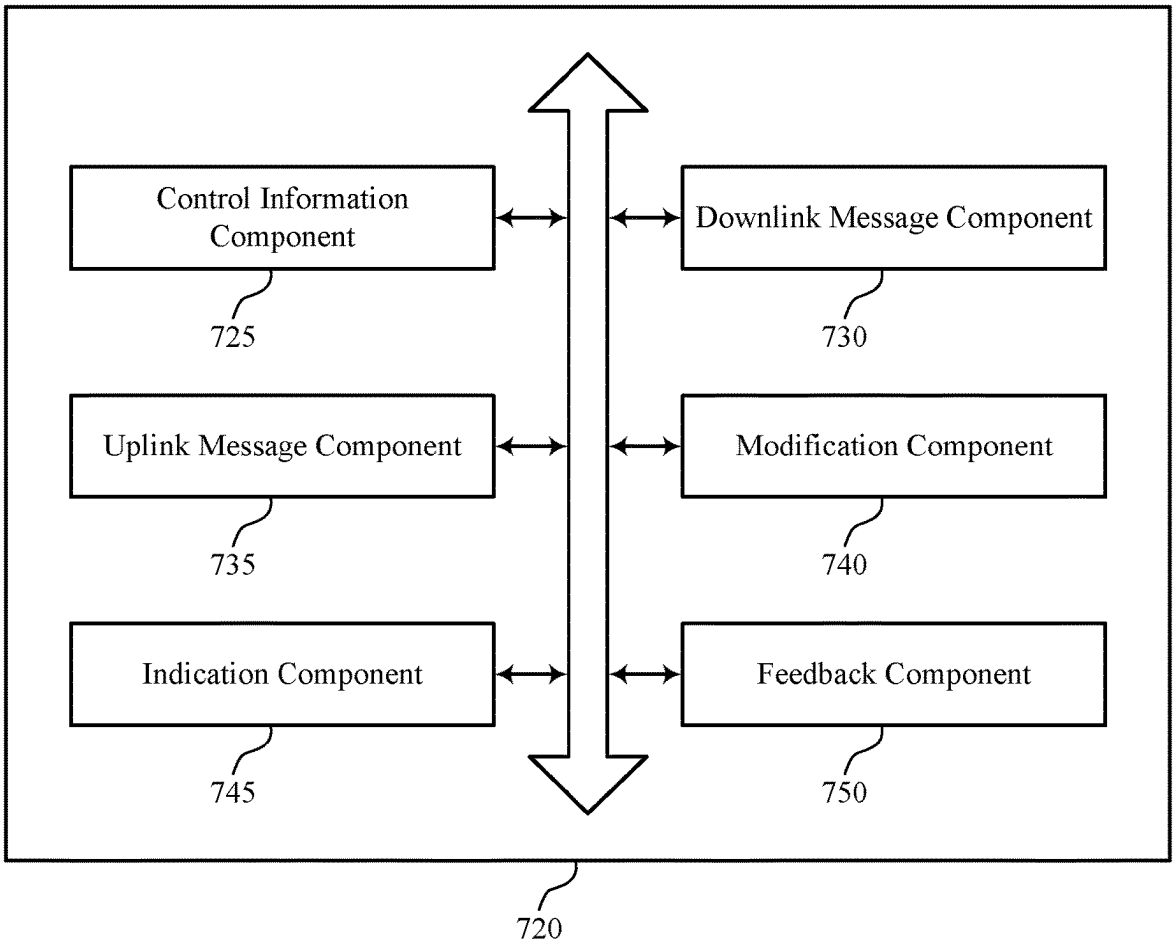

Control Information Component
725
Downlink Message Component
730
Uplink Message Component
735
Modification Component
740
Indication Component
745
Feedback Component
750
720
700

FIG. 7

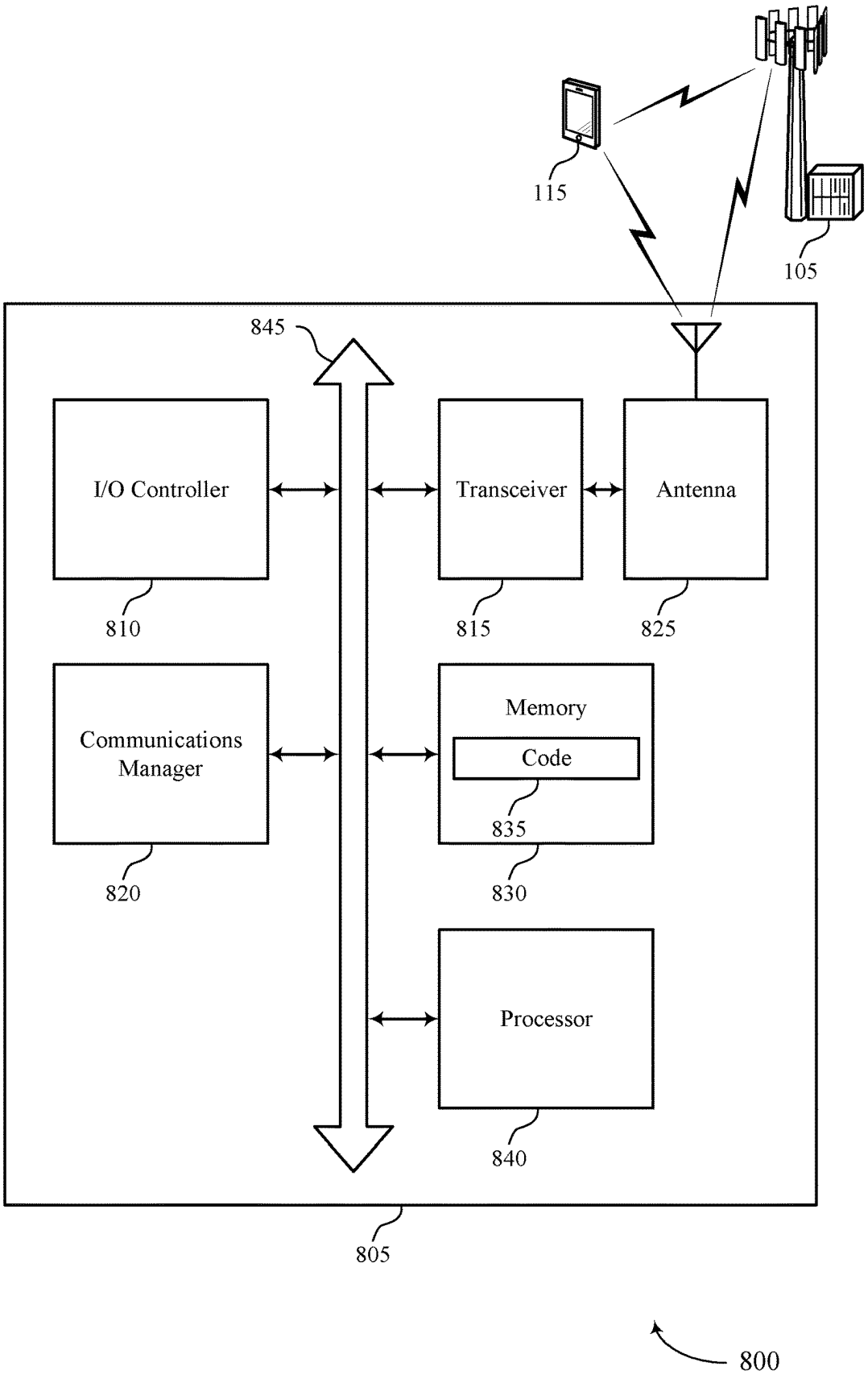

115
105
845
I/O Controller
Transceiver
Antenna
810
815
825
Communications Manager
Memory
Code
835
820
830
Processor
840
805
800

FIG. 8

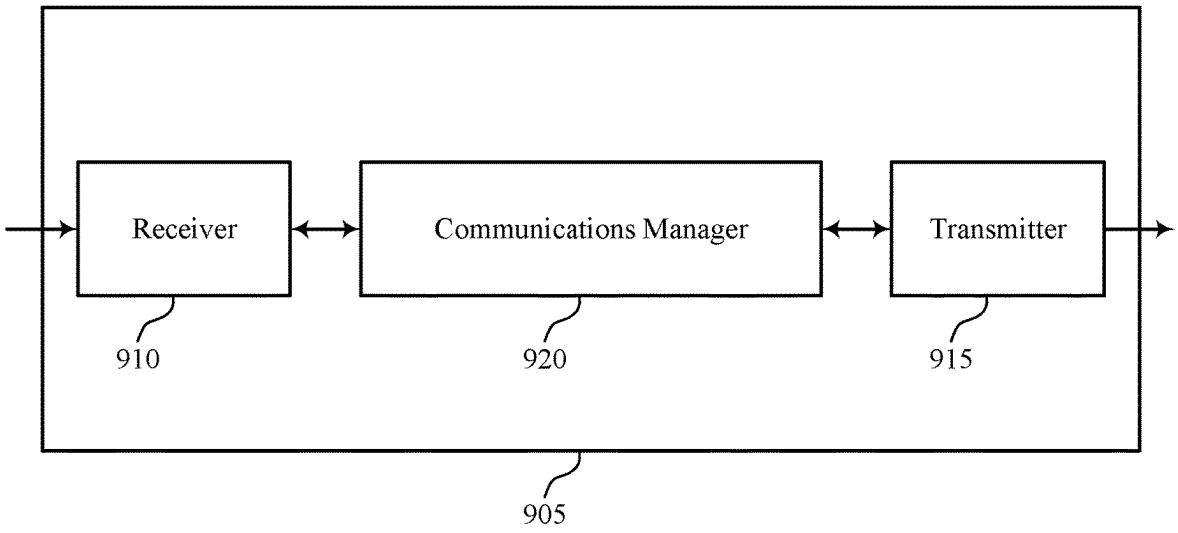

Receiver
Communications Manager
Transmitter
910
920
915
905
900

FIG. 9

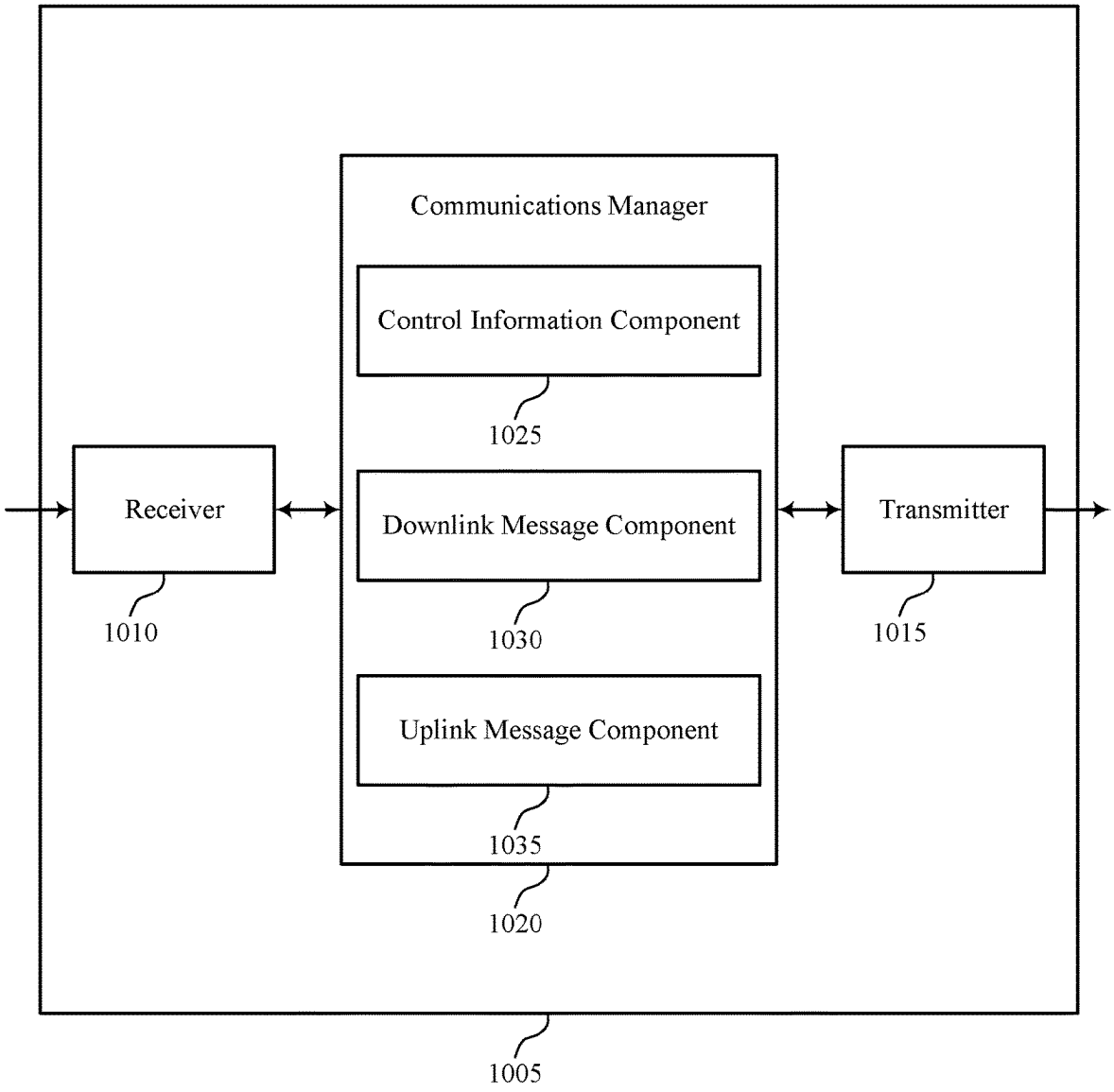

Communications Manager
Control Information Component
1025
Receiver
Downlink Message Component
Transmitter
1010
1030
1015
Uplink Message Component
1035
1020
1005
1000

FIG. 10

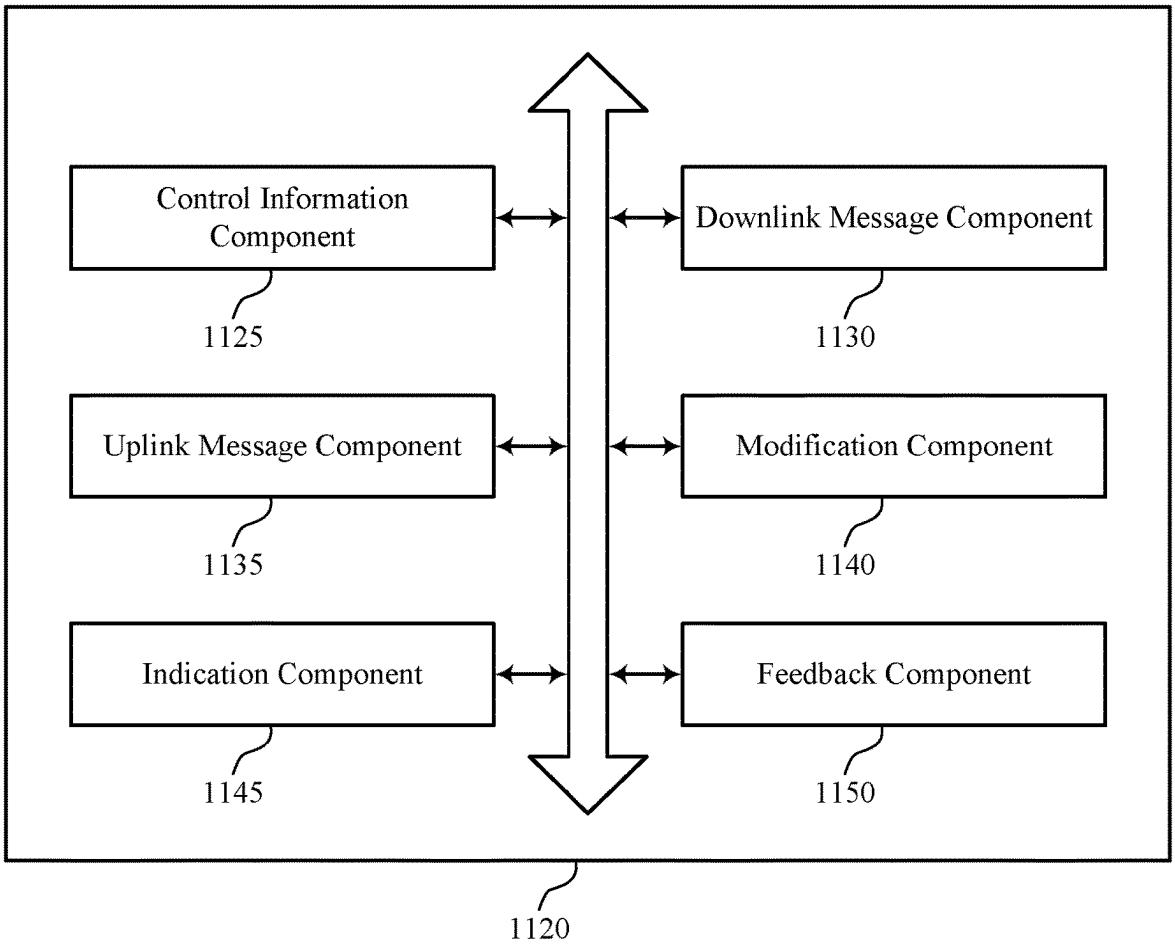

Control Information Component
1125
Downlink Message Component
1130
Uplink Message Component
1135
Modification Component
1140
Indication Component
1145
Feedback Component
1150
1120
1100

FIG. 11

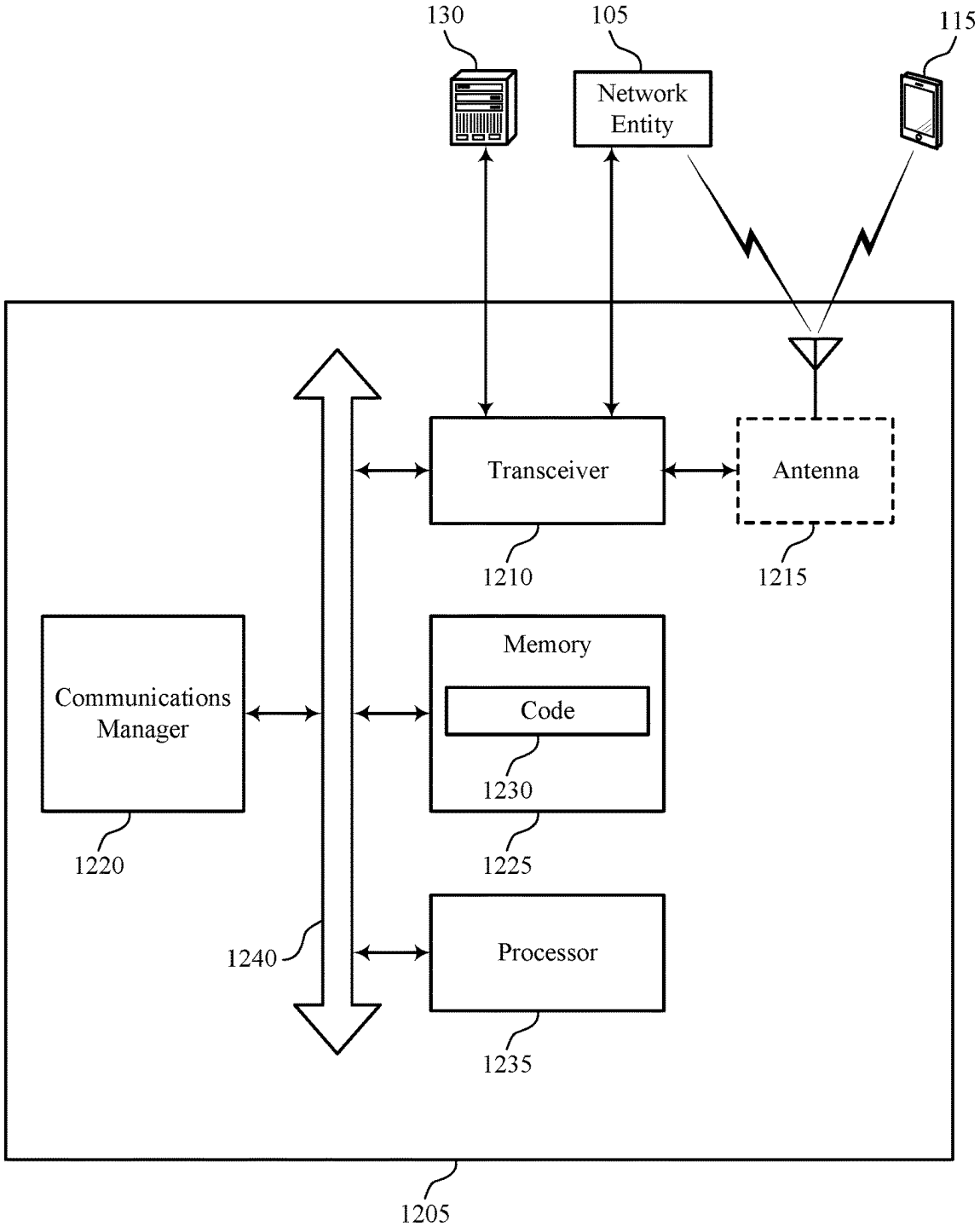

130
105
115
Network Entity
Transceiver
Antenna
1210
1215
Memory
Code
1230
Communications Manager
1220
1225
1240
Processor
1235
1205
1200

FIG. 12

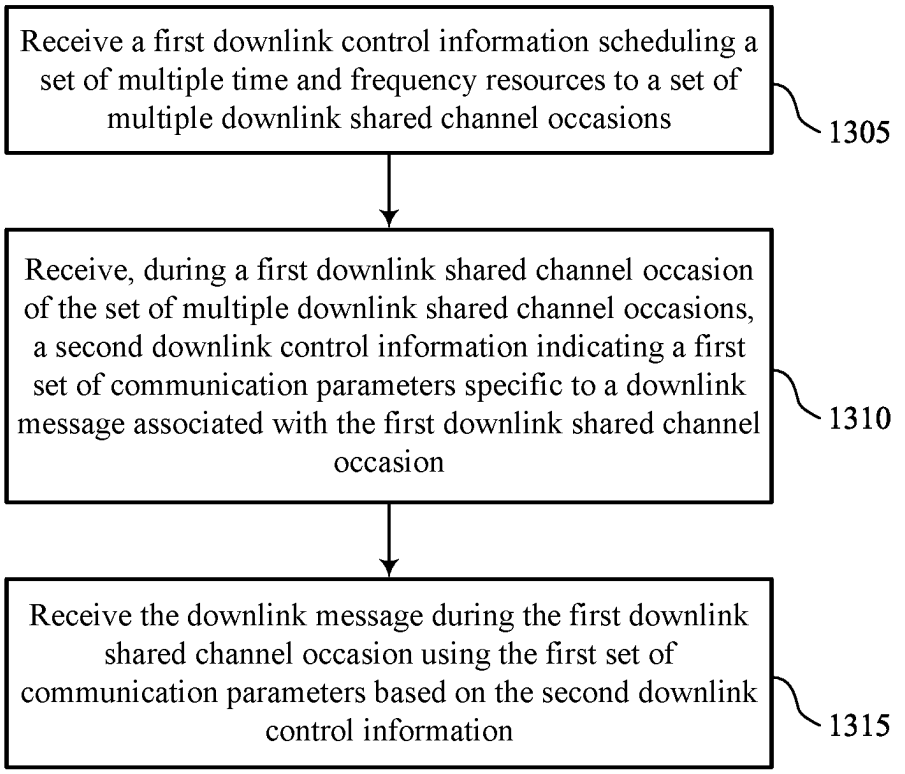

Receive a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions
1305
Receive, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion
1310
Receive the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information
1315
1300

FIG. 13

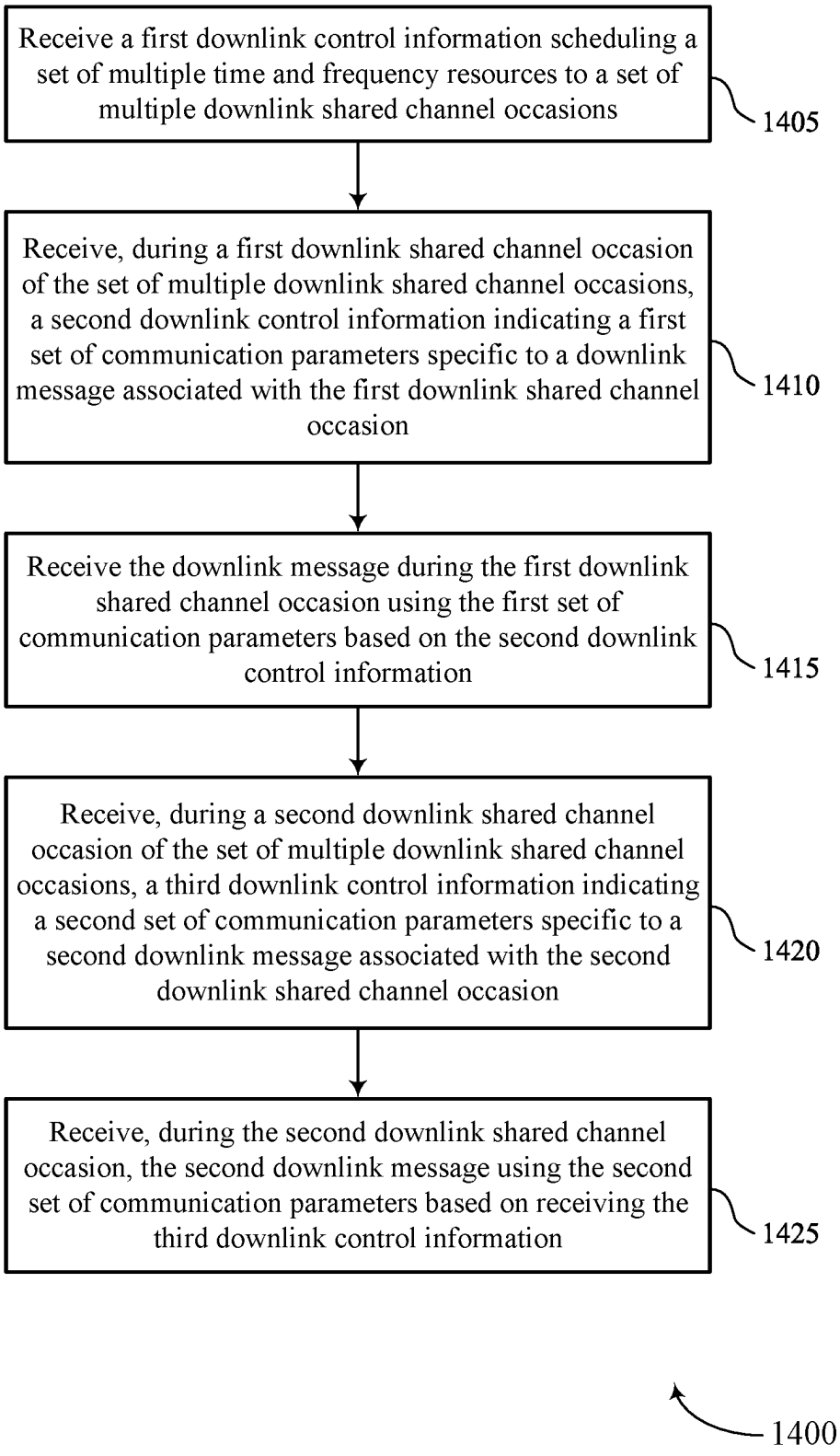

Receive a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions
1405
Receive, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion
1410
Receive the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information
1415
Receive, during a second downlink shared channel occasion of the set of multiple downlink shared channel occasions, a third downlink control information indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion
1420
Receive, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based on receiving the third downlink control information
1425
1400

FIG. 14

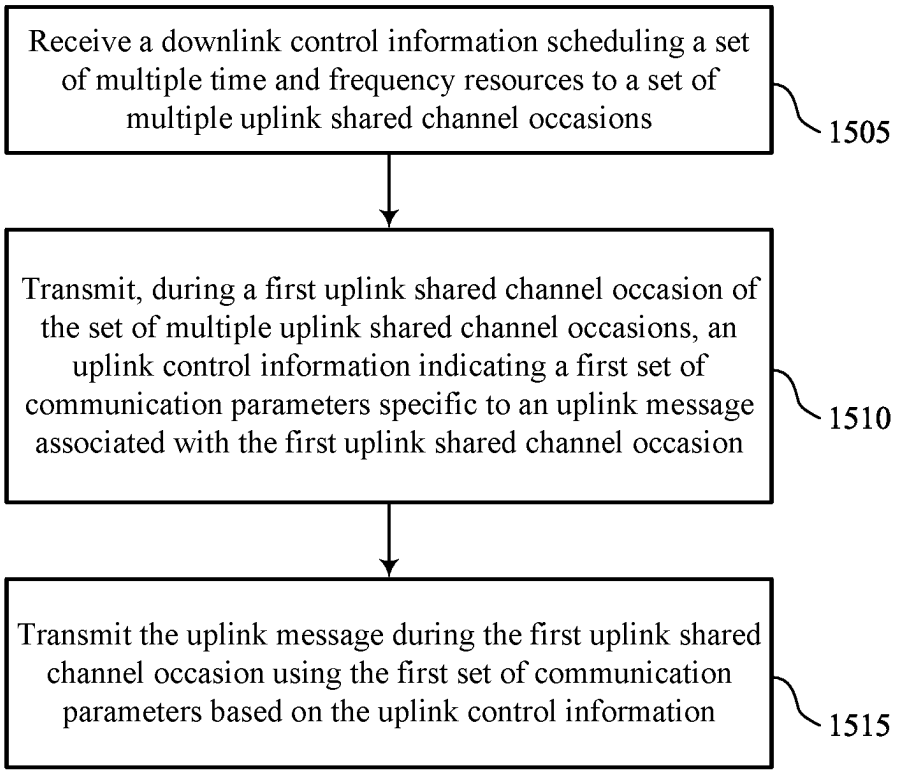

Receive a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions
1505
Transmit, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion
1510
Transmit the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information
1515
1500

FIG. 15

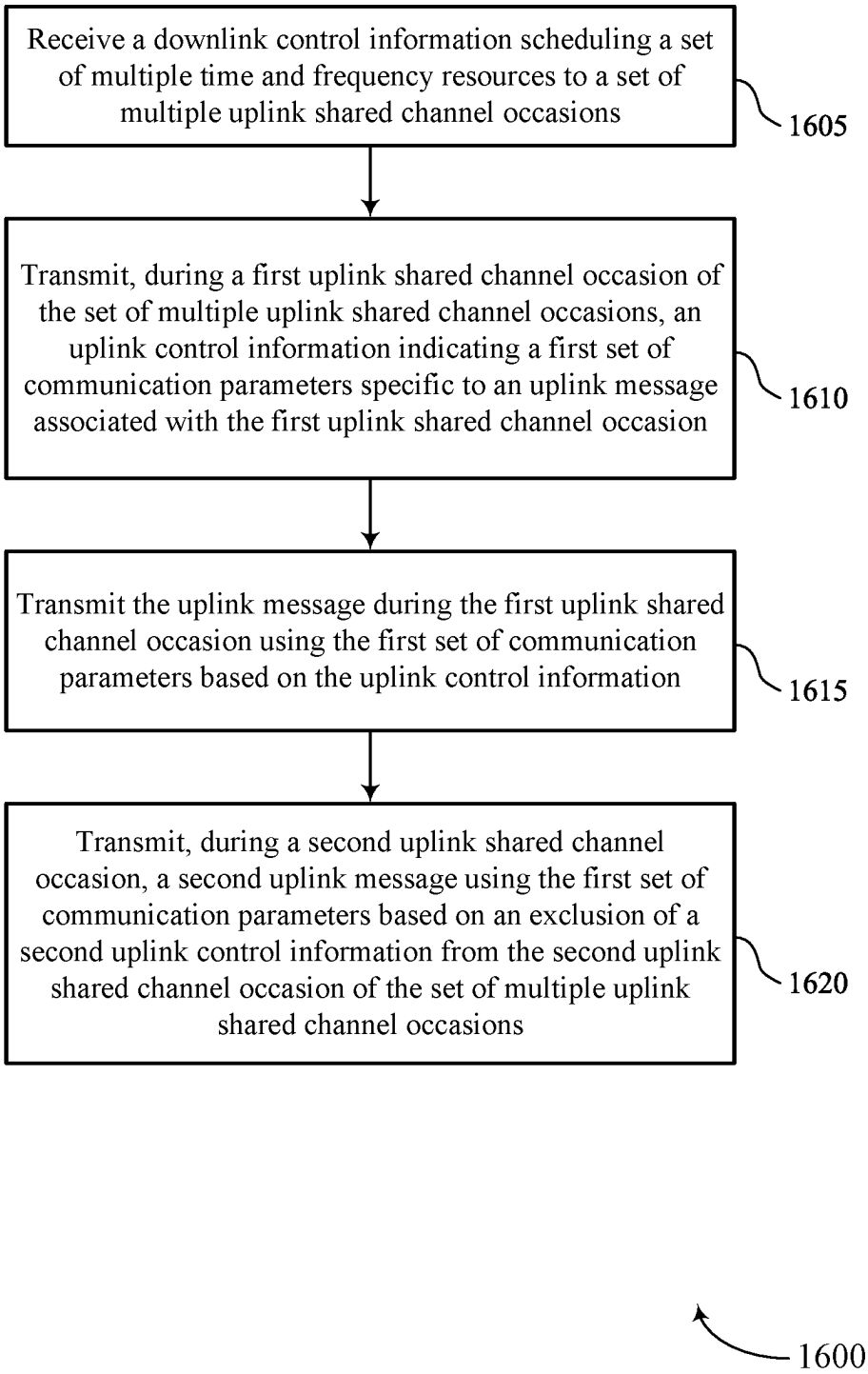

Receive a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions
1605
Transmit, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion
1610
Transmit the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information
1615
Transmit, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based on an exclusion of a second uplink control information from the second uplink shared channel occasion of the set of multiple uplink shared channel occasions
1620
1600

FIG. 16

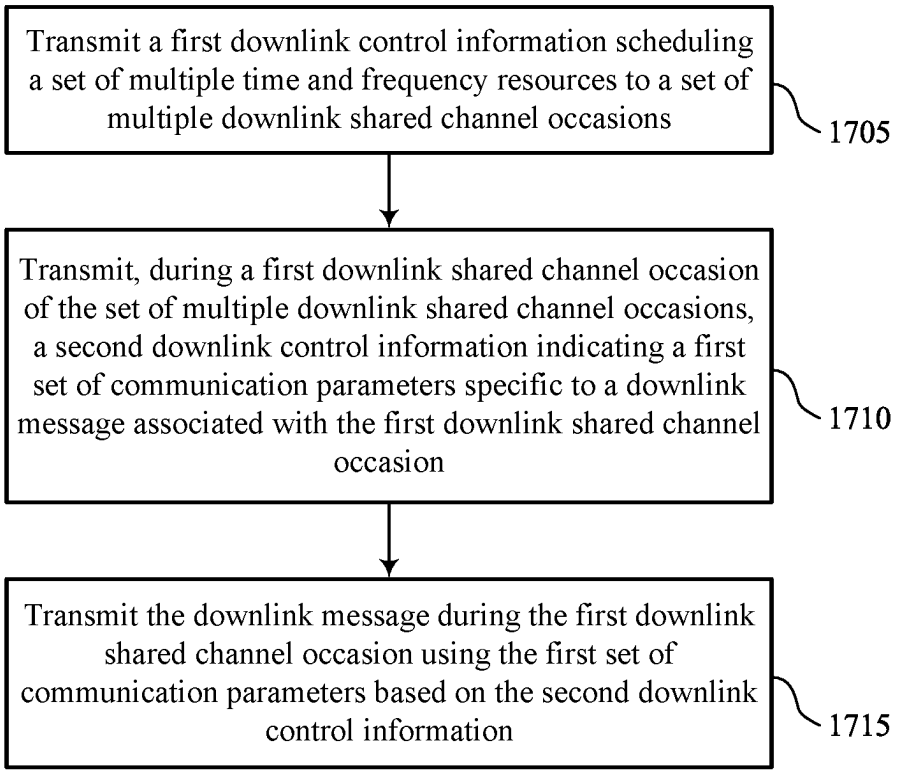

Transmit a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions
1705
Transmit, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion
1710
Transmit the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information
1715
1700

FIG. 17

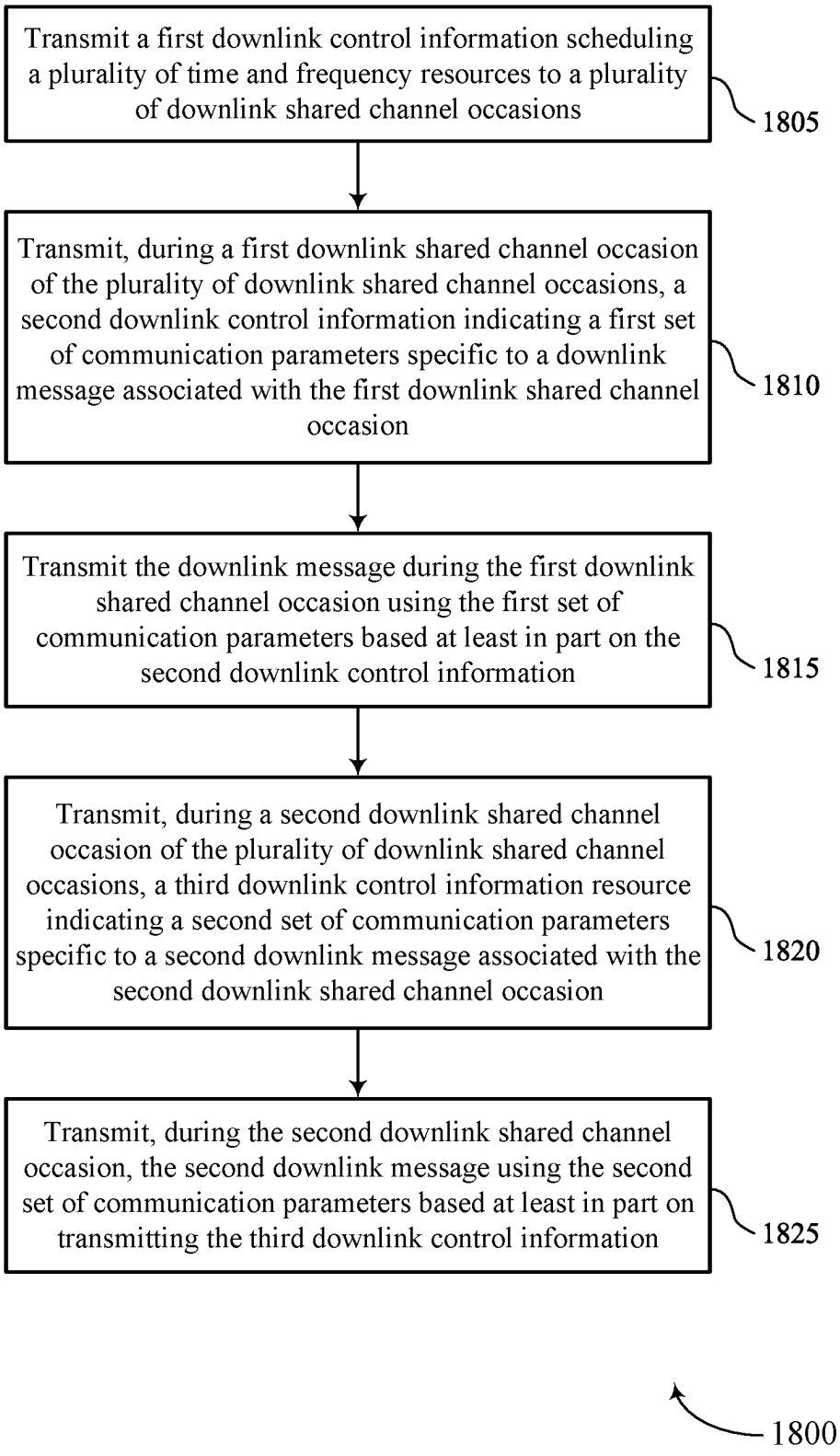

Transmit a first downlink control information scheduling a plurality of time and frequency resources to a plurality of downlink shared channel occasions
1805
Transmit, during a first downlink shared channel occasion of the plurality of downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion
1810
Transmit the downlink message during the first downlink shared channel occasion using the first set of communication parameters based at least in part on the second downlink control information
1815
Transmit, during a second downlink shared channel occasion of the plurality of downlink shared channel occasions, a third downlink control information resource indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion
1820
Transmit, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based at least in part on transmitting the third downlink control information
1825
1800

FIG. 18

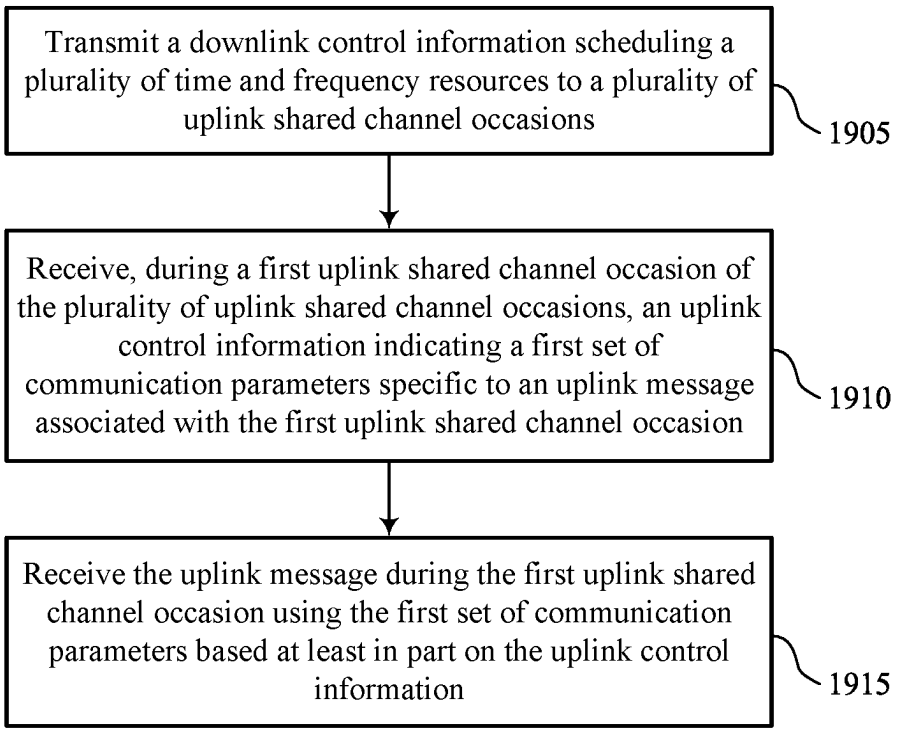

Transmit a downlink control information scheduling a plurality of time and frequency resources to a plurality of uplink shared channel occasions
1905
Receive, during a first uplink shared channel occasion of the plurality of uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion
1910
Receive the uplink message during the first uplink shared channel occasion using the first set of communication parameters based at least in part on the uplink control information
1915
1900

FIG. 19

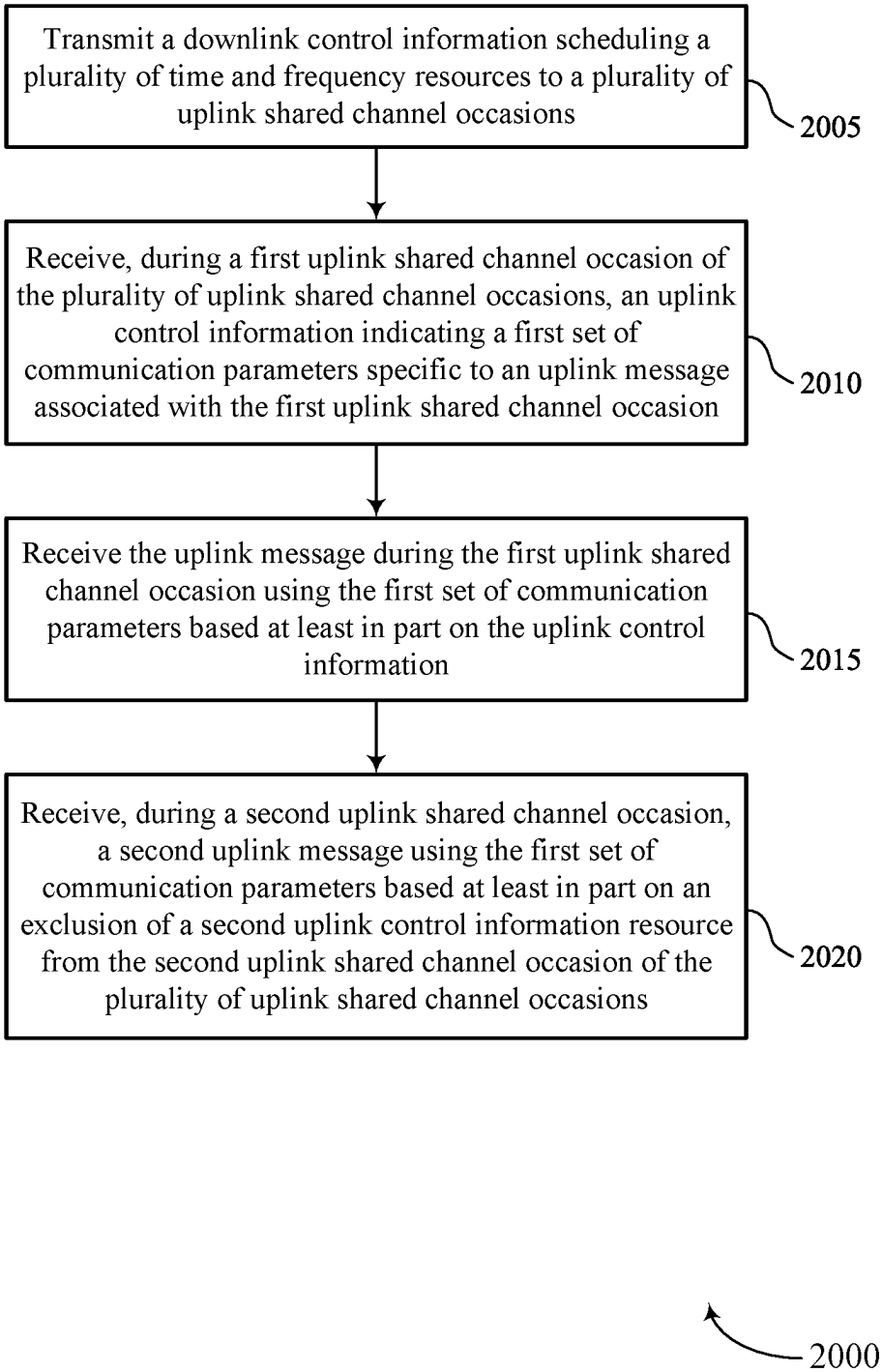

Transmit a downlink control information scheduling a plurality of time and frequency resources to a plurality of uplink shared channel occasions
2005
Receive, during a first uplink shared channel occasion of the plurality of uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion
2010
Receive the uplink message during the first uplink shared channel occasion using the first set of communication parameters based at least in part on the uplink control information
2015
Receive, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based at least in part on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the plurality of uplink shared channel occasions
2020
2000

FIG. 20

TECHNIQUES FOR SCHEDULING USING TWO-STAGE CONTROL MESSAGES

FIELD OF TECHNOLOGY

The following relates to method for wireless communication, including techniques for scheduling using two-stage control messages.

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 network entity may configure a set of downlink control channels. In some cases, however, techniques for downlink control information transmission may be improved.

SUMMARY

The described techniques relate to improved methods, systems, devices, and apparatuses that support techniques for scheduling using two-stage control messages. For example, the described techniques provide for a user equipment (UE) implementing communications in accordance with reception of a two-stage downlink control information or reception of a downlink control information followed by transmission of a companion uplink control information. Techniques depicted herein provide for a UE to use the two-stage downlink control information to receive downlink messages over multiple physical downlink shared channel occasions. The first-stage downlink control information may indicate at least the time and frequency resources of a set of subsequent physical downlink shared channel occasions or physical uplink shared channel occasions. The UE may then receive a second-stage downlink control information or may transmit uplink control information. The second-stage downlink control information (for physical downlink shared channel occasions) or the uplink control information (for physical uplink shared channel occasions) may include information that may not be common to all physical downlink shared channel occasions or physical uplink shared channel occasions. The UE may use the second-stage downlink control information or the uplink control information to receive a downlink message or transmit an uplink message.

A method for wireless communication at a user equipment (UE) is described. The method may include receiving a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions, receiving, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion, and receiving the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information message.

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 receive a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions, receive, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion, and receive the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information message.

Another apparatus for wireless communication at a UE is described. The apparatus may include means for receiving a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions, means for receiving, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion, and means for receiving the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information message.

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 receive a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions, receive, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion, and receive the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information message.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving, during the second downlink shared channel occasion, a second downlink message using the first set of communication parameters based on an exclusion of a third downlink control information resource from a second downlink shared channel occasion of the set of multiple downlink shared channel occasions.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving, during a second downlink shared channel occasion of the set of multiple downlink shared channel

occasions, a third downlink control information indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion and receiving, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based on receiving the third downlink control information.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for modifying the first set of time and frequency resources associated with the first downlink shared channel occasion in accordance with the second downlink control information, where receiving the downlink message during the first downlink shared channel occasion may be based on modifying the first set of time and frequency resources.

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 at least one of a modulation and coding scheme associated with the second downlink control information or a transmission configuration indicator associated with the second downlink control information or both, where receiving the second downlink control information may be based on the received indication.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first downlink control information includes at least one of a modulation and coding scheme associated with the second downlink control information, a feedback identifier, or a combination thereof.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first downlink control information includes an indication of at least one of precoding information associated with the set of multiple downlink shared channel occasions, a set of antenna ports associated with the set of multiple downlink shared channel occasions, a sounding reference signal request, or a combination thereof.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first downlink control information includes a first stage downlink control information and the second downlink control information includes a second stage downlink control information.

A method for wireless communication at a UE is described. The method may include receiving a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions, transmitting, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion, and transmitting the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

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 receive a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions, transmit, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion, and transmit the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

Another apparatus for wireless communication at a UE is described. The apparatus may include means for receiving a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions, means for transmitting, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion, and means for transmitting the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

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 receive a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions, transmit, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion, and transmit the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the set of multiple uplink shared channel occasions.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting, during a second uplink shared channel occasion of the set of multiple uplink shared channel occasions, a second uplink control information indicating a second set of communication parameters specific to a second uplink message associated with the second uplink shared channel occasion and transmitting, during the second uplink shared channel occasion, the second uplink message using the second set of communication parameters based on transmitting the second uplink control information.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for modifying the first set of time and frequency resources associated with the first uplink shared channel occasion in accordance with the uplink control information, where transmitting the uplink message during the first uplink shared channel occasion may be based on modifying the first set of time and frequency resources.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the uplink control information may include operations, features, means, or instructions for transmitting,

via the uplink control information, an indication of feedback information associated with one or more prior transmissions.

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 at least one of a modulation and coding scheme associated with the uplink control information or a precoding indicator associated with the uplink control information or both, where transmitting the uplink control information may be based on the received indication.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first downlink control information includes at least one of a modulation and coding scheme associated with the uplink control information, a feedback identifier, or a combination thereof.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the downlink control information includes an indication of at least one of precoding information associated with the set of multiple uplink shared channel occasions, a set of antenna ports associated with the set of multiple uplink shared channel occasions, a sounding reference signal request, or a combination thereof.

A method for wireless communication at a network entity is described. The method may include transmitting a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions, transmitting, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion, and transmitting the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information message.

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 transmit a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions, transmit, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion, and transmit the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information message.

Another apparatus for wireless communication at a network entity is described. The apparatus may include means for transmitting a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions, means for transmitting, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion, and means for transmitting the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information message.

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 transmit a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions, transmit, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion, and transmit the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information message.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting, during the second downlink shared channel occasion, a second downlink message using the first set of communication parameters based on an exclusion of a third downlink control information resource a second downlink shared channel occasion of the set of multiple downlink shared channel occasions.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting, during a second downlink shared channel occasion of the set of multiple downlink shared channel occasions, a third downlink control information indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion and transmitting, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based on transmitting the third downlink control information.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the second downlink control information may include operations, features, means, or instructions for transmitting the second downlink control information indicating a modification to a first set of time and frequency resources associated with the first downlink shared channel occasion, where the first downlink control information indicates the first set of time and frequency resources, and transmitting the downlink message during the first downlink shared channel occasion may be based on the modification to the first set of time and frequency resources.

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 of at least one of a modulation and coding scheme associated with the second downlink control information or a transmission configuration indicator associated with the second downlink control information or both, where transmitting the second downlink control information may be based on the transmitted indication.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first downlink control information includes at least one of a modulation and coding scheme associated with the second downlink control information, a feedback identifier, or a combination thereof.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first downlink control information includes an indication of

at least one of precoding information associated with the set of multiple downlink shared channel occasions, a set of antenna ports associated with the set of multiple downlink shared channel occasions, a sounding reference signal request, or a combination thereof.

A method for wireless communication at a network entity is described. The method may include transmitting a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions, receiving, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion, and receiving the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

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 transmit a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions, receive, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion, and receive the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

Another apparatus for wireless communication at a network entity is described. The apparatus may include means for transmitting a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions, means for receiving, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion, and means for receiving the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

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 transmit a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions, receive, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion, and receive the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the set of multiple uplink shared channel occasions.

Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving, during a second uplink shared channel occasion of the set of multiple uplink shared channel occasions, a second uplink control information indicating a second set of communication parameters specific to a second uplink message associated with the second uplink shared channel occasion and receiving, during the second uplink shared channel occasion, the second uplink message using the second set of communication parameters based on receiving the second uplink control information.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the uplink message may include operations, features, means, or instructions for receiving the uplink message during the first uplink shared channel occasion based on modifying a first set of time and frequency resources associated with the first uplink shared channel occasion, where the downlink control information indicates the first set of time and frequency resources.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the uplink control information may include operations, features, means, or instructions for receiving, via the uplink control information, an indication of feedback information associated with one or more prior transmissions.

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 of at least one of a modulation and coding scheme associated with the uplink control information or a precoding indicator associated with the uplink control information or both, where receiving the uplink control information may be based on the transmitted indication.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the first downlink control information includes at least one of a modulation and coding scheme associated with the uplink control information, a feedback identifier, or a combination thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an example of a wireless communications system that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIG. **2** illustrates an example of a wireless communications system that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIG. **3** illustrates an example of a communications scheme that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIG. **4** illustrates an example of a process flow that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIGS. **5** and **6** show block diagrams of devices that support techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIG. **7** shows a block diagram of a communications manager that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIG. **8** shows a diagram of a system including a device that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIGS. **9** and **10** show block diagrams of devices that support techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIG. **11** shows a block diagram of a communications manager that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIG. **12** shows a diagram of a system including a device that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

FIGS. **13** through **20** show flowcharts illustrating methods that support techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure.

DETAILED DESCRIPTION

In wireless communications systems, a network entity may transmit downlink transmissions to a user equipment (UE), and the UE may be configured with time and frequency resources for receiving the downlink transmissions. In some examples, a network entity may schedule the transmissions via a radio resource control signaling (e.g., during a radio resource control configuration period) or downlink control information, or both. The network entity may periodically transmit the downlink transmissions to the UE in accordance with the control signaling. In some examples, a UE may blindly decode a set of physical downlink control channels during a monitoring occasion to identify control information directed to the UE. A network entity, in some examples, may schedule multiple physical downlink shared channel occasions using a single transmission of downlink control information. The downlink control information may indicate communication parameters (e.g., transmit configurations) for all physical downlink shared channel occasions. However, using a single downlink control information to indicate communication parameters for multiple physical downlink shared channel occasions may lack the flexibility in scheduling for the network entity. For instance, the network entity may not be able to update communication parameters for a subsequent physical downlink shared channel occasion of a set of physical downlink shared channel occasions if that physical downlink shared channel occasion is scheduled by an earlier downlink control information scheduling the set of physical downlink shared channel occasions.

To enable scheduling flexibility, techniques depicted herein provide for a two-stage downlink control information. A UE may use the two-stage downlink control information to receive downlink messages over multiple physical downlink shared channel occasions. Additionally, or alternatively, the UE may use a downlink control information in conjunction with multiple uplink control information to transmit during multiple physical uplink shared channel occasions. The first-stage downlink control information may indicate at least the time and frequency resources of a set of subsequent physical downlink shared channel occasions or physical uplink shared channel occasions. The first-stage downlink control information may also indicate other information common to all physical downlink shared channel occasions. The network entity may include the second-stage downlink control information in a corresponding physical downlink shared channel occasion. In some examples, the UE may transmit a companion uplink control information in corresponding physical uplink shared channel occasions.

The second-stage downlink control information (for physical downlink shared channel occasions) or companion uplink control information (for physical uplink shared channel occasions) may include information that may not be common to all physical downlink shared channel occasions or physical uplink shared channel occasions. That is, the information in the second-stage downlink control information may be unique to an individual downlink shared channel occasion, or a subset of downlink shared channel occasions, to which the first-stage downlink control information applies. Additionally, or alternatively, the second-stage downlink control information (for physical downlink shared channel occasions) or companion uplink control information (for physical uplink shared channel occasions) may include information that may not be indicated in the first-stage downlink control information. In some examples, the second-stage downlink control information may indicate modulation and coding scheme for the corresponding physical downlink shared channel occasion, a feedback indicator, an indication of a change of resources, or a combination thereof. In some examples, a physical downlink shared channel occasion may not include a second-stage downlink control information. In cases where a physical downlink shared channel occasion does not include a second-stage downlink control information, the UE may use communication parameters from a prior received (the most recent) second-stage downlink control information.

UEs supporting techniques for performing communications in accordance with a two-stage downlink control information as depicted herein may utilize the techniques described herein to experience power savings and extended battery life while ensuring reliable and efficient communications. Particular aspects of the subject matter described in this disclosure may be implemented to support high reliability and enhanced flexibility in communications, among other examples. The described techniques may thus include features for improvements to power consumption, spectral efficiency, higher data rates and, in some examples, may promote efficiency for high reliability and low latency operations, among other benefits.

Aspects of the disclosure are initially described in the context of wireless communications systems. Aspects of the disclosure are further illustrated and described with reference to a communications scheme 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 techniques for scheduling using two-stage control messages.

FIG. **1** illustrates an example of a wireless communications system **100** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. 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 (L3), layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption pro-

tocol (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 (L1) (e.g., physical (PHY) layer) or L2 (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 techniques for scheduling using two-stage control messages 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) ab solute 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).

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 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**.

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 (MIME), 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**.

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.

A UE **115** may receive a first downlink control information scheduling a set of time and frequency resources to a set of downlink shared channel occasions. The UE **115** may receive, during a first downlink shared channel occasion of the set of downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The UE **115** may then receive the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

In some examples, the UE **115** may receive a downlink control information scheduling a set of time and frequency resources to a set of uplink shared channel occasions. The UE **115** may transmit, during a first uplink shared channel occasion of the set of uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The UE **115** may then transmit the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

FIG. **2** illustrates an example of a wireless communications system **200** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The wireless communications system **200** may implement or be implemented by aspects of wireless communications system **100**. For example, the wireless communications system **200** may include a UE **115**-*a* and a network entity **105**-*a*, which may be examples of corresponding devices described with reference to FIG. **1**. The UE **115**-*a* and the network entity **105**-*a* may communicate over a communication link **220**-*a* (e.g., a downlink) and a communication link **220**-*b* (e.g., an uplink), which may be examples of a communication link **125** described with reference to FIG. **1**. The UE **115**-*a* and the network entity **105**-*a* may communicate within a geographic coverage area **110**-*a* of the network entity **105**-*a*, which may be an example of a geographic coverage area **110** described with reference to FIG. **1**. In the wireless communications system **200**, the UE **115**-*a* may use a two-stage control information to communicate with the network entity **105**-*a*.

In some wireless communications, a UE may receive an indication of a set of physical downlink control channels. The UE may blindly decode possible physical downlink control channels in a monitoring occasion. When active, the UE may monitor physical downlink control channels frequently (e.g., every slot) to receive downlink control information directed towards the UE. Such a technique to blindly decode physical downlink control channel may increase power consumption at the UE (e.g., up to 40% of power may be consumed for physical downlink control channel decoding). To save UE power in physical downlink control channel monitoring, techniques depicted herein provide for reduction of the number of monitoring occasions. In some examples, a single downlink control information message may schedule multiple physical downlink shared channels or physical uplink shared channel (for subcarrier spacing 120 to 480 kHz). In cases where a single downlink control information message schedules multiple physical downlink shared channels, all physical downlink shared channels share the same transmit parameters (as indicated by the downlink control information message). Such a technique may lack the flexibility in transmit configurations.

To enable the scheduling flexibility, techniques depicted herein provide for two-stage downlink control information. In some examples, the two-stage downlink control information may be used with multiple physical downlink shared channel scheduling. In some examples, a single downlink control information message may be used with multiple uplink control information messages for physical uplink shared channel scheduling. Two-stage downlink control information may allow reduced downlink control information size that is blind decoded at the UE. In addition, two-stage downlink control information scheduling multiple physical downlink shared channel or physical uplink shared channel allows for a UE to reduce the number of monitoring occasions.

As depicted in the example of FIG. **2**, the UE **115**-*a* may receive a first-stage downlink control information **205** scheduling a set of time and frequency resources common to a set of downlink shared channel occasions. The first downlink control information may be a first-stage downlink control information message that schedules multiple downlink messages, each downlink message including a downlink control information (second-stage downlink control information messages). The UE **115**-*a* may receive, during a first downlink shared channel occasion of the set of downlink shared channel occasions, a second-stage downlink control information **210** indicating a first set of communication parameters specific to a downlink message **215** associated with the first downlink shared channel occasion. The first-stage downlink control information **205** may schedule multiple occasions for transmission of downlink messages (e.g., downlink message **215**). Additionally, or alternatively, each scheduled downlink message (e.g., physical downlink shared channel) may include a second-stage downlink control information. In some examples, the first-stage downlink control information **205** may schedule multiple occasions

for transmission of uplink messages (e.g., uplink message **230**). Additionally, or alternatively, each scheduled uplink message (e.g., physical uplink shared channel) may include a uplink control information message. The second-stage downlink control information associated with a downlink message may include transmission parameters specific to that downlink message. For example, the UE **115**-*a* may receive the downlink message **215** during the first downlink shared channel occasion using the first set of communication parameters as indicated by the second-stage downlink control information **210**.

The first-stage downlink control information **205** may indicate at least the time and frequency resources of the subsequent physical downlink shared channel or physical uplink shared channel or both. Additionally, or alternatively, the first-stage downlink control information **205** may indicate other information common to all physical downlink shared channel or physical uplink shared channel. In some examples, the first-stage downlink control information **205** may indicate information including precoding information and information about antenna ports that are common to all physical downlink shared channel or physical uplink shared channel. In some examples, the first-stage downlink control information **205** may indicate information that is not specific to a subsequent physical downlink shared channel or physical uplink shared channel. In some examples, the second-stage downlink control information **210** or a companion uplink control information message may include information that are not necessarily common to all physical downlink shared channel (e.g., downlink messages) or physical uplink shared channel (e.g., uplink messages). In some examples, the second-stage downlink control information **210** or a companion uplink control information message may include information that is not indicated in the first-stage downlink control information (e.g., modulation and coding scheme specific to the accompanied downlink message, feedback identifier or HARQ process identifier, etc.). In some examples, the second-stage downlink control information **210** or a companion uplink control information message may indicate a change of resources (e.g., reduction of resources for physical uplink shared channel, increase or reduction of resources for physical downlink shared channel, etc.). In some examples, the second-stage downlink control information **210** or a companion uplink control information message may indicate additional feedback not pertaining to the current transmission (e.g., feedback of previous transmissions).

The UE **115**-*a* may continue to use transmission parameters indicated by the second-stage downlink control information **210** unless another second-stage downlink control information (not shown) is transmitted by the network entity **105**-*a*. In some examples, the UE **115**-*a* may receive, during a second downlink shared channel occasion, a second downlink message using the first set of communication parameters based on an exclusion of a third downlink control information resource from the second downlink shared channel occasion of the set of downlink shared channel occasions. For example, if the UE **115**-*a* determines that a subsequent downlink shared channel occasion does not include a second-stage downlink control information, the UE **115**-*a* continues to use the transmission parameters indicated by the previous second-stage downlink control information (until the network entity **105**-*a* transmits a new second-stage downlink control information). In some examples, the UE **115**-*a* may receive, during a second downlink shared channel occasion of the set of downlink shared channel occasions, a third downlink control information (a new second-stage downlink control information) indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion. In such cases, the UE **115**-*a* may receive, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based on receiving the third downlink control information.

The UE **115**-*a* may use the transmit parameters indicated in the second-stage downlink control information **210** to modify the first set of time and frequency resources associated with the first downlink shared channel occasion. The UE **115**-*a* may receive the downlink message **215** during the first downlink shared channel occasion is based on modifying the first set of time and frequency resources. In some examples, the network entity **105**-*a* may transmit the second-stage downlink control information **210** or the UE **115**-*a* may transmit the uplink control information using a predefined modulation and coding scheme and in a known time-frequency resource within the allocated time and frequency resource of the physical downlink shared channel or physical uplink shared channel (as indicated in the first-stage downlink control information **205**), and using a known transmission configuration indication (for downlink) or precoding (for uplink). For example, the UE **115**-*a* may receive an indication of at least one of a modulation and coding scheme associated with the second-stage downlink control information **210** or a transmission configuration indicator associated with the second-stage downlink control information **210** or both (via the first-stage downlink control information **205**).

The UE **115**-*a* may receive the second downlink control information based on the received indication. In some examples, that actual resource for data may be changed, but the resource for second-stage downlink control information **210** or uplink control information may remain the same. In some examples, the modulation and coding scheme, time and frequency resources, and other transmit parameters for second-stage downlink control information or uplink control information may be known to the UE **115**-*a* by a configuration (transmitted by the network entity **105**-*a*) or based on pre-defined rule based on the transmit parameter of the first-stage downlink control information (or physical downlink control channel) or other channel quality indicators. In some cases, such parameters may also be predefined for the UE **115**-*a*.

FIG. **3** illustrates an example of a communications scheme **300** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The communications scheme **300** may implement or be implemented by aspects of the wireless communications system **100** or the wireless communications system **200**. For example, the communications scheme **300** may be implemented by a UE **115** or a network entity **105**, which may be examples of corresponding devices described with reference to FIGS. **1** and **2**. In the communications scheme **300**, the UE **115** may perform communications in accordance with two-stage downlink control information.

In the example of FIG. **3**, the network entity **105** may transmit a first downlink control information **305** to the UE **115**. The first downlink control information **305** may schedule a set of time and frequency resources common to a set of downlink shared channel occasions. For example, the first downlink control information **305** may schedule time and frequency resources for a set of downlink shared channel occasions **315** (including occasions **315**-*a*, **315**-*b*, **315**-*c*, and

315-*d*). In some examples, the first downlink control information **305** may include information common to all downlink shared channel occasions **315**. In some examples, the first downlink control information **305** may include at least one of precoding information associated with the set of downlink shared channel occasions **315**, a set of antenna ports associated with the set of downlink shared channel occasions **315**, a sounding reference signal request, or a combination thereof. The first downlink control information **305** may also include information related to a second downlink control information **310** (e.g., a second-stage downlink control information **310**-*a*, **310**-*b*, and **310**-*c*). In some examples, the first downlink control information **305** may include at least one of a modulation and coding scheme associated with the second downlink control information **310** or a feedback identifier (e.g., HARQ process identifier) or both.

The UE **115** may then receive a second downlink control information **310**. As depicted in the example of FIG. **3**, the UE **115** may receive the second-stage downlink control information **310**-*a* during a first downlink shared channel occasion **315**-*a* of the set of downlink shared channel occasions. The second-stage downlink control information **310**-*a* may indicate a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion **315**-*a*. For instance, the first downlink control information **305** may indicate information common to all downlink shared channel occasions **315**, and the second downlink control information **310** includes information for a downlink shared channel occasion that corresponds to the second downlink control information **310**. For example, the second downlink control information **310** may include communication parameters specific to the corresponding downlink shared channel occasion.

In some cases, if a downlink shared channel occasion does not include a second-stage downlink control information, then the UE **115** may use the communication parameters from the previous second-stage downlink control information to receive the downlink message in that downlink shared channel occasion. As depicted in the example of FIG. **3**, the UE **115** may receive a second-stage downlink control information **310**-*b* corresponding to downlink shared channel occasion **315**-*b*. In such cases, the UE **115** may use the communication parameters indicated in the second-stage downlink control information **310**-*b* to receive a downlink message in the downlink shared channel occasion **315**-*b*. The UE **115** may then receive a downlink shared channel occasion **315**-*c*, which does not include a second-stage downlink control information. The UE **115** may then use the communication parameters indicated in the second-stage downlink control information **310**-*b* to receive a downlink message in the downlink shared channel occasion **315**-*c*.

FIG. **4** illustrates an example of a process flow **400** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The process flow **400** may be implemented by one or more wireless devices, such as a UE **115**-*b*, which may be an example of a UE **115** and a network entity **105**-*b*, which may be an example of a network entity **105** as described with reference to FIG. **1**. In some examples, the process flow **400** may include one or more operations and procedures associated with the network entities **105** and UEs **115**, which may be examples of those discussed with reference to FIGS. **2** and **3**. While specific operations may be discussed below, the operations may be performed in a different order than the example order shown, or the operations performed by the devices may be performed by different devices or at different times.

At **405**, the UE **115**-*b* may receive, from a network entity **105**-*b*, a first downlink control information scheduling a set of time and frequency resources to a set of downlink shared channel occasions. In some examples, the UE **115**-*b* may receive a downlink control information scheduling a set of time and frequency resources to a set of uplink shared channel occasions. In some examples, the first downlink control information may include an indication of at least one of precoding information associated with the set of downlink shared channel occasions, a set of antenna ports associated with the set of downlink shared channel occasions, a sounding reference signal request, or a combination thereof. Additionally, or alternatively, the first downlink control information may include at least one of a modulation and coding scheme associated with the second downlink control information, a feedback identifier (e.g., HARQ process identifier), or a combination thereof.

At **410**, the UE **115**-*b* may identify a set of downlink shared channel occasions based on receiving the first downlink control information. For example, the UE **115**-*b* may identify a first downlink shared channel occasion of the set of downlink shared channel occasions. At **415**, the UE **115**-*b* may receive, during the first downlink shared channel occasion of the set of downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The first downlink control information may include a first-stage downlink control information and the second downlink control information may include a second-stage downlink control information.

At **420**, the UE **115**-*b* may receive the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

FIG. **5** shows a block diagram **500** of a device **505** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The device **505** may be an example of aspects of a UE **115** as described herein. The device **505** may include a receiver **510**, a transmitter **515**, and a communications manager **520**. The device **505** 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 **510** 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 techniques for scheduling using two-stage control messages). Information may be passed on to other components of the device **505**. The receiver **510** may utilize a single antenna or a set of multiple antennas.

The transmitter **515** may provide a means for transmitting signals generated by other components of the device **505**. For example, the transmitter **515** 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 techniques for scheduling using two-stage control messages). In some examples, the transmitter **515** may be co-located with a receiver **510** in a transceiver module. The transmitter **515** may utilize a single antenna or a set of multiple antennas.

The communications manager **520**, the receiver **510**, the transmitter **515**, or various combinations thereof or various

components thereof may be examples of means for performing various aspects of techniques for scheduling using two-stage control messages as described herein. For example, the communications manager **520**, the receiver **510**, the transmitter **515**, 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 **520**, the receiver **510**, the transmitter **515**, 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 **520**, the receiver **510**, the transmitter **515**, 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 **520**, the receiver **510**, the transmitter **515**, 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 **520** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **510**, the transmitter **515**, or both. For example, the communications manager **520** may receive information from the receiver **510**, send information to the transmitter **515**, or be integrated in combination with the receiver **510**, the transmitter **515**, or both to obtain information, output information, or perform various other operations as described herein.

The communications manager **520** may support wireless communication at a UE in accordance with examples as disclosed herein. For example, the communications manager **520** may be configured as or otherwise support a means for receiving a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. The communications manager **520** may be configured as or otherwise support a means for receiving, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The communications manager **520** may be configured as or otherwise support a means for receiving the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

Additionally, or alternatively, the communications manager **520** may support wireless communication at a UE in accordance with examples as disclosed herein. For example, the communications manager **520** may be configured as or otherwise support a means for receiving a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. The communications manager **520** may be configured as or otherwise support a means for transmitting, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The communications manager **520** may be configured as or otherwise support a means for transmitting the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

By including or configuring the communications manager **520** in accordance with examples as described herein, the device **505** (e.g., a processor controlling or otherwise coupled with the receiver **510**, the transmitter **515**, the communications manager **520**, or a combination thereof) may support techniques for reduced processing, reduced power consumption, and more efficient utilization of communication resources.

FIG. **6** shows a block diagram **600** of a device **605** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The device **605** may be an example of aspects of a device **505** or a UE **115** as described herein. The device **605** may include a receiver **610**, a transmitter **615**, and a communications manager **620**. The device **605** 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 **610** 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 techniques for scheduling using two-stage control messages). Information may be passed on to other components of the device **605**. The receiver **610** may utilize a single antenna or a set of multiple antennas.

The transmitter **615** may provide a means for transmitting signals generated by other components of the device **605**. For example, the transmitter **615** 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 techniques for scheduling using two-stage control messages). In some examples, the transmitter **615** may be co-located with a receiver **610** in a transceiver module. The transmitter **615** may utilize a single antenna or a set of multiple antennas.

The device **605**, or various components thereof, may be an example of means for performing various aspects of techniques for scheduling using two-stage control messages as described herein. For example, the communications manager **620** may include a control information component **625**, a downlink message component **630**, an uplink message component **635**, or any combination thereof. The communications manager **620** may be an example of aspects of a communications manager **520** as described herein. In some examples, the communications manager **620**, 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 **610**, the transmitter **615**, or both. For example, the

communications manager **620** may receive information from the receiver **610**, send information to the transmitter **615**, or be integrated in combination with the receiver **610**, the transmitter **615**, or both to obtain information, output information, or perform various other operations as described herein.

The communications manager **620** may support wireless communication at a UE in accordance with examples as disclosed herein. The control information component **625** may be configured as or otherwise support a means for receiving a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. The control information component **625** may be configured as or otherwise support a means for receiving, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The downlink message component **630** may be configured as or otherwise support a means for receiving the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

Additionally, or alternatively, the communications manager **620** may support wireless communication at a UE in accordance with examples as disclosed herein. The control information component **625** may be configured as or otherwise support a means for receiving a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. The control information component **625** may be configured as or otherwise support a means for transmitting, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The uplink message component **635** may be configured as or otherwise support a means for transmitting the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

FIG. **7** shows a block diagram **700** of a communications manager **720** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The communications manager **720** may be an example of aspects of a communications manager **520**, a communications manager **620**, or both, as described herein. The communications manager **720**, or various components thereof, may be an example of means for performing various aspects of techniques for scheduling using two-stage control messages as described herein. For example, the communications manager **720** may include a control information component **725**, a downlink message component **730**, an uplink message component **735**, a modification component **740**, an indication component **745**, a feedback component **750**, or any combination thereof. Each of these components may communicate, directly or indirectly, with one another (e.g., via one or more buses).

The communications manager **720** may support wireless communication at a UE in accordance with examples as disclosed herein. The control information component **725** may be configured as or otherwise support a means for receiving a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. In some examples, the control information component **725** may be configured as or otherwise support a means for receiving, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The downlink message component **730** may be configured as or otherwise support a means for receiving the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

In some examples, the downlink message component **730** may be configured as or otherwise support a means for receiving, during a second downlink shared channel occasion, a second downlink message using the first set of communication parameters based on an exclusion of a third downlink control information resource from the second downlink shared channel occasion of the set of multiple downlink shared channel occasions.

In some examples, the control information component **725** may be configured as or otherwise support a means for receiving, during a second downlink shared channel occasion of the set of multiple downlink shared channel occasions, a third downlink control information indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion. In some examples, the downlink message component **730** may be configured as or otherwise support a means for receiving, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based on receiving the third downlink control information.

In some examples, the modification component **740** may be configured as or otherwise support a means for modifying the first set of time and frequency resources associated with the first downlink shared channel occasion in accordance with the second downlink control information, where receiving the downlink message during the first downlink shared channel occasion is based on modifying the first set of time and frequency resources.

In some examples, the indication component **745** may be configured as or otherwise support a means for receiving an indication of at least one of a modulation and coding scheme associated with the second downlink control information or a transmission configuration indicator associated with the second downlink control information or both, where receiving the second downlink control information is based on the received indication.

In some examples, the first downlink control information includes at least one of a modulation and coding scheme associated with the second downlink control information, a feedback identifier, or a combination thereof. In some examples, the first downlink control information includes an indication of at least one of precoding information associated with the set of multiple downlink shared channel occasions, a set of antenna ports associated with the set of multiple downlink shared channel occasions, a sounding reference signal request, or a combination thereof.

In some examples, the first downlink control information includes a first-stage downlink control information and the second downlink control information includes a second-stage downlink control information.

Additionally, or alternatively, the communications manager **720** may support wireless communication at a UE in accordance with examples as disclosed herein. In some

examples, the control information component **725** may be configured as or otherwise support a means for receiving a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. In some examples, the control information component **725** may be configured as or otherwise support a means for transmitting, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The uplink message component **735** may be configured as or otherwise support a means for transmitting the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

In some examples, the uplink message component **735** may be configured as or otherwise support a means for transmitting, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the set of multiple uplink shared channel occasions.

In some examples, the control information component **725** may be configured as or otherwise support a means for transmitting, during a second uplink shared channel occasion of the set of multiple uplink shared channel occasions, a second uplink control information indicating a second set of communication parameters specific to a second uplink message associated with the second uplink shared channel occasion. In some examples, the uplink message component **735** may be configured as or otherwise support a means for transmitting, during the second uplink shared channel occasion, the second uplink message using the second set of communication parameters based on transmitting the second uplink control information.

In some examples, the modification component **740** may be configured as or otherwise support a means for modifying the first set of time and frequency resources associated with the first uplink shared channel occasion in accordance with the uplink control information, where transmitting the uplink message during the first uplink shared channel occasion is based on modifying the first set of time and frequency resources.

In some examples, to support transmitting the uplink control information, the feedback component **750** may be configured as or otherwise support a means for transmitting, via the uplink control information, an indication of feedback information associated with one or more prior transmissions.

In some examples, the indication component **745** may be configured as or otherwise support a means for receiving an indication of at least one of a modulation and coding scheme associated with the uplink control information or a precoding indicator associated with the uplink control information or both, where transmitting the uplink control information is based on the received indication.

In some examples, the first downlink control information includes at least one of a modulation and coding scheme associated with the uplink control information, a feedback identifier, or a combination thereof. In some examples, the downlink control information includes an indication of at least one of precoding information associated with the set of multiple uplink shared channel occasions, a set of antenna ports associated with the set of multiple uplink shared channel occasions, a sounding reference signal request, or a combination thereof.

FIG. **8** shows a diagram of a system **800** including a device **805** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The device **805** may be an example of or include the components of a device **505**, a device **605**, or a UE **115** as described herein. The device **805** may communicate (e.g., wirelessly) with one or more network entities **105**, one or more UEs **115**, or any combination thereof. The device **805** may include components for bi-directional voice and data communications including components for transmitting and receiving communications, such as a communications manager **820**, an input/output (I/O) controller **810**, a transceiver **815**, an antenna **825**, a memory **830**, code **835**, and a processor **840**. 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 **845**).

The I/O controller **810** may manage input and output signals for the device **805**. The I/O controller **810** may also manage peripherals not integrated into the device **805**. In some cases, the I/O controller **810** may represent a physical connection or port to an external peripheral. In some cases, the I/O controller **810** 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 **810** may represent or interact with a modem, a keyboard, a mouse, a touchscreen, or a similar device. In some cases, the I/O controller **810** may be implemented as part of a processor, such as the processor **840**. In some cases, a user may interact with the device **805** via the I/O controller **810** or via hardware components controlled by the I/O controller **810**.

In some cases, the device **805** may include a single antenna **825**. However, in some other cases, the device **805** may have more than one antenna **825**, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver **815** may communicate bi-directionally, via the one or more antennas **825**, wired, or wireless links as described herein. For example, the transceiver **815** may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver **815** may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas **825** for transmission, and to demodulate packets received from the one or more antennas **825**. The transceiver **815**, or the transceiver **815** and one or more antennas **825**, may be an example of a transmitter **515**, a transmitter **615**, a receiver **510**, a receiver **610**, or any combination thereof or component thereof, as described herein.

The memory **830** may include random access memory (RAM) and read-only memory (ROM). The memory **830** may store computer-readable, computer-executable code **835** including instructions that, when executed by the processor **840**, cause the device **805** to perform various functions described herein. The code **835** may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some cases, the code **835** may not be directly executable by the processor **840** but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some cases, the memory **830** 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 **840** 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 **840** 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 **840**. The processor **840** may be configured to execute computer-readable instructions stored in a memory (e.g., the memory **830**) to cause the device **805** to perform various functions (e.g., functions or tasks supporting techniques for scheduling using two-stage control messages). For example, the device **805** or a component of the device **805** may include a processor **840** and memory **830** coupled with or to the processor **840**, the processor **840** and memory **830** configured to perform various functions described herein.

The communications manager **820** may support wireless communication at a UE in accordance with examples as disclosed herein. For example, the communications manager **820** may be configured as or otherwise support a means for receiving a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. The communications manager **820** may be configured as or otherwise support a means for receiving, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The communications manager **820** may be configured as or otherwise support a means for receiving the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

Additionally, or alternatively, the communications manager **820** may support wireless communication at a UE in accordance with examples as disclosed herein. For example, the communications manager **820** may be configured as or otherwise support a means for receiving a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. The communications manager **820** may be configured as or otherwise support a means for transmitting, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The communications manager **820** may be configured as or otherwise support a means for transmitting the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

By including or configuring the communications manager **820** in accordance with examples as described herein, the device **805** may support techniques for improved communication reliability, reduced latency, improved user experience related to reduced processing, reduced power consumption, and more efficient utilization of communication resources.

In some examples, the communications manager **820** may be configured to perform various operations (e.g., receiving, monitoring, transmitting) using or otherwise in cooperation with the transceiver **815**, the one or more antennas **825**, or any combination thereof. Although the communications manager **820** is illustrated as a separate component, in some examples, one or more functions described with reference to the communications manager **820** may be supported by or performed by the processor **840**, the memory **830**, the code **835**, or any combination thereof. For example, the code **835** may include instructions executable by the processor **840** to cause the device **805** to perform various aspects of techniques for scheduling using two-stage control messages as described herein, or the processor **840** and the memory **830** may be otherwise configured to perform or support such operations.

FIG. **9** shows a block diagram **900** of a device **905** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The device **905** may be an example of aspects of a network entity **105** as described herein. The device **905** may include a receiver **910**, a transmitter **915**, and a communications manager **920**. The device **905** 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 **910** 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 **905**. In some examples, the receiver **910** may support obtaining information by receiving signals via one or more antennas. Additionally, or alternatively, the receiver **910** 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 **915** may provide a means for outputting (e.g., transmitting, providing, conveying, sending) information generated by other components of the device **905**. For example, the transmitter **915** 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 **915** may support outputting information by transmitting signals via one or more antennas. Additionally, or alternatively, the transmitter **915** 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 **915** and the receiver **910** may be co-located in a transceiver, which may include or be coupled with a modem.

The communications manager **920**, the receiver **910**, the transmitter **915**, or various combinations thereof or various components thereof may be examples of means for performing various aspects of techniques for scheduling using two-stage control messages as described herein. For example, the communications manager **920**, the receiver **910**, the transmitter **915**, 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 **920**, the receiver **910**, the transmitter **915**, 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 **920**, the receiver **910**, the transmitter **915**, 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 **920**, the receiver **910**, the transmitter **915**, 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 **920** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **910**, the transmitter **915**, or both. For example, the communications manager **920** may receive information from the receiver **910**, send information to the transmitter **915**, or be integrated in combination with the receiver **910**, the transmitter **915**, or both to obtain information, output information, or perform various other operations as described herein.

The communications manager **920** may support wireless communication at a network entity in accordance with examples as disclosed herein. For example, the communications manager **920** may be configured as or otherwise support a means for transmitting a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. The communications manager **920** may be configured as or otherwise support a means for transmitting, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The communications manager **920** may be configured as or otherwise support a means for transmitting the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

Additionally, or alternatively, the communications manager **920** may support wireless communication at a network entity in accordance with examples as disclosed herein. For example, the communications manager **920** may be configured as or otherwise support a means for transmitting a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. The communications manager **920** may be configured as or otherwise support a means for receiving, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The communications manager **920** may be configured as or otherwise support a means for receiving the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

By including or configuring the communications manager **920** in accordance with examples as described herein, the device **905** (e.g., a processor controlling or otherwise coupled with the receiver **910**, the transmitter **915**, the communications manager **920**, or a combination thereof) may support techniques for reduced processing, reduced power consumption, and more efficient utilization of communication resources.

FIG. **10** shows a block diagram **1000** of a device **1005** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The device **1005** may be an example of aspects of a device **905** or a network entity **105** as described herein. The device **1005** may include a receiver **1010**, a transmitter **1015**, and a communications manager **1020**. The device **1005** 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 **1010** 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 **1005**. In some examples, the receiver **1010** may support obtaining information by receiving signals via one or more antennas. Additionally, or alternatively, the receiver **1010** 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 **1015** may provide a means for outputting (e.g., transmitting, providing, conveying, sending) information generated by other components of the device **1005**. For example, the transmitter **1015** 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 **1015** may support outputting information by transmitting signals via one or more antennas. Additionally, or alternatively, the transmitter **1015** 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 **1015** and the receiver **1010** may be co-located in a transceiver, which may include or be coupled with a modem.

The device **1005**, or various components thereof, may be an example of means for performing various aspects of techniques for scheduling using two-stage control messages as described herein. For example, the communications manager **1020** may include a control information component **1025**, a downlink message component **1030**, an uplink message component **1035**, or any combination thereof. The communications manager **1020** may be an example of aspects of a communications manager **920** as described herein. In some examples, the communications manager **1020**, 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 **1010**, the transmitter **1015**, or both. For example, the communications manager **1020** may

receive information from the receiver **1010**, send information to the transmitter **1015**, or be integrated in combination with the receiver **1010**, the transmitter **1015**, or both to obtain information, output information, or perform various other operations as described herein.

The communications manager **1020** may support wireless communication at a network entity in accordance with examples as disclosed herein. The control information component **1025** may be configured as or otherwise support a means for transmitting a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. The control information component **1025** may be configured as or otherwise support a means for transmitting, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The downlink message component **1030** may be configured as or otherwise support a means for transmitting the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

Additionally, or alternatively, the communications manager **1020** may support wireless communication at a network entity in accordance with examples as disclosed herein. The control information component **1025** may be configured as or otherwise support a means for transmitting a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. The control information component **1025** may be configured as or otherwise support a means for receiving, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The uplink message component **1035** may be configured as or otherwise support a means for receiving the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

FIG. **11** shows a block diagram **1100** of a communications manager **1120** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The communications manager **1120** may be an example of aspects of a communications manager **920**, a communications manager **1020**, or both, as described herein. The communications manager **1120**, or various components thereof, may be an example of means for performing various aspects of techniques for scheduling using two-stage control messages as described herein. For example, the communications manager **1120** may include a control information component **1125**, a downlink message component **1130**, an uplink message component **1135**, a modification component **1140**, an indication component **1145**, a feedback component **1150**, 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.

The communications manager **1120** may support wireless communication at a network entity in accordance with examples as disclosed herein. The control information component **1125** may be configured as or otherwise support a means for transmitting a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. In some examples, the control information component **1125** may be configured as or otherwise support a means for transmitting, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The downlink message component **1130** may be configured as or otherwise support a means for transmitting the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

In some examples, the downlink message component **1130** may be configured as or otherwise support a means for transmitting, during a second downlink shared channel occasion, a second downlink message using the first set of communication parameters based on an exclusion of a third downlink control information resource from the second downlink shared channel occasion of the set of multiple downlink shared channel occasions.

In some examples, the control information component **1125** may be configured as or otherwise support a means for transmitting, during a second downlink shared channel occasion of the set of multiple downlink shared channel occasions, a third downlink control information indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion. In some examples, the downlink message component **1130** may be configured as or otherwise support a means for transmitting, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based on transmitting the third downlink control information.

In some examples, to support transmitting the second downlink control information, the modification component **1140** may be configured as or otherwise support a means for transmitting the second downlink control information indicating a modification to a first set of time and frequency resources associated with the first downlink shared channel occasion, where the first downlink control information indicates the first set of time and frequency resources, and transmitting the downlink message during the first downlink shared channel occasion is based on the modification to the first set of time and frequency resources.

In some examples, the indication component **1145** may be configured as or otherwise support a means for transmitting an indication of at least one of a modulation and coding scheme associated with the second downlink control information or a transmission configuration indicator associated with the second downlink control information or both, where transmitting the second downlink control information is based on the transmitted indication.

In some examples, the first downlink control information includes at least one of a modulation and coding scheme associated with the second downlink control information, a feedback identifier, or a combination thereof. In some

examples, the first downlink control information includes an indication of at least one of precoding information associated with the set of multiple downlink shared channel occasions, a set of antenna ports associated with the set of multiple downlink shared channel occasions, a sounding reference signal request, or a combination thereof.

Additionally, or alternatively, the communications manager **1120** may support wireless communication at a network entity in accordance with examples as disclosed herein. In some examples, the control information component **1125** may be configured as or otherwise support a means for transmitting a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. In some examples, the control information component **1125** may be configured as or otherwise support a means for receiving, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The uplink message component **1135** may be configured as or otherwise support a means for receiving the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

In some examples, the uplink message component **1135** may be configured as or otherwise support a means for receiving, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the set of multiple uplink shared channel occasions.

In some examples, the control information component **1125** may be configured as or otherwise support a means for receiving, during a second uplink shared channel occasion of the set of multiple uplink shared channel occasions, a second uplink control information indicating a second set of communication parameters specific to a second uplink message associated with the second uplink shared channel occasion. In some examples, the uplink message component **1135** may be configured as or otherwise support a means for receiving, during the second uplink shared channel occasion, the second uplink message using the second set of communication parameters based on receiving the second uplink control information.

In some examples, to support receiving the uplink message, the uplink message component **1135** may be configured as or otherwise support a means for receiving the uplink message during the first uplink shared channel occasion based on modifying a first set of time and frequency resources associated with the first uplink shared channel occasion, where the downlink control information indicates the first set of time and frequency resources.

In some examples, to support receiving the uplink control information, the feedback component **1150** may be configured as or otherwise support a means for receiving, via the uplink control information, an indication of feedback information associated with one or more prior transmissions.

In some examples, the indication component **1145** may be configured as or otherwise support a means for transmitting an indication of at least one of a modulation and coding scheme associated with the uplink control information or a precoding indicator associated with the uplink control information or both, where receiving the uplink control information is based on the transmitted indication. In some examples, the first downlink control information includes at least one of a modulation and coding scheme associated with the uplink control information, a feedback identifier, or a combination thereof.

FIG. **12** shows a diagram of a system **1200** including a device **1205** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The device **1205** may be an example of or include the components of a device **905**, a device **1005**, or a network entity **105** as described herein. The device **1205** 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 **1205** may include components that support outputting and obtaining communications, such as a communications manager **1220**, a transceiver **1210**, an antenna **1215**, a memory **1225**, code **1230**, and a processor **1235**. 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 **1240**).

The transceiver **1210** may support bi-directional communications via wired links, wireless links, or both as described herein. In some examples, the transceiver **1210** may include a wired transceiver and may communicate bi-directionally with another wired transceiver. Additionally, or alternatively, in some examples, the transceiver **1210** may include a wireless transceiver and may communicate bi-directionally with another wireless transceiver. In some examples, the device **1205** may include one or more antennas **1215**, which may be capable of transmitting or receiving wireless transmissions (e.g., concurrently). The transceiver **1210** may also include a modem to modulate signals, to provide the modulated signals for transmission (e.g., by one or more antennas **1215**, by a wired transmitter), to receive modulated signals (e.g., from one or more antennas **1215**, from a wired receiver), and to demodulate signals. In some implementations, the transceiver **1210** may include one or more interfaces, such as one or more interfaces coupled with the one or more antennas **1215** that are configured to support various receiving or obtaining operations, or one or more interfaces coupled with the one or more antennas **1215** that are configured to support various transmitting or outputting operations, or a combination thereof. In some implementations, the transceiver **1210** 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 **1210**, or the transceiver **1210** and the one or more antennas **1215**, or the transceiver **1210** and the one or more antennas **1215** and one or more processors or memory components (for example, the processor **1235**, or the memory **1225**, or both), may be included in a chip or chip assembly that is installed in the device **1205**. 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 **1225** may include RAM and ROM. The memory **1225** may store computer-readable, computer-executable code **1230** including instructions that, when executed by the processor **1235**, cause the device **1205** to perform various functions described herein. The code **1230** may be stored in a non-transitory computer-readable

medium such as system memory or another type of memory. In some cases, the code **1230** may not be directly executable by the processor **1235** but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some cases, the memory **1225** 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 **1235** 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 **1235** 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 **1235**. The processor **1235** may be configured to execute computer-readable instructions stored in a memory (e.g., the memory **1225**) to cause the device **1205** to perform various functions (e.g., functions or tasks supporting techniques for scheduling using two-stage control messages). For example, the device **1205** or a component of the device **1205** may include a processor **1235** and memory **1225** coupled with the processor **1235**, the processor **1235** and memory **1225** configured to perform various functions described herein. The processor **1235** 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 **1230**) to perform the functions of the device **1205**. The processor **1235** may be any one or more suitable processors capable of executing scripts or instructions of one or more software programs stored in the device **1205** (such as within the memory **1225**). In some implementations, the processor **1235** 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 **1205**). For example, a processing system of the device **1205** may refer to a system including the various other components or subcomponents of the device **1205**, such as the processor **1235**, or the transceiver **1210**, or the communications manager **1220**, or other components or combinations of components of the device **1205**. The processing system of the device **1205** may interface with other components of the device **1205**, 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 **1205** 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 **1205** 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 **1205** 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 **1240** may support communications of (e.g., within) a protocol layer of a protocol stack. In some examples, a bus **1240** 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 **1205**, or between different components of the device **1205** that may be co-located or located in different locations (e.g., where the device **1205** may refer to a system in which one or more of the communications manager **1220**, the transceiver **1210**, the memory **1225**, the code **1230**, and the processor **1235** may be located in one of the different components or divided between different components).

In some examples, the communications manager **1220** 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 **1220** may manage the transfer of data communications for client devices, such as one or more UEs **115**. In some examples, the communications manager **1220** 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 **1220** may support an X2 interface within an LTE/LTE-A wireless communications network technology to provide communication between network entities **105**.

The communications manager **1220** may support wireless communication at a network entity in accordance with examples as disclosed herein. For example, the communications manager **1220** may be configured as or otherwise support a means for transmitting a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. The communications manager **1220** may be configured as or otherwise support a means for transmitting, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The communications manager **1220** may be configured as or otherwise support a means for transmitting the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information.

Additionally, or alternatively, the communications manager **1220** may support wireless communication at a network entity in accordance with examples as disclosed herein. For example, the communications manager **1220** may be configured as or otherwise support a means for transmitting a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. The communications manager **1220** may be configured as or otherwise support a means for receiving, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The communications manager **1220** may be configured as or otherwise support a means for receiving the uplink message during the

first uplink shared channel occasion using the first set of communication parameters based on the uplink control information.

By including or configuring the communications manager **1220** in accordance with examples as described herein, the device **1205** 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, and improved coordination between devices.

In some examples, the communications manager **1220** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the transceiver **1210**, the one or more antennas **1215** (e.g., where applicable), or any combination thereof. Although the communications manager **1220** is illustrated as a separate component, in some examples, one or more functions described with reference to the communications manager **1220** may be supported by or performed by the transceiver **1210**, the processor **1235**, the memory **1225**, the code **1230**, or any combination thereof. For example, the code **1230** may include instructions executable by the processor **1235** to cause the device **1205** to perform various aspects of techniques for scheduling using two-stage control messages as described herein, or the processor **1235** and the memory **1225** may be otherwise configured to perform or support such operations.

FIG. **13** shows a flowchart illustrating a method **1300** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The operations of the method **1300** may be implemented by a UE or its components as described herein. For example, the operations of the method **1300** may be performed by a UE **115** as described with reference to FIGS. **1** through **8**. 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 **1305**, the method may include receiving a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. The operations of **1305** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1305** may be performed by a control information component **725** as described with reference to FIG. **7**.

At **1310**, the method may include receiving, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The operations of **1310** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1310** may be performed by a control information component **725** as described with reference to FIG. **7**.

At **1315**, the method may include receiving the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information. The operations of **1315** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1315** may be performed by a downlink message component **730** as described with reference to FIG. **7**.

FIG. **14** shows a flowchart illustrating a method **1400** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The operations of the method **1400** may be implemented by a UE or its components as described herein. For example, the operations of the method **1400** may be performed by a UE **115** as described with reference to FIGS. **1** through **8**. 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 **1405**, the method may include receiving a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. The operations of **1405** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1405** may be performed by a control information component **725** as described with reference to FIG. **7**.

At **1410**, the method may include receiving, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The operations of **1410** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1410** may be performed by a control information component **725** as described with reference to FIG. **7**.

At **1415**, the method may include receiving the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information. The operations of **1415** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1415** may be performed by a downlink message component **730** as described with reference to FIG. **7**.

At **1420**, the method may include receiving, during a second downlink shared channel occasion of the set of multiple downlink shared channel occasions, a third downlink control information indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion. The operations of **1420** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1420** may be performed by a control information component **725** as described with reference to FIG. **7**.

At **1425**, the method may include receiving, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based on receiving the third downlink control information. The operations of **1425** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1425** may be performed by a downlink message component **730** as described with reference to FIG. **7**.

FIG. **15** shows a flowchart illustrating a method **1500** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. 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 **8**. 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 receiving a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. 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 control information component **725** as described with reference to FIG. **7**.

At **1510**, the method may include transmitting, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. 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 control information component **725** as described with reference to FIG. **7**.

At **1515**, the method may include transmitting the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information. 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 an uplink message component **735** as described with reference to FIG. **7**.

FIG. **16** shows a flowchart illustrating a method **1600** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The operations of the method **1600** may be implemented by a UE or its components as described herein. For example, the operations of the method **1600** may be performed by a UE **115** as described with reference to FIGS. **1** through **8**. 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 **1605**, the method may include receiving a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. 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 control information component **725** as described with reference to FIG. **7**.

At **1610**, the method may include transmitting, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. 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 control information component **725** as described with reference to FIG. **7**.

At **1615**, the method may include transmitting the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information. 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 an uplink message component **735** as described with reference to FIG. **7**.

At **1620**, the method may include transmitting, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the set of multiple uplink shared channel occasions. The operations of **1620** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1620** may be performed by an uplink message component **735** as described with reference to FIG. **7**.

FIG. **17** shows a flowchart illustrating a method **1700** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The operations of the method **1700** may be implemented by a network entity or its components as described herein. For example, the operations of the method **1700** may be performed by a network entity as described with reference to FIGS. **1** through **4** and **9** through **12**. 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 **1705**, the method may include transmitting a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink shared channel occasions. The operations of **1705** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1705** may be performed by a control information component **1125** as described with reference to FIG. **11**.

At **1710**, the method may include transmitting, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The operations of **1710** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1710** may be performed by a control information component **1125** as described with reference to FIG. **11**.

At **1715**, the method may include transmitting the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information. The operations of **1715** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1715** may be performed by a downlink message component **1130** as described with reference to FIG. **11**.

FIG. **18** shows a flowchart illustrating a method **1800** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The operations of the method **1800** may be implemented by a network entity or its components as described herein. For example, the operations of the method **1800** may be performed by a network entity as described with reference to FIGS. **1** through **4** and **9** through **12**. 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 **1805**, the method may include transmitting a first downlink control information scheduling a set of multiple time and frequency resources to a set of multiple downlink

shared channel occasions. The operations of **1805** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1805** may be performed by a control information component **1125** as described with reference to FIG. **11**.

At **1810**, the method may include transmitting, during a first downlink shared channel occasion of the set of multiple downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion. The operations of **1810** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1810** may be performed by a control information component **1125** as described with reference to FIG. **11**.

At **1815**, the method may include transmitting the downlink message during the first downlink shared channel occasion using the first set of communication parameters based on the second downlink control information. The operations of **1815** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1815** may be performed by a downlink message component **1130** as described with reference to FIG. **11**.

At **1820**, the method may include transmitting, during a second downlink shared channel occasion of the set of multiple downlink shared channel occasions, a third downlink control information indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion. The operations of **1820** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1820** may be performed by a control information component **1125** as described with reference to FIG. **11**.

At **1825**, the method may include transmitting, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based on transmitting the third downlink control information. The operations of **1825** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1825** may be performed by a downlink message component **1130** as described with reference to FIG. **11**.

FIG. **19** shows a flowchart illustrating a method **1900** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The operations of the method **1900** may be implemented by a network entity or its components as described herein. For example, the operations of the method **1900** may be performed by a network entity as described with reference to FIGS. **1** through **4** and **9** through **12**. 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 **1905**, the method may include transmitting a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. The operations of **1905** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1905** may be performed by a control information component **1125** as described with reference to FIG. **11**.

At **1910**, the method may include receiving, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The operations of **1910** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1910** may be performed by a control information component **1125** as described with reference to FIG. **11**.

At **1915**, the method may include receiving the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information. The operations of **1915** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1915** may be performed by an uplink message component **1135** as described with reference to FIG. **11**.

FIG. **20** shows a flowchart illustrating a method **2000** that supports techniques for scheduling using two-stage control messages in accordance with one or more aspects of the present disclosure. The operations of the method **2000** may be implemented by a network entity or its components as described herein. For example, the operations of the method **2000** may be performed by a network entity as described with reference to FIGS. **1** through **4** and **9** through **12**. 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 **2005**, the method may include transmitting a downlink control information scheduling a set of multiple time and frequency resources to a set of multiple uplink shared channel occasions. The operations of **2005** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **2005** may be performed by a control information component **1125** as described with reference to FIG. **11**.

At **2010**, the method may include receiving, during a first uplink shared channel occasion of the set of multiple uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion. The operations of **2010** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **2010** may be performed by a control information component **1125** as described with reference to FIG. **11**.

At **2015**, the method may include receiving the uplink message during the first uplink shared channel occasion using the first set of communication parameters based on the uplink control information. The operations of **2015** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **2015** may be performed by an uplink message component **1135** as described with reference to FIG. **11**.

At **2020**, the method may include receiving, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the set of multiple uplink shared channel occasions. The operations of **2020** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **2020** may be performed by an uplink message component **1135** as described with reference to FIG. **11**.

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

Aspect 1: A method for wireless communication at a UE, comprising: receiving a first downlink control information scheduling a plurality of time and frequency resources to a plurality of downlink shared channel occasions; receiving, during a first downlink shared channel occasion of the plurality of downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion; and receiving the downlink message during the first downlink shared channel occasion using the first set of communication parameters based at least in part on the second downlink control information message.

Aspect 2: The method of aspect 1, further comprising: receiving, during the second downlink shared channel occasion, a second downlink message using the first set of communication parameters based at least in part on an exclusion of a third downlink control information resource from a second downlink shared channel occasion of the plurality of downlink shared channel occasions.

Aspect 3: The method of any of aspects 1 through 2, further comprising: receiving, during a second downlink shared channel occasion of the plurality of downlink shared channel occasions, a third downlink control information indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion; and receiving, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based at least in part on receiving the third downlink control information.

Aspect 4: The method of any of aspects 1 through 3, wherein the first downlink control information indicates a first set of time and frequency resources associated with the first downlink shared channel occasion, and further comprising: modifying the first set of time and frequency resources associated with the first downlink shared channel occasion in accordance with the second downlink control information, wherein receiving the downlink message during the first downlink shared channel occasion is based at least in part on modifying the first set of time and frequency resources.

Aspect 5: The method of any of aspects 1 through 4, further comprising: receiving an indication of at least one of a modulation and coding scheme associated with the second downlink control information or a transmission configuration indicator associated with the second downlink control information or both, wherein receiving the second downlink control information is based at least in part on the received indication.

Aspect 6: The method of any of aspects 1 through 5, wherein the first downlink control information comprises at least one of a modulation and coding scheme associated with the second downlink control information, a feedback identifier, or a combination thereof.

Aspect 7: The method of any of aspects 1 through 6, wherein the first downlink control information comprises an indication of at least one of precoding information associated with the plurality of downlink shared channel occasions, a set of antenna ports associated with the plurality of downlink shared channel occasions, a sounding reference signal request, or a combination thereof.

Aspect 8: The method of any of aspects 1 through 7, wherein the first downlink control information comprises a first stage downlink control information and the second downlink control information comprises a second stage downlink control information.

Aspect 9: A method for wireless communication at a UE, comprising: receiving a downlink control information scheduling a plurality of time and frequency resources to a plurality of uplink shared channel occasions; transmitting, during a first uplink shared channel occasion of the plurality of uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion; and transmitting the uplink message during the first uplink shared channel occasion using the first set of communication parameters based at least in part on the uplink control information.

Aspect 10: The method of aspect 9, further comprising: transmitting, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based at least in part on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the plurality of uplink shared channel occasions.

Aspect 11: The method of any of aspects 9 through 10, further comprising: transmitting, during a second uplink shared channel occasion of the plurality of uplink shared channel occasions, a second uplink control information indicating a second set of communication parameters specific to a second uplink message associated with the second uplink shared channel occasion; and transmitting, during the second uplink shared channel occasion, the second uplink message using the second set of communication parameters based at least in part on transmitting the second uplink control information.

Aspect 12: The method of any of aspects 9 through 11, wherein the downlink control information indicates a first set of time and frequency resources associated with the first uplink shared channel occasion, and further comprising: modifying the first set of time and frequency resources associated with the first uplink shared channel occasion in accordance with the uplink control information, wherein transmitting the uplink message during the first uplink shared channel occasion is based at least in part on modifying the first set of time and frequency resources.

Aspect 13: The method of any of aspects 9 through 12, wherein transmitting the uplink control information further comprises: transmitting, via the uplink control information, an indication of feedback information associated with one or more prior transmissions.

Aspect 14: The method of any of aspects 9 through 13, further comprising: receiving an indication of at least one of a modulation and coding scheme associated with the uplink control information or a precoding indicator associated with the uplink control information or both, wherein transmitting the uplink control information is based at least in part on the received indication.

Aspect 15: The method of any of aspects 9 through 14, wherein the first downlink control information comprises at least one of a modulation and coding scheme

associated with the uplink control information, a feedback identifier, or a combination thereof.

Aspect 16: The method of any of aspects 9 through 15, wherein the downlink control information comprises an indication of at least one of precoding information associated with the plurality of uplink shared channel occasions, a set of antenna ports associated with the plurality of uplink shared channel occasions, a sounding reference signal request, or a combination thereof.

Aspect 17: A method for wireless communication at a network entity, comprising: transmitting a first downlink control information scheduling a plurality of time and frequency resources to a plurality of downlink shared channel occasions; transmitting, during a first downlink shared channel occasion of the plurality of downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion; and transmitting the downlink message during the first downlink shared channel occasion using the first set of communication parameters based at least in part on the second downlink control information message.

Aspect 18: The method of aspect 17, further comprising: transmitting, during the second downlink shared channel occasion, a second downlink message using the first set of communication parameters based at least in part on an exclusion of a third downlink control information resource from a second downlink shared channel occasion of the plurality of downlink shared channel occasions.

Aspect 19: The method of any of aspects 17 through 18, further comprising: transmitting, during a second downlink shared channel occasion of the plurality of downlink shared channel occasions, a third downlink control information indicating a second set of communication parameters specific to a second downlink message associated with the second downlink shared channel occasion; and transmitting, during the second downlink shared channel occasion, the second downlink message using the second set of communication parameters based at least in part on transmitting the third downlink control information.

Aspect 20: The method of any of aspects 17 through 19, wherein transmitting the second downlink control information comprises: transmitting the second downlink control information indicating a modification to a first set of time and frequency resources associated with the first downlink shared channel occasion, wherein the first downlink control information indicates the first set of time and frequency resources, and transmitting the downlink message during the first downlink shared channel occasion is based at least in part on the modification to the first set of time and frequency resources.

Aspect 21: The method of any of aspects 17 through 20, further comprising: transmitting an indication of at least one of a modulation and coding scheme associated with the second downlink control information or a transmission configuration indicator associated with the second downlink control information or both, wherein transmitting the second downlink control information is based at least in part on the transmitted indication.

Aspect 22: The method of any of aspects 17 through 21, wherein the first downlink control information comprises at least one of a modulation and coding scheme associated with the second downlink control information, a feedback identifier, or a combination thereof.

Aspect 23: The method of any of aspects 17 through 22, wherein the first downlink control information comprises an indication of at least one of precoding information associated with the plurality of downlink shared channel occasions, a set of antenna ports associated with the plurality of downlink shared channel occasions, a sounding reference signal request, or a combination thereof.

Aspect 24: A method for wireless communication at a network entity, comprising: transmitting a downlink control information scheduling a plurality of time and frequency resources to a plurality of uplink shared channel occasions; receiving, during a first uplink shared channel occasion of the plurality of uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion; and receiving the uplink message during the first uplink shared channel occasion using the first set of communication parameters based at least in part on the uplink control information.

Aspect 25: The method of aspect 24, further comprising: receiving, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based at least in part on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the plurality of uplink shared channel occasions.

Aspect 26: The method of any of aspects 24 through 25, further comprising: receiving, during a second uplink shared channel occasion of the plurality of uplink shared channel occasions, a second uplink control information indicating a second set of communication parameters specific to a second uplink message associated with the second uplink shared channel occasion; and receiving, during the second uplink shared channel occasion, the second uplink message using the second set of communication parameters based at least in part on receiving the second uplink control information.

Aspect 27: The method of any of aspects 24 through 26, wherein receiving the uplink message further comprises: receiving the uplink message during the first uplink shared channel occasion based at least in part on modifying a first set of time and frequency resources associated with the first uplink shared channel occasion, wherein the downlink control information indicates the first set of time and frequency resources.

Aspect 28: The method of any of aspects 24 through 27, wherein receiving the uplink control information further comprises: receiving, via the uplink control information, an indication of feedback information associated with one or more prior transmissions.

Aspect 29: The method of any of aspects 24 through 28, further comprising: transmitting an indication of at least one of a modulation and coding scheme associated with the uplink control information or a precoding indicator associated with the uplink control information or both, wherein receiving the uplink control information is based at least in part on the transmitted indication.

Aspect 30: The method of any of aspects 24 through 29, wherein the first downlink control information comprises at least one of a modulation and coding scheme

associated with the uplink control information, a feedback identifier, or a combination thereof.

Aspect 31: 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 8.

Aspect 32: An apparatus for wireless communication at a UE, comprising at least one means for performing a method of any of aspects 1 through 8.

Aspect 33: 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 8.

Aspect 34: 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 9 through 16.

Aspect 35: An apparatus for wireless communication at a UE, comprising at least one means for performing a method of any of aspects 9 through 16.

Aspect 36: 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 9 through 16.

Aspect 37: 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 17 through 23.

Aspect 38: An apparatus for wireless communication at a network entity, comprising at least one means for performing a method of any of aspects 17 through 23.

Aspect 39: 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 17 through 23.

Aspect 40: 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 24 through 30.

Aspect 41: An apparatus for wireless communication at a network entity, comprising at least one means for performing a method of any of aspects 24 through 30.

Aspect 42: 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 24 through 30.

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 magneti-

cally, 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:

receive a first downlink control information scheduling a plurality of time and frequency resources to a plurality of downlink shared channel occasions;

receive, during a first downlink shared channel occasion of the plurality of downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion;

receive the downlink message during the first downlink shared channel occasion using the first set of communication parameters based at least in part on the second downlink control information; and

receive, during a second downlink shared channel occasion, a second downlink message using the first set of communication parameters based at least in part on an exclusion of a third downlink control information resource from the second downlink shared channel occasion of the plurality of downlink shared channel occasions.

2. The apparatus of claim **1**, wherein the first downlink control information indicates a first set of time and frequency resources associated with the first downlink shared channel occasion, and wherein the instructions are further executable by the processor to cause the apparatus to:

modify the first set of time and frequency resources associated with the first downlink shared channel occasion in accordance with the second downlink control information, wherein receiving the downlink message during the first downlink shared channel occasion is based at least in part on modifying the first set of time and frequency resources.

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

receive an indication of at least one of a modulation and coding scheme associated with the second downlink control information or a transmission configuration indicator associated with the second downlink control information or both, wherein receiving the second downlink control information is based at least in part on the received indication.

4. The apparatus of claim **1**, wherein the first downlink control information comprises at least one of a modulation and coding scheme associated with the second downlink control information, a feedback identifier, or a combination thereof.

5. The apparatus of claim **1**, wherein the first downlink control information comprises an indication of at least one of precoding information associated with the plurality of downlink shared channel occasions, a set of antenna ports associated with the plurality of downlink shared channel occasions, a sounding reference signal request, or a combination thereof.

6. The apparatus of claim **1**, wherein the first downlink control information comprises a first-stage downlink control information and the second downlink control information comprises a second-stage downlink control information.

7. 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:

receive a downlink control information scheduling a plurality of time and frequency resources to a plurality of uplink shared channel occasions;

transmit, during a first uplink shared channel occasion of the plurality of uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion;

transmit the uplink message during the first uplink shared channel occasion using the first set of communication parameters based at least in part on the uplink control information; and

transmit, during a second uplink shared channel occasion, a second uplink message using the first set of communication parameters based at least in part on an exclusion of a second uplink control information resource from the second uplink shared channel occasion of the plurality of uplink shared channel occasions.

8. The apparatus of claim **7**, wherein the instructions are further executable by the processor to cause the apparatus to:

transmit, during a second uplink shared channel occasion of the plurality of uplink shared channel occasions, a second uplink control information indicating a second set of communication parameters specific to a second uplink message associated with the second uplink shared channel occasion; and

transmit, during the second uplink shared channel occasion, the second uplink message using the second set of communication parameters based at least in part on transmitting the second uplink control information.

9. The apparatus of claim **7**, wherein the instructions to transmit the uplink control information are further executable by the processor to cause the apparatus to:

transmit, via the uplink control information, an indication of feedback information associated with one or more prior transmissions.

10. The apparatus of claim **7**, wherein the instructions are further executable by the processor to cause the apparatus to:

receive an indication of at least one of a modulation and coding scheme associated with the uplink control information or a precoding indicator associated with the uplink control information or both, wherein transmitting the uplink control information is based at least in part on the received indication.

11. The apparatus of claim **7**, wherein the first downlink control information comprises at least one of a modulation and coding scheme associated with the uplink control information, a feedback identifier, or a combination thereof.

12. The apparatus of claim **7**, wherein the downlink control information comprises an indication of at least one of precoding information associated with the plurality of uplink shared channel occasions, a set of antenna ports associated with the plurality of uplink shared channel occasions, a sounding reference signal request, or a combination thereof.

13. 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:

receive a first downlink control information scheduling a plurality of time and frequency resources to a plurality of downlink shared channel occasions;

receive, during a first downlink shared channel occasion of the plurality of downlink shared channel occasions, a second downlink control information indicating a first set of communication parameters specific to a downlink message associated with the first downlink shared channel occasion;

receive the downlink message during the first downlink shared channel occasion using the first set of communication parameters based at least in part on the second downlink control information; and

receive, during a second downlink shared channel occasion, a second downlink message using the first set of communication parameters based at least in part on an exclusion of a third downlink control information resource from the second downlink shared channel occasion of the plurality of downlink shared channel occasions.

14. 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:

receive a downlink control information scheduling a plurality of time and frequency resources to a plurality of uplink shared channel occasions;

transmit, during a first uplink shared channel occasion of the plurality of uplink shared channel occasions, an uplink control information indicating a first set of communication parameters specific to an uplink message associated with the first uplink shared channel occasion;

transmit the uplink message during the first uplink shared channel occasion using the first set of communication parameters based at least in part on the uplink control information; and

wherein the downlink control information indicates a first set of time and frequency resources associated with the first uplink shared channel occasion, and wherein the instructions are further executable by the processor to cause the apparatus to:

modify the first set of time and frequency resources associated with the first uplink shared channel occasion in accordance with the uplink control information, wherein transmitting the uplink message during the first uplink shared channel occasion is based at least in part on modifying the first set of time and frequency resources.

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