US012395999B2

(12) **United States Patent**
Khoshnevisan et al.

(10) **Patent No.: US 12,395,999 B2**
(45) **Date of Patent: Aug. 19, 2025**

(54) **COMMON MESSAGE SPLIT INDICATORS FOR RATE- SPLITTING MIMO**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 618 days.

(21) Appl. No.: **17/809,264**

(22) Filed: **Jun. 27, 2022**

(65) **Prior Publication Data**

US 2023/0422254 A1 Dec. 28, 2023

(51) **Int. Cl.**

H04W 72/23	(2023.01)
H04B 7/06	(2006.01)
H04L 1/00	(2006.01)
H04W 72/1263	(2023.01)

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

CPC ***H04W 72/23*** (2023.01); ***H04B 7/0639*** (2013.01); ***H04L 1/0047*** (2013.01); ***H04L 1/0061*** (2013.01); ***H04W 72/1263*** (2013.01)

(58) **Field of Classification Search**

CPC H04W 76/25; H04W 72/23

See application file for complete search history.

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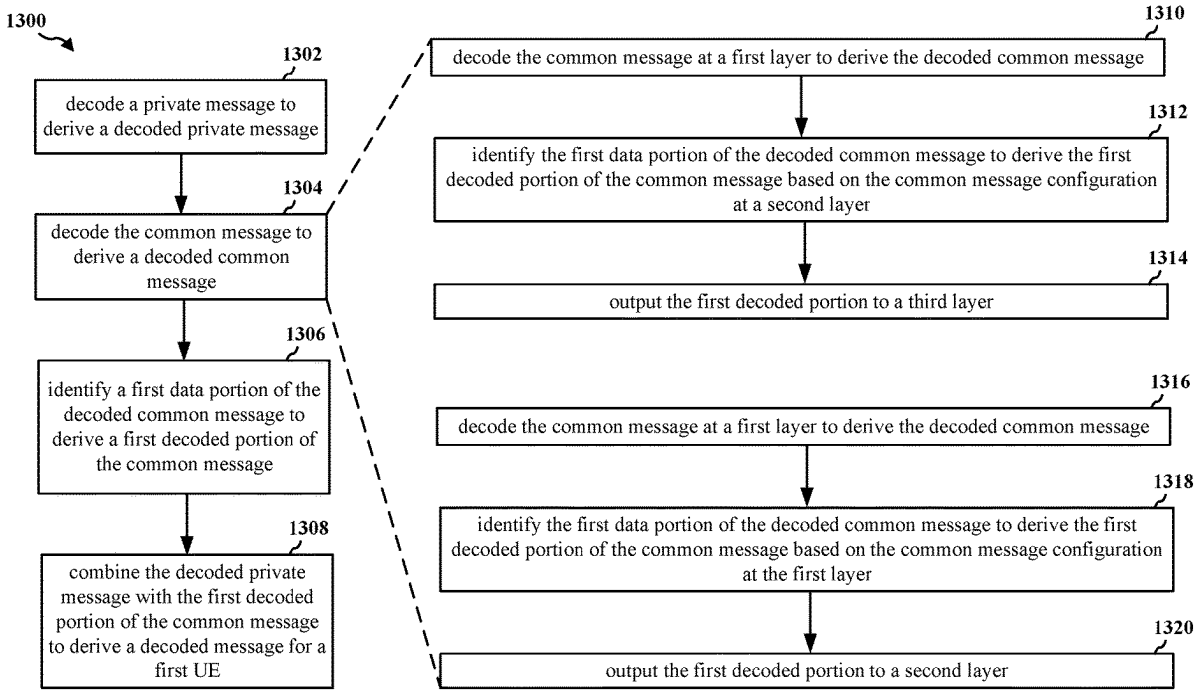
(57) **ABSTRACT**

A first UE may be configured to receive a common message associated with the first UE and at least one second UE. The first UE may be configured to obtain a common message configuration having at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE. The common message configuration may be obtained from at least one of a header of the common message or DCI scheduling the common message.

23 Claims, 17 Drawing Sheets



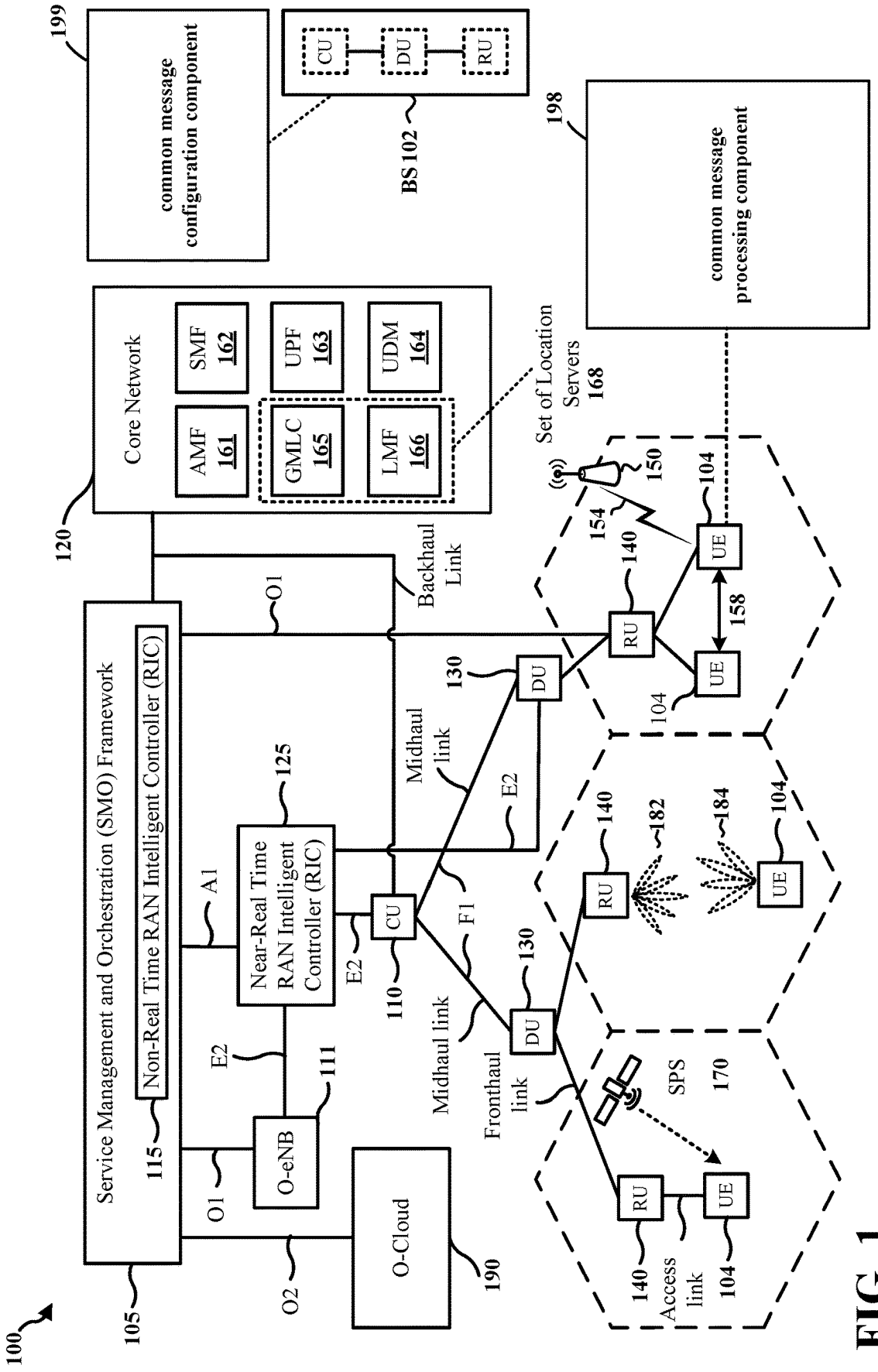
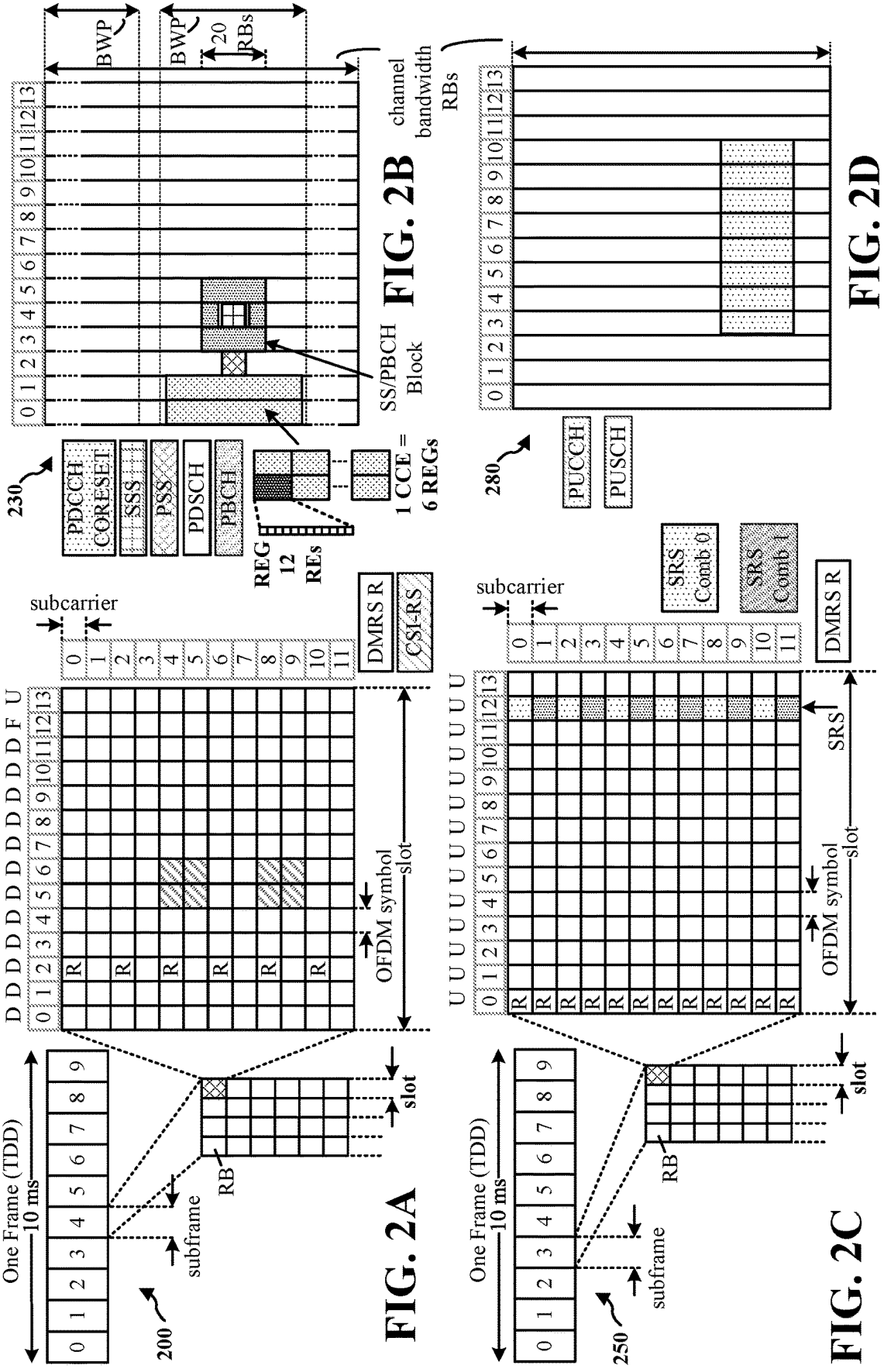

100
105
Service Management and Orchestration (SMO) Framework
Non-Real Time RAN Intelligent Controller (RIC)
115
O1
O2
O-Cloud
190
O-eNB
111
E2
Near-Real Time RAN Intelligent Controller (RIC)
125
A1
E2
CU
110
F1
Midhaul link
DU
130
Midhaul link
Fronthaul link
O1
Backhaul Link
120
Core Network
AMF 161
SMF 162
GMLC 165
LMF 166
UPF 163
UDM 164
Set of Location Servers 168
199
common message configuration component
CU
DU
RU
BS 102
198
common message processing component
150
154
RU
140
UE
104
158
SPS
170
182
184
Access link

FIG. 1


One Frame (TDD)
10 ms
0 1 2 3 4 5 6 7 8 9
subframe
slot
RB
200
D D D D D D D D D D D F U
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R
OFDM symbol
subcarrier
0 1 2 3 4 5 6 7 8 9 10 11
DMRS R
CSI-RS
FIG. 2A
230
PDCCH CORESET
SSS
PSS
PDSCH
PBCH
REG
12 REs
1 CCE = 6 REGs
BWP
20 RBs
SS/PBCH Block
channel bandwidth RBs
FIG. 2B
280
PUCCH
PUSCH
FIG. 2D
U U U U U U U U U U U U U U
SRS
SRS Comb 0
SRS Comb 1
DMRS R
250
FIG. 2C

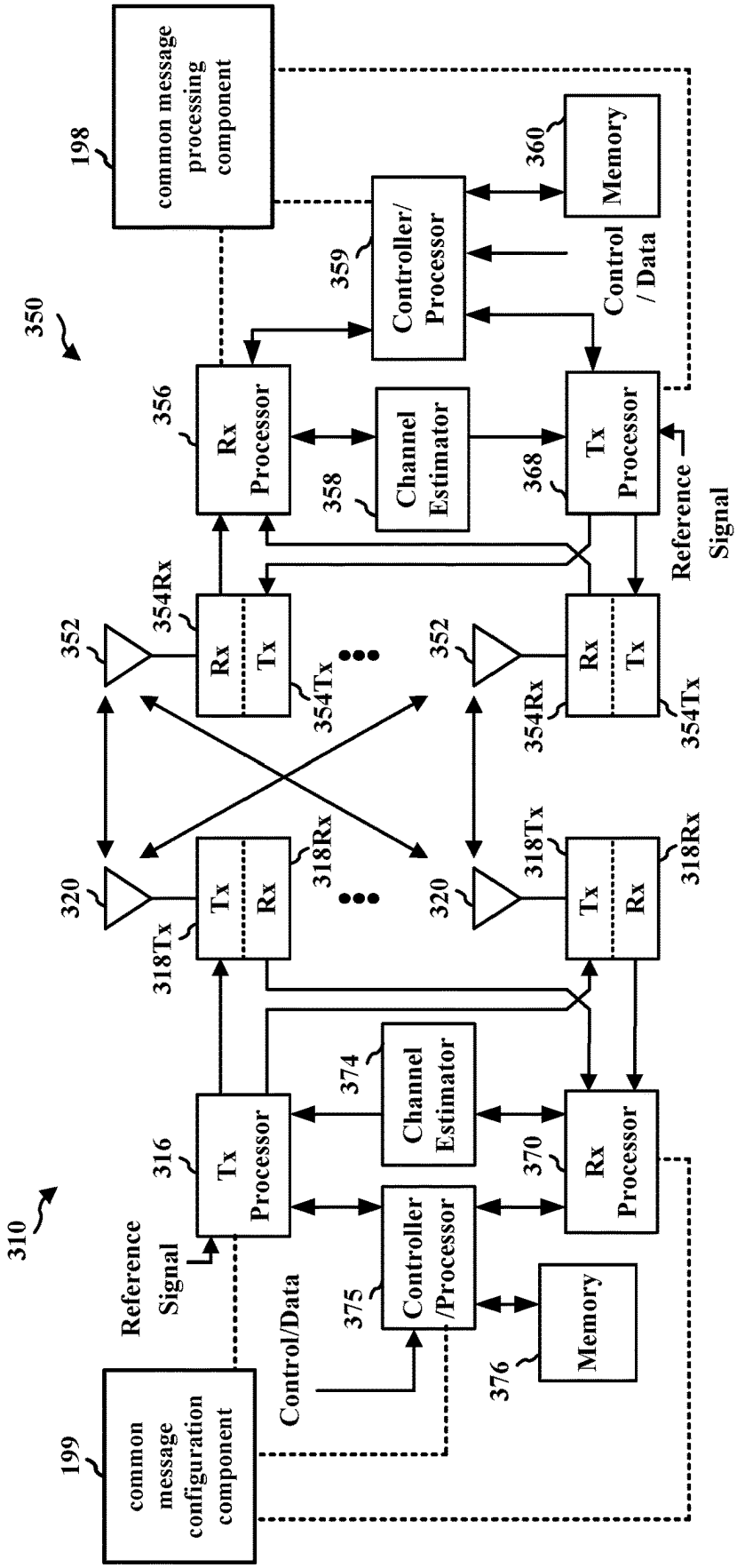

198
common message processing component
360
Memory
359
Controller/ Processor
Control / Data
350
356
Rx Processor
358
Channel Estimator
368
Tx Processor
Reference Signal
354Rx
352
Rx
Tx
354Tx
320
318Tx
318Rx
310
316
Tx Processor
374
Channel Estimator
370
Rx Processor
Reference Signal
Control/Data
375
Controller /Processor
376
Memory
199
common message configuration component

FIG. 3

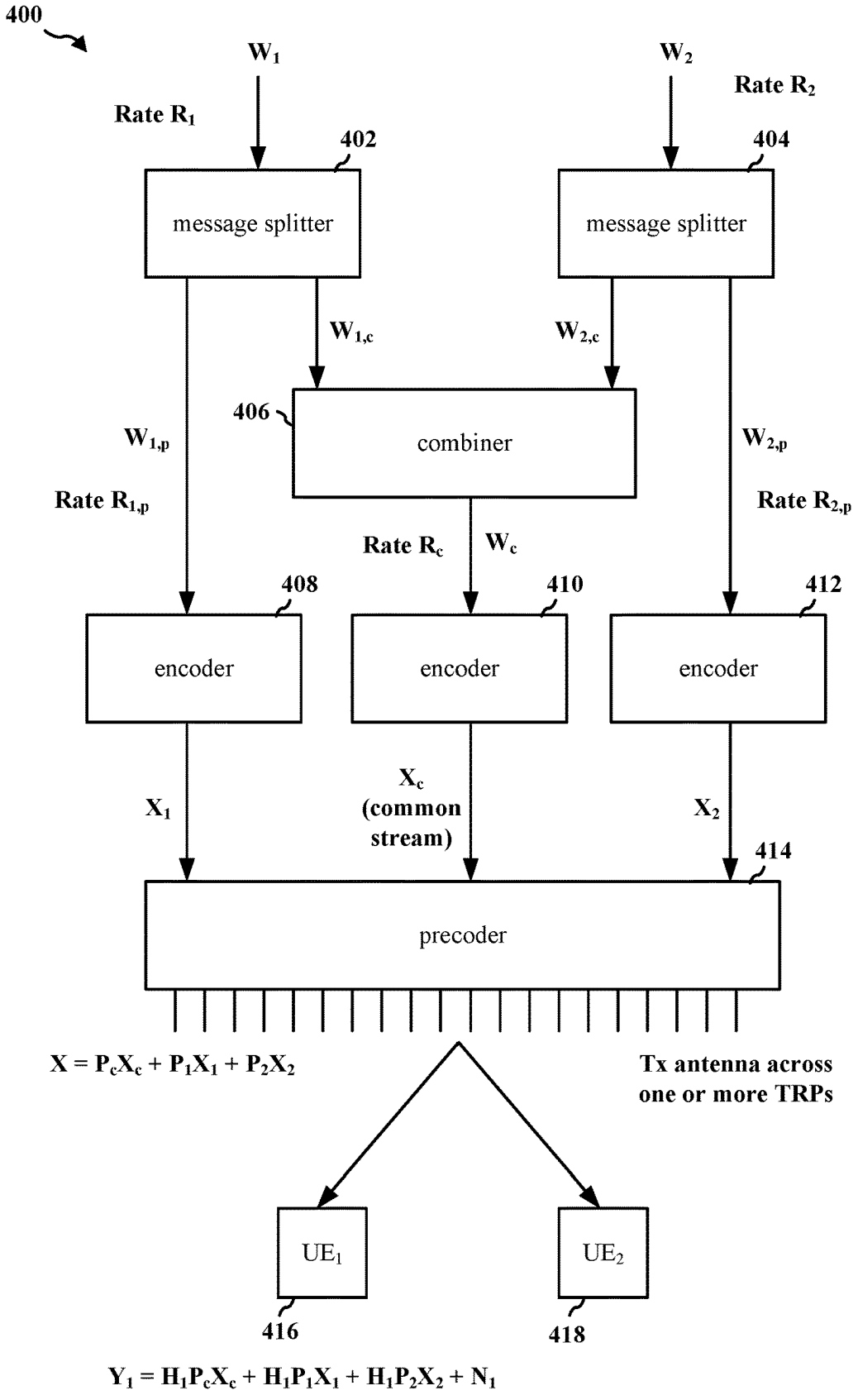

400
W1
Rate R1
W2
Rate R2
402
404
message splitter
message splitter
W1,c
W2,c
406
combiner
W1,p
W2,p
Rate R1,p
Rate R2,p
Rate Rc
Wc
408
410
412
encoder
encoder
encoder
X1
Xc (common stream)
X2
414
precoder
X = PcXc + P1X1 + P2X2
Tx antenna across one or more TRPs
UE1
UE2
416
418
Y1 = H1PcXc + H1P1X1 + H1P2X2 + N1

FIG. 4

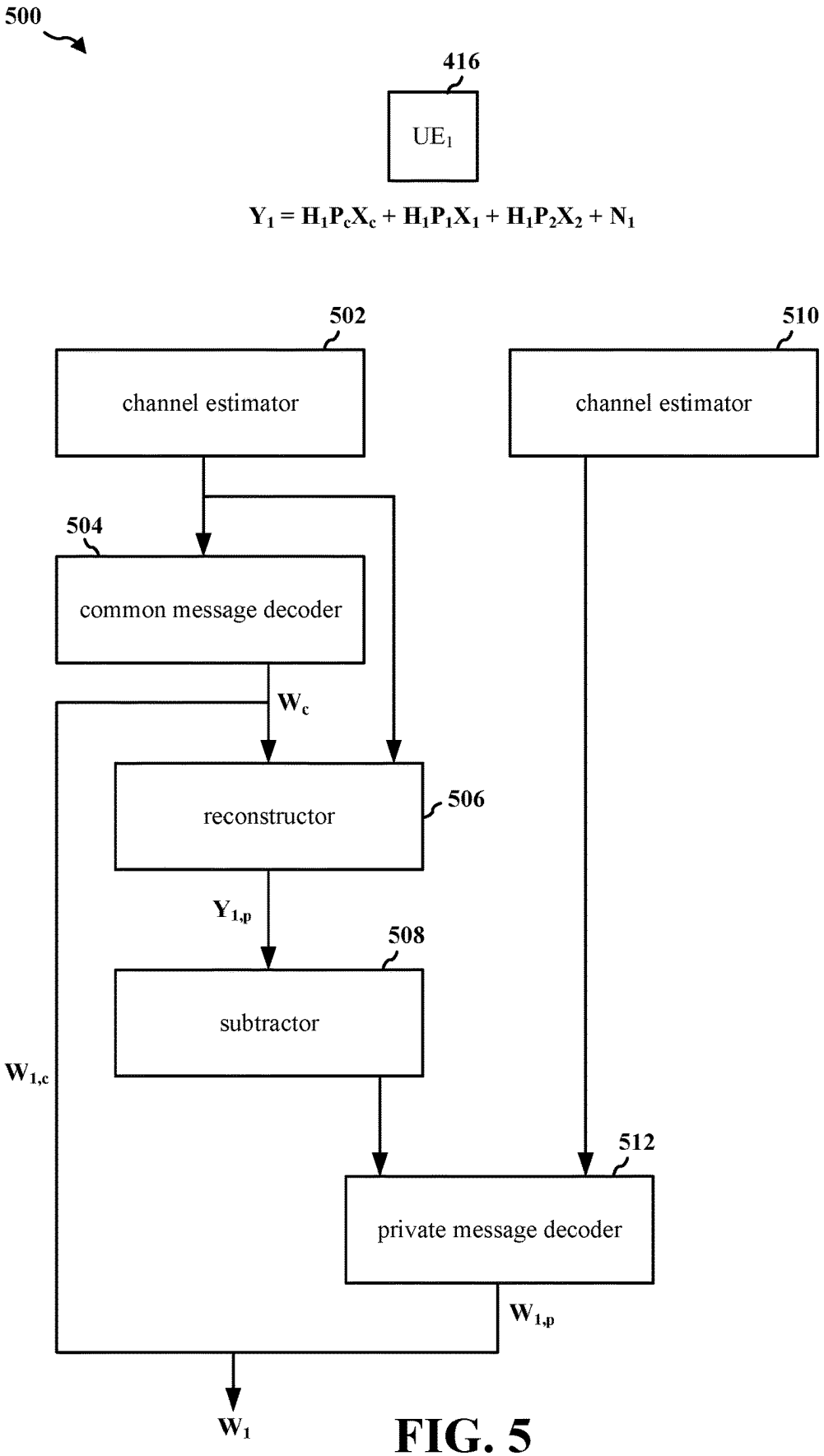

500
416
UE1
Y1 = H1PcXc + H1P1X1 + H1P2X2 + N1
502
channel estimator
510
channel estimator
504
common message decoder
Wc
reconstructor
506
Y1,p
508
subtractor
W1,c
512
private message decoder
W1,p
W1

FIG. 5

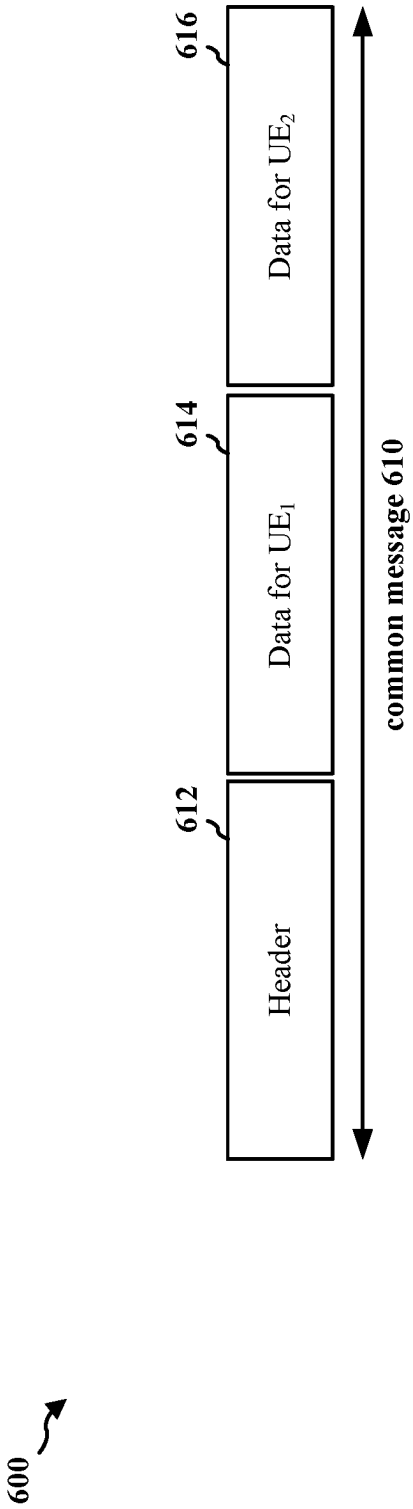

600
612
Header
614
Data for UE1
616
Data for UE2
common message 610

FIG. 6A

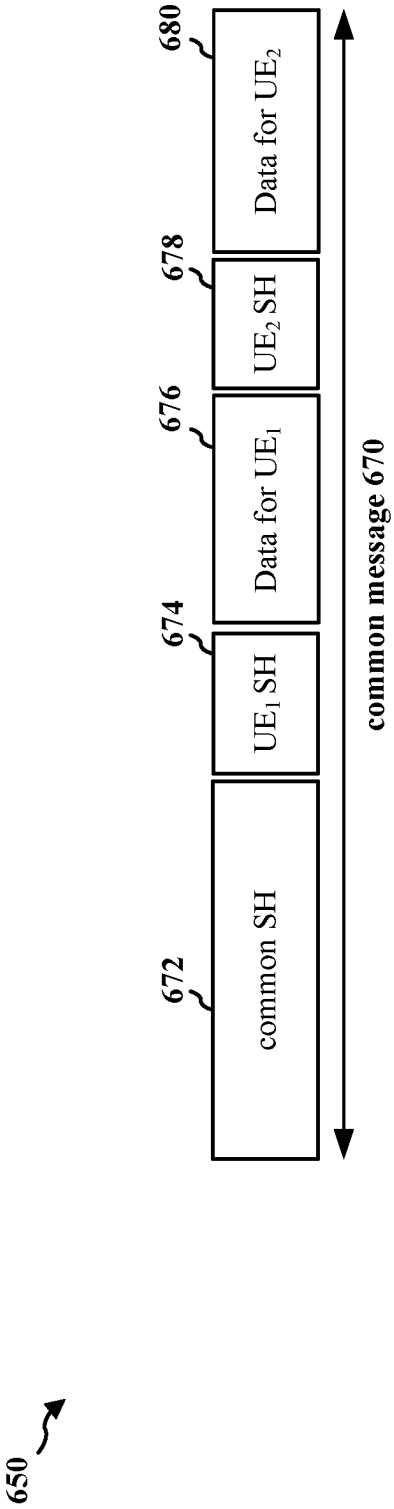

650
672
common SH
674
UE1 SH
676
Data for UE1
678
UE2 SH
680
Data for UE2
common message 670

FIG. 6B

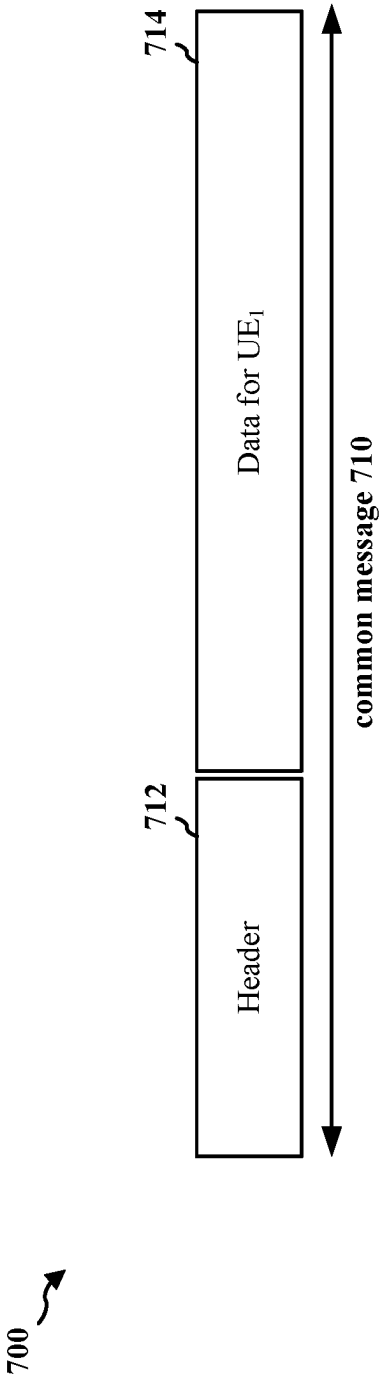

700
712
Header
714
Data for UE1
common message 710

FIG. 7A

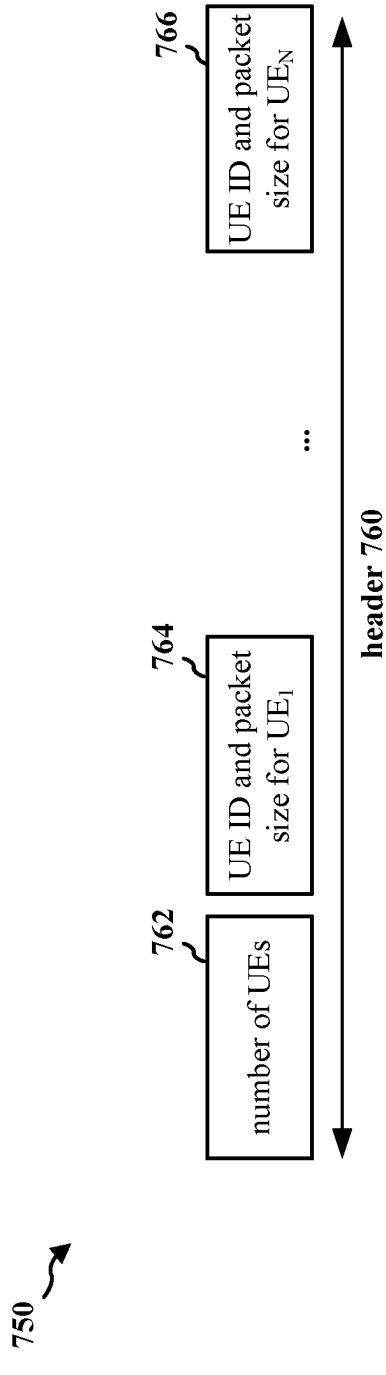

750
762
number of UEs
764
UE ID and packet size for UE1
...
766
UE ID and packet size for UEN
header 760

FIG. 7B

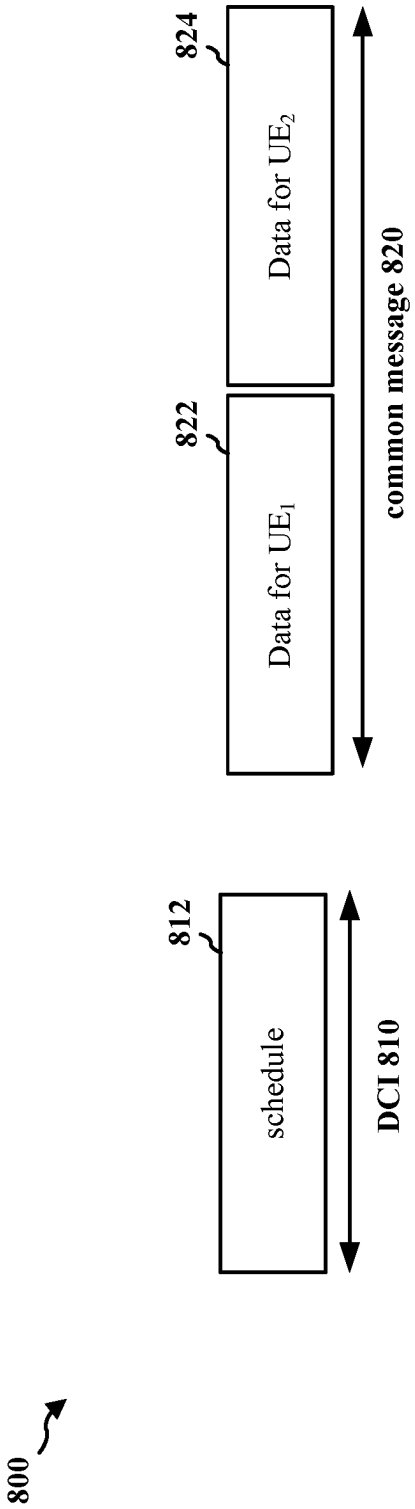

800
812
schedule
DCI 810
822
Data for UE1
824
Data for UE2
common message 820

FIG. 8A

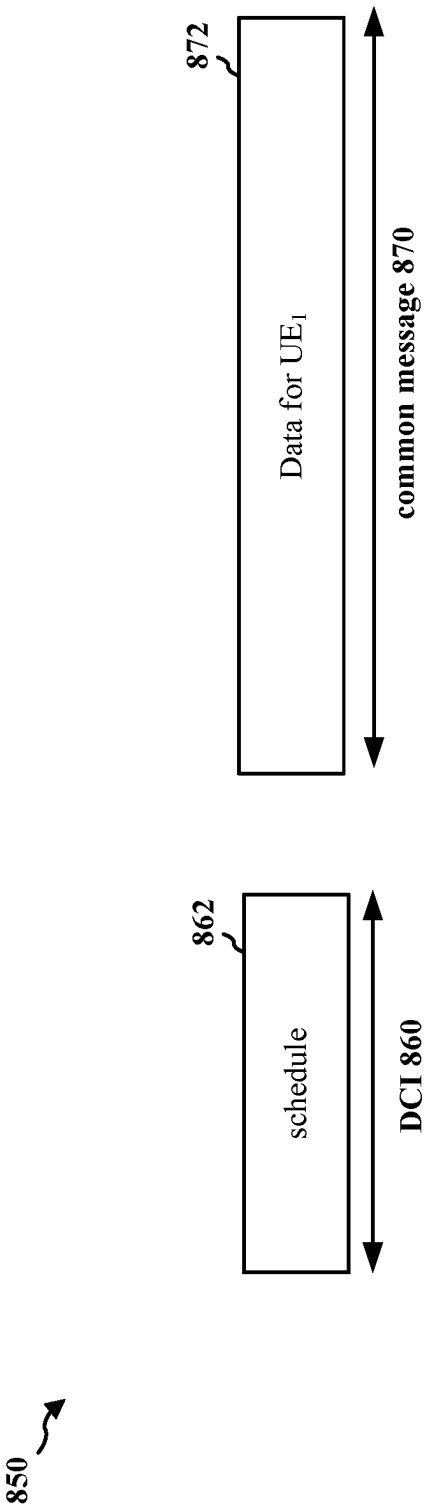

850
862
schedule
DCI 860
872
Data for UE1
common message 870

FIG. 8B

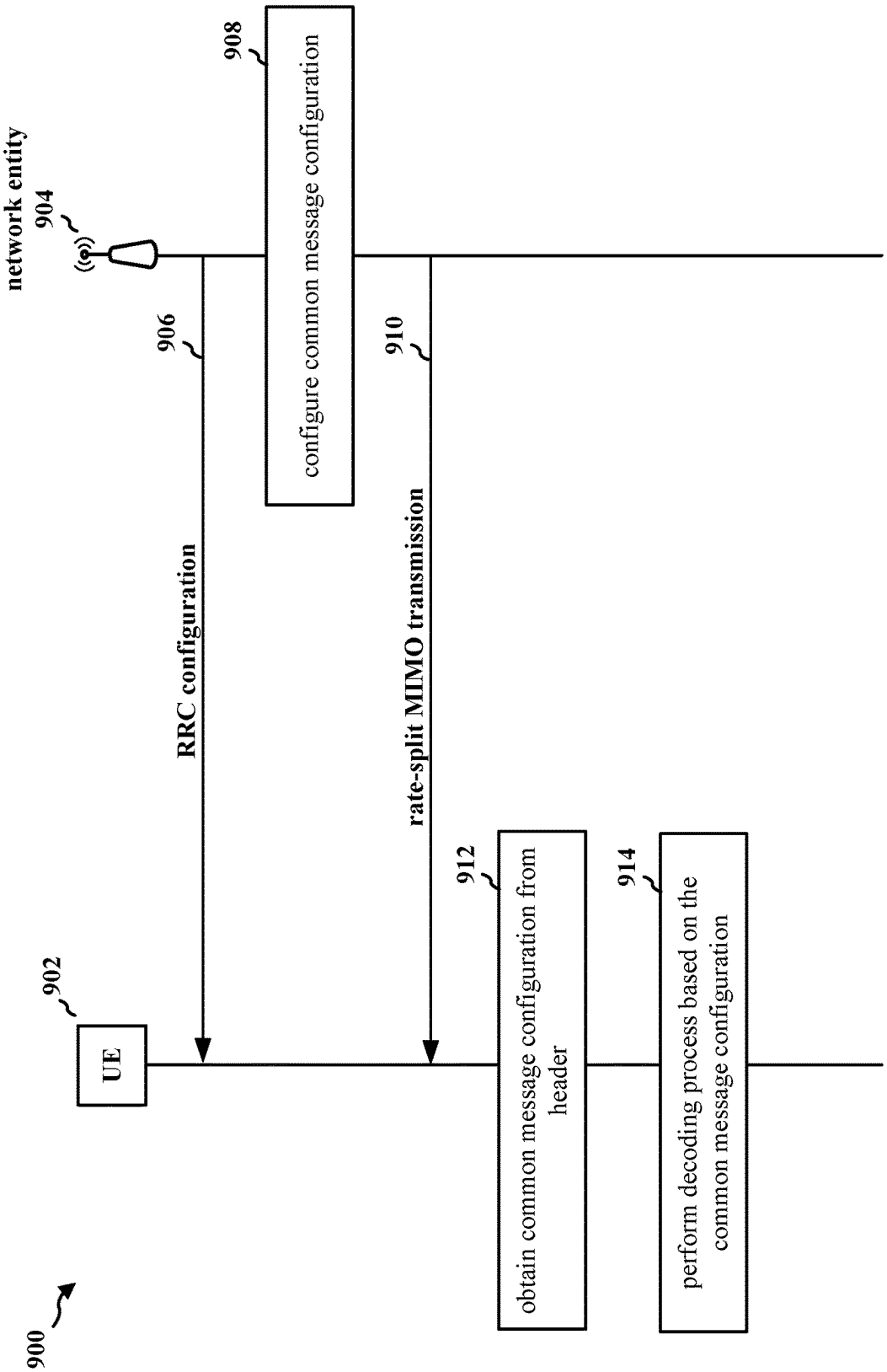

900
UE
902
network entity
904
RRC configuration
906
configure common message configuration
908
rate-split MIMO transmission
910
obtain common message configuration from header
912
perform decoding process based on the common message configuration
914

FIG. 9

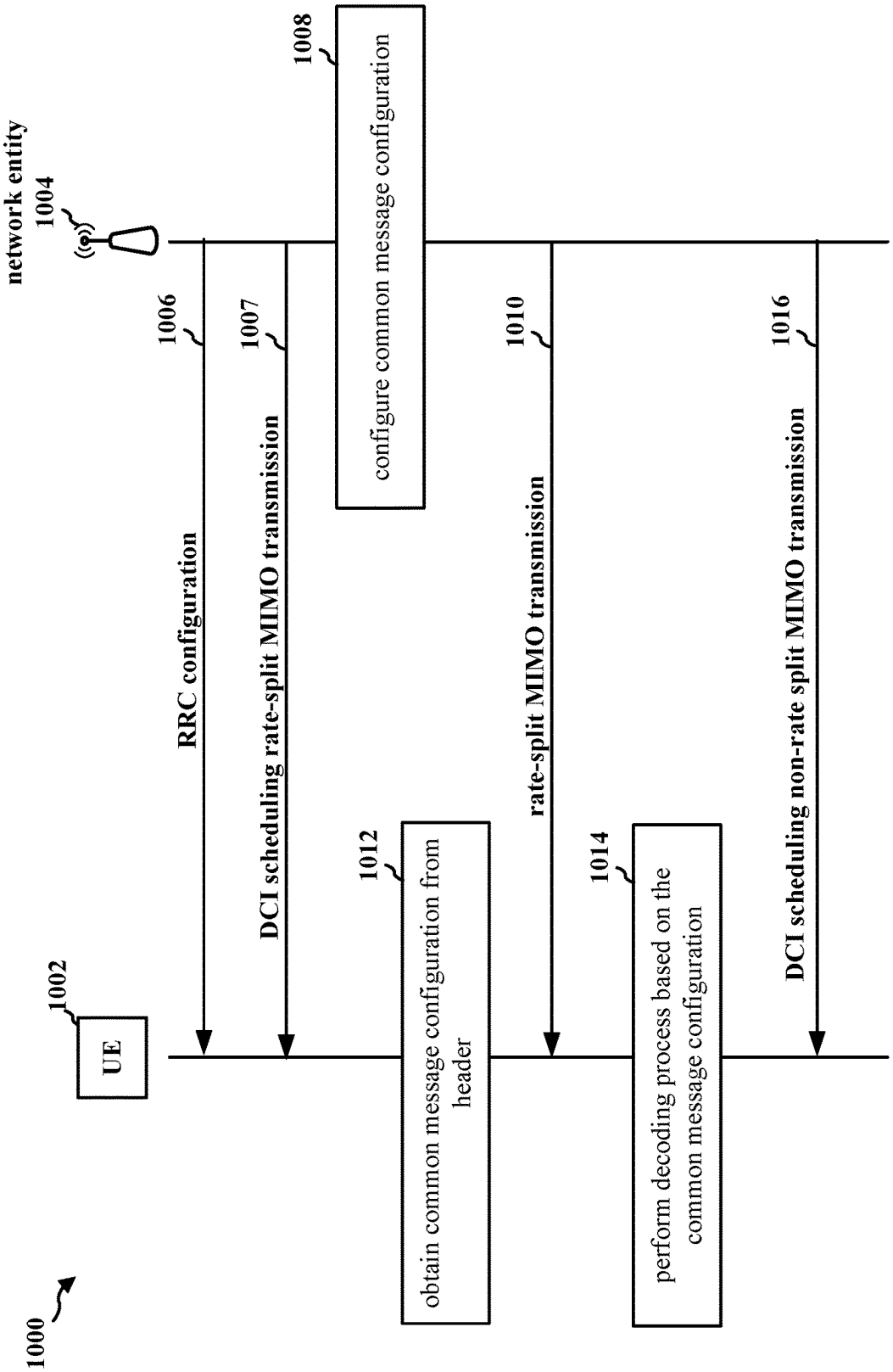

1000
UE
1002
network entity
1004
1006
RRC configuration
1007
DCI scheduling rate-split MIMO transmission
1008
configure common message configuration
1010
rate-split MIMO transmission
1012
obtain common message configuration from header
1014
perform decoding process based on the common message configuration
1016
DCI scheduling non-rate split MIMO transmission

FIG. 10

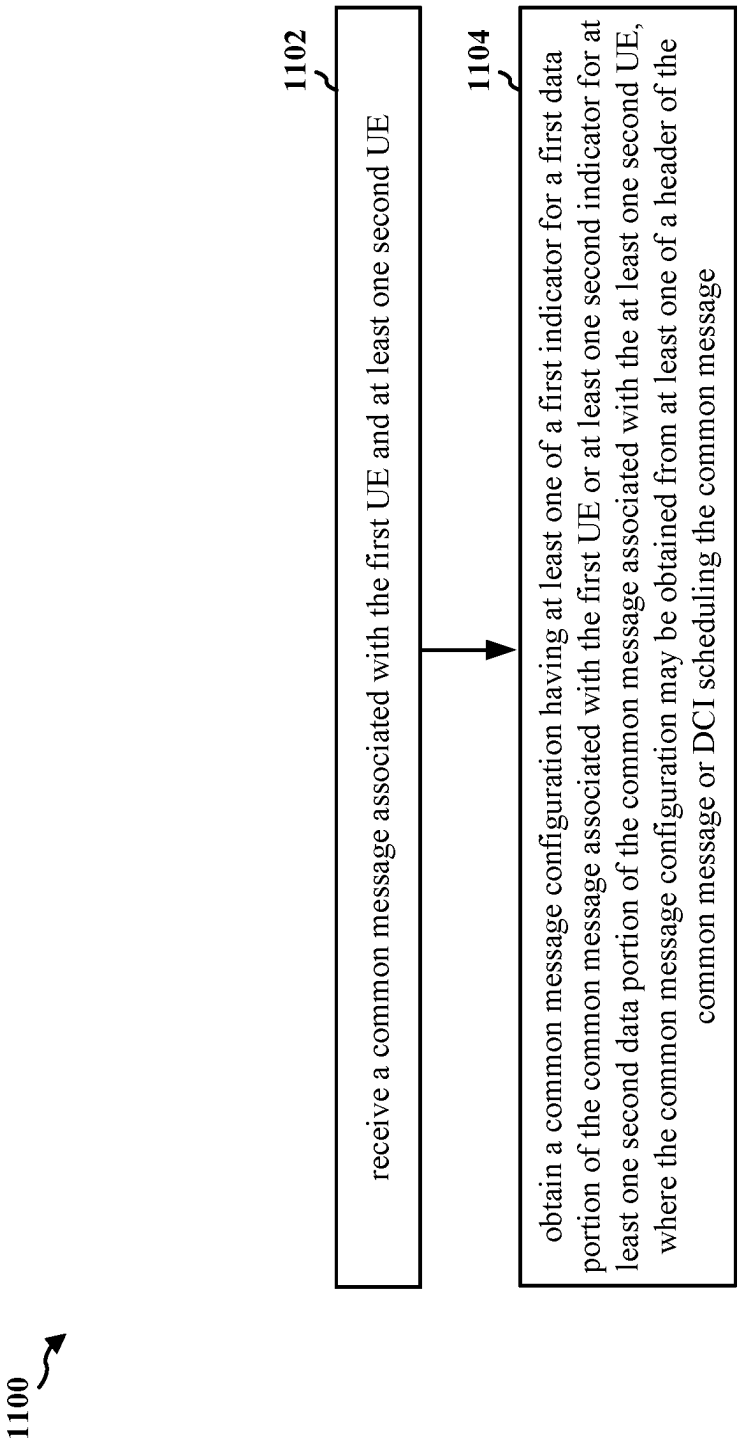

1100
1102
receive a common message associated with the first UE and at least one second UE
1104
obtain a common message configuration having at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE, where the common message configuration may be obtained from at least one of a header of the common message or DCI scheduling the common message

FIG. 11

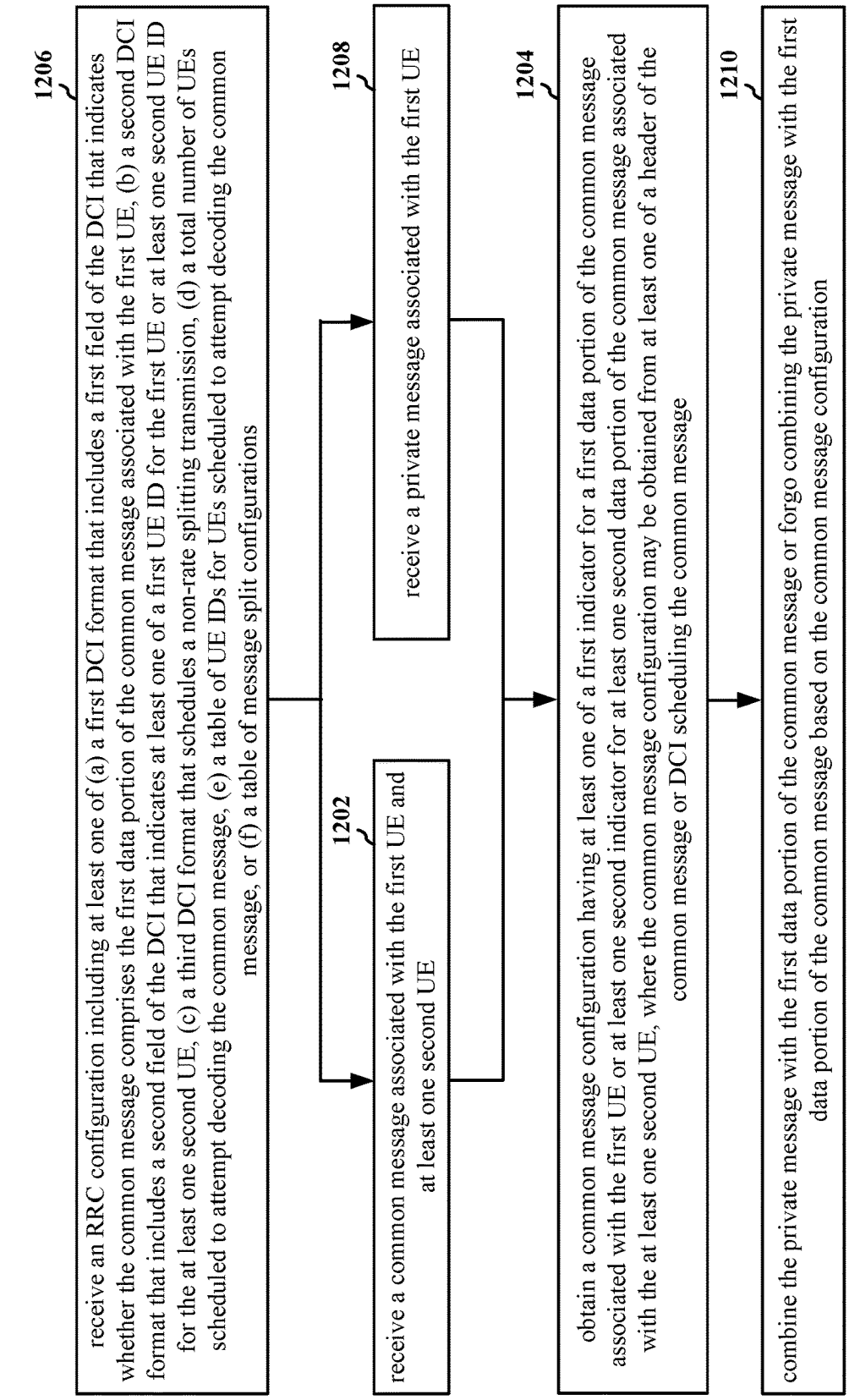

1200
1206
receive an RRC configuration including at least one of (a) a first DCI format that includes a first field of the DCI that indicates whether the common message comprises the first data portion of the common message associated with the first UE, (b) a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, (c) a third DCI format that schedules a non-rate splitting transmission, (d) a total number of UEs scheduled to attempt decoding the common message, (e) a table of UE IDs for UEs scheduled to attempt decoding the common message, or (f) a table of message split configurations
1202
receive a common message associated with the first UE and at least one second UE
1208
receive a private message associated with the first UE
1204
obtain a common message configuration having at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE, where the common message configuration may be obtained from at least one of a header of the common message or DCI scheduling the common message
1210
combine the private message with the first data portion of the common message or forgo combining the private message with the first data portion of the common message based on the common message configuration

FIG. 12

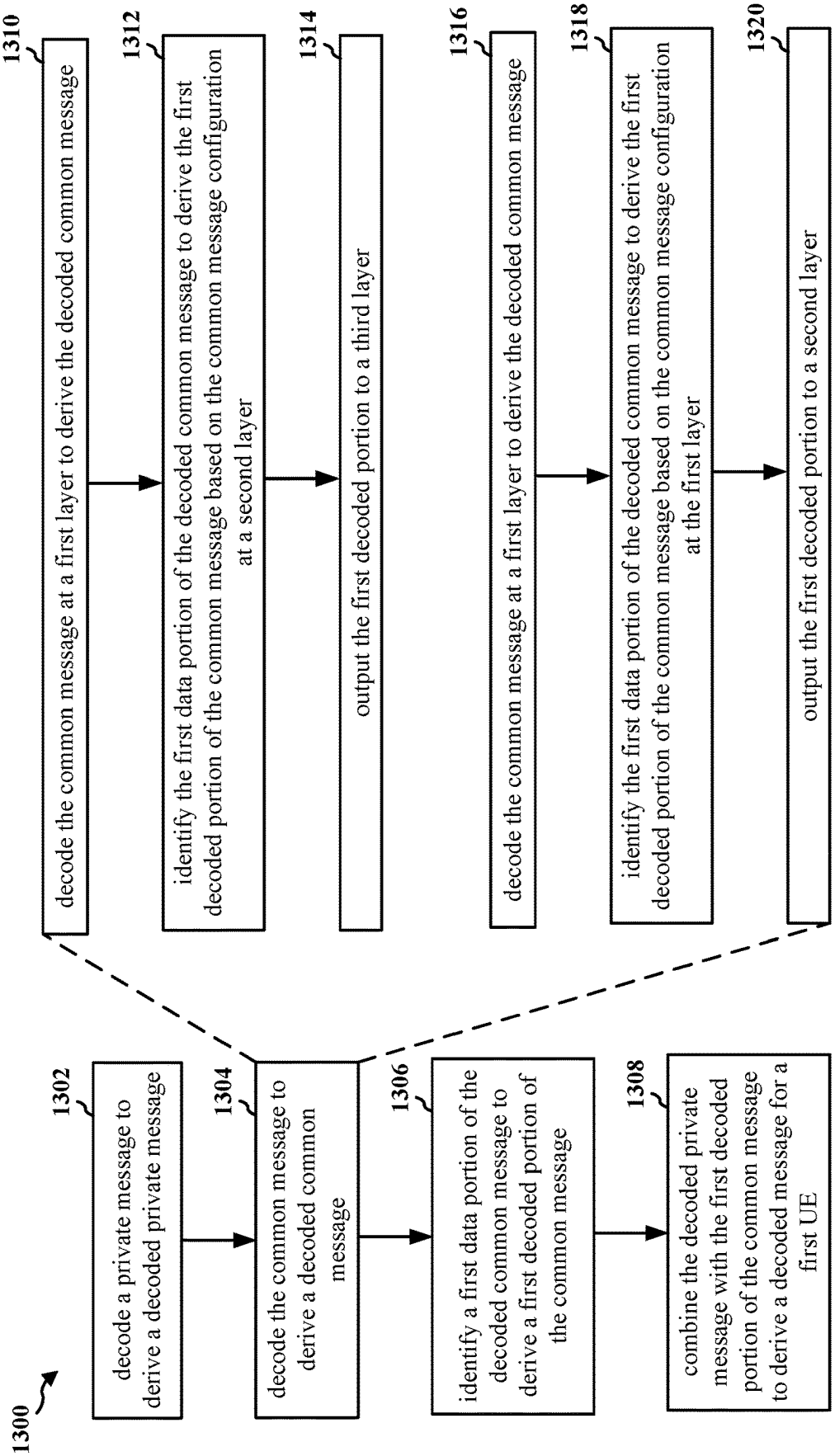

1300
1302
decode a private message to derive a decoded private message
1304
decode the common message to derive a decoded common message
1306
identify a first data portion of the decoded common message to derive a first decoded portion of the common message
1308
combine the decoded private message with the first decoded portion of the common message to derive a decoded message for a first UE
1310
decode the common message at a first layer to derive the decoded common message
1312
identify the first data portion of the decoded common message to derive the first decoded portion of the common message based on the common message configuration at a second layer
1314
output the first decoded portion to a third layer
1316
decode the common message at a first layer to derive the decoded common message
1318
identify the first data portion of the decoded common message to derive the first decoded portion of the common message based on the common message configuration at the first layer
1320
output the first decoded portion to a second layer

FIG. 13

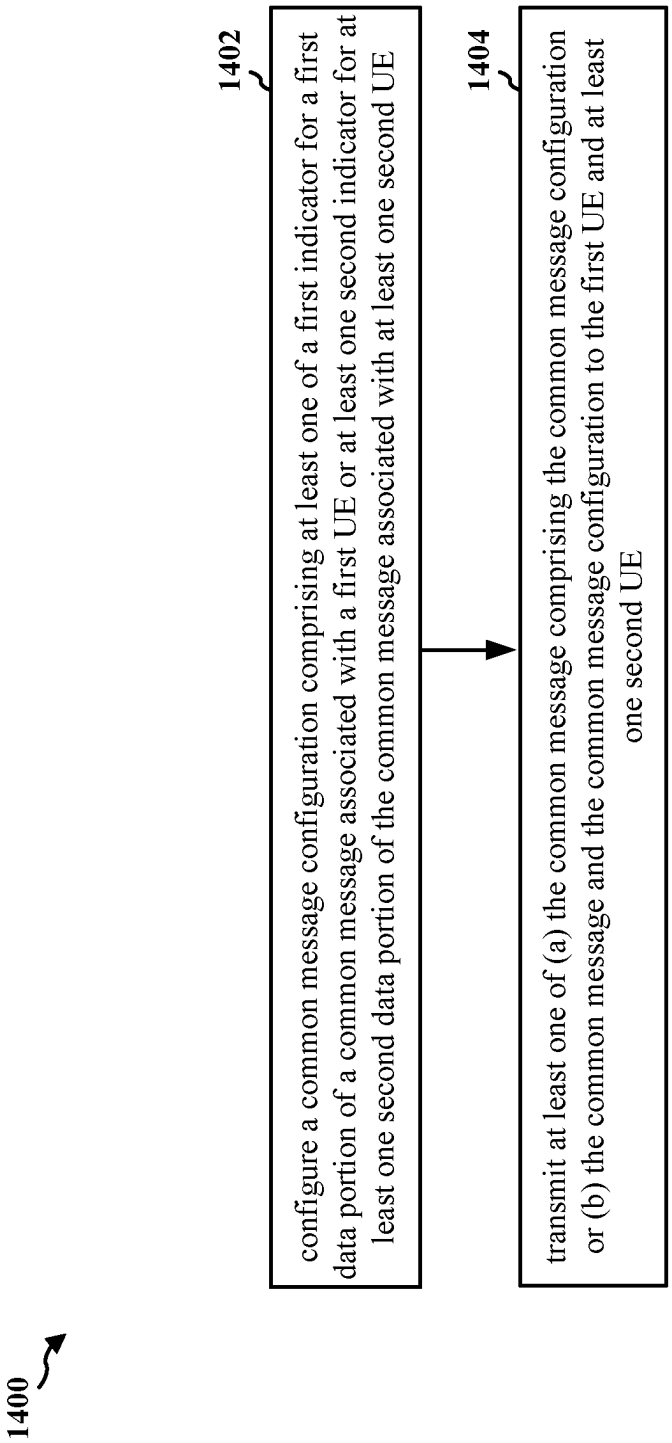

1400
1402
configure a common message configuration comprising at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE
1404
transmit at least one of (a) the common message comprising the common message configuration or (b) the common message and the common message configuration to the first UE and at least one second UE

FIG. 14

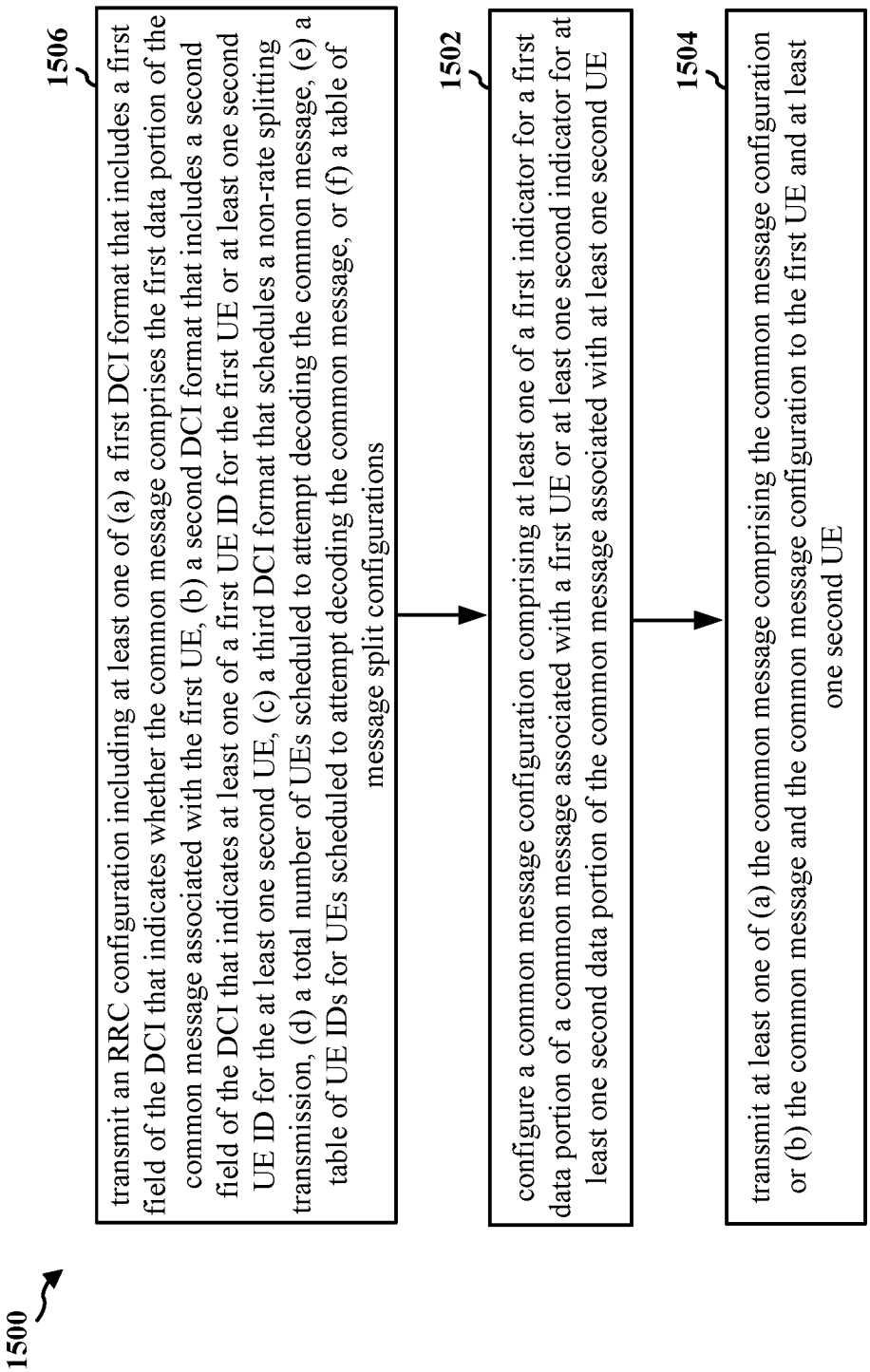

1500
1506
transmit an RRC configuration including at least one of (a) a first DCI format that includes a first field of the DCI that indicates whether the common message comprises the first data portion of the common message associated with the first UE, (b) a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, (c) a third DCI format that schedules a non-rate splitting transmission, (d) a total number of UEs scheduled to attempt decoding the common message, (e) a table of UE IDs for UEs scheduled to attempt decoding the common message, or (f) a table of message split configurations
1502
configure a common message configuration comprising at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE
1504
transmit at least one of (a) the common message comprising the common message configuration or (b) the common message and the common message configuration to the first UE and at least one second UE

FIG. 15

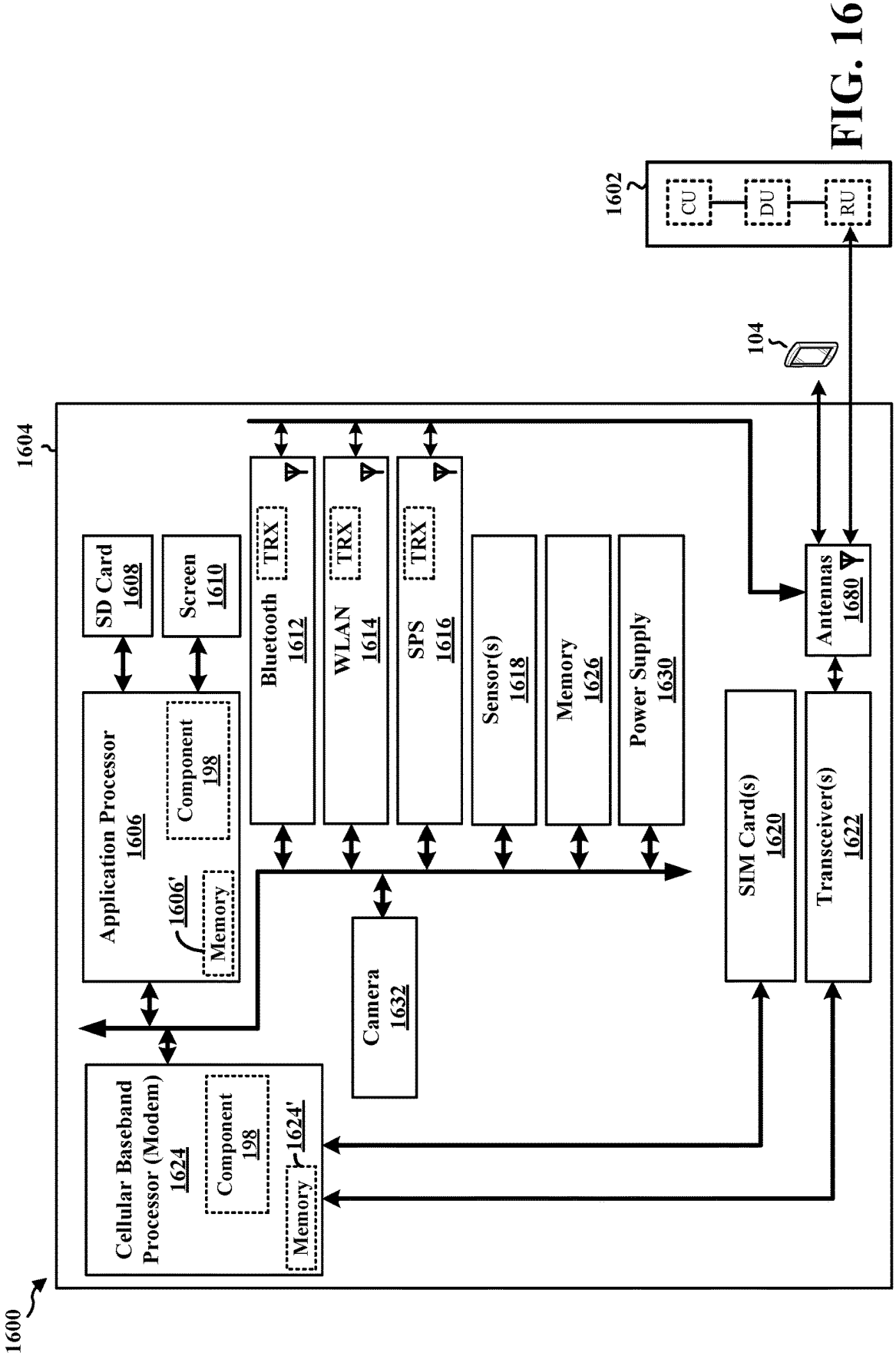

1600
1604
1602
CU
DU
RU
104
Antennas 1680
SIM Card(s) 1620
Transceiver(s) 1622
Cellular Baseband Processor (Modem) 1624
Component 198
Memory 1624'
Application Processor 1606
Component 198
Memory 1606'
SD Card 1608
Screen 1610
Camera 1632
Bluetooth 1612
TRX
WLAN 1614
TRX
SPS 1616
TRX
Sensor(s) 1618
Memory 1626
Power Supply 1630

FIG. 16

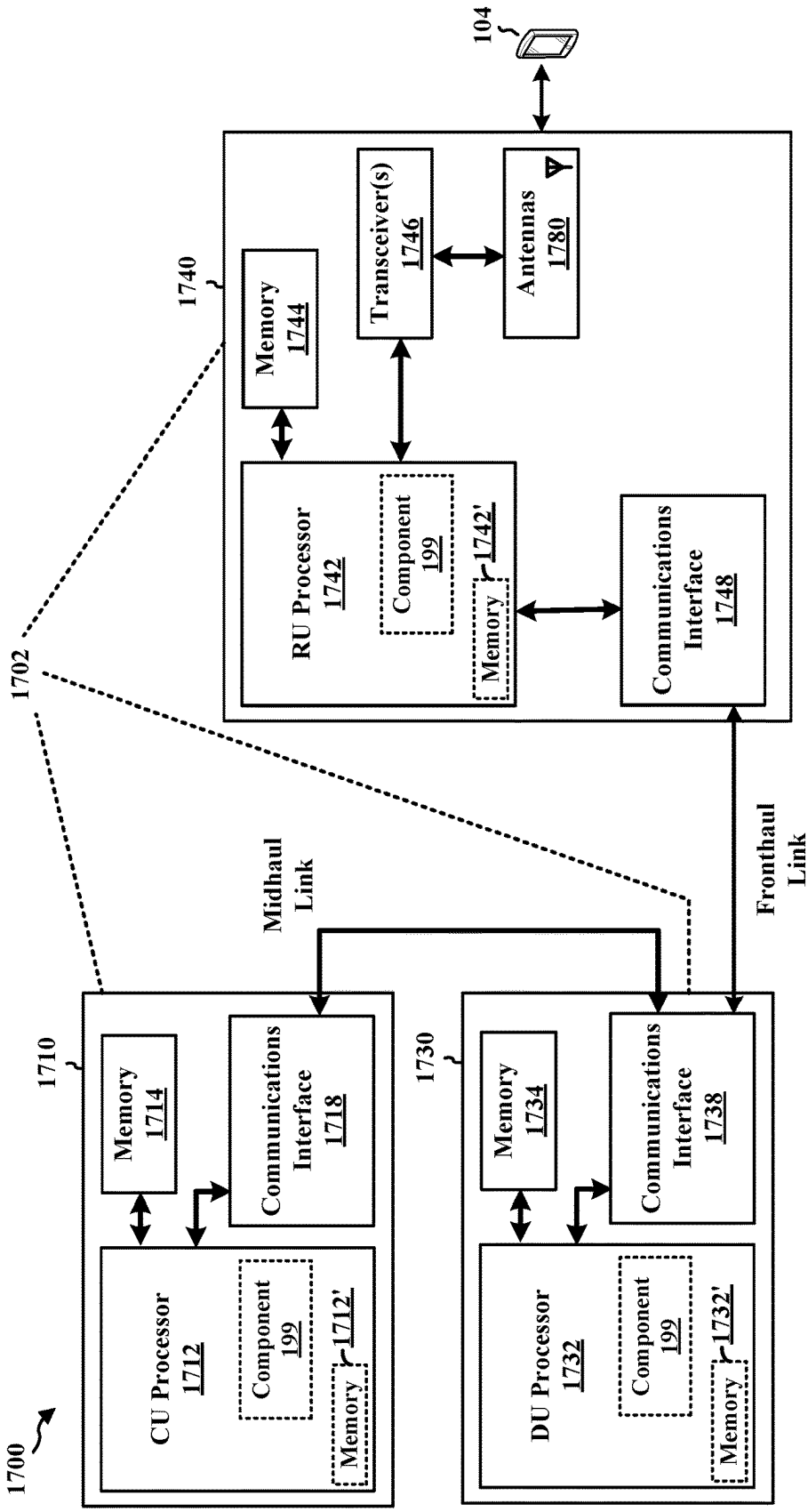

1700
1702
104
1710
CU Processor 1712
Component 199
Memory 1712'
Memory 1714
Communications Interface 1718
Midhaul Link
1730
DU Processor 1732
Component 199
Memory 1732'
Memory 1734
Communications Interface 1738
Fronthaul Link
1740
RU Processor 1742
Component 199
Memory 1742'
Memory 1744
Transceiver(s) 1746
Antennas 1780
Communications Interface 1748

FIG. 17

COMMON MESSAGE SPLIT INDICATORS FOR RATE- SPLITTING MIMO

TECHNICAL FIELD The present disclosure relates generally to communication systems, and more

particularly, to a rate-splitting multiple input-multiple output (MIMO) communication system.

INTRODUCTION

Wireless communication systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, and broadcasts. Typical wireless communication systems may employ multiple-access technologies capable of supporting communication with multiple users by sharing available system resources. Examples of such multiple-access technologies include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency division multiple access (SC-FDMA) systems, and time division synchronous code division multiple access (TD-SCDMA) systems.

These multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different wireless devices to communicate on a municipal, national, regional, and even global level. An example telecommunication standard is 5G New Radio (NR). 5G NR is part of a continuous mobile broadband evolution promulgated by Third Generation Partnership Project (3GPP) to meet new requirements associated with latency, reliability, security, scalability (e.g., with Internet of Things (IoT)), and other requirements. 5G NR includes services associated with enhanced mobile broadband (eMBB), massive machine type communications (mMTC), and ultra-reliable low latency communications (URLLC). Some aspects of 5G NR may be based on the 4G Long Term Evolution (LTE) standard. There exists a need for further improvements in 5G NR technology. These improvements may also be applicable to other multi-access technologies and the telecommunication standards that employ these technologies.

BRIEF SUMMARY

The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects. This summary neither identifies key or critical elements of all aspects nor delineates the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

In an aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided. The apparatus may have a memory and at least one processor coupled to the memory at a first UE. Based at least in part on information stored in the memory, the at least one processor may be configured to receive a common message associated with the first UE and at least one second UE. Based at least in part on information stored in the memory, the at least one processor may be configured to obtain a common message configuration having at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE. The common message configuration may be obtained from at least one of a header of the common message or DCI scheduling the common message.

In an aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided. The apparatus may have a memory and at least one processor coupled to the memory at a network entity. Based at least in part on information stored in the memory, the at least one processor may be configured to configure a common message configuration having at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE. Based at least in part on information stored in the memory, the at least one processor may be configured to transmit at least one of (a) the common message having the common message configuration or (b) the common message and the common message configuration to the first UE and at least one second UE.

To the accomplishment of the foregoing and related ends, the one or more aspects include the features hereinafter fully described and particularly pointed out in the claims. The following description and the drawings set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating an example of a wireless communications system and an access network.

FIG. **2**A is a diagram illustrating an example of a first frame, in accordance with various aspects of the present disclosure.

FIG. **2**B is a diagram illustrating an example of DL channels within a subframe, in accordance with various aspects of the present disclosure.

FIG. **2**C is a diagram illustrating an example of a second frame, in accordance with various aspects of the present disclosure.

FIG. **2**D is a diagram illustrating an example of UL channels within a subframe, in accordance with various aspects of the present disclosure.

FIG. **3** is a diagram illustrating an example of a base station and user equipment (UE) in an access network.

FIG. **4** is a diagram illustrating an example of a multi-user rate-splitting MIMO system at a transmitting network entity.

FIG. **5** is a diagram illustrating an example of a multi-user rate-splitting MIMO system at a receiving UE.

FIG. **6**A is a diagram illustrating an example of a common message format for a multi-user rate-splitting MIMO system.

FIG. **6**B is a diagram illustrating another example of a common message format for a multi-user rate-splitting MIMO system.

FIG. **7**A is a diagram illustrating another example of a common message format for a multi-user rate-splitting MIMO system.

FIG. **7**B is a diagram illustrating an example of a header format for a common message of a multi-user rate-splitting MIMO system.

FIG. **8**A is a diagram illustrating an example of DCI and a common message format for a multi-user rate-splitting MIMO system.

FIG. **8**B is a diagram illustrating another example of DCI and a common message format for a multi-user rate-splitting MIMO system.

FIG. **9** is a connection flow diagram illustrating an example of a common message split communication between a UE and a network entity.

FIG. **10** is a connection flow diagram illustrating another example of a common message split communication between a UE and a network entity.

FIG. **11** is a flowchart of a method of wireless communication.

FIG. **12** is another flowchart of a method of wireless communication.

FIG. **13** is another flowchart of a method of wireless communication.

FIG. **14** is another flowchart of a method of wireless communication.

FIG. **15** is another flowchart of a method of wireless communication.

FIG. **16** is a diagram illustrating an example of a hardware implementation for an example apparatus and/or network entity.

FIG. **17** is a diagram illustrating an example of a hardware implementation for an example network entity.

DETAILED DESCRIPTION

The detailed description set forth below in connection with the drawings describes various configurations and does not represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

Several aspects of telecommunication systems are presented with reference to various apparatus and methods. These apparatus and methods are described in the following detailed description and illustrated in the accompanying drawings by various blocks, components, circuits, processes, algorithms, etc. (collectively referred to as "elements"). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

By way of example, an element, or any portion of an element, or any combination of elements may be implemented as a "processing system" that includes one or more processors. Examples of processors include microprocessors, microcontrollers, graphics processing units (GPUs), central processing units (CPUs), application processors, digital signal processors (DSPs), reduced instruction set computing (RISC) processors, systems on a chip (SoC), baseband processors, field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software. Software, whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise, shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software components, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, or any combination thereof.

Accordingly, in one or more example aspects, implementations, and/or use cases, the functions described may be implemented in hardware, software, or any combination thereof. If implemented in software, the functions may be stored on or encoded as one or more instructions or code on a computer-readable medium. Computer-readable media includes computer storage media. Storage media may be any available media that can be accessed by a computer. By way of example, such computer-readable media can include a random-access memory (RAM), a read-only memory (ROM), an electrically erasable programmable ROM (EEPROM), optical disk storage, magnetic disk storage, other magnetic storage devices, combinations of the types of computer-readable media, or any other medium that can be used to store computer executable code in the form of instructions or data structures that can be accessed by a computer.

While aspects, implementations, and/or use cases are described in this application by illustration to some examples, additional or different aspects, implementations and/or use cases may come about in many different arrangements and scenarios. Aspects, implementations, and/or use cases described herein may be implemented across many differing platform types, devices, systems, shapes, sizes, and packaging arrangements. For example, aspects, implementations, and/or use cases may come about via integrated chip implementations and other non-module-component based devices (e.g., end-user devices, vehicles, communication devices, computing devices, industrial equipment, retail/purchasing devices, medical devices, artificial intelligence (AI)-enabled devices, etc.). While some examples may or may not be specifically directed to use cases or applications, a wide assortment of applicability of described examples may occur. Aspects, implementations, and/or use cases may range a spectrum from chip-level or modular components to non-modular, non-chip-level implementations and further to aggregate, distributed, or original equipment manufacturer (OEM) devices or systems incorporating one or more techniques herein. In some practical settings, devices incorporating described aspects and features may also include additional components and features for implementation and practice of claimed and described aspect. For example, transmission and reception of wireless signals necessarily includes a number of components for analog and digital purposes (e.g., hardware components including antenna, RF-chains, power amplifiers, modulators, buffer, processor(s), interleaver, adders/summers, etc.). Techniques described herein may be practiced in a wide variety of devices, chip-level components, systems, distributed arrangements, aggregated or disaggregated components, end-user devices, etc. of varying sizes, shapes, and constitution.

Deployment of communication systems, such as 5G NR systems, may be arranged in multiple manners with various components or constituent parts. In a 5G NR system, or network, a network node, a network entity, a mobility element of a network, a radio access network (RAN) node, a core network node, a network element, or a network equipment, such as a base station (BS), or one or more units (or one or more components) performing base station functionality, may be implemented in an aggregated or disaggregated architecture. For example, a BS (such as a Node B (NB), evolved NB (eNB), NR BS, 5G NB, access point (AP), a transmit receive point (TRP), or a cell, etc.) may be

implemented as an aggregated base station (also known as a standalone BS or a monolithic BS) or a disaggregated base station.

An aggregated base station may be configured to utilize a radio protocol stack that is physically or logically integrated within a single RAN node. A disaggregated base station may be configured to utilize a protocol stack that is physically or logically distributed among two or more units (such as one or more central or centralized units (CUs), one or more distributed units (DUs), or one or more radio units (RUs)). In some aspects, a CU may be implemented within a RAN node, and one or more DUs may be co-located with the CU, or alternatively, may be geographically or virtually distributed throughout one or multiple other RAN nodes. The DUs may be implemented to communicate with one or more RUs. Each of the CU, DU and RU can be implemented as virtual units, i.e., a virtual central unit (VCU), a virtual distributed unit (VDU), or a virtual radio unit (VRU).

Base station operation or network design may consider aggregation characteristics of base station functionality. For example, disaggregated base stations may be utilized in an integrated access backhaul (IAB) network, an open radio access network (O-RAN (such as the network configuration sponsored by the O-RAN Alliance)), or a virtualized radio access network (vRAN, also known as a cloud radio access network (C-RAN)). Disaggregation may include distributing functionality across two or more units at various physical locations, as well as distributing functionality for at least one unit virtually, which can enable flexibility in network design. The various units of the disaggregated base station, or disaggregated RAN architecture, can be configured for wired or wireless communication with at least one other unit.

FIG. **1** is a diagram **100** illustrating an example of a wireless communications system and an access network. The illustrated wireless communications system includes a disaggregated base station architecture. The disaggregated base station architecture may include one or more CUs **110** that can communicate directly with a core network **120** via a backhaul link, or indirectly with the core network **120** through one or more disaggregated base station units (such as a Near-Real Time (Near-RT) RAN Intelligent Controller (RIC) **125** via an E2 link, or a Non-Real Time (Non-RT) RIC **115** associated with a Service Management and Orchestration (SMO) Framework **105**, or both). A CU **110** may communicate with one or more DUs **130** via respective midhaul links, such as an F1 interface. The DUs **130** may communicate with one or more RUs **140** via respective fronthaul links. The RUs **140** may communicate with respective UEs **104** via one or more radio frequency (RF) access links. In some implementations, the UE **104** may be simultaneously served by multiple RUs **140**.

Each of the units, i.e., the CUs **110**, the DUs **130**, the RUs **140**, as well as the Near-RT RICs **125**, the Non-RT RICs **115**, and the SMO Framework **105**, may include one or more interfaces or be coupled to one or more interfaces configured to receive or to transmit signals, data, or information (collectively, signals) via a wired or wireless transmission medium. Each of the units, or an associated processor or controller providing instructions to the communication interfaces of the units, can be configured to communicate with one or more of the other units via the transmission medium. For example, the units can include a wired interface configured to receive or to transmit signals over a wired transmission medium to one or more of the other units. Additionally, the units can include a wireless interface, which may include a receiver, a transmitter, or a transceiver (such as an RF transceiver), configured to receive or to transmit signals, or both, over a wireless transmission medium to one or more of the other units.

In some aspects, the CU **110** may host one or more higher layer control functions. Such control functions can include radio resource control (RRC), packet data convergence protocol (PDCP), service data adaptation protocol (SDAP), or the like. Each control function can be implemented with an interface configured to communicate signals with other control functions hosted by the CU **110**. The CU **110** may be configured to handle user plane functionality (i.e., Central Unit-User Plane (CU-UP)), control plane functionality (i.e., Central Unit-Control Plane (CU-CP)), or a combination thereof. In some implementations, the CU **110** can be logically split into one or more CU-UP units and one or more CU-CP units. The CU-UP unit can communicate bidirectionally with the CU-CP unit via an interface, such as an E1 interface when implemented in an O-RAN configuration. The CU **110** can be implemented to communicate with the DU **130**, as necessary, for network control and signaling.

The DU **130** may correspond to a logical unit that includes one or more base station functions to control the operation of one or more RUs **140**. In some aspects, the DU **130** may host one or more of a radio link control (RLC) layer, a medium access control (MAC) layer, and one or more high physical (PHY) layers (such as modules for forward error correction (FEC) encoding and decoding, scrambling, modulation, demodulation, or the like) depending, at least in part, on a functional split, such as those defined by 3GPP. In some aspects, the DU **130** may further host one or more low PHY layers. Each layer (or module) can be implemented with an interface configured to communicate signals with other layers (and modules) hosted by the DU **130**, or with the control functions hosted by the CU **110**.

Lower-layer functionality can be implemented by one or more RUs **140**. In some deployments, an RU **140**, controlled by a DU **130**, may correspond to a logical node that hosts RF processing functions, or low-PHY layer functions (such as performing fast Fourier transform (FFT), inverse FFT (iFFT), digital beamforming, physical random access channel (PRACH) extraction and filtering, or the like), or both, based at least in part on the functional split, such as a lower layer functional split. In such an architecture, the RU(s) **140** can be implemented to handle over the air (OTA) communication with one or more UEs **104**. In some implementations, real-time and non-real-time aspects of control and user plane communication with the RU(s) **140** can be controlled by the corresponding DU **130**. In some scenarios, this configuration can enable the DU(s) **130** and the CU **110** to be implemented in a cloud-based RAN architecture, such as a vRAN architecture.

The SMO Framework **105** may be configured to support RAN deployment and provisioning of non-virtualized and virtualized network elements. For non-virtualized network elements, the SMO Framework **105** may be configured to support the deployment of dedicated physical resources for RAN coverage requirements that may be managed via an operations and maintenance interface (such as an O1 interface). For virtualized network elements, the SMO Framework **105** may be configured to interact with a cloud computing platform (such as an open cloud (O-Cloud) **190**) to perform network element life cycle management (such as to instantiate virtualized network elements) via a cloud computing platform interface (such as an O2 interface). Such virtualized network elements can include, but are not limited to, CUs **110**, DUs **130**, RUs **140** and Near-RT RICs **125**. In some implementations, the SMO Framework **105**

can communicate with a hardware aspect of a 4G RAN, such as an open eNB (O-eNB) **111**, via an O1 interface. Additionally, in some implementations, the SMO Framework **105** can communicate directly with one or more RUs **140** via an O1 interface. The SMO Framework **105** also may include a Non-RT RIC **115** configured to support functionality of the SMO Framework **105**.

The Non-RT RIC **115** may be configured to include a logical function that enables non-real-time control and optimization of RAN elements and resources, artificial intelligence (AI)/machine learning (ML) (AI/ML) workflows including model training and updates, or policy-based guidance of applications/features in the Near-RT RIC **125**. The Non-RT RIC **115** may be coupled to or communicate with (such as via an A1 interface) the Near-RT RIC **125**. The Near-RT RIC **125** may be configured to include a logical function that enables near-real-time control and optimization of RAN elements and resources via data collection and actions over an interface (such as via an E2 interface) connecting one or more CUs **110**, one or more DUs **130**, or both, as well as an O-eNB, with the Near-RT RIC **125**.

In some implementations, to generate AI/ML models to be deployed in the Near-RT RIC **125**, the Non-RT RIC **115** may receive parameters or external enrichment information from external servers. Such information may be utilized by the Near-RT RIC **125** and may be received at the SMO Framework **105** or the Non-RT RIC **115** from non-network data sources or from network functions. In some examples, the Non-RT RIC **115** or the Near-RT RIC **125** may be configured to tune RAN behavior or performance. For example, the Non-RT RIC **115** may monitor long-term trends and patterns for performance and employ AI/ML models to perform corrective actions through the SMO Framework **105** (such as reconfiguration via O1) or via creation of RAN management policies (such as A1 policies).

At least one of the CU **110**, the DU **130**, and the RU **140** may be referred to as a base station **102**. Accordingly, a base station **102** may include one or more of the CU **110**, the DU **130**, and the RU **140** (each component indicated with dotted lines to signify that each component may or may not be included in the base station **102**). The base station **102** provides an access point to the core network **120** for a UE **104**. The base stations **102** may include macrocells (high power cellular base station) and/or small cells (low power cellular base station). The small cells include femtocells, picocells, and microcells. A network that includes both small cell and macrocells may be known as a heterogeneous network. A heterogeneous network may also include Home Evolved Node Bs (eNBs) (HeNBs), which may provide service to a restricted group known as a closed subscriber group (CSG). The communication links between the RUs **140** and the UEs **104** may include uplink (UL) (also referred to as reverse link) transmissions from a UE **104** to an RU **140** and/or downlink (DL) (also referred to as forward link) transmissions from an RU **140** to a UE **104**. The communication links may use multiple-input and multiple-output (MIMO) antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity. The communication links may be through one or more carriers. The base stations **102**/UEs **104** may use spectrum up to Y MHz (e.g., 5, 10, 15, 20, 100, 400, etc. MHz) bandwidth per carrier allocated in a carrier aggregation of up to a total of Yx MHz (x component carriers) used for transmission in each direction. The carriers may or may not be adjacent to each other. Allocation of carriers may be asymmetric with respect to DL and UL (e.g., more or fewer carriers may be allocated for DL than for UL). The component carriers may include a primary component carrier and one or more secondary component carriers. A primary component carrier may be referred to as a primary cell (PCell) and a secondary component carrier may be referred to as a secondary cell (SCell).

Certain UEs **104** may communicate with each other using device-to-device (D2D) communication link **158**. The D2D communication link **158** may use the DL/UL wireless wide area network (WWAN) spectrum. The D2D communication link **158** may use one or more sidelink channels, such as a physical sidelink broadcast channel (PSBCH), a physical sidelink discovery channel (PSDCH), a physical sidelink shared channel (PSSCH), and a physical sidelink control channel (PSCCH). D2D communication may be through a variety of wireless D2D communications systems, such as for example, Bluetooth, Wi-Fi based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard, LTE, or NR.

The wireless communications system may further include a Wi-Fi AP **150** in communication with UEs **104** (also referred to as Wi-Fi stations (STAs)) via communication link **154**, e.g., in a 5 GHz unlicensed frequency spectrum or the like. When communicating in an unlicensed frequency spectrum, the UEs **104**/AP **150** may perform a clear channel assessment (CCA) prior to communicating in order to determine whether the channel is available.

The electromagnetic spectrum is often subdivided, based on frequency/wavelength, into various classes, bands, channels, etc. In 5G NR, two initial operating bands have been identified as frequency range designations FR1 (410 MHz-7.125 GHz) and FR2 (24.25 GHz-52.6 GHz). Although a portion of FR1 is greater than 6 GHz, FR1 is often referred to (interchangeably) as a "sub-6 GHz" band in various documents and articles. A similar nomenclature issue sometimes occurs with regard to FR2, which is often referred to (interchangeably) as a "millimeter wave" band in documents and articles, despite being different from the extremely high frequency (EHF) band (30 GHz-300 GHz) which is identified by the International Telecommunications Union (ITU) as a "millimeter wave" band.

The frequencies between FR1 and FR2 are often referred to as mid-band frequencies. Recent 5G NR studies have identified an operating band for these mid-band frequencies as frequency range designation FR3 (7.125 GHz-24.25 GHz). Frequency bands falling within FR3 may inherit FR1 characteristics and/or FR2 characteristics, and thus may effectively extend features of FR1 and/or FR2 into mid-band frequencies. In addition, higher frequency bands are currently being explored to extend 5G NR operation beyond 52.6 GHz. For example, three higher operating bands have been identified as frequency range designations FR2-2 (52.6 GHz-71 GHz), FR4 (71 GHz-114.25 GHz), and FR5 (114.25 GHz-300 GHz). Each of these higher frequency bands falls within the EHF band.

With the above aspects in mind, unless specifically stated otherwise, the term "sub-6 GHz" or the like if used herein may broadly represent frequencies that may be less than 6 GHz, may be within FR1, or may include mid-band frequencies. Further, unless specifically stated otherwise, the term "millimeter wave" or the like if used herein may broadly represent frequencies that may include mid-band frequencies, may be within FR2, FR4, FR2-2, and/or FR5, or may be within the EHF band.

The base station **102** and the UE **104** may each include a plurality of antennas, such as antenna elements, antenna panels, and/or antenna arrays to facilitate beamforming. The base station **102** may transmit a beamformed signal **182** to the UE **104** in one or more transmit directions. The UE **104**

may receive the beamformed signal from the base station **102** in one or more receive directions. The UE **104** may also transmit a beamformed signal **184** to the base station **102** in one or more transmit directions. The base station **102** may receive the beamformed signal from the UE **104** in one or more receive directions. The base station **102**/UE **104** may perform beam training to determine the best receive and transmit directions for each of the base station **102**/UE **104**. The transmit and receive directions for the base station **102** may or may not be the same. The transmit and receive directions for the UE **104** may or may not be the same.

The base station **102** may include and/or be referred to as a gNB, Node B, eNB, an access point, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), a transmit reception point (TRP), network node, network entity, network equipment, or some other suitable terminology. The base station **102** can be implemented as an integrated access and backhaul (IAB) node, a relay node, a sidelink node, an aggregated (monolithic) base station with a baseband unit (BBU) (including a CU and a DU) and an RU, or as a disaggregated base station including one or more of a CU, a DU, and/or an RU. The set of base stations, which may include disaggregated base stations and/or aggregated base stations, may be referred to as next generation (NG) RAN (NG-RAN).

The core network **120** may include an Access and Mobility Management Function (AMF) **161**, a Session Management Function (SMF) **162**, a User Plane Function (UPF) **163**, a Unified Data Management (UDM) **164**, one or more location servers **168**, and other functional entities. The AMF **161** is the control node that processes the signaling between the UEs **104** and the core network **120**. The AMF **161** supports registration management, connection management, mobility management, and other functions. The SMF **162** supports session management and other functions. The UPF **163** supports packet routing, packet forwarding, and other functions. The UDM **164** supports the generation of authentication and key agreement (AKA) credentials, user identification handling, access authorization, and subscription management. The one or more location servers **168** are illustrated as including a Gateway Mobile Location Center (GMLC) **165** and a Location Management Function (LMF) **166**. However, generally, the one or more location servers **168** may include one or more location/positioning servers, which may include one or more of the GMLC **165**, the LMF **166**, a position determination entity (PDE), a serving mobile location center (SMLC), a mobile positioning center (MPC), or the like. The GMLC **165** and the LMF **166** support UE location services. The GMLC **165** provides an interface for clients/applications (e.g., emergency services) for accessing UE positioning information. The LMF **166** receives measurements and assistance information from the NG-RAN and the UE **104** via the AMF **161** to compute the position of the UE **104**. The NG-RAN may utilize one or more positioning methods in order to determine the position of the UE **104**. Positioning the UE **104** may involve signal measurements, a position estimate, and an optional velocity computation based on the measurements. The signal measurements may be made by the UE **104** and/or the serving base station **102**. The signals measured may be based on one or more of a satellite positioning system (SPS) **170** (e.g., one or more of a Global Navigation Satellite System (GNSS), global position system (GPS), non-terrestrial network (NTN), or other satellite position/location system), LTE signals, wireless local area network (WLAN) signals, Bluetooth signals, a terrestrial beacon system (TBS), sensor-based information (e.g., barometric pressure sensor, motion sensor), NR enhanced cell ID (NR E-CID) methods, NR signals (e.g., multi-round trip time (Multi-RTT), DL angle-of-departure (DL-AoD), DL time difference of arrival (DL-TDOA), UL time difference of arrival (UL-TDOA), and UL angle-of-arrival (UL-AoA) positioning), and/or other systems/signals/sensors.

Examples of UEs **104** include a cellular phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal digital assistant (PDA), a satellite radio, a global positioning system, a multimedia device, a video device, a digital audio player (e.g., MP3 player), a camera, a game console, a tablet, a smart device, a wearable device, a vehicle, an electric meter, a gas pump, a large or small kitchen appliance, a healthcare device, an implant, a sensor/actuator, a display, or any other similar functioning device. Some of the UEs **104** may be referred to as IoT devices (e.g., parking meter, gas pump, toaster, vehicles, heart monitor, etc.). The UE **104** may also be referred to as a station, a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client, or some other suitable terminology. In some scenarios, the term UE may also apply to one or more companion devices such as in a device constellation arrangement. One or more of these devices may collectively access the network and/or individually access the network.

Referring again to FIG. **1**, in certain aspects, the UE **104** may have a common message processing component **198** configured to receive a common message associated with the first UE and at least one second UE. The common message processing component **198** may be configured to obtain a common message configuration having at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE. The common message configuration may be obtained from at least one of a header of the common message or DCI scheduling the common message. In certain aspects, the base station **102** may have a common message configuration component **199** configured to configure a common message configuration having at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE. The common message configuration component **199** may be configured to transmit at least one of (a) the common message having the common message configuration or (b) the common message and the common message configuration to the first UE and at least one second UE. Although the following description may be focused on multi-user rate-splitting MIMO transmissions, the concepts described herein may be applicable to other similar areas, such as any transmissions having private and common elements. Although the following description may be focused on 5G NR, the concepts described herein may be applicable to other similar areas, such as LTE, LTE-A, CDMA, GSM, and other wireless technologies.

FIG. **2**A is a diagram **200** illustrating an example of a first subframe within a 5G NR frame structure. FIG. **2**B is a diagram **230** illustrating an example of DL channels within a 5G NR subframe. FIG. **2**C is a diagram **250** illustrating an example of a second subframe within a 5G NR frame

structure. FIG. **2**D is a diagram **280** illustrating an example of UL channels within a 5G NR subframe. The 5G NR frame structure may be frequency division duplexed (FDD) in which for a particular set of subcarriers (carrier system bandwidth), subframes within the set of subcarriers are dedicated for either DL or UL, or may be time division duplexed (TDD) in which for a particular set of subcarriers (carrier system bandwidth), subframes within the set of subcarriers are dedicated for both DL and UL. In the examples provided by FIGS. **2**A, **2**C, the 5G NR frame structure is assumed to be TDD, with subframe 4 being configured with slot format 28 (with mostly DL), where D is DL, U is UL, and F is flexible for use between DL/UL, and subframe 3 being configured with slot format 1 (with all UL). While subframes 3, 4 are shown with slot formats 1, 28, respectively, any particular subframe may be configured with any of the various available slot formats 0-61. Slot formats 0, 1 are all DL, UL, respectively. Other slot formats 2-61 include a mix of DL, UL, and flexible symbols. UEs are configured with the slot format (dynamically through DL control information (DCI), or semi-statically/statically through radio resource control (RRC) signaling) through a received slot format indicator (SFI). Note that the description infra applies also to a 5G NR frame structure that is TDD.

FIGS. **2**A-**2**D illustrate a frame structure, and the aspects of the present disclosure may be applicable to other wireless communication technologies, which may have a different frame structure and/or different channels. A frame (10 ms) may be divided into 10 equally sized subframes (1 ms). Each subframe may include one or more time slots. Subframes may also include mini-slots, which may include 7, 4, or 2 symbols. Each slot may include 14 or 12 symbols, depending on whether the cyclic prefix (CP) is normal or extended. For normal CP, each slot may include 14 symbols, and for extended CP, each slot may include 12 symbols. The symbols on DL may be CP orthogonal frequency division multiplexing (OFDM) (CP-OFDM) symbols. The symbols on UL may be CP-OFDM symbols (for high throughput scenarios) or discrete Fourier transform (DFT) spread OFDM (DFT-s-OFDM) symbols (also referred to as single carrier frequency-division multiple access (SC-FDMA) symbols) (for power limited scenarios; limited to a single stream transmission). The number of slots within a subframe is based on the CP and the numerology. The numerology defines the subcarrier spacing (SCS) and, effectively, the symbol length/duration, which is equal to 1/SCS.

μ	SCS $\Delta f = 2^{\mu} \cdot 15$[kHz]	Cyclic prefix
0	15	Normal
1	30	Normal
2	60	Normal, Extended
3	120	Normal
4	240	Normal

For normal CP (14 symbols/slot), different numerologies μ 0 to 4 allow for 1, 2, 4, 8, and 16 slots, respectively, per subframe. For extended CP, the numerology 2 allows for 4 slots per subframe. Accordingly, for normal CP and numerology μ, there are 14 symbols/slot and 2^{μ} slots/subframe. The subcarrier spacing may be equal to 2^{μ}* 15 kHz, where μ is the numerology 0 to 4. As such, the numerology μ=0 has a subcarrier spacing of 15 kHz and the numerology μ=4 has a subcarrier spacing of 240 kHz. The symbol length/duration is inversely related to the subcarrier spacing. FIGS. **2**A-**2**D provide an example of normal CP with 14 symbols per slot and numerology μ=2 with 4 slots per subframe. The slot duration is 0.25 ms, the subcarrier spacing is 60 kHz, and the symbol duration is approximately 16.67 μs. Within a set of frames, there may be one or more different bandwidth parts (BWPs) (see FIG. **2**B) that are frequency division multiplexed. Each BWP may have a particular numerology and CP (normal or extended).

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

As illustrated in FIG. **2**A, some of the REs carry reference (pilot) signals (RS) for the UE. The RS may include demodulation RS (DM-RS) (indicated as R for one particular configuration, but other DM-RS configurations are possible) and channel state information reference signals (CSI-RS) for channel estimation at the UE. The RS may also include beam measurement RS (BRS), beam refinement RS (BRRS), and phase tracking RS (PT-RS).

FIG. **2**B illustrates an example of various DL channels within a subframe of a frame. The physical downlink control channel (PDCCH) carries DCI within one or more control channel elements (CCEs) (e.g., 1, 2, 4, 8, or 16 CCEs), each CCE including six RE groups (REGs), each REG including 12 consecutive REs in an OFDM symbol of an RB. A PDCCH within one BWP may be referred to as a control resource set (CORESET). A UE is configured to monitor PDCCH candidates in a PDCCH search space (e.g., common search space, UE-specific search space) during PDCCH monitoring occasions on the CORESET, where the PDCCH candidates have different DCI formats and different aggregation levels. Additional BWPs may be located at greater and/or lower frequencies across the channel bandwidth. A primary synchronization signal (PSS) may be within symbol 2 of particular subframes of a frame. The PSS is used by a UE **104** to determine subframe/symbol timing and a physical layer identity. A secondary synchronization signal (SSS) may be within symbol 4 of particular subframes of a frame. The SSS is used by a UE to determine a physical layer cell identity group number and radio frame timing. Based on the physical layer identity and the physical layer cell identity group number, the UE can determine a physical cell identifier (PCI). Based on the PCI, the UE can determine the locations of the DM-RS. The physical broadcast channel (PBCH), which carries a master information block (MIB), may be logically grouped with the PSS and SSS to form a synchronization signal (SS)/PBCH block (also referred to as SS block (SSB)). The MIB provides a number of RBs in the system bandwidth and a system frame number (SFN). The physical downlink shared channel (PDSCH) carries user data, broadcast system information not transmitted through the PBCH such as system information blocks (SIBs), and paging messages.

As illustrated in FIG. **2**C, some of the REs carry DM-RS (indicated as R for one particular configuration, but other DM-RS configurations are possible) for channel estimation at the base station. The UE may transmit DM-RS for the physical uplink control channel (PUCCH) and DM-RS for the physical uplink shared channel (PUSCH). The PUSCH DM-RS may be transmitted in the first one or two symbols of the PUSCH. The PUCCH DM-RS may be transmitted in different configurations depending on whether short or long PUCCHs are transmitted and depending on the particular PUCCH format used. The UE may transmit sounding ref-

erence signals (SRS). The SRS may be transmitted in the last symbol of a subframe. The SRS may have a comb structure, and a UE may transmit SRS on one of the combs. The SRS may be used by a base station for channel quality estimation to enable frequency-dependent scheduling on the UL.

FIG. **2**D illustrates an example of various UL channels within a subframe of a frame. The PUCCH may be located as indicated in one configuration. The PUCCH carries uplink control information (UCI), such as scheduling requests, a channel quality indicator (CQI), a precoding matrix indicator (PMI), a rank indicator (RI), and hybrid automatic repeat request (HARQ) acknowledgment (ACK) (HARQ-ACK) feedback (i.e., one or more HARQ ACK bits indicating one or more ACK and/or negative ACK (NACK)). The PUSCH carries data, and may additionally be used to carry a buffer status report (BSR), a power headroom report (PHR), and/or UCI.

FIG. **3** is a block diagram of a base station **310** in communication with a UE **350** in an access network. In the DL, Internet protocol (IP) packets may be provided to a controller/processor **375**. The controller/processor **375** implements layer 3 and layer 2 functionality. Layer 3 includes a radio resource control (RRC) layer, and layer 2 includes a service data adaptation protocol (SDAP) layer, a packet data convergence protocol (PDCP) layer, a radio link control (RLC) layer, and a medium access control (MAC) layer. The controller/processor **375** provides RRC layer functionality associated with broadcasting of system information (e.g., MIB, SIBs), RRC connection control (e.g., RRC connection paging, RRC connection establishment, RRC connection modification, and RRC connection release), inter radio access technology (RAT) mobility, and measurement configuration for UE measurement reporting; PDCP layer functionality associated with header compression/decompression, security (ciphering, deciphering, integrity protection, integrity verification), and handover support functions; RLC layer functionality associated with the transfer of upper layer packet data units (PDUs), error correction through ARQ, concatenation, segmentation, and reassembly of RLC service data units (SDUs), re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto transport blocks (TBs), demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

The transmit (Tx) processor **316** and the receive (Rx) processor **370** implement layer 1 functionality associated with various signal processing functions. Layer 1, which includes a physical (PHY) layer, may include error detection on the transport channels, forward error correction (FEC) coding/decoding of the transport channels, interleaving, rate matching, mapping onto physical channels, modulation/demodulation of physical channels, and MIMO antenna processing. The Tx processor **316** handles mapping to signal constellations based on various modulation schemes (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM)). The coded and modulated symbols may then be split into parallel streams. Each stream may then be mapped to an OFDM subcarrier, multiplexed with a reference signal (e.g., pilot) in the time and/or frequency domain, and then combined together using an Inverse Fast Fourier Transform (IFFT) to produce a physical channel carrying a time domain OFDM symbol stream. The OFDM stream is spatially precoded to produce multiple spatial streams. Channel estimates from a channel estimator **374** may be used to determine the coding and modulation scheme, as well as for spatial processing. The channel estimate may be derived from a reference signal and/or channel condition feedback transmitted by the UE **350**. Each spatial stream may then be provided to a different antenna **320** via a separate transmitter **318**Tx. Each transmitter **318**Tx may modulate a radio frequency (RF) carrier with a respective spatial stream for transmission.

At the UE **350**, each receiver **354**Rx receives a signal through its respective antenna **352**. Each receiver **354**Rx recovers information modulated onto an RF carrier and provides the information to the receive (Rx) processor **356**. The Tx processor **368** and the Rx processor **356** implement layer 1 functionality associated with various signal processing functions. The Rx processor **356** may perform spatial processing on the information to recover any spatial streams destined for the UE **350**. If multiple spatial streams are destined for the UE **350**, they may be combined by the Rx processor **356** into a single OFDM symbol stream. The Rx processor **356** then converts the OFDM symbol stream from the time-domain to the frequency domain using a Fast Fourier Transform (FFT). The frequency domain signal includes a separate OFDM symbol stream for each subcarrier of the OFDM signal. The symbols on each subcarrier, and the reference signal, are recovered and demodulated by determining the most likely signal constellation points transmitted by the base station **310**. These soft decisions may be based on channel estimates computed by the channel estimator **358**. The soft decisions are then decoded and deinterleaved to recover the data and control signals that were originally transmitted by the base station **310** on the physical channel. The data and control signals are then provided to the controller/processor **359**, which implements layer 3 and layer 2 functionality.

The controller/processor **359** can be associated with a memory **360** that stores program codes and data. The memory **360** may be referred to as a computer-readable medium. In the UL, the controller/processor **359** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, and control signal processing to recover IP packets. The controller/processor **359** is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

Similar to the functionality described in connection with the DL transmission by the base station **310**, the controller/processor **359** provides RRC layer functionality associated with system information (e.g., MIB, SIBs) acquisition, RRC connections, and measurement reporting; PDCP layer functionality associated with header compression/decompression, and security (ciphering, deciphering, integrity protection, integrity verification); RLC layer functionality associated with the transfer of upper layer PDUs, error correction through ARQ, concatenation, segmentation, and reassembly of RLC SDUs, re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto TBs, demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

Channel estimates derived by a channel estimator **358** from a reference signal or feedback transmitted by the base station **310** may be used by the Tx processor **368** to select the appropriate coding and modulation schemes, and to facilitate spatial processing. The spatial streams generated

by the Tx processor **368** may be provided to different antenna **352** via separate transmitters **354**Tx. Each transmitter **354**Tx may modulate an RF carrier with a respective spatial stream for transmission.

The UL transmission is processed at the base station **310** in a manner similar to that described in connection with the receiver function at the UE **350**. Each receiver **318**Rx receives a signal through its respective antenna **320**. Each receiver **318**Rx recovers information modulated onto an RF carrier and provides the information to a Rx processor **370**.

The controller/processor **375** can be associated with a memory **376** that stores program codes and data. The memory **376** may be referred to as a computer-readable medium. In the UL, the controller/processor **375** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover IP packets. The controller/processor **375** is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

At least one of the Tx processor **368**, the Rx processor **356**, and the controller/processor **359** may be configured to perform aspects in connection with the common message processing component **198** of FIG. **1**.

At least one of the Tx processor **316**, the Rx processor **370**, and the controller/processor **375** may be configured to perform aspects in connection with the common message configuration component **199** of FIG. **1**.

FIG. **4** is a diagram **400** illustrating an example of a multi-user rate-splitting MIMO system at a transmitting network entity, such as the base station **102** in FIG. **1**. A rate-splitting system for broadcast channels may be able to achieve a larger degree of freedom and/or capacity than a non-rate splitting system. A network entity may have a message W_1 for a UE_1 **416** and a message W_2 for a UE_2 **418**. Each message may be divided into a private portion and a public/common portion. The message splitter **402** may split the message W_1 for the UE_1 **416** into a private portion $W_{1,p}$ and a common portion $W_{1,c}$. Similarly, the message splitter **404** may split the message W_2 for the UE_2 **418** into a private portion $W_{2,p}$ and a common portion $W_{2,c}$. The combiner **406** may combine the common portion $W_{1,c}$ and the common portion $W_{2,c}$ into a common message W_c. The combiner **406** may concatenate the common portion $W_{1,c}$ and the common portion $W_{2,c}$ to generate the common message W_c. The encoder **410** may encode the common message W_c to generate the encoded common portion X_c, which also may be referred to as a common stream. The common stream may have one or more layers. The encoder **410** may modulate the common message W_c. The encoder **410** may map the data of the common message W_c to one or more layers, for example by using a code word layer mapping system, in addition to encoding the common message W_c. The precoder **414** may precode the encoded common portion X_c by P_c, and may transmit the portion P_cX_c by one or more transmitting antennas (e.g., from one or more transmission and reception points (TRPs) or a base station such as BS **102** in FIG. **1**).

The encoder **408** may encode the private portion $W_{1,p}$ to generate the encoded private portion X_1 for the UE_1 **416**, which also may be referred to as a private stream for the UE_1 **416**. The private stream may have one or more layers. The encoder **408** may modulate the private portion $W_{1,p}$. The encoder **408** may map the data to one or more layers in addition to encoding the private portion $W_{1,p}$. The precoder **414** may precode the encoded private portion X_1 by P_1, and may transmit the portion P_1X_1 by one or more transmitting antennas/TRPs/BSs. The encoder **412** may encode the private portion $W_{2,p}$ to generate the encoded private portion X_2 for the UE_2 **418**, which also may be referred to as a private stream for the UE_2 **418**. The private stream may have one or more layers. The encoder **412** may also modulate the private portion $W_{2,p}$ and map the data to one or more layers, for example by using a CW-layer mapping system, in addition to encoding the private portion $W_{2,p}$. The precoder **414** may precode the encoded private portion X_2 by P_2, and may transmit the portion P_2X_2 by one or more transmitting antennas/TRPs/BSs.

The signal output by the precoder **414** may be represented by $X=P_cX_c+P_1X_1+P_2X_2$, where X_1 may represent a private portion of the message associated with the UE_1 **416**, P_1 may represent the precoder for X_1, X_2 may represent a private portion of the message associated with the UE_2 **418**, P_2 may represent the precoder for X_2, X_c may represent a common portion of the message associated with both the UE_1 **416** and the UE_2 **418**, and P_c may represent the precoder for X_c. The transmitted signal X may be transmitted to the UE_1 **416** using the H_1 channel for the UE_1 **416**. The signal received by the UE_1 **416** may be represented by $Y_1=H_1P_cX_c+H_1P_1X_1+H_1P_2X_2+N_1$, where $H_1P_cX_c$ may represent a private portion of the message associated with the UE_1 **416** received via the H_1 channel for the UE_1 **416**, $H_1P_2H_2$ may represent a private portion of the message associated with the UE_2 **418** received via the H_1 channel for the UE_1 **416**, $H_2P_cX_c$ may represent a common portion of the message associated with both the UE_1 **416** and the UE_2 **418** received via the H_1 channel for the UE_1 **416**, and N_1 may represent the noise of the signal Y_1. Similarly, the transmitted signal X may be transmitted to the UE_2 **418** using the H_2 channel for the UE_2 **418**. The signal received by the UE_2 **418** may be represented by $Y_2=H_2P_cX_c+H_2P_1X_1+H_2P_2X_2+N_2$, where $H_2P_cX_c$ may represent a private portion of the message associated with the UE_1 **416** received via the H_2 channel for the UE_2 **418**, $H_2P_2X_2$ may represent a private portion of the message associated with the UE_2 **418** received via the H_2 channel for the UE_2 **418**, $H_2P_cX_c$ may represent a common portion of the message associated with both the UE_1 **416** and the UE_2 **418** received via the H_2 channel for the UE_2 **418**, and N_2 may represent the noise of the signal Y_2.

FIG. **5** is a diagram **500** illustrating an example of a multi-user rate-splitting MIMO system at a receiving UE, such as the UE **104** in FIG. **1** or the UE_1 **416** in FIG. **4**. The UE_1 **416** in FIG. **4** may receive the signal $Y_1=H_1P_cX_c+H_1P_1X_1+H_1P_2X_2+N_1$, and may decode the common portion $H_1P_cX_c$ and the private portion $H_1P_1X_1$ to reconstruct the message for the UE_1-W_1. At the receiver side, the UE_1 **416** may first decode the common message using the common message decoder **504** for two purposes. The first purpose may be to retrieve the common portion $W_{1,c}$, since a part of the individual message for each UE (e.g., $W_{1,c}$ for the UE_1 **416** and $W_{2,c}$ for the UE_2 **418**) may be embedded in the common message W_c. The second purpose may be to perform successive interference cancellation on the signal Y_1 to decode the private portion $W_{1,p}$.

The channel estimator **502** may estimate the effective channel H_1P_c corresponding with the received common stream $H_1P_cX_c$. The common message decoder **504** may use the channel estimate (CE) for the received common stream to decode the common message W_c, which may be a concatenation of the common portion $W_{1,c}$ and the common portion $W_{2,c}$. The common message decoder **504** may also perform demodulation and demapping on the common stream $H_1P_cX_c$ of the signal Y_1 in addition to decoding. The reconstructor **506** may reconstruct the received common stream $H_1P_cX_c$ from the common message W_c by re-encoding the common message W_c to generate an estimate of the

common stream X_c, and multiply the estimate of the effective channel H_1P_c with the estimate of the common stream X_c to obtain an estimate of the received common stream $H_1P_cX_c$. The subtractor **508** may subtract the estimate of the received common stream $H_1P_cX_c$ from the signal Y_1 to perform interference cancellation on the signal Y_1. Assuming perfect channel estimation by the channel estimator **502** and successful decoding by the common message decoder **504**, the subtractor may be able to clean up the signal $Y_1=H_1P_cX_c+H_1P_1X_1+H_1P_2X_2+N_1$ by subtracting the estimate of the received common stream $H_1P_cX_c$ to obtain an estimate of $Y_{1,p}=Y_1-H_1P_cX_c=H_1P_1X_1+H_1P_2X_2+N_1$.

The channel estimator **510** may estimate the effective channel H_1P_1 corresponding with the received private stream $H_1P_1X_1$. The private message decoder **512** may use the estimate of the effective channel H_1P_1 and the estimate of $Y_{1,p}$ to decode the private portion $W_{1,p}$. The private message decoder **512** may also perform demodulation and demapping on the private stream $H_1P_1X_1$ of the signal Y_1 in addition to decoding. The common portion $W_{1,c}$ and the private portion $W_{1,p}$ may be concatenated to obtain the message W_1 for the UE_1 **416**. In some aspects, the UE_1 **416** may be configured to jointly decode the private stream and the public stream without performing interference cancellation to decode the private portion $W_{1,p}$ of the message W_1 for the UE_1 **416**.

While FIG. **4** shows an example of a multi-user rate-splitting MIMO system splitting two messages, message W_1 for a UE_1 **416** and a message W_2 for a UE_2, more or less messages may be combined into a common stream in other aspects. In some aspects, the message splitter **402** in FIG. **4** may not split any of the message W_1 for the UE_1 **416** into a common portion $W_{1,c}$. In such aspects, the precoder **414** may output a signal $X=P_cX_c+P_1X_1+P_2X_2$, where P_1X_1 may represent a private portion of the message associated with the UE_1 **416**, P_2X_2 may represent a private portion of the message associated with the UE_2 **418**, and P_cX_c may represent a common portion of the message associated with both the UE_1 **416** and the UE_2 **418** which does not contain any portion of the message W_1. The UE_1 **416** in FIG. **5** may decode the common message $H_1P_cX_c$ for the purpose of successive interference cancellation (SIC) and decoding the private message $H_1P_1X_1$. In such aspects, the UE_1 **416** may decode the common message $H_1P_cX_c$ at a PHY layer, and may not pass on the common message, decoded or otherwise, to the higher layers.

Similarly, in some aspects, the message splitter **404** in FIG. **4** may not split any of the message W_2 for the UE_2 **418** into a common portion $W_{2,c}$. In such aspects, the precoder **414** may output a signal $X=P_cX_c+P_1X_1+P_2X_2$, where P_1X_1 may represent a private portion of the message associated with the UE_1 **416**, P_2X_2 may represent a private portion of the message associated with the UE_2 **418**, and P_cX_c may represent a common portion of the message associated with both the UE_1 **416** and the UE_2 **418** which does not contain any portion of the message W_2. The UE_2 **418** may decode the common message $H_1P_cX_c$ for the purpose of successive interference cancellation (SIC) and decoding the private message $H_1P_1X_1$. In such aspects, the UE_1 **416** may decode the common message $H_1P_cX_c$ at a PHY layer, and may not pass on the common message, decoded or otherwise, to the higher layers.

Similarly, messages for three or more UEs may be split and combined into a common stream. A subset of a set of UEs may have messages split and combined into a common stream. For example, a network entity may be configured to transmit four private messages and a common message for four UEs, a first UE, a second UE, a third UE, and a fourth UE, and the common message may combine portions of the message for the first UE, the second UE, and the third UE, but not the fourth UE. The fourth UE may decode the common message at the PHY layer for the purpose of SIC and decoding the private message for the fourth UE, but the common message may not be used by the layers higher than the PHY layer. In other words, referring to FIG. **5**, the private message decoder **512** may be implemented on the PHY layer of a UE, and the output W_1 may be output to a higher layer.

The communication rate region may be characterized as a function of a rate of common message(s) and private messages irrespective of how a common message may be distributed among UEs. How a common message may be split between two or more UEs may impact the rate region of the UEs, and may not impact the sum rate across the UEs. In one aspect, in FIG. **4**, the achievable rate regions may be characterized as $(R_c, R_{p,1}, R_{p,2})$ irrespective of which part of R_c may be for the UE_1 **416** or the UE_2 **418**. Such a split may impact the rate region (R_1, R_2). Such a split may not impact the achievable sum rate R_1+R_2.

In rate-splitting MIMO, a network entity may provide a UE with one or more indications of which part of the common message may contain data for the UE. (e.g., one half, one third, or no part of the common message). The portion of the common message for the UE may be referred to as the UE's data portion of the common message, and may include part of the individual message for the UE. For example, in FIG. **4**, the data portion for the UE_1 **416** may be $W_{1,c}$, which may include part of the individual message W_1 for the UE_1 **416**. Similarly, the data portion for the UE_2 **418** may be $W_{2,c}$, which may include part of the individual message W_2 for the UE_2 **418**. In an aspect with two co-scheduled UEs, the common message may include parts of individual messages for the two UEs (e.g., $W_c=(W_{1,c}, W_{2,c})$). In another aspect with more than two co-scheduled UEs, a UE may receive two separately encoded common messages, where the first common message may include parts of individual messages for three UEs of a set of three UEs (e.g., $W_c^1=(W_{1,c}^1, W_{2,c}^1, W_{3,c}^1)$), and the second common message may include parts of individual messages for two UEs of the set of three UEs (e.g., $W_c^2=(W_{1,c}^2, W_{3,c}^2)$). After the UE decodes the common message, the UE may use information from the network entity to understand which part of the decoded common message includes information for the UE. The UE may pass the portion of the decoded common message that includes information for the UE to one or more higher layers for message assembly.

FIG. **6A** is a diagram **600** illustrating an example of a common message format for a multi-user rate-splitting MIMO system. The common message **610** may have an indication of which part of the common message includes data for a given UE. The common message **610** may have a header **612**, a data portion **614** having data for a first UE, and a data portion **616** having data for a second UE. The header **612** may be, for example, a MAC header. A network entity may add one or more such headers to the common message **610** for such an indication. The header **612** may indicate information, such as a UE identifier (ID) that has data in the common message **610**, the order of the data in the common message for UEs that have data portions in the common message **610** (e.g., data for the first UE followed by data for the second UE), or a size of each packet with data for each UE (i.e., the size of data portion **614** for the first UE and the size of data portion **616** for the second UE). In some aspects, the packet size for each data portion may be the same when

the common message **610** includes data portions for a plurality of UEs. In one aspect, the packet size for each of the data portions may be indicated in the header **612**. In another aspect, the packet size may be derived by the UE after excluding sub-headers by knowing the number of UEs (e.g., (size of common message **610**−size of header **612**)/number of UEs) The header **612** may indicate one of the set of UEs who have a data portion in the common message **610**. Information indicated in the header **612** may be referred to as common message configuration information. In one aspect, the UE ID may be a cell radio network temporary identifier (C-RNTI). In another aspect, the UE ID may indicate an index associated with a UE within a set of UEs configured to attempt decoding the common message **610**. The index may refer to a position in a table of UE IDs for UEs scheduled to attempt decoding the common message **610**. An index may be used to reduce overhead for indicating a UE ID. In one aspect, when a set of eight UEs are scheduled to attempt decoding of the common message **610**, the UE ID may be three bits to identify which UE has a data portion in the common message **610**. A PHY layer may decode and pass a decoded common TB or message to the higher layers, such as a MAC layer or an RLC layer. A higher layer may extract the relevant data for the UE once the PHY layer decodes and passes the common TB or message to the higher layer. The PHY layer may not be aware of how the common message may be split across a plurality of UEs and which part of the common message is addressed to the UE.

An index in the header **612** may reference a table that maps to one or more possibilities for the common message **610** may be split across a plurality of UEs. The different possibilities and corresponding indices may be pre-defined or RRC configured to the UE. In one aspect, a first UE, a second UE, and a third UE may decode the common message **610**, and the header **612** may include three bits indicating one of the following eight possibilities in Table 1. Table 1 is an example of message split configurations for a number of UEs that may have data portions encoded in the common message **610**.

TABLE 1

Index	Common message split
0	Includes data for UE_1
1	Includes data for UE_2
2	Includes data for UE_3
3	Includes data for UE_1 and UE_2 with equal split
4	Includes data for UE1 and UE_3 with equal split
5	Includes data for UE_2 and UE_3 with equal split
6	Includes data for UE_2 and UE_3 with 20/80% split
7	Includes data for UE_2 and UE_3 with 80/20% split

FIG. **6**B is a diagram **650** illustrating another example of a common message format for a multi-user rate-splitting MIMO system. The common message **670** may have plurality of indications of which part of the common message includes data for a given UE. A plurality of sub-headers may be used to indicate information for a data portion, such as a UE ID and a packet size. Each of the sub-headers corresponding to each UE may be placed before the data portion for the same UE in the common message **670**. The common message **670** may have a common header **672**, a sub-header **674** for a first UE, a data portion **676** having data for the first UE, a sub-header **678** for a second UE, and a data portion **680** having data for the second UE. The common header **672**, sub-header **674** for the first UE, and sub-header **678** for the second UE, may each be a MAC header. In an aspect where the number of UEs for the common message **670** may be variable, the common header **672** may indicate the number of UEs for which the common message includes data portions. The common header **672** may indicate an index to a table of message split configurations, such as Table 1. A network entity may add one or more such headers or sub-headers to the common message **670** for such an indication. In some aspects, the packet size for each data portion may be the same when the common message **670** includes data portions for a plurality of UEs. In one aspect, the packet size for each of the data portions may be indicated in the common header **672**. In another aspect, the packet size may be derived by the UE after excluding sub-headers by knowing the number of UEs (e.g., (size of common message **670**−sub-header sizes)/number of UEs) The common header **672**, the sub-header **674**, or the sub-header **678** may indicate one of the set of UEs who have a data portion in the common message **670**. Information indicated in the common header **672**, the sub-header **674**, or the sub-header **678** may be referred to as common message configuration information. In one aspect, the UE ID may be a C-RNTI. In another aspect, the UE ID may indicate an index associated with a UE within a set of UEs configured to attempt decoding the common message **670**. The index may refer to a position in a table of UE IDs for UEs scheduled to attempt decoding the common message **670**. An index may be used to reduce overhead for indicating a UE ID. A PHY layer may decode and pass a decoded common TB or message to the higher layers, such as a MAC layer or an RLC layer. A higher layer may extract the relevant data for the UE once the PHY layer decodes and passes the common TB or message to the higher layer. The PHY layer may not be aware of how the common message may be split across a plurality of UEs and which part of the common message is addressed to the UE.

FIG. **7**A is a diagram **700** illustrating another example of a common message format for a multi-user rate-splitting MIMO system. The common message **710** may have one or more indications of which part of the common message includes data for a given UE. The common message **710** may include data for one UE. Other UEs may still decode the common message **710** for the purpose of SIC and decoding the private message for the other UEs. The header **712** may indicate a single UE ID. The header **712** may not indicate a number of UEs for which the common message includes data portions. The header may have one data portion **714**, having data for the first UE. Encoding a common message **710** having a data portion for one UE may not impact the overall sum rate (e.g., (R_1+R_2)) in rate splitting MIMO, but may impact the rate region (e.g., (R_1, R_2)) The indicated information in the header **712** may be referred to as common message configuration information. In one aspect, the UE ID may be a C-RNTI. In another aspect, the UE ID may indicate an index associated with a UE within a set of UEs configured to attempt decoding the common message **710**. The index may refer to a position in a table of UE IDs for UEs scheduled to attempt decoding the common message **710**. An index may be used to reduce overhead for indicating a UE ID. A PHY layer may decode and pass a decoded common TB or message to the higher layers, such as a MAC layer or an RLC layer. A higher layer may extract the relevant data for the UE once the PHY layer decodes and passes the common TB or message to the higher layer. The PHY layer may not be aware of how the common message may be split across a plurality of UEs and which part of the common message is addressed to the UE.

FIG. **7**B is a diagram **750** illustrating an example of a header format for a common message of a multi-user rate-splitting MIMO system. A common message, such as the common message **610** in FIG. **6**A, may have an indication of which part of the common message includes data for a given UE. The common message may have a header **760** having a plurality of sub-headers. The header **760** may have a first sub-header **762**, a second sub-header **764**, and a third sub-header **766**. The first sub-header **762** may indicate a number of UEs that the common message includes data packets for. The remaining sub-headers of the header **760** may each indicate a UE ID and packet length for each of the number of UEs that the common message includes data packets for. For example, the second sub-header **764** may have a UE ID and a packet size (i.e., packet length) for a first UE of a set of N UEs. The third sub-header **766** may have a UE ID and a packet size for an Nth UE of a set of N UEs. A plurality of sub-headers may be located between the second sub-header **764** and the third sub-header **766** numbering N-**2**. The header **760** may be a MAC header. Each of the first sub-header **762**, the second sub-header **764**, and the third sub-header **766** may be, a MAC header. A network entity may add one or more such headers or sub-headers to a common message, such as the common message **610**, for such an indication. The information in the header **760** may be referred to as common message configuration information. In one aspect, the UE ID may be a C-RNTI. In another aspect, the UE ID may indicate an index associated with a UE within a set of UEs configured to attempt decoding a common message associated with the header **760**. The index may refer to a position in a table of UE IDs for UEs scheduled to attempt decoding the common message. An index may be used to reduce overhead for indicating a UE ID.

FIG. **8**A is a diagram **800** illustrating an example of DCI and a common message format for a multi-user rate-splitting MIMO system. A DCI **810** may have configuration information **812** that schedules a common message **820**. The common message **820** may have data portions for one or more UEs, such as the data portion **822** for a first UE and a data portion **824** for a second UE. The configuration information **812** may have an indication of which part of the common message **820** includes data for a given UE. The PHY layer of the UE may use the configuration information **812** to understand how the common message **820** is split across a set of UEs. The PHY layer of the UE may use the configuration information **812** to understand which part of the common message **820** is addressed to the UE. The PHY layer of the UE may decode the common message **820**, identify the data portion of the common message **820** for the UE (e.g., data portion **822** for the first UE), and deliver the decoded data relevant to the UE to one or more layers higher than the PHY layer, such as a MAC layer or an RLC layer. The configuration information **812** may schedule the private message for the UE as well as the common message **820**.

A Unicast DCI (not common to more than one UE) may schedule the private message for the UE. The DCI **810** have one or more fields that have common message configuration information, such as a field that indicates whether the common message includes the first data portion of the common message associated with the first UE a field that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, a field that indicates a total number of UEs scheduled to attempt decoding the common message **820**, a field that indicates an index to a table of UE IDs for UEs scheduled to attempt decoding the common message **820**, or an index to a table of split configurations. A DCI field that has common message configuration information may be RRC configured to the UE per DCI format. For example, an RRC configuration may have a first DCI format that includes a first field of DCI that indicates whether the common message includes the first data portion of the common message associated with the first UE, a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, or a third DCI format that schedules a non-rate splitting transmission. A DCI format that schedules a non-rate splitting transmission may be used for regular DL scheduling and may not be used for rate splitting.

FIG. **8**B is a diagram **850** illustrating another example of DCI and a common message format for a multi-user rate-splitting MIMO system. A DCI **860** may have configuration information **862** that schedules a common message **870**. The common message **870** may have a data portion for one UE, such as the data portion **872** for a first UE. Other UEs that the first UE may decode the common message **870** for the purpose of SIC and decoding the private message for the other UEs. In one aspect, the DCI **860** may be a unicast DCI. The configuration information **862** may have cyclic redundancy check (CRC) scrambled with C-RNTI. The DCI **860** may not be a common DCI with CRC scrambled with a group RNTI (G-RNTI). The configuration information **862** may include a DCI field (e.g., a single bit) that indicates whether the common message **870** includes data for the UE or not. A DCI **860** with such configuration information **862** may minimizes DCI overhead. In one aspect, the DCI **860** may be a group-common DCI. The configuration information **862** may have CRC scrambled with G-RNTI. The configuration information **862** may include a DCI field (e.g., two bits for a set of four UEs, three bits for a set of eight UEs) to indicate a UE ID for which the common message **870** includes a data portion. The configuration information **862** may have an indication of which part of the data portion **872** includes data for a given UE. The PHY layer of the UE may decode the common message **870**, identify the data portion of the common message **870** for the UE (e.g., data portion **872** for the first UE), and deliver the decoded data relevant to the UE to one or more layers higher than the PHY layer, such as a MAC layer or an RLC layer. The configuration information **862** may schedule the private message for the UE as well as the common message **870**.

A network entity may transmit an RRC configuration for one or more types of common messages to use in a multi-user rate-splitting MIMO system in response to a trigger. For example, a network entity may transmit an RRC configuration for a common message having a header with a common message configuration for the common message (e.g., common message **670** in FIG. **6**B) in response to the network entity indicating a plurality of possibilities for a common message to split to achieve plurality of different points in a rate region (R_1, R_2). In response to the network entity indicating a single possibility, the network entity may transmit an RRC configuration for a common message having a DCI scheduling a common message having one data portion for one UE, such as the DCI **860** scheduling the common message **870**. A network entity may also transmit an RRC configuration of a total number of UEs that are scheduled to attempt decoding a common message and who may have data in the common message. The total number may be different from the actual number of UEs that have data portions in the common message. A table of UE IDs for UEs scheduled to attempt decoding the common message, a table of message split configurations may be provided by an

RRC configuration. The length of a header or sub-headers, such as the header **612** in FIG. **6**A, or the common header **672** or the sub-header **674** in FIG. **6**B may be a function of the total number of UEs that are scheduled to attempt decoding a common message and who may have data in the common message. The length of a DCI-field having an index to such a table may be a function of the total number of UEs that are scheduled to attempt decoding a common message and who may have data in the common message.

FIG. **9** is a connection flow diagram **900** illustrating an example of a common message split communication between a UE **902** and a network entity **904**. The network entity **904** may output an RRC configuration **906** to the UE **902**. The network entity **904** may output the RRC configuration **906** to one or more UEs, such as UE_1 to UE_N in FIG. **7**B. The UE **902** may receive the RRC configuration **906** from the network entity **904**. The RRC configuration **906** may pre-define one or more possible configurations for a multi-user rate-splitting MIMO. For example, the RRC configuration **906** may have at least one of a first DCI format that includes a first field of the DCI that indicates whether the common message includes the first data portion of the common message associated with the first UE, a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, a third DCI format that schedules a non-rate splitting transmission, a total number of UEs scheduled to attempt decoding the common message, a table of UE IDs for UEs scheduled to attempt decoding the common message, or a table of message split configurations. The RRC configuration may provide indications for one or more header and/or sub-header configurations for a common message, such as the header **612** in FIG. **6**A, common header **672** and UE-specific sub-headers, such as sub-headers **674** and sub-header **678** in FIG. **6**B, or header **712** in FIG. **7**A. For example, the RRC configuration may define a packet size of data portions of a common message or may define a table of message split configurations.

At **908**, the network entity may configure a common message configuration for a rate-split MIMO transmission **910**. The common message configuration may be provided as one or more headers of the rate-split MIMO transmission **910**, such as the header **612** in FIG. **6**A, the common header **672**, the sub-header **674**, or the sub-header **678** in FIG. **6**B, the header **712** in FIG. **7**A, or the header **760** in FIG. **7**B. The network entity **904** may output a rate-split MIMO transmission **910** to the UE **902**. The network entity **904** may output the rate-split MIMO transmission **910** to one or more UEs, such as UE_1 to UE_N in FIG. **7**B. The rate-split MIMO transmission **910** may include one or more private messages and one or more common messages, such as the signal $Y_1=H_1P_cX_c+H_1P_1X_1+H_1P_2X_2+N_1$ or $Y_2=H_2P_cX_c+H_2P_1X_1+H_2P_2X_2+N_2$ in FIG. **4**. One or more of the common messages may be configured using the common message configuration configured at **908**.

At **912**, the UE **902** may obtain the common message configuration from the header of the rate-split MIMO transmission **910**. The header may be contiguous, as in FIG. **6**A, **7**A or **7**B, or non-contiguous, as in FIG. **6**B. The UE **902** may use the common message configuration to determine if a common message of the rate-split MIMO transmission **910** has a data portion addressed for the UE **902**, and if so, where the data portion is located in the common message. The header may indicate which part of the common message includes data for the UE **902**, which may be used to extract relevant data for the UE **902** once a PHY layer of the UE **902** decodes and passes the common TB or message to one or more higher layers.

At **914**, the UE **902** may perform a decoding process of the rate-split MIMO transmission **910** based on the common message configuration. In one aspect, in response to the UE **902** determining that a common message of the rate-split MIMO transmission **910** does not have a data portion addressed for the UE **902**, the UE **902** may forego combining the private message with the data portion of the common message when performing the decoding process. In another aspect, in response to the UE **902** determining that a common message of the rate-split MIMO transmission **910** has a data portion addressed for the UE **902**, the UE **902** may combine a private message with the data portion of the common message when performing the decoding process. In either aspect, the UE **902** may decode the common message for the purpose of SIC and to decode the private message.

FIG. **10** is a connection flow diagram **1000** illustrating another example of a common message split communication between a UE **1002** and a network entity **1004**. The network entity **1004** may output an RRC configuration **1006** to the UE **1002**. The network entity **1004** may output the RRC configuration **1006** to one or more UEs, such as UE_1 to UE_N in FIG. **7**B. The UE **1002** may receive the RRC configuration **1006** from the network entity **1004**. The RRC configuration **1006** may pre-define one or more possible configurations for a multi-user rate-splitting MIMO. For example, the RRC configuration **1006** may have at least one of a first DCI format that includes a first field of the DCI that indicates whether the common message includes the first data portion of the common message associated with the first UE, a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, a third DCI format that schedules a non-rate splitting transmission, a total number of UEs scheduled to attempt decoding the common message, a table of UE IDs for UEs scheduled to attempt decoding the common message, or a table of message split configurations. The RRC configuration may provide indications for one or more header and/or sub-header configurations for a common message, such as the header **612** in FIG. **6**A, common header **672** and UE-specific sub-headers, such as sub-headers **674** and sub-header **678** in FIG. **6**B, or header **712** in FIG. **7**A. For example, the RRC configuration may define a packet size of data portions of a common message or may define a table of message split configurations.

The network entity **1004** may output DCI **1007** scheduling the rate-split MIMO transmission **1010** to one or more UEs, such as UE_1 to UE_N in FIG. **7**B. The UE **1002** may receive the DCI **1007** scheduling the rate-split MIMO transmission **1010**. The DCI **1007** may select a configuration of the RRC configuration **1006** output by the network entity **1004**. For example, the DCI **1007** may have an index to a table of message split configurations configured by the RRC configuration **1006**. The DCI **1007** may provide an indication of which part of a common message of the rate-split MIMO transmission **1010** includes data for the UE **1002**.

At **1008**, the network entity may configure a common message configuration for a rate-split MIMO transmission **1010**. The common message configuration may be provided as one or more headers of the rate-split MIMO transmission **1010**, such as the header **612** in FIG. **6**A, the common header **672**, the sub-header **674**, or the sub-header **678** in FIG. **6**B, the header **712** in FIG. **7**A, or the header **760** in FIG. **7**B.

At **1012**, the UE **1002** may obtain the common message configuration from the header of the rate-split MIMO transmission **1010**. The header may be contiguous, as in FIGS. **6**A, **7**A or **7**B, or non-contiguous, as in FIG. **6**B. The UE **1002** may use the common message configuration to determine if a common message of the rate-split MIMO transmission **1010** has a data portion addressed for the UE **1002**, and if so, where the data portion is located in the common message. The header may indicate which part of the common message includes data for the UE **1002**, which may be used to extract relevant data for the UE **1002** once a PHY layer of the UE **1002** decodes and passes the common TB or message to one or more higher layers.

The network entity **1004** may output a rate-split MIMO transmission **1010** to the UE **1002**. The network entity **1004** may output the rate-split MIMO transmission **1010** to one or more UEs, such as UE_1 to UE_N in FIG. **7**B. The rate-split MIMO transmission **1010** may include one or more private messages and one or more common messages, such as the signal $Y_1=H_1P_cX_c+H_1P_1X_1+H_1P_2X_2+N_1$ or $Y_2=H_2P_cX_c+H_2P_1X_1+H_2P_2X_2+N_2$ in FIG. **4**. One or more of the common messages may be configured using the common message configuration configured at **1008**.

At **1014**, the UE **1002** may perform a decoding process of the rate-split MIMO transmission **1010** based on the common message configuration. In one aspect, in response to the UE **1002** determining that a common message of the rate-split MIMO transmission **1010** does not have a data portion addressed for the UE **1002**, the UE **1002** may forego combining the private message with the data portion of the common message when performing the decoding process. In another aspect, in response to the UE **1002** determining that a common message of the rate-split MIMO transmission **1010** has a data portion addressed for the UE **1002**, the UE **1002** may combine a private message with the data portion of the common message when performing the decoding process. In either aspect, the UE **1002** may decode the common message for the purpose of SIC and to decode the private message.

The network entity **1004** may output a DCI **1016** scheduling a non-rate split MIMO transmission for the UE **1002**. The UE **1002** may receive the DCI **1016** scheduling a non-rate split MIMO transmission for the UE **1002**. The DCI **1016** scheduling a non-rate split MIMO transmission may not have the fields that the DCI **1007** scheduling the rate-split MIMO transmission has. For the example, the DCI **1007** may have a field that indicates whether the common message of a transmission includes a data portion associated with the UE **1002**, and the DCI **1016** may not have that field, or the DCI **1007** may have a field that indicates a UE ID for the UE **1002** or a UE ID for one or more other UEs while the DCI **1016** may not have that field. The DCI **1016** may have a zero buffer instead of the fields that the DCI **1007** has, or the DCI **1016** may have other fields instead of the fields that the DCI **1007** has.

FIG. **11** is a flowchart **1100** of a method of wireless communication. The method may be performed by a UE (e.g., the UE **104**, the UE **350**, the UE_1 **416**, the UE_2 **418**, the UE **902**, the UE **1002**; the apparatus **1604**). At **1102**, the UE may receive a common message associated with the first UE and at least one second UE. For example, **1102** may be performed by the UE **1002** in FIG. **10**, which may receive a common message of the rate-split MIMO transmission **1010**. The common message may be associated with the UE **1002** and at least one other UE, similar to W_c in FIGS. **4** and **5**. Moreover, **1102** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1104**, the UE may obtain a common message configuration having at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE. The common message configuration may be obtained from at least one of a header of the common message or DCI scheduling the common message. For example, **1104** may be performed by the UE **1002** in FIG. **10**, which may obtain a common message configuration via a header of the rate-split MIMO transmission **1010** or a DCI **1007** scheduling the rate-split MIMO transmission **1010**. The common message configuration may have at least one of an indicator for a data portion of the common message associated with the UE **1002** or an indicator for at least one second data portion of the common message associated with the at least one second UE, such as the data portions for UE_2-UE_N in FIG. **7**B. The common message configuration may be obtained from at least one of a header of the common message for the rate-split MIMO transmission **1010**, or DCI **1007** scheduling the common message for the rate-split MIMO transmission **1010**. Moreover, **1102** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

FIG. **12** is a flowchart **1200** of a method of wireless communication. The method may be performed by a UE (e.g., the UE **104**, the UE **350**, the UE_1 **416**, the UE_2 **418**, the UE **902**, the UE **1002**; the apparatus **1604**). At **1202**, the UE may receive a common message associated with the first UE and at least one second UE. For example, **1202** may be performed by the UE **1002** in FIG. **10**, which may receive a common message of the rate-split MIMO transmission **1010**. The common message may be associated with the UE **1002** and at least one other UE, similar to W_c in FIGS. **4** and **5**. Moreover, **1202** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1204**, the UE may obtain a common message configuration having at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE. The common message configuration may be obtained from at least one of a header of the common message or DCI scheduling the common message. For example, **1204** may be performed by the UE **1002** in FIG. **10**, which may obtain a common message configuration via a header of the rate-split MIMO transmission **1010** or a DCI **1007** scheduling the rate-split MIMO transmission **1010**. The common message configuration may have at least one of an indicator for a data portion of the common message associated with the UE **1002** or an indicator for at least one second data portion of the common message associated with the at least one second UE, such as the data portions for UE_2-UE_N in FIG. **7**B. The common message configuration may be obtained from at least one of a header of the common message for the rate-split MIMO transmission **1010**, or DCI **1007** scheduling the common message for the rate-split MIMO transmission **1010**. Moreover, **1204** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1206**, the UE may receive an RRC configuration including at least one of (a) a first DCI format that includes a first field of the DCI that indicates whether the common message includes the first data portion of the common message associated with the first UE, (b) a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, (c) a third DCI format that schedules a non-rate splitting transmission, (d) a

total number of UEs scheduled to attempt decoding the common message, (e) a table of UE IDs for UEs scheduled to attempt decoding the common message, or (f) a table of message split configurations. For example, **1206** may be performed by the UE **1002** in FIG. **10**, which may receive an RRC configuration **1006** that includes at least one of (a) a first DCI format for the DCI **1007** scheduling the rate-split MIMO transmission **1010** that includes a first field of the DCI **1007** that indicates whether the common message includes the first data portion of the common message associated with the UE **1002**, (b) a second DCI format for the DCI **1007** scheduling the rate-split MIMO transmission **1010** that includes a second field of the DCI **1007** that indicates at least one of a first UE ID for the UE **1002** or at least one second UE ID for the at least one second UE (e.g., UE_2 to UE_N referred to in FIG. **7**B), (c) a third DCI format for the DCI **1016** scheduling a non-rate split MIMO transmission, (d) a total number of UEs scheduled to attempt decoding the common message, which may include the UE **1002**, (e) a table of UE IDs for UEs scheduled to attempt decoding the common message, which may include the UE **1002**, or (f) a table of message split configurations that may be selected by an index, such as an index of DCI **1007** scheduling the rate-split MIMO transmission **1010**. Moreover, **1206** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1208**, the UE may receive a private message associated with the first UE. For example, **1208** may be performed by the UE **1002** in FIG. **10**, which may receive a private message (e.g., $H_1P_1X_1$ in FIG. **5**) associated with the UE **1002**. Moreover, **1208** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1210**, the UE may combine the private message with the first data portion of the common message or forgo combining the private message with the first data portion of the common message based on the common message configuration. For example, **1210** may be performed by the UE **1002** in FIG. **10**, which may combine the private message with the first data portion of the common message, such as by combining $W_{1,c}$ and $W_{1,p}$ to construct W_1 in FIG. **5**, based on the common message configuration of whether the common message has a portion for the UE **1002**. In another aspect, the UE **1002** may forego combining the private message with the first data portion of the common message, such as when Y_1 in FIG. **5** has a $H_1P_1X_1$ component but does not have a $H_1P_cX_c$ component, based on the common message configuration of whether the common message has a portion for the UE **1002**. Moreover, **1210** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

FIG. **13** is a flowchart **1300** of a method of wireless communication. The method may be performed by a UE (e.g., the UE **104**, the UE **350**, the UE_1 **416**, the UE_2 **418**, the UE **902**, the UE **1002**; the apparatus **1604**). At **1302**, the UE may decode a private message to derive a decoded private message. For example, **1302** may be performed by the UE_1 **416** in FIG. **5**, which may decode a private message, such as the $H_1P_1X_1$ component of Y_1, to derive $W_{1,p}$. Moreover, **1302** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1304**, the UE may decode the common message to derive a decoded common message. For example, **1304** may be performed by the UE_1 **416** in FIG. **5**, which may decode a common message, such as $H_1P_cX_c$, P_cX_c, or X_c, to derive $W_{1,c}$. Moreover, **1304** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1306**, the UE may identify a first data portion of the decoded common message to derive a first decoded portion of the common message. For example, **1306** may be performed by the UE_1 **416** in FIG. **5**, which may identify a data portion of the decoded common message to derive a first decoded portion of the common message, such as $W_{1,c}$ of W_c. Moreover, **1306** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1308**, the UE may combine the decoded private message with the first decoded portion of the common message to derive a decoded message for a first UE. For example, **1308** may be performed by the UE_1 **416** in FIG. **5**, which may combine the decoded private message, such as $W_{1,p}$, with the decoded portion of the common message, such as W_c, to derive a decoded message, such as W_1, for the UE **1002**. Moreover, **1308** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1310**, the UE may decode the common message at a first layer to derive the decoded common message. For example, **1310** may be performed by the UE_1 **416** in FIG. **5**, which may decode the common message, such as $H_1P_cX_c$, P_cX_c, or X_c, at a first layer, such as a PHY layer, to derive the decoded common message, such as W_c. Moreover, **1310** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1312**, the UE may identify the first data portion of the decoded common message to derive the first decoded portion of the common message based on the common message configuration at a second layer. For example, **1312** may be performed the UE_1 **416** in FIG. **5**, which may identify the first data portion of the decoded common message, such as W_c, to derive the first decoded portion of the common message, such as $W_{1,c}$, based on the common message configuration at a second layer, such as a MAC layer. Moreover, **1312** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1314**, the UE may output the first decoded portion to a third layer. For example, **1314** may be performed by the UE_1 **416** in FIG. **5**, which may output the first decoded portion, such as $W_{1,c}$, to a third layer, such as an RLC layer. Moreover, **1314** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1316**, the UE may decode the common message at a first layer to derive the decoded common message. For example, **1316** may be performed by the UE_1 **416** in FIG. **5**, which may decode the common message, such as $H_1P_cX_c$, P_cX_c, or X_c, at a first layer, such as a PHY layer, to derive the decoded common message, such as W_c. Moreover, **1316** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1318**, the UE may identify the first data portion of the decoded common message to derive the first decoded portion of the common message based on the common message configuration at the first layer. For example, **1318** may be performed by the UE_1 **416** in FIG. **5**, which may identify the first data portion of the decoded common message, such as W_c, to derive the first decoded portion of the common message, such as $W_{1,c}$, based on the common message configuration at the first layer, such as the PHY layer. Moreover, **1318** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

At **1320**, the UE may output the first decoded portion to a second layer. For example, **1320** may be performed by output the first decoded portion, such as $W_{1,c}$, to a second layer, such as a MAC or an RLC layer. Moreover, **1320** may be performed by the component **198** of apparatus **1604** in FIG. **16**.

FIG. **14** is a flowchart **1400** of a method of wireless communication. The method may be performed by a net-

work entity (e.g., the base station **102**, the base station **310**; the network entity **904**, the network entity **1004**, the network entity **1602**, the network entity **1702**). At **1402**, the network entity may configure a common message configuration including at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE. For example, **1402** may be performed by the network entity **1004** in FIG. **10**, which may configure a common message configuration including at least one of an indicator for a data portion of a common message associated with the UE **1002** or an indicator for at least one second data portion of the common message associated with at least one second UE, such as UE_2 to UE_N in FIG. **7**B. Moreover, **1402** may be performed by the component **199** of network entity **1702** in FIG. **17**.

At **1404**, the network entity may transmit at least one of (a) the common message including the common message configuration or (b) the common message and the common message configuration to the first UE and at least one second UE. For example, **1404** may be performed by the network entity **1004** in FIG. **10**, which may transmit at least one of (a) the common message including the common message configuration as the rate-split MIMO transmission **1010** or (b) the common message as the rate-split MIMO transmission and the common message configuration as the DCI **1007** scheduling the rate-split MIMO transmission **1010** to the UE **1002** and at least one second UE, such as UE_2 to UE_N in FIG. **7**B. Moreover, **1404** may be performed by the component **199** of network entity **1702** in FIG. **17**.

FIG. **15** is a flowchart **1500** of a method of wireless communication. The method may be performed by a network entity (e.g., the base station **102**, the base station **310**; the network entity **904**, the network entity **1004**, the network entity **1602**, the network entity **1702**). At **1502**, the network entity may configure a common message configuration including at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE. For example, **1502** may be performed by the network entity **1004** in FIG. **10**, which may configure a common message configuration including at least one of an indicator for a data portion of a common message associated with the UE **1002** or an indicator for at least one second data portion of the common message associated with at least one second UE, such as UE_2 to UE_N in FIG. **7**B. Moreover, **1502** may be performed by the component **199** of network entity **1702** in FIG. **17**.

At **1504**, the network entity may transmit at least one of (a) the common message including the common message configuration or (b) the common message and the common message configuration to the first UE and at least one second UE. For example, **1504** may be performed by the network entity **1004** in FIG. **10**, which may transmit at least one of (a) the common message including the common message configuration as the rate-split MIMO transmission **1010** or (b) the common message as the rate-split MIMO transmission and the common message configuration as the DCI **1007** scheduling the rate-split MIMO transmission **1010** to the UE **1002** and at least one second UE, such as UE_2 to UE_N in FIG. **7**B. Moreover, **1504** may be performed by the component **199** of network entity **1702** in FIG. **17**.

At **1506**, the network entity may transmit an RRC configuration including at least one of (a) a first DCI format that includes a first field of the DCI that indicates whether the common message includes the first data portion of the common message associated with the first UE, (b) a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, (c) a third DCI format that schedules a non-rate splitting transmission, (d) a total number of UEs scheduled to attempt decoding the common message, (e) a table of UE IDs for UEs scheduled to attempt decoding the common message, or (f) a table of message split configurations. For example, **1506** may be performed by the network entity **1004** in FIG. **10**, which may transmit an RRC configuration **1006** that includes at least one of (a) a first DCI format for the DCI **1007** scheduling the rate-split MIMO transmission **1010** that includes a first field of the DCI **1007** that indicates whether the common message includes the first data portion of the common message associated with the UE **1002**, (b) a second DCI format for the DCI **1007** scheduling the rate-split MIMO transmission **1010** that includes a second field of the DCI **1007** that indicates at least one of a first UE ID for the UE **1002** or at least one second UE ID for the at least one second UE (e.g., UE_2 to UE_N referred to in FIG. **7**B), (c) a third DCI format for the DCI **1016** scheduling a non-rate split MIMO transmission, (d) a total number of UEs scheduled to attempt decoding the common message, which may include the UE **1002**, (e) a table of UE IDs for UEs scheduled to attempt decoding the common message, which may include the UE **1002**, or (f) a table of message split configurations that may be selected by an index, such as an index of DCI **1007** scheduling the rate-split MIMO transmission **1010**. Moreover, **1504** may be performed by the component **199** of network entity **1702** in FIG. **17**.

FIG. **16** is a diagram **1600** illustrating an example of a hardware implementation for an apparatus **1604**. The apparatus **1604** may be a UE, a component of a UE, or may implement UE functionality. In some aspects, the apparatus **1604** may include a cellular baseband processor **1624** (also referred to as a modem) coupled to one or more transceivers **1622** (e.g., cellular RF transceiver). The cellular baseband processor **1624** may include on-chip memory **1624'**. In some aspects, the apparatus **1604** may further include one or more subscriber identity modules (SIM) cards **1620** and an application processor **1606** coupled to a secure digital (SD) card **1608** and a screen **1610**. The application processor **1606** may include on-chip memory **1606'**. In some aspects, the apparatus **1604** may further include a Bluetooth module **1612**, a WLAN module **1614**, an SPS module **1616** (e.g., GNSS module), one or more sensor modules **1618** (e.g., barometric pressure sensor/altimeter; motion sensor such as inertial management unit (IMU), gyroscope, and/or accelerometer(s); light detection and ranging (LIDAR), radio assisted detection and ranging (RADAR), sound navigation and ranging (SONAR), magnetometer, audio and/or other technologies used for positioning), additional memory modules **1626**, a power supply **1630**, and/or a camera **1632**. The Bluetooth module **1612**, the WLAN module **1614**, and the SPS module **1616** may include an on-chip transceiver (TRX) (or in some cases, just a receiver (Rx)). The Bluetooth module **1612**, the WLAN module **1614**, and the SPS module **1616** may include their own dedicated antennas and/or utilize the antennas **1680** for communication. The cellular baseband processor **1624** communicates through the transceiver(s) **1622** via one or more antennas **1680** with the UE **104** and/or with an RU associated with a network entity **1602**. The cellular baseband processor **1624** and the application processor **1606** may each include a computer-readable medium/memory **1624'**, **1606'**, respectively. The addi-

tional memory modules **1626** may also be considered a computer-readable medium/memory. Each computer-readable medium/memory **1624'**, **1606'**, **1626** may be non-transitory. The cellular baseband processor **1624** and the application processor **1606** are each responsible for general processing, including the execution of software stored on the computer-readable medium/memory. The software, when executed by the cellular baseband processor **1624**/application processor **1606**, causes the cellular baseband processor **1624**/application processor **1606** to perform the various functions described supra. The computer-readable medium/memory may also be used for storing data that is manipulated by the cellular baseband processor **1624**/application processor **1606** when executing software. The cellular baseband processor **1624**/application processor **1606** may be a component of the UE **350** and may include the memory **360** and/or at least one of the Tx processor **368**, the Rx processor **356**, and the controller/processor **359**. In one configuration, the apparatus **1604** may be a processor chip (modem and/or application) and include just the cellular baseband processor **1624** and/or the application processor **1606**, and in another configuration, the apparatus **1604** may be the entire UE (e.g., see UE **350** of FIG. **3**) and include the additional modules of the apparatus **1604**.

As discussed supra, the component **198** is configured to receive a common message associated with the first UE and at least one second UE. The component **198** may be configured to obtain a common message configuration having at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE. The common message configuration may be obtained from at least one of a header of the common message or DCI scheduling the common message. The component **198** may be within the cellular baseband processor **1624**, the application processor **1606**, or both the cellular baseband processor **1624** and the application processor **1606**. The component **198** may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by one or more processors configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by one or more processors, or some combination thereof. As shown, the apparatus **1604** may include a variety of components configured for various functions. In one configuration, the apparatus **1604**, and in particular the cellular baseband processor **1624** and/or the application processor **1606**, includes means for receiving a common message associated with the first UE and at least one second UE. The apparatus **1604** may include means for obtaining a common message configuration including at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE. The apparatus **1604** may include means for receiving a private message associated with the first UE. The apparatus **1604** may include means for combining the private message with the first data portion of the common message or forgo combining the private message with the first data portion of the common message based on the common message configuration. The apparatus **1604** may include means for combining the private message with the first data portion of the common message by decoding the private message to derive a decoded private message. The apparatus **1604** may include means for combining the private message with the first data portion of the common message by decoding the common message to derive a decoded common message. The apparatus **1604** may include means for combining the private message with the first data portion of the common message by identifying the first data portion of the decoded common message to derive a first decoded portion of the common message. The apparatus **1604** may include means for combining the private message with the first data portion of the common message by combining the decoded private message with the first decoded portion of the common message to derive a decoded message for the first UE. The apparatus **1604** may include means for receiving an RRC configuration having at least one of a first DCI format that includes a first field of the DCI that indicates whether the common message includes the first data portion of the common message associated with the first UE, a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, a third DCI format that schedules a non-rate splitting transmission, a total number of UEs scheduled to attempt decoding the common message, a table of UE IDs for UEs scheduled to attempt decoding the common message, or a table of message split configurations. The means may be the component **198** of the apparatus **1604** configured to perform the functions recited by the means. As described supra, the apparatus **1604** may include the Tx processor **368**, the Rx processor **356**, and the controller/processor **359**. As such, in one configuration, the means may be the Tx processor **368**, the Rx processor **356**, and/or the controller/processor **359** configured to perform the functions recited by the means.

FIG. **17** is a diagram **1700** illustrating an example of a hardware implementation for a network entity **1702**. The network entity **1702** may be a BS, a component of a BS, or may implement BS functionality. The network entity **1702** may include at least one of a CU **1710**, a DU **1730**, or an RU **1740**. For example, depending on the layer functionality handled by the component **199**, the network entity **1702** may include the CU **1710**; both the CU **1710** and the DU **1730**; each of the CU **1710**, the DU **1730**, and the RU **1740**; the DU **1730**; both the DU **1730** and the RU **1740**; or the RU **1740**. The CU **1710** may include a CU processor **1712**. The CU processor **1712** may include on-chip memory **1712'**. In some aspects, the CU **1710** may further include additional memory modules **1714** and a communications interface **1718**. The CU **1710** communicates with the DU **1730** through a midhaul link, such as an F1 interface. The DU **1730** may include a DU processor **1732**. The DU processor **1732** may include on-chip memory **1732'**. In some aspects, the DU **1730** may further include additional memory modules **1734** and a communications interface **1738**. The DU **1730** communicates with the RU **1740** through a fronthaul link. The RU **1740** may include an RU processor **1742**. The RU processor **1742** may include on-chip memory **1742'**. In some aspects, the RU **1740** may further include additional memory modules **1744**, one or more transceivers **1746**, antennas **1780**, and a communications interface **1748**. The RU **1740** communicates with the UE **104**. The on-chip memory **1712'**, **1732'**, **1742'** and the additional memory modules **1714**, **1734**, **1744** may each be considered a computer-readable medium/memory. Each computer-readable medium/memory may be non-transitory. Each of the processors **1712**, **1732**, **1742** is responsible for general processing, including the execution of software stored on the computer-readable medium/memory. The software, when executed by the corresponding processor(s) causes the processor(s) to perform the various functions described supra.

The computer-readable medium/memory may also be used for storing data that is manipulated by the processor(s) when executing software.

As discussed supra, the component **199** is configured to configure a common message configuration having at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE. The component **199** may be configured to transmit at least one of (a) the common message having the common message configuration or (b) the common message and the common message configuration to the first UE and at least one second UE. The component **199** may be within one or more processors of one or more of the CU **1710**, DU **1730**, and the RU **1740**. The component **199** may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by one or more processors configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by one or more processors, or some combination thereof. The network entity **1702** may include a variety of components configured for various functions. In one configuration, the network entity **1702** includes means for configuring a common message configuration including at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE. The network entity **1702** may include means for transmitting at least one of (a) the common message including the common message configuration or (b) the common message and the common message configuration to the first UE and the at least one second UE. The network entity **1702** may include means for transmitting an RRC configuration including at least one of a first DCI format that includes a first field of DCI that indicates whether the common message includes the first data portion of the common message associated with the first UE, a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, a third DCI format that schedules a non-rate splitting transmission, a total number of UEs scheduled to attempt decoding the common message, a table of UE IDs for UEs scheduled to attempt decoding the common message, or a table of message split configurations. The means may be the component **199** of the network entity **1702** configured to perform the functions recited by the means. As described supra, the network entity **1702** may include the Tx processor **316**, the Rx processor **370**, and the controller/processor **375**. As such, in one configuration, the means may be the Tx processor **316**, the Rx processor **370**, and/or the controller/processor **375** configured to perform the functions recited by the means.

It is understood that the specific order or hierarchy of blocks in the processes/flowcharts disclosed is an illustration of example approaches. Based upon design preferences, it is understood that the specific order or hierarchy of blocks in the processes/flowcharts may be rearranged. Further, some blocks may be combined or omitted. The accompanying method claims present elements of the various blocks in a sample order, and are not limited to the specific order or hierarchy presented.

The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not limited to the aspects described herein, but are to be accorded the full scope consistent with the language claims. Reference to an element in the singular does not mean "one and only one" unless specifically so stated, but rather "one or more." Terms such as "if," "when," and "while" do not imply an immediate temporal relationship or reaction. That is, these phrases, e.g., "when," do not imply an immediate action in response to or during the occurrence of an action, but simply imply that if a condition is met then an action will occur, but without requiring a specific or immediate time constraint for the action to occur. The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects. Unless specifically stated otherwise, the term "some" refers to one or more. Combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. Sets should be interpreted as a set of elements where the elements number one or more. Accordingly, for a set of X, X would include one or more elements. If a first apparatus receives data from or transmits data to a second apparatus, the data may be received/transmitted directly between the first and second apparatuses, or indirectly between the first and second apparatuses through a set of apparatuses. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are encompassed by the claims. Moreover, nothing disclosed herein is dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. The words "module," "mechanism," "element," "device," and the like may not be a substitute for the word "means." As such, no claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

As used herein, the phrase "based on" shall not be construed as a reference to a closed set of information, one or more conditions, one or more factors, or the like. In other words, the phrase "based on A" (where "A" may be information, a condition, a factor, or the like) shall be construed as "based at least on A" unless specifically recited differently.

The following aspects are illustrative only and may be combined with other aspects or teachings described herein, without limitation.

Aspect 1 is a method of wireless communication at a UE, where the method may include receiving a common message associated with the first UE and at least one second UE. The method may further include obtaining a common message configuration including at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE. The common message configuration may

be obtained from at least one of a header of the common message or DCI scheduling the common message.

Aspect 2 is the method of aspect 1, where the method may include receiving a private message associated with the first UE. The method may further include combining the private message with the first data portion of the common message or forgo combining the private message with the first data portion of the common message based on the common message configuration.

Aspect 3 is the method of aspect 2, where the method may include combining the private message with the first data portion of the common message by decoding the private message to derive a decoded private message. The method may include combining the private message with the first data portion of the common message by decoding the common message to derive a decoded common message. The method may include combining the private message with the first data portion of the common message by identifying the first data portion of the decoded common message to derive a first decoded portion of the common message. The method may include combining the private message with the first data portion of the common message by combining the decoded private message with the first decoded portion of the common message to derive a decoded message for the first UE.

Aspect 4 is the method of any of aspects 1 to 3, where the header includes at least one of a first UE identifier (ID) for the first UE, at least one second UE ID for the at least one second UE, an order of the first data portion and the at least one second data portion, a first packet size for the first data portion, at least one second packet size for the at least one second data portion, a number of UEs having data portions encoded in the common message, or an index to a table of message split configurations.

Aspect 5 is the method of aspect 4, where the header may be contiguous in the common message. The header may include a MAC header.

Aspect 6 is the method of any of aspects 4 to 5, where the UE ID may include at least one of a C-RNTI or an index for a table of UEs including the first UE and the at least one second UE.

Aspect 7 is the method of any of aspects 4 to 6, where the first packet size of the first data portion of the common message may be equal to the at least one second packet size of the at least one second data portion of the common message. The first packet size may be based on the number of UEs associated with the common message.

Aspect 8 is the method of any of aspects 4 to 7, where the header may include a fourth set of sub-headers that are non-contiguous in the common message. Each of the fourth set of sub-headers may include a MAC header. The fourth set of sub-headers may include a first sub-header having a first UE ID for the first UE preceding the first data portion and at least one second sub-header having at least one second UE ID for the at least one second UE preceding the at least one second data portion.

Aspect 9 is the method of any of aspects 1 to 8, where the DCI includes a private message configuration.

Aspect 10 is the method of any of aspects 1 to 9, where the DCI includes unicast DCI. The DCI may include CRC scrambled with C-RNTI. The DCI may include a field that indicates whether the common message includes the first data portion of the common message associated with the first UE.

Aspect 11 is the method of any of aspects 1 to 10, where the DCI may include group-common DCI. The DCI may include CRC scrambled with G-RNTI. The DCI may include a field that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE.

Aspect 12 is the method of any of aspects 1 to 11, where the method may include receiving an RRC configuration having at least one of a first DCI format that includes a first field of the DCI that indicates whether the common message includes the first data portion of the common message associated with the first UE, a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, a third DCI format that schedules a non-rate splitting transmission, a total number of UEs scheduled to attempt decoding the common message, a table of UE IDs for UEs scheduled to attempt decoding the common message, or a table of message split configurations.

Aspect 13 is the method of aspect 3, where the method may include decoding the common message by decoding the common message at a first layer to derive the decoded common message. The method may include decoding the common message by identifying the first data portion of the decoded common message to derive the first decoded portion of the common message based on the common message configuration at a second layer. The method may include decoding the common message by outputting the first decoded portion to a third layer.

Aspect 14 is the method of aspect 3, where the method may include decoding the common message by decoding the common message at a first layer to derive the decoded common message. The method may include decoding the common message by identifying the first data portion of the decoded common message to derive the first decoded portion of the common message based on the common message configuration at the first layer. The method may include decoding the common message by outputting the first decoded portion to a second layer.

Aspect 15 is a method of wireless communication at a network entity, where the method may include configuring a common message configuration including at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE. The method may further include transmitting at least one of (a) the common message including the common message configuration or (b) the common message and the common message configuration to the first UE and the at least one second UE.

Aspect 16 is the method of aspect 15, where the common message configuration may be included in a header of the common message.

Aspect 17 is the method of aspect 16, where the header may be contiguous in the common message. The header may include a MAC header.

Aspect 18 is the method of any of aspects 16 to 17, where the header includes at least one of a first UE ID for the first UE, at least one second UE ID for the at least one second UE, an order of the first data portion and the at

least one second data portion, a first packet size for the first data portion, at least one second packet size for the at least one second data portion, a number of UEs having data portions encoded in the common message, or an index to a table of message split configurations.

Aspect 19 is the method of aspect 18, where the UE ID may include at least one of a C-RNTI or an index for a table of UEs including the first UE and the at least one second UE.

Aspect 20 is the method of any of aspects 18 to 19, where the first packet size of the first data portion of the common message may be equal to the at least one second packet size of the at least one second data portion of the common message. The first packet size may be based on the number of UEs associated with the common message.

Aspect 21 is the method of any of aspects 16 to 20, where the header may include a fourth set of sub-headers that are non-contiguous in the common message. The fourth set of sub-headers may include a first sub-header including a first UE ID for the first UE preceding the first data portion and at least one second sub-header including at least one second UE ID for the at least one second UE preceding the at least one second data portion.

Aspect 22 is the method of aspect 15, where the common message configuration may be included in DCI.

Aspect 23 is the method of aspect 22, where the DCI may include a private message configuration.

Aspect 24 is the method of any of aspects 22 to 23, where the DCI may be unicast. The DCI may include CRC scrambled with C-RNTI. The DCI may include a field that indicates whether the common message includes the first data portion of the common message associated with the first UE.

Aspect 25 is the method of any of aspects 22 to 23, where the DCI may be group-common. The DCI may include CRC scrambled with G-RNTI. The DCI may include a field that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE.

Aspect 26 is the method of any of aspects 15 to 25, where the method may include transmitting an RRC configuration including at least one of a first DCI format that includes a first field of DCI that indicates whether the common message includes the first data portion of the common message associated with the first UE, a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, a third DCI format that schedules a non-rate splitting transmission, a total number of UEs scheduled to attempt decoding the common message, a table of UE IDs for UEs scheduled to attempt decoding the common message, or a table of message split configurations.

Aspect 27 is an apparatus for wireless communication, including: a memory; and at least one processor coupled to the memory and, based at least in part on information stored in the memory, the at least one processor is configured to implement any of aspects 1 to 26.

Aspect 28 is the apparatus of aspect 27, further including at least one of an antenna or a transceiver coupled to the at least one processor.

Aspect 29 is an apparatus for wireless communication including means for implementing any of aspects 1 to 26.

Aspect 30 is a computer-readable medium (e.g., a non-transitory computer-readable medium) storing computer executable code, where the code when executed by a processor causes the processor to implement any of aspects 1 to 26.

What is claimed is:

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

a memory; and

at least one processor coupled to the memory and, based at least in part on information stored in the memory, the at least one processor is configured to:

receive a common message associated with the first UE and at least one second UE;

obtain a common message configuration comprising at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE, wherein the common message configuration is obtained from at least one of a header of the common message or downlink control information (DCI) scheduling the common message;

a transceiver coupled to the at least one processor, wherein the at least one processor is further configured to:

receive, via the transceiver, a private message associated with the first UE; and

combine the private message with the first data portion of the common message or forgo combining the private message with the first data portion of the common message based on the common message configuration,

wherein to combine the private message with the first data portion of the common message, the at least one processor is configured to:

decode the private message to derive a decoded private message;

decode the common message to derive a decoded common message,

identify a first data portion of the decoded common message to derive a first decoded portion of the common message; and

combine the decoded private message with the first decoded portion of the common message to derive a decoded message for the first UE;

wherein to decode the common message, the at least one processor is configured to:

decode the common message at a first layer to derive the decoded common message;

identify the first data portion of the decoded common message to derive the first decoded portion of the common message based on the common message configuration at a second layer; and

output the first decoded portion to a third layer.

2. The apparatus of claim **1**, wherein the header comprises at least one of a first UE identifier (ID) for the first UE, at least one second UE ID for the at least one second UE, an order of the first data portion and the at least one second data portion, a first packet size for the first data portion, at least one second packet size for the at least one second data

portion, a number of UEs having data portions encoded in the common message, or an index to a table of message split configurations.

3. The apparatus of claim 2, wherein the header is contiguous in the common message, wherein the header comprises a medium access control (MAC) header.

4. The apparatus of claim 2, wherein the UE ID comprises at least one of a cell radio network temporary identifier (C-RNTI) or a second index for a second table of UEs comprising the first UE and the at least one second UE.

5. The apparatus of claim 2, wherein the first packet size of the first data portion of the common message is equal to the at least one second packet size of the at least one second data portion of the common message, wherein the first packet size is based on the number of UEs associated with the common message.

6. The apparatus of claim 2, wherein the header comprises a fourth set of sub-headers that are non-contiguous in the common message, wherein each of the fourth set of sub-headers comprise a medium access control (MAC) header, wherein the fourth set of sub-headers comprises a first sub-header comprising a first UE ID for the first UE preceding the first data portion and at least one second sub-header comprising the at least one second UE ID for the at least one second UE preceding the at least one second data portion.

7. The apparatus of claim 1, wherein the DCI comprises a private message configuration.

8. The apparatus of claim 1, wherein the DCI comprises unicast DCI, wherein the DCI comprises cyclic redundancy check (CRC) scrambled with C-RNTI, wherein the DCI comprises a field that indicates whether the common message comprises the first data portion of the common message associated with the first UE.

9. The apparatus of claim 1, wherein the DCI comprises group-common DCI, wherein the DCI comprises CRC scrambled with group RNTI (G-RNTI), wherein the DCI comprises a field that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE.

10. The apparatus of claim 1, wherein the at least one processor is further configured to:

receive a radio resource control (RRC) configuration comprising at least one of a first DCI format that includes a first field of the DCI that indicates whether the common message comprises the first data portion of the common message associated with the first UE, a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE, a third DCI format that schedules a non-rate splitting transmission, a total number of UEs scheduled to attempt decoding the common message, a table of UE IDs for UEs scheduled to attempt decoding the common message, or a table of message split configurations.

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

a memory; and

at least one processor coupled to the memory and, based at least in part on information stored in the memory, the at least one processor is configured to:

configure a common message configuration comprising at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE;

transmit at least one of (a) the common message comprising the common message configuration or (b) the common message and the common message configuration to the first UE and the at least one second UE;

wherein the common message configuration is included in a header of the common message; and

wherein the header comprises a fourth set of sub-headers that are non-contiguous in the common message, wherein the fourth set of sub-headers comprises a first sub-header comprising a first UE ID for the first UE preceding the first data portion and at least one second sub-header comprising at least one second UE ID for the at least one second UE preceding the at least one second data portion.

12. The apparatus of claim 11, wherein the header is contiguous in the common message, wherein the header comprises a medium access control (MAC) header.

13. The apparatus of claim 11, wherein the header comprises at least one of a first UE identifier (ID) for the first UE, at least one second UE ID for the at least one second UE, an order of the first data portion and the at least one second data portion, a first packet size for the first data portion, at least one second packet size for the at least one second data portion, a number of UEs having data portions encoded in the common message, or an index to a table of message split configurations.

14. The apparatus of claim 13, wherein the UE ID comprises at least one of a cell radio network temporary identifier (C-RNTI) or a second index for a second table of UEs comprising the first UE and the at least one second UE.

15. The apparatus of claim 13, wherein the first packet size of the first data portion of the common message is equal to the at least one second packet size of the at least one second data portion of the common message, wherein the first packet size is based on the number of UEs associated with the common message.

16. The apparatus of claim 11, wherein the common message configuration is included in downlink control information (DCI).

17. The apparatus of claim 16, wherein the DCI comprises a private message configuration.

18. The apparatus of claim 16, wherein the DCI is unicast, wherein the DCI comprises cyclic redundancy check (CRC) scrambled with C-RNTI, wherein the DCI comprises a field that indicates whether the common message comprises the first data portion of the common message associated with the first UE.

19. The apparatus of claim 16, wherein the DCI is group-common, wherein the DCI comprises CRC scrambled with group RNTI (G-RNTI), wherein the DCI comprises a field that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second UE.

20. The apparatus of claim 11, wherein the at least one processor is further configured to:

transmit a radio resource control (RRC) configuration comprising at least one of a first DCI format that includes a first field of DCI that indicates whether the common message comprises the first data portion of the common message associated with the first UE, a second DCI format that includes a second field of the DCI that indicates at least one of a first UE ID for the first UE or at least one second UE ID for the at least one second

UE, a third DCI format that schedules a non-rate splitting transmission, a total number of UEs scheduled to attempt decoding the common message, a table of UE IDs for UEs scheduled to attempt decoding the common message, or a table of message split configurations.

21. The apparatus of claim **11**, further comprising a transceiver coupled to the at least one processor, wherein the at least one processor is further configured to transmit at least one of (a) the common message comprising the common message configuration or (b) the common message and the common message configuration to the first UE and the at least one second UE using the transceiver.

22. A method of wireless communication at a first user equipment (UE), comprising:

receiving a common message associated with the first UE and at least one second UE; and

obtaining a common message configuration comprising at least one of a first indicator for a first data portion of the common message associated with the first UE or at least one second indicator for at least one second data portion of the common message associated with the at least one second UE, wherein the common message configuration is obtained from at least one of a header of the common message or downlink control information (DCI) scheduling the common message;

receiving a private message associated with the first UE; and

combining the private message with the first data portion of the common message or forgo combining the private message with the first data portion of the common message based on the common message configuration,

wherein to combine the private message with the first data portion of the common message, the at least one processor is configured to:

decode the private message to derive a decoded private message;

decode the common message to derive a decoded common message,

identify a first data portion of the decoded common message to derive a first decoded portion of the common message; and

combine the decoded private message with the first decoded portion of the common message to derive a decoded message for the first UE;

wherein to decode the common message, the at least one processor is configured to:

decode the common message at a first layer to derive the decoded common message;

identify the first data portion of the decoded common message to derive the first decoded portion of the common message based on the common message configuration at the first layer; and

output the first decoded portion to a second layer.

23. A method of wireless communication at a network entity, comprising:

configuring a common message configuration comprising at least one of a first indicator for a first data portion of a common message associated with a first UE or at least one second indicator for at least one second data portion of the common message associated with at least one second UE;

transmitting at least one of (a) the common message comprising the common message configuration or (b) the common message and the common message configuration to the first UE and the at least one second UE;

wherein the common message configuration is included in a header of the common message; and

wherein the header comprises a fourth set of sub-headers that are non-contiguous in the common message, wherein the fourth set of sub-headers comprises a first sub-header comprising a first UE ID for the first UE preceding the first data portion and at least one second sub-header comprising at least one second UE ID for the at least one second UE preceding the at least one second data portion.

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